The Persuasion Effect of Sociability in the Design and Use of an Augmented Reality Wedding Invitation App

Hui-Fei Lin[1], Chi-Hua Chen[2]

[1] Graduate Institute of Mass Communication, National Taiwan Normal University, Taiwan
[2] College of Mathematics and Computer Science, Fuzhou University, China
huifeilin@ntnu.edu.tw, chihua0826@gmail.com

Abstract

With the popularization of smartphones and the associated increase in the use of mobile applications (apps), the effect of mobile advertising apps on consumers should not be overlooked. Some apps include augmented reality capabilities in an attempt to bring some novelty to their users' experience. Previous studies examining the use of AR in advertising and marketing are scarce. Additionally, there are currently several business owners and advertising agencies with reservations about the efficacy of using AR in advertising, making further research into the effect of AR on consumer awareness, attitudes, and behaviors especially necessary. Therefore, the purpose of this research is to design an augmented reality wedding invitation app and to investigate the effectiveness of this app. This paper uses the attention, interest, search, action, share (AISAS) advertising model as its theoretical foundation and adds sociability to derive the new attention, interest, search, sociability, action, share (AISSAS) model to further verify the usage behaviors of the AR wedding invitation app. This study applies structural equation modeling (SEM) to the data to analyze, compare, and verify the model. The results reveal that there are significant and positive direct effects of attention on interest, of interest on search, of search on sociability, of sociability on action, and of action on share. This indicates that the AISSAS model is suitable for explaining the transmission process of AR apps. Furthermore, this study demonstrates that the inclusion of sociability in the AISSAS model results in a better fit and prediction than the conventional AISAS model.

Keywords: Structural equation modeling, Augmented reality, Mobile application

1 Introduction

With the popularization of smartphones and the associated increase in the use of mobile applications (apps), advertisers are becoming increasingly attentive to mobile app marketing strategies. With the added prevalence of smartphone cameras, the concept of augmented reality (AR) has garnered discussion and use by the mobile service industry. However, research on mobile advertising is still in its infancy, and research related to the use of advertising within AR mobile apps has not yet been conducted on a wide scale. Due to the rapid development of mobile device technology, potential opportunities for mobile advertising brought on by these advances cannot be ignored. Thus, the goal of this study is to investigate the effectiveness of AR app advertisements using the five stages: attention, interest, search, action, share (AISAS) advertising model first proposed by the Japanese firm Dentsu in 2004 [1]. Simultaneously, the AISAS model was used to propose improvements to the characteristics of apps, and discuss whether the social activity capabilities of apps affect the efficacy of app-based mobile advertisements. Specifically, "augmented reality wedding invitation app" was designed to investigate whether it makes consumers more willing to attend weddings and share the app.

Smartphone penetration has increased consistently. In the latter half of 2015, smartphone penetration reached 70% in Taiwan and continues to increase [2]. Ericsson's (2015) Mobility Report shows that in 2015, more than one third of the world's population were smartphone users, and predicts that this figure will exceed 70% by 2020 [3]. With the increasing prevalence of smartphones, the market for mobile advertising has significant potential. The market research company eMarketer estimates that 2016 will be the first year in which global mobile marketing expenditure will exceed US$100 billion, or 50% of all digital ad expenditure. This expenditure is currently increasing, and is predicted to comprise 70% of digital advertisement spending by 2019, the equivalent of one fourth of total media ad spending globally [4]. In recent years, most revenue for mobile advertisements has come from display ads, in which an advertisement is displayed within a user's app; this is also the market segment with the highest growth rate [5]. According to a survey by the market research firm Statista, mobile in-app advertising spending worldwide has reached

*Corresponding Author: Hui-Fei Lin; E-mail: huifeilin@ntnu.edu.tw
DOI: 10.3966/160792642019012001025

US$20.7 billion, or six times as much as 2013 spending [6]. According to the abovementioned survey, the effect of mobile advertising apps on consumers should not be overlooked.

Smartphones are highly personal portable devices, and the influence of mobile advertising is important. A survey by Ipsos and Google detailed that close to 90% of smartphone users notice mobile advertisements [7]. Thus, advertisements can use smartphones to connect with consumers. Due to the prevalence of smartphones, smartphone apps have become a dominant theme among advertisers [8]. The interactivity and novelty of in-app advertisements has attracted the attention of marketing communications professionals, and are viewed as a new type of communications technology advertising strategy [9]. In-app advertisements are distinct from traditional advertisements in that the audience is less likely to view app content as a type of commercial message. Apps have a key advantage over text messages in that the user must first decide to download an app, rather than receive messages without consent [10]; thus, the user's rejection of the app is comparatively low. Additionally, if an app is relatively novel and innovative, it increases the recipient's acceptance of the app and also improves their likability, engagement [9], usage, and sharing. Unlike traditional advertisements, a key advantage of apps is their ability to reach an audience with enough interest in the product to download the app as well as to provide a bi-directional line of communication between consumers and advertisers, making apps a highly convenient and personalized mobile technology [10]. Additionally, marketers view app-based advertisements as a low-overhead form of advertising, making them a more profitable form of marketing [8].

With the flourishing market for mobile devices, some apps include augmented reality capabilities in an attempt to bring some novelty to their users' experience. With advances in mobile computing, wireless, and computer graphics technologies, the number of smartphone apps that include AR features is increasing rapidly [11]. AR systems use the overlay of virtual information onto a physical target to strengthen the temporal and spatial proximity of the system [12]. Virtual reality is referred to as a visualization technique that uses rapid video processing, precise tracking, and computer graphics to combine the physical and virtual worlds, allowing users to observe reality in a way that includes all varieties of media messages [13-14]. With the overlay of virtual entities onto the real world, virtual entities become a part of the user's environment, thereby expanding their vision of the world [15]. For example, the use of AR on smartphones can be based on the use of a smartphone's camera to photograph a subject, which after instant identification enables the smartphone to display an interactive multimedia message.

