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What drives stickiness in location-based AR games? An examination of flow and satisfaction

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ABSTRACT

Although location-based augmented reality (AR) games are popular in recent years, the motivates of the game's stickiness still need further investigation. The main goal of this research is to investigate the antecedents of the game's stickiness. This research develops a conceptual model and hypotheses based on the theory of flow and satisfaction to investigate the antecedents. An online questionnaire was developed and distributed on popular websites to collect data, and 1028 usable responses are collected from the players of Pokémon Go in Taiwan. The eleven hypotheses and control variables were validated by using structural equation modeling (SEM) techniques. Among the antecedents of the game's stickiness in the model, the flow and satisfaction were found to have strong direct effects. The effects of control variables (age, gender, platform, game experience, and in-app expense) on the stickiness were significant as well. Moreover, telepresence, challenge, perceived control, curiosity, and concentration all have direct influences on the flow. Only perceived currency and responsiveness were found to have a direct impact on players' satisfaction. The model demonstrated good explanatory power for flow and stickiness in the context of location-based AR game. The proposed model can provide insights to location-based AR game developers to design their games and marketing strategies.

1. Introduction

Mobile game developers are bringing augmented reality (AR) technology to the forefront of the gaming industry. AR technology augments the real world with virtual data. Pokémon GO is a well-known example of how AR can be applied to gaming. This mobile game combines AR and location-based service (LBS) technology. As the player plays the game, the system first locates the player's current location via LBS technology and displays a virtual map that corresponds to the updated location information. Following the virtual map provided by the game, players can walk around the area to encounter randomly appearing Pokémon (a term that describes one or more of a series of cartoon characters). The game's ultimate goal is to capture Pokémon to complete the entries in the Pokédex, a comprehensive Pokémon encyclopedia. When a player encounters a Pokémon, s/he can choose whether or not to capture it.

Since its launch, Pokémon GO has been reverberating around the world and has set a number of records, including being "the most downloaded mobile app in its first week of release" and "[passing the milestone of] 50 million downloads on Google Play over the shortest period of time" (TechCrunch, 2016). Though AR technology has been in development for years, the Pokémon GO phenomenon has brought it back to the forefront of public attention. SimilarWeb, the global leader in Web traffic measurement, did a

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survey focused on Android devices in the United States and noted that, as of July 8, 2016, the average time Pokémon GO players spent playing the game was 43 min and 23 s: higher than the average usage time of Whatsapp, Instagram, Snapchat and Messenger (SimilarWeb, 2016).

Nevertheless, related surveys in growing numbers have pointed out that Pokémon GO fever is dying off as time goes on, indicating that players do not seem to be as engaged. According to a 2016 Bloomberg report, statistics from Sensor Tower, SurveyMonkey and Apptopia show a gradual decline in Pokémon GO's daily active user count, download rate, and playtime. Although user participation rapidly reached 100% when Pokémon GO was first launched in 15 countries in Asia in August of 2016, it has since dropped to 50% (Bloomberg, 2016).

The persistence with which users play mobile games (i.e., the "stickiness" of the game) and the revenue of game providers are closely related. A game's high level of stickiness prompts players to purchase goods and services—and watch ads—at a higher rate. Thus, mobile game developers must take into account the key factors that, in the players' experience, make the game sticky. Past studies on Computer-Mediated Environments (CME) have found that flow, service quality and satisfaction directly or indirectly impact the intention to continue usage. Since people play games in order to feel that sense of flow, this factor has a strong influence on a user's willingness to play a mobile game (Lee and Tsai, 2010); hence this study first explores flow related factors. Since past scholars' assessments of flow have been inconsistent, this study focuses on analyzing the technical aspects of Pokémon GO to identify the factors that deepen players' immersion in the game, and to determine whether these factors actually contribute to the occurrence of flow. "Service quality" is the term that describes the overall *evaluation* that a player makes regarding the entertainment value of Pokémon GO (Lien et al., 2017). The term "satisfaction" refers to players' overall *assessment* of the entertainment service provided by Pokémon GO. Satisfaction is known to be predicted by service quality, yet this relationship requires further verification in the context of Pokémon GO. Newly emergent among mobile games, location-based AR games require further exploration. The mobile gaming market is expanding rapidly and is fiercely competitive. Thus, it behooves us to more deeply investigate how satisfaction and service quality relate to each other in an AR game context.

According to a report of BusinessofApps.com in 2018, the cumulative worldwide revenue of Pokémon GO is still grow up although the number of active user decreases (BusinessofApps, 2018). The understanding of the perceptions of active users can help developers improve the service quality and satisfaction of the games. Past research also indicated that the emotional value of a game, such as flow, will enhance usage or payment intention (Hsiao and Chen, 2016). However, few studies integrate flow, service quality, and satisfaction concepts to understand the stickiness of AR game. Therefore, this study proposed a research based on flow and satisfaction-related theories and collect the data to examine the antecedents of location-based AR game stickiness.

2. Literature review

2.1. Mobile games

Growth in the mobile gaming market has been driven primarily by the huge popularity of mobile devices, which are characteristically simple, highly mobile, accessible, and networkable (Koutromanos and Avraamidou, 2014). Any game that works on a mobile device (e.g., cellphone, tablet) can be described as a mobile game. Such games are often classified as casual games (Merikivi et al., 2017). Not only can users play these games anywhere and anytime (Koutromanos and Avraamidou, 2014), but such play requires no special game skills (Merikivi et al., 2017). Classifications of mobile games include such distinctions as social games, and games based on movie themes. The most famous mobile social game is Candy Crush Saga. Integrated with Facebook, the game displays the achievement levels of players' Facebook friends in the game map to enhance competition between players and to enable them to continue to participate in the game, share their achievements, and ask for additional lives and moves (Chen and Leung, 2016). The mobile game is characterized by a theme and characters that are all from movies, and is often considered to be a new strategy for promoting movies. Minion Rush is an example of a mobile movie-themed game.

AR games represent the latest trend in mobile gaming (Koutromanos and Avraamidou, 2014). Besides the well-known Pokémon GO, another mobile game that integrates AR technology is Shark Fingers 3D Aquarium, which uses the mobile device's camera lens to turn the real world into a dangerous water world. Sharks will try to bite players' fingers, so players must avoid shark' attacks by tilting the mobile device (Kim, 2013). Developments in mobile technology continue, and although mobile games attract players via content and features, the success of a mobile game still depends on reducing player churn and sustaining continuous play. To help us better understand the factors that affect game stickiness (according to past research), we develop a new research model.

2.2. Flow theory

Computer-mediated communication, online shopping and online games are typical contexts in which consumers experience the mental state of flow. The term "flow" first appeared in a book by Csikszentmihalyi (1975). When people are fully immersed in an activity and enjoying the experience of the process, this holistic sensation is referred to as "flow" (Csikszentmihalyi, 2000). According to past research, the most popular elements of flow are (1) immediate feedback, (2) a sense of potential control, (3) a distortion of temporal experience, (4) concentration, (5) the merging of action and awareness, and (6) autotelic experience (Csikszentmihalyi, 1993). Quinn (2005) indicated that the relationships between these elements are not modeled with any consistency. The same constructs could serve as either the antecedents or consequences of the flow experience. Ghani and Deshpande suggested that the flow experience includes concentration and enjoyment, and that challenge and sense of potential control are the antecedents. Regarding social media usage, Pelet et al. (2017) suggested that the flow experience consists of enjoyment, concentration, challenge,

control and curiosity, and that telepresence is an antecedent. Zhao et al. (2011) demonstrated that the concept of flow could not neglect telepresence, while enjoyment and curiosity were found to enhance the flow experience.

Curiosity and enjoyment have similar, important effects on the flow experience in the virtual environment (Wu et al., 2016). Concentration is usually considered as a key factor of flow as well (Koufaris, 2002; Pelet et al., 2017). While playing online/offline computer games, players are subject to time distortion. Usually, they have difficulty breaking off from the games unless intruded upon by others in the real world (Rau et al., 2006). Therefore, in location-based AR games, concentration and time distortion are expected to be key elements when the player is experiencing a state of flow.

To sum up, in the mobile game context, flow has been considered as a key factor of positive attitude, usage, and in-app purchase (Rauschnabel et al., 2017). For example, Rauschnabel et al. (2017) found that flow significantly affected the usage and in-app purchase of Pokémon Go. Bachen et al. (2016) also found flow would enhance users' interest in learning from a serious computer game. Su et al. (2016) demonstrated that flow-related factors, perceived enjoyment and attention focus, significantly affected play loyalty in mobile game context. Hence, flow will also play an important role in game stickiness.

2.3. Service quality

E-service quality is a multi-dimensional concept. Liljander et al. (2002) listed the elements of e-service quality as assurance/trust, customization, responsiveness, reliability, and the user interface. Assurance/trust is based on the faith users place in the system's ability to maintain privacy and security. Customization refers to the ability to modify services according to the individual's specifications or preferences. Responsiveness has been interpreted as the ability of the e-service to react to stimuli in real time. Reliability depends on accurate and up-to-date information, along with the system's ability to deliver services as promised (Kaynama and Black, 2000; Zeithaml et al., 2000). The term "user interface" refers to the system's overall design and aesthetics, as well as the ease with which the e-service can be navigated and used (Liljander et al., 2002).

In the context of mobile location-based emergency management services at the governmental level, Aloudat et al. (2014) suggested that quality of such services is comprised of perceived accuracy, perceived currency and perceived responsiveness. These three constructs determine quality, in accordance with the real-time characteristics of location-based e-services. Similarly, in a location-based mobile AR game, relevant game information must be accurately and instantaneously delivered to users' mobile devices (Lifehacker, 2016). Therefore, the three constructs are suitable for the evaluation of service quality.

The characteristics of Pokémon GO service are as the following (Lifehacker, 2016). First, the map in Pokémon GO can display the correct location information of the Pokémons around the players. Second, players are able to catch the Pokémons instantly through the features in the game. Third, the game services can immediately respond to players' requests and help them get game information and interact with other players. Based on the three characteristics, perceived accuracy, currency, and responsiveness are considered as the main antecedents of the service satisfaction.

2.4. Satisfaction and stickiness

Customer satisfaction is an important issue in information system usage. Satisfaction is an emotional reaction of moderate strength; it is induced by a combination of the feelings experienced by the consumer and the performance level of the service (Liljander et al., 2002). The antecedents of customer satisfaction have already received a great deal of attention in the extant literature. Significant antecedents of satisfaction include perceived usefulness, perceived value, perceived quality, and so on (Mouakket, 2015; Wang et al., 2016). Moreover, many past studies have proven that usage continuance intention (regarding a product or service) is significantly affected by satisfaction (Alraimi et al., 2015; Chang, 2013; Zhou, 2013). Thus, users are more willing to use a product/service when it satisfies their needs. In a study on social networking sites, Mouakket (2015) also found that satisfaction had a significant impact on usage continuation.

Not only does customer satisfaction predict usage intention, it can also enhance the stickiness of a mobile game. Stickiness behaviors have been discussed widely in the Internet context. The total number of visits or the cumulative amount of time spent on a given website over a certain period of time defines the website's level of stickiness, for example (Hsu and Liao, 2014). Stickiness can increase a service company's revenue, enhance online transactions, and increase online word of mouth (Elliot et al., 2013; Kim et al., 2016). Thus, e-service and mobile game success is partially dependent on the stickiness factor.