Previous studies addressing the use of AR in advertising are scarce. Most tended to focus on the design level and few had established theoretical frameworks to conduct empirical research. Additionally, there are currently several business owners and advertising agencies with reservations about the efficacy of using AR in advertising, making further research into the effect of AR on consumer awareness, attitudes, and behaviors especially necessary. Gupta divides apps into five categories: games and entertainment, social networks, utilities, discovery, and brands [8]. Gupta describes how mobile app marketing techniques allow advertisers to send advertising messages directly to their target audiences, and through interactive advertisements, immediately initiate a dialogue [8]. Mobile apps allow users to select message content that is more interesting to them, instead of passively receiving marketing messages. This study uses Gupta's [8] entertainment apps as its point of departure, combined with AR to verify the marketing efficacy of AR smartphone app advertisements. Previous research has focused primarily on the development of AR technologies, while the usage behaviors for AR advertisements has received relatively little discussion. The goal of this study is to investigate the use of AR with in-app advertisements, and to understand whether the uniqueness of AR advertisements creates a new user experience or improves advertising efficacy. This study's conclusions regarding mobile advertising present an aggregation of relevant research results that provide a marketing strategy for AR advertisements.

2 Literature Review

2.1 Augmented Reality

AR refers to the overlay of computer-generated components onto a real environment [16]. For users, virtual objects become a part of their real environment [15], allowing them to view computer generated information in an expanded view of their true environment, which provides them with a heightened perception of the world around them [12, 17]. Thus, AR technology is a type of human-computer interaction in which users' natural visual perception and computer-generated information, such as 3D models, are overlaid [17]. According to the definition by Azuma et al., AR must include three components: (1) combining the real and the virtual, (2) real time action and interaction, and (3) a 3D world [12]. In virtual reality, all experiences are computer-generated; this is distinct from AR in that AR provides a seamless interface of the real and the virtual [18]. Thus, AR can be defined as a new technology that combines the real world with digital information [16].

With the development of mobile computing, wireless, and computer graphics technologies, AR is being used in multiple fields, including industry, medical care, education, and mobile apps [12]. For example, AR smartphone apps use the smartphone's camera to capture a subject and, after instant identification, the smartphone presents interactive multimedia messages. This study examines the use of AR in the design of wedding invitations, and by following the AISAS model expanded to the attention, interest, search, sociability, action, share (AISSAS) model, examines whether AR apps generate the hierarchical advertising effects of attention, interest, searching, sociability, action, and sharing.

2.2 The AISAS Model (five stages advertising effect model)

Traditional consumer behavior models include the attention, interest, desire, and action (AIDA) theory, as well as the attention, interest, desire, memory, and action (AIDMA) theory. The AIDMA media-marketing model uses a linear method to describe the consumer's mental process when purchasing goods. In the process of making purchases, consumers experience the five stages of attention, interest, desire, memory, and action. Once a consumer notices an advertisement, the next step is to arouse the consumer's interest in the advertised product, after which they will desire the product, retain a memory of it, and finally purchase the product [19].

With the arrival of the Internet age, changes in the media environment and consumer lifestyles make traditional media consumer behavior models insufficient for explaining current advertising efficacy. Dentsu, the largest advertising agency in Japan, amended the AIDMA model in 2004 and proposed the attention, interest, search, action, and share (AISAS) model [1]. In the sequential order of the AISAS model, the consumer's attention is first captured and interest is aroused. At the third stage, the consumer uses the Internet to search for information, after which they purchase the product and use the Internet to share their experience. When compared to the AIDMA model, the AISAS model introduces the two new steps of searching and sharing. To precisely describe the behavior of consumers on the Internet, one should note the importance of customer generated messages (CGMs) [20]. While the AISAS model includes the element of sharing, it does not include variables of social interactions. Recently, the prevalence of interactive devices, such as smartphones and tablets, has amplified the popularity of mobile apps. With the additions of sharing and social networking capabilities, such as check-ins and uploading photos, apps are taking on a new form. Thus, this study addresses the capabilities of the "Augmented Reality Wedding Invitation" app, the amended AISAS model, the addition of sociability between search and action, and the importance of social capabilities in app based marketing models.

2.3 Sociability

Sociability refers to the ability to interact with or socialize with others [21]. Apart from direct interactions, users can use computer-mediated systems to interact with others, such as through the use of personal profiles on online dating sites [22]. Preece and Maloney-Krichmar believe that there are three elements that are key to the assessment of online social interaction and sociability: purpose, people, and policy [23]. Purpose refers to the stated purpose of a social group and the reasons for joining the group. For example, the purpose of Flickr is to share photos, and people join Classmates.com to connect with old classmates. People refers to the composition of a social group, or what type of people join a group. Policy refers to the methods of managing social groups [22-23]. Research by Wohn and Lee [24] discovered that social groups can be divided into two types: those established around an existing network of people and those established through design-driven reciprocal reciprocity. This paper focuses on the groups established around an existing network, as this group is the family and friends of the wedding couple.

Keenan and Shiri describe some unique characteristics of sociability on the Internet, such as the design standards or technology that promote social capabilities [22]. For example, the inclusion of user review blogs help readers respond to a topic and allows for interaction between the author and reader. Additionally, some researchers explored the sociability of video games. For example, Sweester and Wyeth's "GameFlow" model includes the eight factors of concentration, challenge, skills, control, clear goals, feedback, immersion, and social interaction [25]. In relation to sociability, Sweester and Wyeth believe that video games can help social interactions and provide opportunities for social interaction [25]. Previously, relatively few studies have examined the social capabilities of apps. Consequently, this study discusses whether the social interaction capabilities provided by an app's unique characteristics increase the efficacy of the products or activities advertised through the app. Thus, this study examines whether an AR wedding invitation app can achieve the same effects of a video game in increasing interaction between an engaged couple and their family and friends. This is achieved by the sharing of and interaction through self-shot videos and allowing those friends and family to search for information related to the wedding.

Previous research has discovered that consumers' motivations for using mobile services include entertainment, pleasure, enjoyment, passing time, social interaction, sociability, and expressiveness [26-27]. Social features are an important driver in the consumer's use of mobile services and therefore an important capability in apps; thus, this paper adds sociability to the AISAS model.

3 Hypotheses

In the AISAS model, Dentsu Inc. [1] proposed that after an advertisement attracts the attention of an audience, viewers become interested in the advertised product. Research by Wei and Lu [20] discovered that after consumers become interested in a product, they use the Internet to search for information related to the product, after which they purchase the product, and finally use the Internet to share their experience and assessment with other potential customers. Generally, people frequently rely on and attentively listen to the assessments of others. In the Web 2.0 era, it is increasingly convenient for customers to leave reviews on the web. Thus, electronic word of mouth (eWOM) based advertising campaigns have created new types of search and purchasing behaviors [20]. Animesh et al. [28] used the "Stimulus-Organism-Response" (SOR) to investigate the causal relationship of the purchasing intentions of users for digital products. Their research discovered that the high sociability and added social presence of virtual environments increased users' purchasing intentions. The most important factor in this being that the high sociability of the virtual world facilitated intimacy and warmth, thus affecting the social affordances of users and the subjective perception of social presence [29]. Therefore, sociability can not only improve interpersonal relations, but can actually increase consumers' intention to purchase. Thus, in the advertisement 2.0 era, the assessment of advertising efficacy should include the initiative of the audience and the product's word of mouth reputation.

In accordance with this literature review, this study deduces that the use of the AR wedding invitation app will develop according to the following hypotheses:

H1: Attention is positively related to interest.

H2: Interest is positively related to search.

H3: Search is positively related to social interaction.

H4: Social interaction is positively related to action.

H5: Action is positively related to sharing.

H6: When compared to the AISAS model excluding social interaction, the AISSAS model has better model-fit.

4 Design and Implementation of Interaction Wedding Invitation System

4.1 The Design of Interaction Wedding Invitation System

This study proposes and implements an interaction wedding invitation system (IWIS) that includes an AR wedding invitation app and a cloud server (shown in Figure 1). A wedding photographer can rotate the camera to scan the 360-degree images of a newlywed (shown in Figure 2) for 3D model generation (shown in Figure 3). Then, the 3D model can be used and installed in AR applications. Mobile devices provide AR functions to recognize camera images and present 3D objects or interactive videos on mobile device screens. A cloud server provides newlywed photo album services, 3D newlywed model services, and interactive video services. A case study of "Eton Company" that provides interactive wedding invitation services based on the proposed service and system is presented in the following subsection.

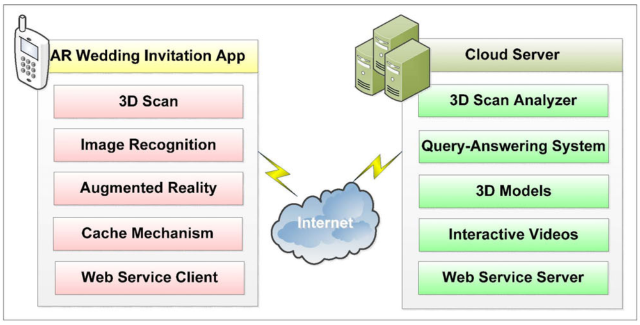

Figure 1. The architecture of IWIS

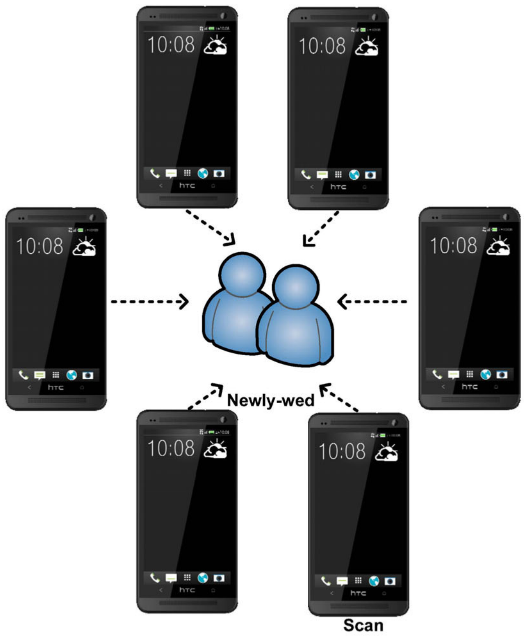

Figure 2. 3D scan

Figure 3. 3D model

4.2 A Case Study of Interaction Wedding Invitation System

The procedure of IWIS includes four steps as follows.

Step 1: A 3D scan technique can be used to scan and generate a newlywed 3D model.

Step 2: A newlywed can make a movie of a wedding invitation, and this movie and the newlywed 3D model can be embedded in the client's IWIS mobile app (i.e., the AR wedding invitation app).

Step 3: The newlywed can send the wedding invitation card (shown in Figure 4) to family and friends. After receiving the wedding invitation card, the recipients can download the AR wedding invitation app and execute this app to scan the wedding invitation card and display a newlywed 3D model or the movie of the wedding invitation using AR techniques (shown in Figure 5). Moreover, they can make a movie of felicitation and send this movie to the newlywed.

Step 4: The newlywed can browse and watch the felicitation videos from family and friends via a mobile app or online system.

(a) the front of wedding invitation card

(b) the back of wedding invitation card

Figure 4. A wedding invitation card

(a) newly-wed 3D model

(b) interactive videos

Figure 5. The AR wedding invitation app

4.3 Power Saving Issues for Location-Based Services

A cache mechanism included in the proposed AR wedding invitation app is proposed to analyze the movement of the mobile phone and measure the adaptable amount of cache in the mobile phone for minimizing power consumption on the basis of location-based services (LBS). A model that is embedded in the cache mechanism adopts a queueing model to estimate the mobile phone's power consumption in accordance with movement behaviors. This subsection presents (1) the problem definition, (2) a power consumption model based on movement behaviors, and (3) the evaluation of the proposed power consumption model.

4.3.1 The Definition of Problem

This subsection defines (1) the direction of movement, (2) the movement state of mobile phone, and (3) the amount of cache in the mobile phone.