3. Conceptual framework and hypothesis development

We developed our research model (Fig. 1) using the flow framework as a basis (Finneran and Zhang, 2005). This framework defines three stages of flow in a computer-mediated environment: antecedents, experience and consequences (Chen, 2000; Finneran and Zhang, 2005). According to related studies, the flow antecedents in a location-based AR environment are telepresence, challenge, control, concentration, and curiosity. The existence of a state of flow is measured by the perception of time distortion. The consequences of continuous usage are satisfaction and stickiness. Below, we describe the hypotheses derived from our research model.

In an AR context, the term "telepresence" describes the level to which users lose awareness of their actual physical environment and believe themselves to exist in the virtual world (Hoffman and Novak, 1996). Past studies have adopted telepresence to evaluate users' experience in virtual environments (Guo et al., 2016; Weibel et al., 2008). Moreover, the effect of telepresence has been widely verified in the computer-mediated environment. For example, Guo et al. (2016) found that, in the online learning environment, telepresence is the factor that most influences flow and learners' continuance intention. In the social media context, telepresence can

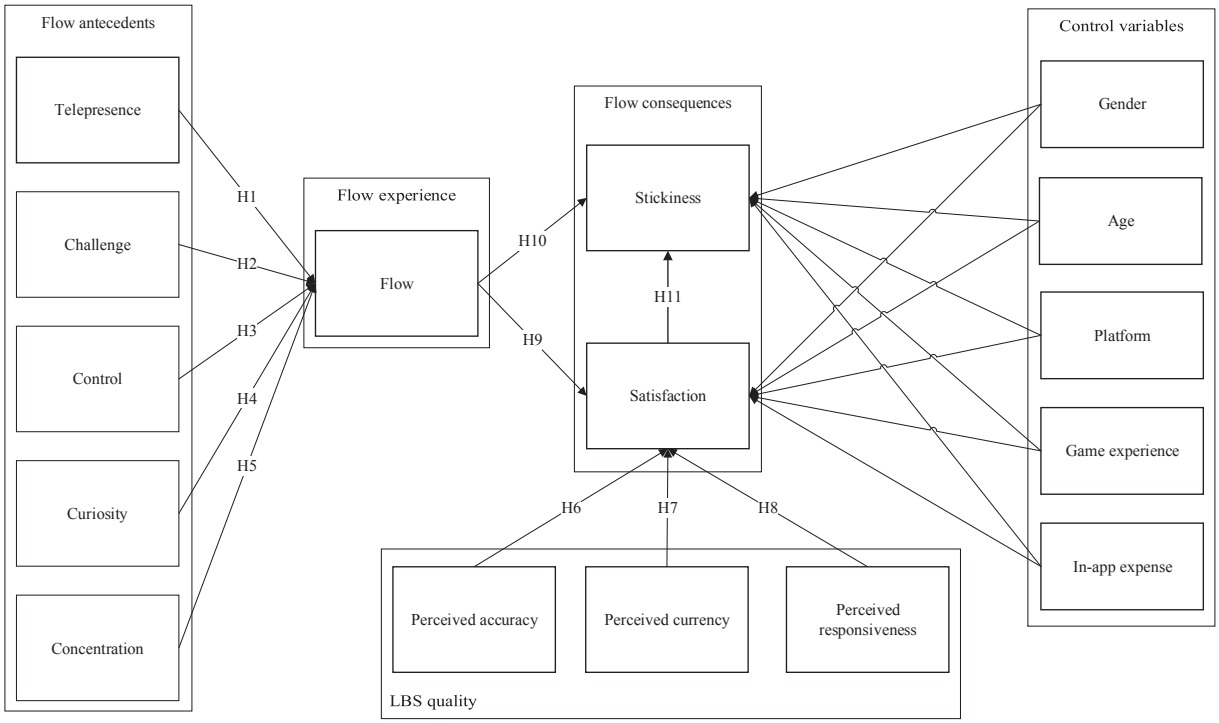

Fig. 1. Research model.

also enhance users' flow state (Pelet et al., 2017). Flow has also been found to be positively and significantly affected by telepresence, according to a study on instant messaging (Zaman et al., 2010). Similarly, in the AR game environment, telepresence allows players to feel captivated by the game. Thus, we hypothesize as follows.

H1. Telepresence positively influences flow in a location-based AR game.

In a game context, the level to which the game stretches one's capabilities is referred to as "challenge" (Bridges and Florsheim, 2008). In this study, it refers to the achievability of in-game goals. Thus, challenge is related to the difficulty of the missions in the game. Past research has indicated that challenge can significantly affect flow (Teng, 2013). Generally speaking, users do not need many skills to play mobile games. The difficulty of achieving the goals of the game thus becomes the main challenge. In the context of online games, Teng (2013) found that flow is positively and significantly impacted by challenge. Therefore, challenge is expected to have a positive effect on users playing location-based AR games. We propose the following hypothesis.

H2. Challenge positively influences flow in a location-based AR game.

We define perceived control as the users' sense that the game precisely executes their intended actions (Koufaris, 2002). In a computer game context, perceived control is also related to the user interface. A well-designed user interface helps users control their actions in the game. The extant literature has shown that the flow experience depends on the users' sense of control (Mathwick and Rigdon, 2004; Pearce et al., 2005). Zaman et al. (2010) also found that, in the usage of instant messaging services, flow is positively affected by users' perception of control. Therefore, when players feel that they have good control over their own actions within the game, their flow state is enhanced. The following hypothesis is proposed.

H3. Perceived control positively influences flow in a location-based AR game.

In the game context, curiosity is often the reason why users continue to interact with the game content (Hsu et al., 2009). Curiosity will also enhance users' desire to acquire and investigate new information in a mobile game. The revelation of hidden objects or environments in the game world may surprise and delight users, increasing their motivation to explore the game. Zhao et al. (2011) demonstrated that, on the Internet, curiosity can increase the possibility that users will experience addiction and flow. In a location-based AR game, users must change location to explore new items via AR technology. Therefore, curiosity will motivate users to explore, and cause them to lose track of time. Thus, we hypothesize as follows.