4.3.1.1 The Direction of Movement

For simplifying problem, two directions which include left-direction and right-direction (shown in Figure 6) are considered in this study.

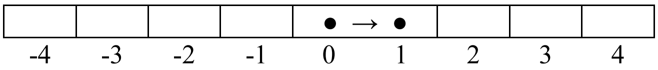

Figure 6. The movement direction and movement state

4.3.1.2 The Movement State of Mobile Phone

For presenting the movement state, this study represents a geo-map as a grid map, and a number is assigned to each cell (i.e., location area) in the grid (shown in Figure 6). In this case, the origin point is labeled as State 0. The state is unchanged if the mobile phone remains at the origin point. If the mobile phone moves from the origin point to next location area to the right in the next time cycle, the state of the movement is changed from State 0 to State 1; if the mobile phone moves from the origin point to next location area to the left in the next time cycle, the state of movement is changed from State 0 to State −1.

4.3.1.3 The Amount of Cache in the Mobile Phone

This study assumes that the amount of data for each cell is the same. For instance, the amount of data for each cell is 1 KB. When a mobile phone moves into a new cell (i.e., new location area), the amount of data transmission is 1 KB. Furthermore, the transmitted data can be stored in the cache of the mobile phone in accordance with the amount of cache. If the amount of cache is determined as 1, the data of States −1, 0, and 1 (i.e., 3 KB) can be cached in the mobile phone. This study used the number of cells as the amount of cache, and a queueing model was designed to determine the adaptable amount of cache. The parameters in the queueing model are summarized in Table 1.

4.3.2 A Power Consumption Model Based on Movement Behaviors

The queueing model considers the probabilities of staying, moving, turning right, and turning left to estimate power consumption and determine the adaptable amount of cache (shown in Figure 7). The assumptions of the proposed model are as follows:

- This model includes (2 x N + 1) states (i.e., $-N \leqq i \leqq N$).
- Three decisions which include (1) stay, (2) movement in right-direction, and (3) movement in left-direction can be selected.
- The probability of stay is smaller than 100% (i.e., $q \leqq$ 100%).

Table 1. The movement direction and movement state

Parameters	Description
N	The maximum of state
$-N$	The minimum of state
q	The probability of stay
$1-q$	The probability of movement
p	The probability of turning-right
$(1-q)q$	The probability of movement in right-direction
$1-p$	The probability of turning-left
$(1-q)(1-p)$	The probability of movement in left-direction
m	The amount of cache
f_i	The probability of reaching State i
$addition\_C(m, i)$	The additional power consumption for reaching State i if the amount of cache is equal to m
$C(m, i)$	The total power consumption for reaching State i if the amount of cache is equal to m
$Cstable(m, i)$	The total power consumption for reaching State i in stable condition if the amount of cache is equal to m
Cm	The average power consumption for reaching each state in stable condition if the amount of cache is equal to m
c_l	The power consumption of querying the local database of mobile phone (i.e., cache)
c_s	The power consumption of querying the cloud database
r_l	The power consumption of querying the local database of mobile phone for single record
r_s	The power consumption of querying the cloud database for single record
g	The power consumption of mobile phone in standby mode

- The value of r_s is larger than the value of r_l.
- The stable condition is acceptable, so the total of the probability of each state are summarized as 100%.
- The amount of cache is m, and the mobile phone moves at State i. The records of the left m states, State i, and the right m states are cached in the mobile phone.

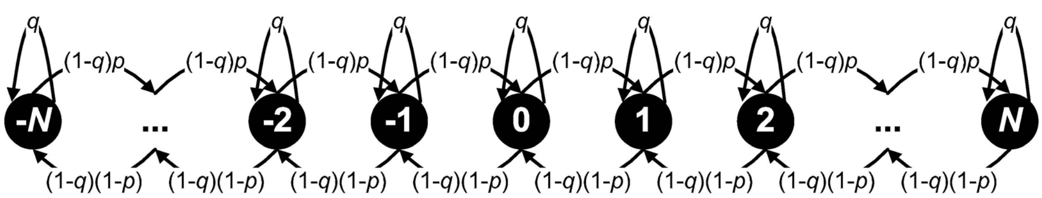

Figure 7. The queueing model for power consumption estimation

4.3.2.1 The Direction of Movement

The probability of moving to State i in stable condition can be estimated by Equations (1) and (2).

$$p \times f_{-N} = (1-p) \times f_{-N+1}$$
$$\Rightarrow \frac{p}{1-p} \times f_{-N} = f_{-N+1}$$
$$\Rightarrow f_{-N+i} = \rho^i \times f_{-N},\ where\ \rho = \frac{p}{1-p} \quad \textbf{(1)}$$
$$\Rightarrow f_0 = \rho^N \times f_{-N}$$
$$\Rightarrow f_i = \rho^i \times f_0$$

$$\sum_{i=-N}^{N} f_i = 1$$
$$\Rightarrow \sum_{i=-N}^{N} \left(\rho^i \times f_0\right) = 1,\ where\ \rho = \frac{p}{1-p}$$
$$\Rightarrow f_0 \times \sum_{i=-N}^{N} \rho^i = 1 \Rightarrow f_0 = \frac{1}{\sum_{i=-N}^{N} \rho^i} \quad \textbf{(2)}$$
$$\Rightarrow f_i = \frac{\rho^i}{\sum_{j=-N}^{N} \rho^j}$$

$$addition\_C(m,i) = \begin{cases} r_s \times (2\times m+1) + c_s + g,\ if\ i=0 \\ \left[r_l \times (2\times m+1) + c_l + g\right] \times \left[|i| (\bmod m+1)\right] + \\ \left(r_s \times (m+1) + c_s + g\right) \times \left\lfloor \frac{|i|}{m+1} \right\rfloor,\ otherwise \end{cases} \quad \textbf{(3)}$$
$$where\ -N \le i \le N\ and\ 0 \le m \le N$$

4.3.2.2 The Power Consumption of Mobile Phone for Moving to State *i*

When the mobile phone is at the initial state (i.e., State 0), the amount of data transmission from cloud server is $2\times m+1$. Furthermore, these data can be stored in the mobile phone. Therefore, the power consumption is measured as $r_s \times (2\times m+1) + c_s + g$ for this state. Data transmission is not required when the mobile phone moves in the area range from State $m-1$ to Stage $m+1$; the power consumption is measured as $r_l \times (2\times m+1) + c_l + g$ for querying local data when the mobile phone moves in the area range from State $m-1$ to Stage $m+1$. However, the amount of data transmission from cloud server is $m+1$ for retrieving new data of states when the mobile phone moves to State $m-2$ or Stage $m+2$; the power consumption is measured as $r_s \times (m+1) + c_s + g$ when the mobile phone moves in the area range from State $m-2$ to Stage $m+2$. Therefore, the power consumption for moving to State i can be measured as Equation (3). The algorithm of the proposed cache mechanism is presnted in Algorithm 1.