H4. Curiosity positively influences flow in a location-based AR game.

In the mobile game context, concentration is expected to be relevant to the flow experience (Liu and Li, 2011). Concentration in this study refers to the attention required of users during their involvement with the game. Users who are in a state of flow must concentrate on their activities (Koufaris, 2002). Thus, online game behaviors are highly influenced by concentration. According to

Jung et al. (2009), behavioral intentions are driven by the user's beliefs, which are influenced by concentration. Similarly, when users focus their attention on playing location-based AR games, they may experience a high level of flow. Based on the above studies on flow, we hypothesize as follows.

H5. Concentration positively influences flow in a location-based AR game.

The relationships between service quality and user satisfaction has been examined widely. User satisfaction with a mobile e-service has been found to be positively influenced by the quality of that service (Kuo et al., 2009). Deng et al. (2010) also demonstrated that the service quality of mobile instant messages enhances user satisfaction and can help maintain consumer loyalty. In this study, the service quality of a location-based AR game is comprised of perceived accuracy, perceived currency and perceived responsiveness. Perceived accuracy is the degree to which the information provided by a location-based AR game appears to be correct. Providing correct information that corresponds to the user's location is critical in location-based AR games. Perceived currency refers to the presentation of apparently up-to-the-minute mobile game information (Aloudat et al., 2014). Perceived responsiveness is the degree to which the game reacts to users' information requests in a timely manner (Kim and Han, 2011). Based on the above studies regarding the quality of online services, we hypothesize as follows.

H6. Perceived accuracy positively influences satisfaction with a location-based AR game.

H7. Perceived currency positively influences satisfaction with a location-based AR game.

H8. Perceived responsiveness positively influences satisfaction with a location-based AR game.

We define flow as the degree to which time passage feels subjectively different to the user. We define satisfaction as the level to which the user is comfortable playing a location-based AR game and has a positive attitude toward the game (Lu et al., 2010). Game stickiness is the consequence of flow and satisfaction. We define the stickiness of a location-based AR game as the level to which the player is willing to return to the game and to lengthen the playing time during each session (Wu et al., 2010). Gao et al. (2015) studied mobile shopping and determined that both shopping intention and satisfaction are positively affected by flow. Satisfaction and shopping intention also have a positive relationship. Studies on online games have also shown flow to be the key antecedent of the intention to play (Lee and Tsai, 2010), and that game loyalty is enhanced when users experience flow and involvement in the game (Su et al., 2016).

The relationship between satisfaction and stickiness has been widely explored. For example, Tsao (2014) examined this relationship in the LINE app and found that the relationship is positive. Lien et al. (2017) examined the same relationship in the WeChat app, with similar results. Based on the results of related research, the relationship between satisfaction and stickiness in a location-based AR game is expected to be positive and significant. Thus, we hypothesize as follows.

H9. Flow positively influences satisfaction with a location-based AR game.

H10. Flow positively influences game stickiness.

H11. Satisfaction with a location-based AR game positively influences game stickiness.

3.1. Control variables

Past research has found that age, gender, platform (iOS or Android), game experience, and in-app expense may influence users' online usage intention and behaviors (Hsiao and Chen, 2016). According to Hsiao and Chen (2016), the intention to use mobile apps and to make purchases via such apps is greater among male players and older players. iPhone users are another group that generally spends more on mobile apps. Thus, in order to determine their effect on stickiness and satisfaction, our model includes age, gender, platform, game experience and in-app expense as control variables.

4. Methodology

4.1. Data collection and sampling

Our study sampled users of Pokémon GO in Taiwan. Data were collected via a Google Form, i.e., an online survey questionnaire. The number of Internet users in Taiwan is estimated to exceed 18 million. According to a 2017 survey, 91.3% of Internet users in Taiwan have accessed the Internet via a mobile device (TWNIC, 2017). In particular, social media apps are the main type of mobile apps used by such users, followed by game apps. According to the statistics of Google play and App Store in Taiwan in May 2018, the app of Pokémon GO has been download more than 20 million times. There are still more than 1 million active players in Taiwan in 2017.

An invitation to participate in our survey was distributed to mobile game communities and social networking sites that are popular among players of Pokémon GO. To encourage participation in the survey, we offered a raffle. The survey was made available online from February to April 2017. Following the survey description, respondents were offered the opportunity to fill out the questionnaire. The survey took about 12 min to complete. Our sample was comprised of 1,028 valid surveys after duplicates and incomplete responses were eliminated. Table 1 summarizes the demographics of the respondents.

Table 1
Profile of respondents.

Measure	Item	Frequency	%
Gender	Male	648	63.0
	Female	380	37.0
Age	Under 19	137	13.3
	20–29	500	48.6
	30–39	232	22.6
	40–49	105	10.2
	Over 50	54	5.3
Occupation	Office worker	377	36.7
	Self-employed	76	7.4
	Home maker	24	2.3
	Student	379	36.9
	Others	130	12.6
Smartphone OS	Android	590	57.4
	iOS	438	42.6
Education level	High school	164	16.0
	Undergraduate	627	61.0
	Graduate degree	237	23.0
Dollars spent in the mobile game ($NT)	Never	795	77.3
	< 500	77	7.5
	500–1000	62	6.0
	1000–2000	42	4.1
	2000–4000	27	2.6
	4000–6000	14	1.4
	Over 6000	11	1.1
Mobile game experience (year)	< 0.5	109	10.6
	0.5–1 y	159	15.5
	1–3 y	251	24.4
	3–5 y	285	27.7
	5–7 y	106	10.3
	> 7 y	118	11.5
Play time per day (hour)	< 1 h	35	3.4
	1–3 h	327	31.8
	3–5 h	361	35.1
	5–7 h	145	14.1
	> 7 h	160	15.6

4.2. Measures

Validated multi-item scales were adapted from previous studies to measure our research constructs. To fit our research context, we also reworded the questionnaire. All items were measured using a five-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5). We adapted items from Wei et al. (2015) to measure game stickiness. We adapted items from Aloudat et al. (2014) to measure perceived responsiveness, currency and accuracy. Chang’s (2013) scale was used to assess flow. We measured continuance intention using items from (Chiang and Hsiao, 2015). Items were adapted from Wang et al. (2016) to measure satisfaction. Telepresence was adapted from Guo et al. (2016), and we used measures from Badrinarayanan et al. (2015) to assess challenge. Curiosity and concentration items were adapted from Zhao et al. (2011). The assessment of the degree of perceived control was based on items from Qin et al. (2009). We performed a pretest with the help of three experts and ten persons with Pokémon GO experience. The pretest helped us identify unclear expressions, clarify scale wording, and set the instrument to the proper length. We then administered a pilot test to a sample of 40 respondents who were selected from among the pool of students at a university. The pilot test identified practical implementation issues. Using this data, we initially assessed the measurement model via factor analysis. In accordance with the accepted standard, we removed items with factor loadings that did not reach the 0.5 threshold (Hair et al., 1998). Ultimately, we retained 39 items. The list of items used in the online questionnaire is found in the Appendix.

4.3. Results

Structural equation modeling (SEM) was employed to test the measurement and structural models. The latent variables are defined via observed items in the measurement model. The relationships between the latent variables are evaluated via the structural model. Such fields as psychology, education and marketing have often used the computer algorithms and statistical methods included in SEM. We used SPSS and AMOS 24.0 software to assess the models.

Table 2 shows the means and standard deviations of the model constructs. Perceived responsiveness and accuracy is the construct that has the highest mean and lowest standard deviation. While having a relatively high standard deviation, telepresence has the lowest mean. This means that the response time and accuracy of LBS are acceptable, but the telepresence in the Pokémon GO AR game is not strong. The other means of the constructs range between 3.180 and 3.883, which means that users’ perceptions of the

Table 2
Individual item reliability of potential user group.

Construct	Mean	S.D.	Composite reliability	AVE	Cronbach's α
Perceived accuracy (PA)	3.996	0.675	0.803	0.580	0.657
Perceived currency (PCU)	3.883	0.816	0.909	0.769	0.851
Perceived responsiveness (PR)	3.946	0.656	0.859	0.606	0.789
Telepresence (TELE)	2.405	1.013	0.943	0.846	0.909
Challenge (CHA)	3.450	0.892	0.948	0.821	0.927
Perceived control (PCO)	3.823	0.728	0.906	0.660	0.871
Curiosity (CUR)	3.657	0.825	0.932	0.821	0.890
Satisfaction (SAT)	3.612	0.813	0.929	0.813	0.885
Flow (FLO)	3.345	0.861	0.886	0.723	0.808
Stickiness (STI)	3.180	1.011	0.947	0.856	0.916
Concentration (CON)	3.649	0.873	0.958	0.820	0.945

constructs are positive.

We used confirmatory factor analysis to test the measurement model. In order to assess how well the model fitted the research data, we evaluated the following fit indicators: the ratio of chi-square statistics to degree of freedom (χ^2/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), normed fit index (NFI), incremental fit index (IFI), Tucker–Lewis index (TLI), the standardized root mean squared residual (SRMR), and the root mean square error of approximation (RMSEA). Table 4 shows the test results, which indicate that all fit indices exceeded their suggested thresholds except for SRMR and RMSEA. Thus, we conclude that our model fits the data well.

Before testing the hypotheses, we examined the constructs' reliability, convergent validity and discriminant validity. We measured reliability using Cronbach's alpha and composite reliability (CR). Table 2 shows that the values of CR and Cronbach's alpha ranged from 0.657 to 0.958, exceeding the acceptable reliability threshold of 0.6 (Fornell and Larcker, 1981). The level of effectiveness with which questionnaire items reflect their corresponding factors is known as convergent validity. Measurement models must adhere to the following standards: (1) factor loadings for all indicators must be greater than 0.5 (Hair et al., 1998), (2) values for composite reliability (CR) must be greater than 0.6, and (3) each construct's average variance extracted (AVE) must be greater than 0.5 (Fornell and Larcker, 1981). Our results show that the indicator factor loadings of all items were greater than the 0.5 threshold, AVE values were within an acceptable range (0.580–0.856), and all composite reliability values were of an acceptable standard. Thus, convergent validity was ensured.

Discriminant validity measures the statistical difference between two factors by comparing each construct's square root of AVE with that construct's correlation coefficients with the remaining constructs. Proper discriminant validity requires that the correlation coefficients be less than the square root of the AVE. Table 3 shows that the measurement scale has satisfactory discriminant validity.

4.4. Structural model and hypothesis testing

Table 4 shows that, according to the structural model's fitness measures, the model fits the data well. The standardized path coefficients (Fig. 2) explain the direction of the relationships among the variables. As the explained proportion of variance in the endogenous variables, the R^2 values represent the structural model's explanatory power. The antecedents of flow were all found to have strong effects on flow (Fig. 2), supporting H1-H5 ($b = 0.211$, $p < 0.001$; $b = 0.176$, $p < 0.001$; $b = 0.101$, $p < 0.001$;

Table 3
Discriminant validity of paying user group.