Algorithm 1. The proposed cache mechanism

Definitions:
1. The value can be randomly generated as -1, 0 or 1 by the function Random(-1, 0, 1).
2. The data of the j-th state can be retrieved by the function GetData(j).

Initial State:
```
   i = 0
   For j = -m to m
         GetData(j)
Next
```
Movement State:
```
   movement = Random(-1, 0, 1)
   i = i + movement
   If i mod (m + 1) = 0 Then
         cycle = (int)[i / (m + 1)]
         If movement > 0 Then
               For j = 0 to m
                     GetData(cycle x (m + 1) + j)
               Next
         End If
         If movement < 0 Then
               For j = 0 to -m
                     GetData(cycle x (m + 1) + j)
               Next
         End If
End If
```

4.3.2.3 The Power Consumption of Mobile Phone in Stable Condition

The total power consumption of the mobile phone for moving to State i can be estimated by Equation (4). Moreover, the power consumption of the mobile phone in a stable condition for moving to State i can be estimated by Equation (5) in accordance with Equations (2) and (4). Finally, when the amount of cache is m, the total power consumption of the mobile phone in stable condition for moving to each state can be estimated by Equation (6).

$$C(m,i) = \sum_{i=0}^{i} addition\_C(m,i) \quad s.t.\ 0 \le m \le N \quad \textbf{(4)}$$

$$C_{stable}(m,i) = f_i \times C(m,i) \quad s.t.\ 0 \le m \le N \quad \textbf{(5)}$$

$$C_m = \sum_{i=-N}^{N} C_{stable}(m,i) \quad \text{s.t. } 0 \le m \le N \tag{6}$$

4.3.2.4 The Optimization of Cache Amount for Lower Power Consumption

The optimization of cache amount can be estimated by Equation (7) in accordance with Equation (6)(i.e., the total power consumption of mobile phone in stable condition).

$$min\ C_m = \min(C_0, C_1, ...C_N) \quad \text{s.t. } 0 \le m \le N \tag{7}$$

4.3.3 The Evaluation of the Proposed Power Consumption Model

This study designed some experimental cases to measure the value of each power consumption parameter in the proposed model. Practical results of these experimental cases were collected, and the value of each power consumption parameter was adopted to evaluate the proposed model for the optimization of power consumption.

4.3.3.1 The Design of Experimental Cases

Five cases (shown in Table 2) were designed to evaluate the values of five power consumption parameters, including (1) c_l (power consumption for querying the mobile phone's local database), (2) r_l (power consumption for querying the mobile phone's local database for a single record), (3) c_s (power consumption for querying the cloud database), (4) r_s (power consumption for querying the cloud database for a single record), and (5) g (power consumption of the mobile phone in standby mode) [30].

Table 2. Experimental Cases and the Power Consumption of Each Case

Case	Description	Power Consumption
Case 1	The status of mobile phone is standby mode.	g
Case 2	The mobile phone queries the local database for single record.	r_l+c_l+g
Case 3	The mobile phone queries the local database for 1,000 records.	$1{,}000 \times r_l+c_l+g$
Case 4	The mobile phone queries the cloud database for single record.	r_s+c_s+g
Case 5	The mobile phone queries the cloud database for 1,000 records.	$1{,}000 \times r_s+c_s+g$

This study extracted the lowest power consumption parameter and used the relative power consumption to express the five power consumption parameters (i.e., c_l, r_l, c_s, r_s, and g). The value of r_l can be measured in accordance with Case 2 and Case 3. Furthermore, the value of c_l can be estimated according to the value of r_l, Case 1, and Case 2. Finally, the value of g can be measured in accordance with Case 2 and the values of r_l and c_l. Therefore, the values of r_s and c_s can be estimated according to Cases 4 and 5. Five assumptions were made as follows for these experimental cases:

- Assumption 1. The value of N is 100.
- Assumption 2. The amount of cache is m.
- Assumption 3. The probability of q and p are both 0.5.
- Assumption 4. Three movement strategies include (1) stay, (2) movement in right-direction, and (3) movement in left-direction.
- Assumption 5. When the mobile phone is at the initial state (i.e., State 0), the amount of data transmission from cloud server is $2 \times m + 1$. The amount of data transmission from cloud server is $m + 1$ for retrieving new data of states when the mobile phone moves to State $m - 2$ or Stage $m + 2$.

4.3.3.2 Practical Experimental Results

This study implemented the experimental cases in Samsung Note 8 and Android 4.4. The wireless networks of long term evolution (LTE) and WiFi were used to transmit data for the evaluation of power consumption.

(1) The evaluation results in the wireless networks of LTE

The values of the five power consumption parameters were collected and estimated in Table 3. The lowest power consumption parameter is r_l in experiments. These values can be adopted into Equation (6) to calculate the power consumption when the amount of cache is m. Furthermore, the optimization of power consumption can be estimated by Equation (7). In experiments, the optimized amount of cache is 10.