Construct											
	PA	CON	CUR	FLO	PR	SAT	PC	STI	TELE	CHA	PCO
PA	**0.762**										
CON	0.550	**0.906**									
CUR	0.458	0.541	**0.906**								
FLO	0.524	0.799	0.519	**0.850**							
PR	0.590	0.495	0.534	0.460	**0.778**						
SAT	0.413	0.560	0.540	0.524	0.456	**0.902**					
PCU	0.562	0.476	0.442	0.460	0.573	0.416	**0.877**				
STI	0.434	0.633	0.462	0.611	0.402	0.605	0.428	**0.925**			
TELE	0.329	0.508	0.417	0.590	0.352	0.386	0.331	0.517	**0.920**		
CHA	0.437	0.567	0.538	0.586	0.446	0.590	0.487	0.591	0.473	**0.906**	
PCO	0.512	0.548	0.470	0.511	0.567	0.508	0.560	0.486	0.323	0.508	**0.812**

Notes: The diagonal elements show the square root of the average variance extracted; The off diagonal elements show the correlations between the constructs.
The bold numbers are the square root of the average variance extracted.

Table 4
Measures of the model fit.

Goodness of fit measures	χ^2/df	GFI	AGFI	CFI	NFI	IFI	TLI	RESEA	SRMR
Recommended value	≦5.00[a]	≧0.8[e]	≧0.8[f]	≧0.9[b]	≧0.9[b]	≧0.9[b]	≧0.9[b]	≦0.08[c]	≦0.1[d]
CFA model	4.527	0.857	0.827	0.929	0.911	0.929	0.919	0.059	0.066
Structural model	4.157	0.855	0.822	0.921	0.900	0.922	0.908	0.055	0.063

Source:
[a] Bentler (1989).
[b] Bagozzi and Yi (1988).
[c] Browne and Cudeck (1993).
[d] Hoang et al. (2006).
[e] Seyal et al. (2002).
[f] Scott (1994).

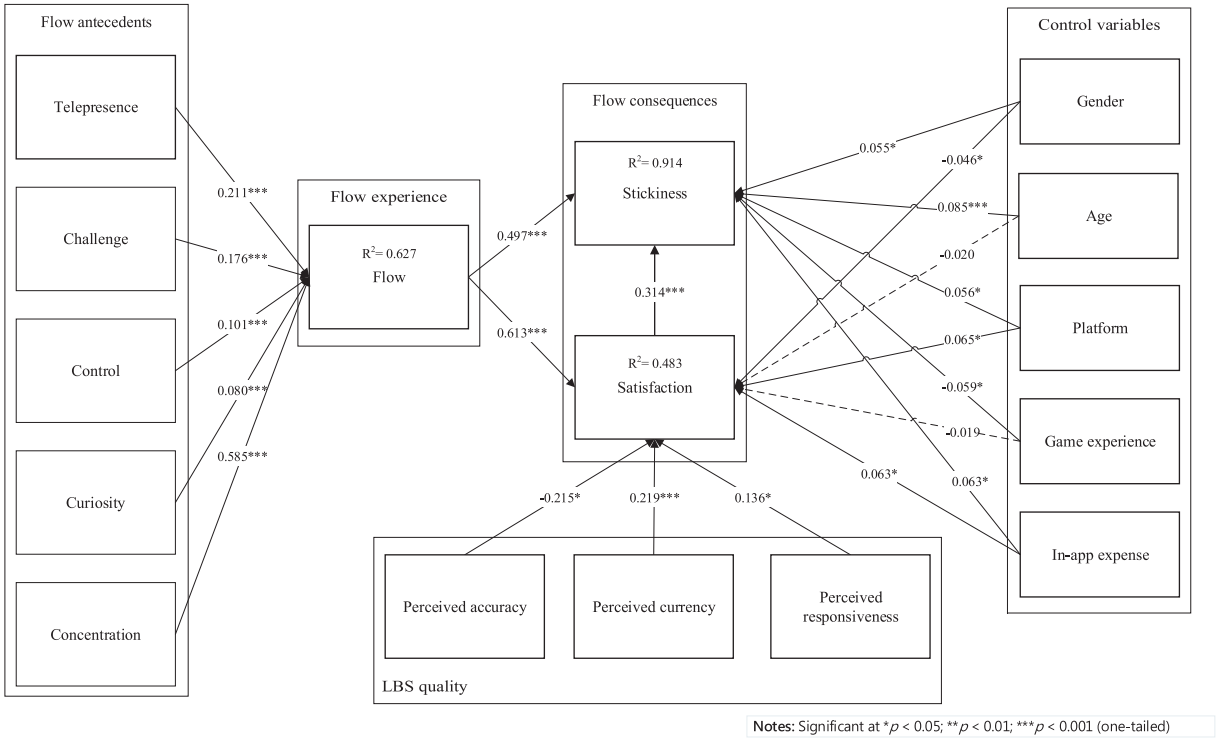

Fig. 2. Analysis results.

b = 0.080, p < 0.001; b = 0.585, p < 0.001). In our location-based AR game context, these antecedents account for 91.4% of the variance in flow. The LBS quality factors significantly influenced satisfaction, but accuracy had a negative effect. Thus, H7 and H8 were supported, but H6 was not. The results also show that flow has a strong direct influence on game satisfaction and game stickiness, thereby supporting H9 and H10. The path coefficient of 0.314 (p < 0.001) indicates that stickiness is strongly impacted by satisfaction. This supports H11. Platform (0 = iOS, 1 = Android), gender (0 = male, 1 = female), and in-app expense were the only control variables found to have any effect on satisfaction. Age and platform game experience had no significant impact. In addition, the control variables were found to have a significant effect on stickiness. Together, these paths account for 48.3% and 62.7% of the variance in satisfaction and stickiness, respectively. The testing results are summarized in Table 5.

5. Discussion and implications

Many scholars have conducted detailed and specific studies on mobile games recently to explore mobile game usage behaviors such as loyalty, usage intention and purchase intention. This study adds to our understanding of these behaviors in the context of location-based AR games, and identifies important factors that influence game stickiness.

Among the antecedents of flow, concentration was found to have the strongest effect. The state of concentration allows users to become fully involved in the game world. This means that the attractiveness of the game content is still critical: the content must

Table 5
Results of testing.