Table 3. The Relative Power Consumption of Each Parameter in LTE networks

Parameter	Power Consumption
g	$869 \times r_l$
c_l	$382 \times r_l$
c_s	$5724 \times r_l$
r_l	$1 \times r_l$
r_s	$5 \times r_l$

(2) The evaluation results in the wireless networks of WiFi

The evaluation results in the wireless networks of WiFi were measured in Table 4. The values of g, c_l, and r_l in WiFi networks were the same as these parameters in LTE networks. Furthermore, the lower powers were consumed for data transmission in WiFi networks. In experiments, the optimized amount of cache is 15.

Table 4. The Relative Power Consumption of Each Parameter in WiFi networks

Parameter	Power Consumption
g	$869 \times r_l$
c_l	$382 \times r_l$
c_s	$4959 \times r_l$
r_l	$1 \times r_l$
r_s	$2 \times r_l$

5 Research Methodology

This paper based on the AISAS model as its theoretical foundation and adds sociability to derive the new AISSAS model to further verify the usage behaviors of the AR wedding invitation app. Figure 8 details the model. This study applied structural equation modeling (SEM) to the data to analyze, compare, and verify the model. This study designed an AR wedding invitation app in which users use their smartphones to scan a wedding invitation, whereupon they will be able to view the couple's wedding invitation video (see Figure 9). Users can then use the wedding invitation to search for information related to the wedding, for example, the location of the venue (see Figure 10), the wedding reception menu, and a list of members of the wedding party. They can also record a congratulatory video to send to the couple and share information (see Figure 11) and videos of the wedding invitation with others.

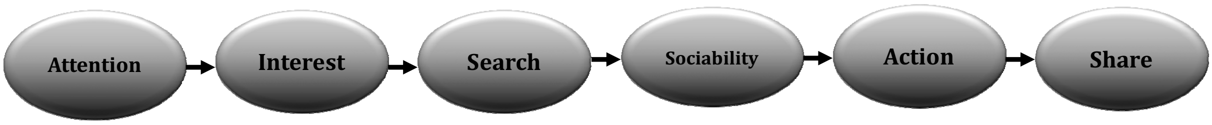

Figure 8. Research framework

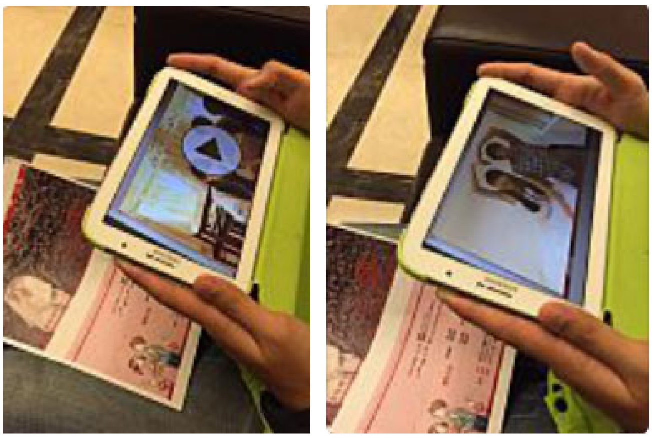

Figure 9. AR wedding invitation app

Figure 10. AR wedding invitation app

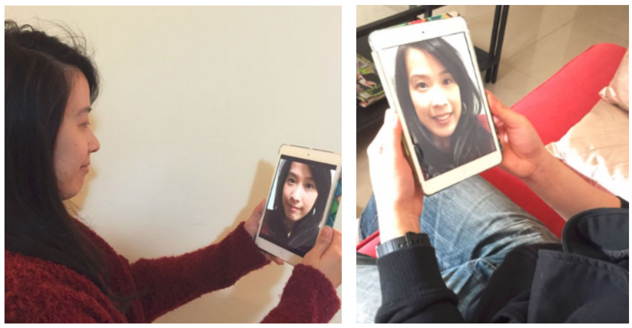

Figure 11. AR wedding invitation app

This study used questionnaires at public universities as a convenient sampling method, where subjects were recruited to take the questionnaire. Before beginning the questionnaire, subjects first learned how to use their smartphones for AR. Once they were familiar with the process, they used it independently and finally completed the questionnaire. The questionnaire process specifically involved first having the subject read an explanation and use their imagination. The situation described: "First, please imagine that you have received a wedding invitation from a friend. The invitation has augmented reality capabilities: please use your smartphone to scan the invitation. In addition to displaying an invitation video from the couple, you can also search for information related to the wedding day, shoot your own video to congratulate the couple, or share with your friends." After reading the description, surveyors assisted the subjects in using the AR wedding app. When finished using the app, subjects completed the questionnaire. The whole survey process took about 30 minutes.

5.1 Variables

The variables for this study include attention, interest, search, sociability, action, and share. Questions for each variable were amended from the question scale used by [20, 31-33]. The questionnaire used a seven point Likert-type scale in which 1 represented extreme disagreement and 7 represented extreme agreement. The measurement of these variables is described below.

Attention: Attention refers to the attractiveness of the app to the user. Users were asked the extent to which they agreed with the following statements: "I think this APP attracts me," "I think this APP draws my full attention," and "I think this APP catches my eye."

Interest: Interest refers to the level interest the user has towards the app. Questions for this variable are as follows: "After using this APP, I feel an interest in this wedding," "After using this APP, I like this wedding," and "After using this APP, I have a good impression of this wedding."

Search: Search refers to the user using the app to search for related information after receiving the messages sent by the app. Questions for this variable included: "I think I will use this APP to search for information about the wedding," "I think I will use this APP to search for information about the bride and groom," and "After using this app, I feel that I will look up the wedding guest list using the app."

Sociability: Sociability refers to the ability of the users to generate social interaction with friends using the interface provided by the app. Questions for this variable were adapted from Shu's measure of sociability [34] and include: "I can socialize with friends via this APP," "I feel a sense of amiability when I use this APP," and I like the feeling of interacting with other people when use this APP."

Action: Action refers to the actions taken by the users after using the app.

Questions measuring this variable include: "After using this app, I feel that this wedding is worth attending," "After using this APP, I think I am willing to attend this wedding," and "After using this app, I feel that this wedding is very interesting."

Share: Share refers to the users transmitting the app and app messages.