Hypothesis	Path	Coefficient	Conclusion
H1	TELE → FLO	0.211***	Supported
H2	CHA → FLO	0.176***	Supported
H3	PCO → FLO	0.101***	Supported
H4	CUR → FLO	0.080***	Supported
H5	CON → FLO	0.585***	Supported
H6	PA → SAT	−0.215*	Unsupported
H7	PCU → SAT	0.219***	Supported
H8	PR → SAT	0.136*	Supported
H9	FLO → SAT	0.613***	Supported
H10	FLO → STI	0.497***	Supported
H11	SAT → STI	0.314***	Supported
	AGE → SAT	−0.020	Insignificant
	GEND → SAT	−0.046*	Significant
	GE → SAT	−0.019	Insignificant
	EXP → SAT	0.063*	Significant
	PLAT → SAT	0.065*	Significant
	AGE → STI	0.085***	Significant
	GEND → STI	0.055*	Significant
	GE → STI	−0.059*	Significant
	EXP → STI	0.063*	Significant
	PLAT → STI	0.056*	Significant

GE: Game experience; PLAT: Platform; GEND: Gender; EXP: In-app expense.
* $p < 0.05$.
*** $p < 0.001$ (one-tailed).

catch users' attention. As expected, we found that telepresence has a positive influence on flow, and is the next most influential factor after concentration. This is consistent with past findings (Guo et al., 2016). Telepresence can be strengthened through vividness and interactivity (Steuer, 1992). Therefore, we believe that Pokémon GO creates a highly dynamic and interactive game world for the players, giving them a sense of vicarious experience which causes them to ignore various events and conditions in the real world, inducing a sense of flow. Accidents have been a frequent occurrence among users playing Pokémon GO, and telepresence has been noted as a significant reason behind such mishaps.

Our findings also confirm that challenge, control, and curiosity have a positive correlation with flow, which is consistent with past flow-related studies (Teng, 2013; Zaman et al., 2010; Zhao et al., 2011). Thus, to give players the experience of flow, mobile games should induce curiosity while offering a good challenge along with a great sense of control. Players often obtain a sense of achievement by overcoming challenges, so we suggest that appropriate increases in the level of challenge within the game can increase the difficulty of obtaining such achievements, thereby enhancing the sense of flow. In terms of perceived control, we suggest that developers create a usable and friendly interface that gives players a powerful sense of control within the game. Hence players can fully control their behaviors as they desire, and interact with the game content smoothly. When mobile game players feel in control of the game, they will focus more on the game and less on the external world while playing. Since novelty can arouse curiosity (Huang, 2003), we believe that as players walk and play in the real world using LBS technology, they will be curious about rare or special Pokémon, thus increasing their experience of flow.

Perceived accuracy is found to have a significant negative impact on satisfaction. In fact, among the three dimensions of service quality, only perceived currency and responsiveness have a significant positive impact on satisfaction. This suggests that responsiveness and perceived currency are important factors for service quality. In other words, when the level of perceived currency and responsiveness of a game is higher, players will be more satisfied with the entertainment services provided by the mobile game. Since the appearance of Pokémon within the game of Pokémon GO is time-based, players will care about the synchronization of the appearance of Pokémon in the virtual world. When the perceived currency and responsiveness of the game is high (i.e., the latest Pokémon appear in a timely manner), players will be more satisfied with the game. To improve service quality, game developers should give renewed attention to the synchronization and response mechanisms of the game. The most attractive aspect of Pokémon GO is the virtual map by which players can navigate the real world and capture randomly appearing Pokémon. Thus, the game's map information should be reliable. In order to provide good service quality to game players, Pokémon GO should provide correct map and game information instantly. Although interference may cause the location information to be inaccurate on occasion, the inaccurate information may help players catch more Pokémon and, surprisingly, enhance their satisfaction with the game. Hence, perceived accuracy has a negative significant impact on satisfaction. However, such inaccuracy can cause injustice within the game. Thus, inaccurate location information should be reduced in location-based games.

Though many studies have explored continuance intention in a game context, few studies have explored game stickiness, especially regarding mobile games that integrate AR and LBS technology. Therefore, our study serves to enhance our understanding of the stickiness of location-based AR games. Flow and satisfaction are found to significantly impact game stickiness. These results echo past studies on games (Chang, 2013). According to our results, player satisfaction and game stickiness can be predicted by flow. The results indicate that, across the entire research model, flow has the strongest impact on satisfaction. In comparison to satisfaction,

flow also has a stronger impact on stickiness, suggesting that flow is a significant reason why players continue to play Pokémon GO. If mobile game players have more opportunities to experience flow, their satisfaction and the game's stickiness will be strengthened. The results confirm that flow is the antecedent of satisfaction. Our study of stickiness shows that flow and satisfaction are important antecedents.

We found that gender, age, platforms, in-app expense and experience in mobile games all have significant effects on stickiness. Moreover, gender, platforms, and in-app expense also have a significant influence on satisfaction. The results indicate that Pokémon GO has a higher level of stickiness among male players. Pokémon GO is a game whose goal is to capture Pokémon to complete the entries in the Pokémon encyclopedia. Male players tend to be more likely to pursue this achievement (Yee, 2006), so Pokémon GO attracts more male players. Female players, on the other hand, tend to be more satisfied with the game. The reason may be that female players tend to play "pink games." Not only is Pokémon GO a game that includes dressing up avatars, but the design of Pokémon is cute. This study also found that age positively affects game stickiness. This indicates that Pokémon GO has a higher level of stickiness for older players. Possible reasons for this may include the following: (1) the game allows older players to have a common subject for communication with younger family members; (2) the game taps into the strong feeling of nostalgia associated with Pokémon; and (3) the game provides increased opportunities to get to know more friends.

In terms of mobile platforms, this study found that Pokémon GO has a higher level of stickiness and induces greater satisfaction for iOS users. Apple's mobile devices are considered to provide a better user experience. Moreover, Pokémon GO provides Apple Watch system support for iOS players (The Economic Times, 2016), allowing iOS players to operate most aspects of the game via their Apple watch. We speculate that it is easier for iOS players to have an excellent user experience while playing Pokémon GO. Consequently, in comparison to Android players, iOS players hold a more positive view of Pokémon GO, which makes them willing to continue to play the game. Our analysis shows that Pokémon GO is stickier for players with less experience using mobile games. Perhaps this is because playing Pokémon GO is relatively simple, and the game is easy to operate, which allows less experienced mobile game players to be more likely to intend to continue playing the game. In regard to in-game purchasing, our analysis confirms that Pokémon GO is stickier and induces a higher level of satisfaction among paying players as opposed to non-paying players. Researchers have found that highly loyal players tend to have higher levels of purchase intention. Therefore, we speculate, reasonably, that paying players of Pokémon GO are highly loyal to the game and, thus, experience Pokémon GO as having a higher level of stickiness.

This study developed a research framework to understand the stickiness of location-based AR games. The results show that the flow-based framework has good explanatory power. The model accounts for more than 60% of the variance in mobile game stickiness. In this context, flow and the LBS quality factors can also be used to explain user satisfaction. These factors account for more than 45% of the variance in satisfaction. Thus, while we provide insight into the effects of the control variables, we confirm flow and satisfaction as key determinants of the stickiness of a mobile game.

The results give developers greater insight into preferable ways to entice players to play their mobile games. As the key factor, flow has the strongest direct and indirect effects on game stickiness. As noted before: the main reason for players to continue to play a game is because they are experiencing a sense of flow. According to our findings, the flow experience in AR games can be enhanced effectively by strengthening the aspects of concentration, telepresence, curiosity, challenge and perceived control. In particular, concentration and telepresence have the strongest effects, and, thus, should receive the highest consideration during AR game design.

According to the research results, the following points are proposed for the developers to attract or retain users. The points could also enhance users' flow and satisfaction. First, using new AR technology or features to help users get more involved in the game. Second, continuously providing new game challenges and rewards. Third, continuously improving the service quality of the game. Forth, creating more game roles in the game to enhance players' curiosity.

6. Conclusions, limitations and future research

We explored the antecedents of flow and stickiness in the context of location-based AR mobile games. The research model and hypotheses improve our understanding of the influence of flow and stickiness. The results indicate that flow and satisfaction mediate the effects of certain factors on stickiness. Our results also provide insights that can help guide the design of location-based AR mobile games.

Several limitations to this study are notable. First, all of our respondents were voluntary participants (i.e., a convenience sampling). Thus, this set of mobile game users may not represent all users. Second, the focus of our study was one specific game: Pokémon Go. Other location-based AR mobile games (e.g., Ingress, Parallel Mafia) also deserve investigation. Third, we investigated usage continuance intention using a research framework that integrates flow and satisfaction. Future studies can investigate these phenomena using a wider variety of factors and implement such theoretical models as motivation theories. Lastly, the subjects were Pokémon GO players in Taiwan. Since countries differ in terms of lifestyle and culture, the results may also differ outside of Taiwan. Future studies must enhance the generalizability of the findings by investigating other countries.

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Appendix A

Telepresence

1 Pokémon Go created a new world for me, and this world suddenly disappeared when I stopped browsing.
2 When I played Pokémon Go, my body was in the real world, but my mind was inside the world created by this game.
3 When I played Pokémon Go, the world generated by the game was more real for me than “the real world“.

Concentration

1 When playing Pokémon Go, I am absorbed intensely in the activity.
2 When playing Pokémon Go, my attention is focused on the activity.
3 When playing Pokémon Go, I concentrates fully on the activity.
4 When playing Pokémon Go, I am deeply engrossed in the activity.
5 When playing Pokémon Go, I am totally absorbed in what I am doing.

Challenge

1 Playing Pokémon Go challenges me to perform to the best of my ability.
2 I find that playing Pokémon Go stretches my capabilities to my limits.
3 Playing Pokémon Go challenges me.
4 Playing Pokémon Go provides a good test of my skills.

Perceived control

1 I can control the character to move according to my arrangement.
2 I can control the game interface.
3 I explore actively what I want to in the game story.
4 Parts of the story are formed by me in the course of playing the game.
5 I can control the progress of the game story.

Curiosity

1 Playing Pokémon Go excites my curiosity.
2 Playing Pokémon Go makes me curious.
3 Playing Pokémon Go arouses my imagination.

Perceived accuracy

1 I would expect the message of the service of when I am playing Pokémon Go delivered to me to be always accurate.
2 I would find it unacceptable to receive inaccurate information when playing Pokémon Go.
3 Overall, the service of Pokémon Go are reliable to be played.

Perceived currency

1 I would expect the message content delivered to my phone to have up-to-the-minute information when I am playing Pokémon Go.
2 I would be concerned if the information provided to me was not up-to-date when I am playing Pokémon Go.
3 I think the service of Pokémon Go should always have the latest information in order to be reliable.

Perceived responsiveness

1 I would expect the service of Pokémon Go to be timely.
2 If I played Pokémon Go, I would always expect a prompt response.
3 I do mind if there is a delay in response to a location service query when I am playing Pokémon Go.
4 Overall, the service of Pokémon Go should offer safety information in a timely manner.

Flow

1 When I was playing in Pokémon Go, I felt totally captivated.
2 When I was playing Pokémon Go, time seemed to pass very quickly.
3 When I was playing Pokémon Go, nothing seemed to matter to me.

Satisfaction

1 I am satisfied with the service of Pokémon Go.
2 My experience with the service of Pokémon Go is very pleasing.
3 Pokémon Go has met my expectations.

Stickiness

1 I would spend a longer time on Pokémon Go than other mobile games.
2 I intend to prolong my time spent on Pokémon Go.
3 I would play Pokémon Go as often as I can.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.tele.2018.06.008.

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