Questions measuring this variable include: "After using this APP, I think I will forward this APP to my friends," After using this APP, I think I will share the information about this wedding with my friends," and "After using this app, I feel that I would share my experience of using the app."

5.2 Data Analysis and Results

According to the results of relevant descriptive statistics, among the 307 valid samples, the sample was comprised of 134 men, or 43.6%, and 173 women, or 56.4%. Of the sample population, 90% was between the ages of 18 and 28. First, Amos 2.0 software was used to run a confirmatory factor analysis (CFA), and a test of convergent validity, discriminant validity, and reliability was conducted for each construct of the model. For the test of convergent validity, the results show that the average variance extracted (AVE) for each construct are all greater than 0.5, consistent with the threshold value of 0.5 suggested by [35], and therefore have convergent validity. For the test of discriminant validity, the results show that the square roots of each construct's AVE value are greater than the relatedness between each construct, consistent with the discriminant validity test guidelines of Fornell and Larcker [35]. For the reliability test, research results show that the Chronbach α values for each construct are greater than 0.7, lying between 0.88 and0.93, and therefore have high reliability Table 5.

Table 5. CFA Results

Construct	Indicator	Standardized Factor Loadings	Composite Reliability	AVE
attention	atte1	.82	.90	.75
	atte2	.88		
	att3	.90		
interest	inte1	.88	.89	.73
	inet2	.73		
	inte3	.94		
search	sear1	.85	.88	.70
	sear2	.92		
	sear3	.74		
sociability	soci1	.92	.92	.80
	soci2	.85		
	soci3	.90		
action	act1	.86	.93	.81
	act2	.92		
	act3	.92		
share	sha1	.89	.92	.79
	sha2	.90		
	sha3	.87		

For the test of model fit, the ratio between chi-square and its degrees of freedom is 2.8, less than the upper threshold ratio of 3.0 [36]. After collocation, root mean square error of approximation (RMSEA) is 0.07, and is therefore consistent with the upper threshold value of 0.08. Additionally, the goodness-of-fit index (GFI) value of this study is 0.89 (>0.8), and the adjusted goodness-of-fit index (AGFI) value is 0.85 (>0.8). These are consistent with the GFI and AGFI values suggested by Jöreskog and Sörbom [37] of between 0.8 and 0.9. The comparative fit index (CFI) value is 0.95 (>0.9), and the incremental fit index (IFI) value is 0.95 (>0.9), which also meet test criteria. The above figures show that the fit of the theoretical model falls within the acceptable range, and the linear structural relationship of the model is shown in Table 6.

Table 6. Proposed Structural Model Estimation Results (Linear Structural Relation Analysis)

Hypotheses	Unstandardized Coefficients	Standardized Coefficients	Standard Error	p
H1: attention→ interest	.839	.860	.048	***
H2: interest→search	.727	.838	.056	***
H3:search→sociability	.912	.835	.071	***
H4: sociablity→action	.908	.866	.047	***
H5: action→share	.673	.740	.047	***

After determining whether the fit of the model falls within the acceptable range, the coefficients of the causal relationships between the variables must be considered (see Figure 12). Attention has a significant positive effect on interest (standardized coefficients= 0.86, p<0.001), therefore hypothesis 1 is supported. Interest has a significant positive effect on search (standardized coefficients=0.84, p<0.001), therefore hypothesis 2 is supported. Search has a significant positive effect on social interaction, (standardized coefficients=0.84, p<0.001) therefore hypothesis 3 is supported. Social interaction has a significant positive effect on action, (standardized coefficients=0.87, p<0.001) therefore hypothesis 4 is supported. Action has a significant positive effect on share, (standardized coefficients=0.74, p<0.001) therefore hypothesis 5 is supported.

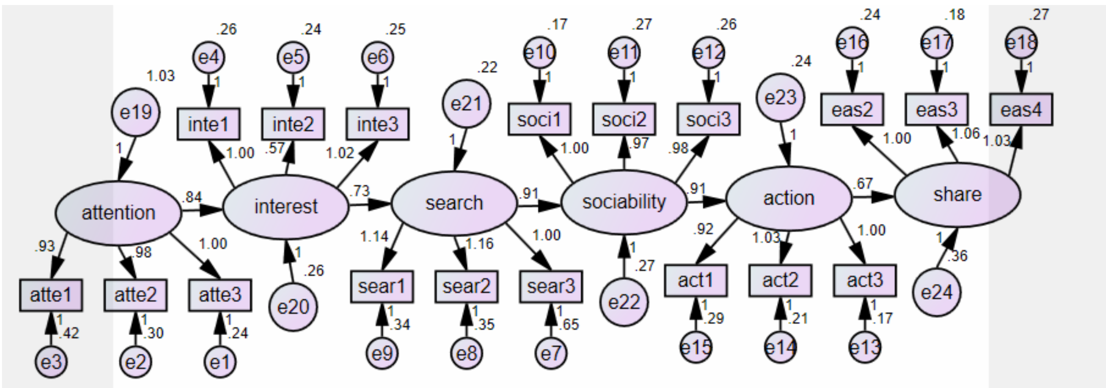

Figure 12. Linear structural relations model and unstandardized coefficients

In testing hypothesis 6, the AISAS model without social interaction calculated that the ratio between the chi-square and its degrees of freedom exceeded the upper threshold of 3.0 [36]. Additionally, its RMSEA is 0.81, exceeding the upper threshold of 0.08. Thus, when compared to the AISAS model excluding social interaction, the AISSAS model indeed has better fit; therefore, hypothesis 6 is supported.

6 Conclusions and Suggestions

This study designed and conducted an empirical study on an AR wedding invitation app, and also verified the efficacy of this app. The results of this research and discussion are presented below.

Firstly, this study discovered that attention, interest, search, sociability, action, and share have a hierarchical relationship. When users scan an invitation and use the AR app, it begins an advertisement communications process. This study uses Dentsu's AISAS model for understanding online consumption patterns and advertising effectiveness [1] in its expanded AISSAS model. Through CFA and the tests of convergent validity, discriminant validity, and GFI, this study notes that there are significant and positive direct effects of attention on interest, of interest on search, of search on sociability, of sociability on action, and of action on share. This indicates that the AISSAS model is suitable for explaining the transmission process of AR apps. Additionally, statistical results indicate that the ratio between the chi-square and its degrees of freedom is 2.4, RMSEA<0.08, and GFI is 0.92 (>0.9). As the GFI value approaches 1, the fit of the model improves. The CFI value of the circular model is higher than that of the linear model. Thus, this study reveals that if the AISSAS were a circular process, the fit of the circular model would be higher than that of the linear model.

According to these discoveries, within marketing strategies for AR apps, the AISSAS model can be divided between two stages. The first is “Attention-Interest,” and is more useful for attracting users to an app. The second is “Search-Sociability-Action-Share,” and is more useful in encouraging interaction between customers, where sociability and sharing allow the app to be introduced to a greater number of people. These two sections can be viewed as a circular process. As “Search-Action-Share” behaviors undertaken, there are more opportunities for people to enter the “Attention-Interest” segment, which allows for the continuation of the “Search-Action-Share” marketing process. Thus, in addition to the importance of designing an app to attract the attention and interest of users, placing a greater emphasis on the “Search-Sociability-Action-Share” elements increases the marketing efficacy of an app.

Secondly, this study discovered that when compared to the AISAS model without sociability, the AISSAS model has a better model fit. Previous studies, such as Kreijns et al. [38] defined sociability as computer mediated communication, which through social affordance can improve the degree of social space. This is a computer mediated communication environment in which users can interact with one another. In a virtual world, Kreijns et al. believed that a design that is capable of initiating and maintaining social interaction in a virtual space is important [38]. With the development of smartphones, the era in which a computer was necessary to enter the Internet has ended. Today, highly personalized smartphones make entering a virtual space always possible. Since people of today find it more difficult to tolerate loneliness, there is a constant need to be noticed. For this reason, the social interactivity generated by mobile device apps has become especially important. This study suggests that if increased online social interactivity between friends can be extended to offline activities, it can improve the linkages of social relationships, instead of decreasing real interactions between friends simply because they are offline.

In addition, new forms of marketing driven by the transmission of new technology shape the purchasing behaviors of nontraditional media consumers. For example, consumers can actively search for information regarding a product and have the ability to create consumer generated message (CGM). This study found that sociability plays an important role in the use of apps, as its inclusion expands the app’s marketing efficacy by one tier within the model. Transmitters use the app to send information and, after recipients receive the information, the interactive sending and receiving of information on the app makes the positions of sender and recipient flexible, thus increasing the rates of interaction and strengthening the engagement of the app. For this reason, this study echoes the suggestions of Gupta [8]: advertisers should engage in the R&D of value-added apps, of which one of these values is social value that allows users to develop engagement with the app. The AR wedding invitation app developed for this study emphasizes social value by allowing the couple’s family and friends to interact through the app. Specifically, the app allows users to search for information related to the wedding or the guest list and share the app with others, ultimately strengthening their intention to attend the wedding.

Regarding theoretical and practical implications, the importance of the AISAS model proposed by Dentsu [1] is derived from the emergence of the Internet and the subsequent changes to how consumers make contact with advertisements and make purchases. For this reason, amendments to the classical four-step AIDA advertising model were made. Due to the wide use of mobile devices, mobile apps have become immensely popular in recent years. Thus, this study relies on the unique characteristics of apps in its empirical research to amend the AISAS model to include sociability. Additionally, the original linear hierarchy of the AISAS model has become a circular relationship in the new AISSAS model. When the last step of “share” is reached, the circular process of the model restarts with “attention.” Therefore, advertising techniques ought to develop according to the advances in communications technologies.

By combining new communications technologies with advertisements and marketing to gather more information for consumers, consumers can use advanced technologies to discover products and services and eventually make purchases. On the Internet, it is important to create and sustain social interaction between users in the virtual environment [38]. Similarly, with the release of an endless stream of apps, the key feature in the design of a successful app is the creation of opportunities for social interaction among its users. In the plan for this study’s AR wedding invitation app, user experience was used as a starting point in the design process of the advertising methodology. This allows the message content to become a part of the app content and creates targeted advertisements. As expectations suit consumer preferences, advertising efficacy increases. Similarly, the inclusion of sociability in an app allows users to increase their preference for and engagement with the app through social interaction.

With regard to research limitations and directions for future research, as the subjects were not acquainted with the wedding couple, a fictional situation was designed to help subjects imagine the upcoming wedding of a real friend. Following this, the subjects used the app and completed the questionnaire. In future studies, collaboration with a wedding company could allow the app to be used by a real engaged couple, whose family and friends could use the app and complete the questionnaires. In future studies, as noted by Okazaki and Barwise [39], it is necessary to develop suitable theories on smartphone-based advertising to develop research related to mobile advertising. Gupta [8] identified five different types of apps: games and entertainment, social networks, utilities, discovery, and brands. Future studies should research the use of AR by these types of apps individually to test for efficacy and establish new theoretical bases for mobile advertising research. The results and discoveries of related future research can be applied to new aspects of app advertising and can develop new patterns of advertising and marketing strategies that use communications technologies, such as AR, to connect with targeted and potential audiences.

Acknowledgments

This study was supported by the Ministry of Science and Technology, Taiwan, R.O.C. under Grant no. MOST 106-2410-H-003 -064. This work was also supported by Aiming for the Top University Program of the National Chiao Tung University and Ministry of Education of Taiwan.

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Biographies

Hui-Fei Lin received a Ph.D. degree in Mass Communications from Pennsylvania State University, U.S., in 2007. She is an associate professor in the Graduate Institute of Mass Communication, National Taiwan Normal University, Taiwan. Her research focuses on advertising and strategic communications. She has presented numerous research papers in several journals.

Chi-Hua Chen is a professor for College of Mathematics and Computer Science of Fuzhou University. He received his Ph.D. degree from the Department of Information Management and Finance of National Chiao Tung University in 2013. His recent research interests include Internet of things and deep learning.