Would You Turn on Bluetooth for Location-Based Advertising?

Heng-Li Yang, Shiang-Lin Lin, and Jui-Yen Chang

1 Introduction and Research Backgrounds

Smart phones have become an indispensable mobile device in daily lives and changed models of advertising. Traditional advertising media such as print ads, radio, and TV commercials have been transformed into mobile advertising models. Advertisers now can deliver messages that contain information of products, services, or promotion directly to mobile users on the basis of current location and specific time, who might read the advertisements and then become motivated for shopping [1]. Currently, mobile advertising agencies are able to deliver advertisements to customers in targeted locations and provide product and service information of their local businesses. This type of push advertising that delivers local shopping information to potential customers is called location-based advertising (LBA) [2].

LBA service can provide ads that are from businesses in the neighborhood of consumers and provide them with more relevant and quicker shopping information, which enhances the accuracy of advertisement delivery [3]. The service delivers higher-quality advertisements to users through certain components in a mobile device such as Bluetooth, Wi-Fi, and Globe Positioning System (GPS) and collect users' information of their current locations. It is helpful for a business to customize the contents of their advertisements. Compared to GPS, Bluetooth is the short distance positioning method. The commonly applied Bluetooth version 4.x Class 2 radios has a range of 10 meters and the accuracy of positioning can reach 2 to 5 meters, and the Class 3 and 4 have better positioning accuracy. Many studies have indicated that the effectiveness of mobile advertising would be enhanced if the location of advertising store is near the mobile device users (i.e., "location-

H.-L. Yang (✉) · S.-L. Lin · J.-Y. Chang
National Cheng-Chi University, Taipei, Taiwan
e-mail: yanh@nccu.edu.tw

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congruency") [4, 5]. In other words, via the Bluetooth positioning users' location and calculating the distance between a local store and the users, then pushing relevant advertisements to the customers, it can efficiently improve click-through rate and wiliness to consume. However, for pushing more accurate advertisements to consumers, the LBA service requires consumers to provide their current location, which increases the risk of personal information leakage. Some studies have pointed out that most young mobile users are willing to receive advertisements through Bluetooth, but are concerned about the frequency of advertisement delivery. As a result, while collecting personal information, an advertising agency may need to take good care of users' privacy issue [6].

Although LBA service can increase the exposure and click-through rate of advertisements among consumers, and give advertisers more opportunities to reach consumers, its technologies are still developing and expected to make progress in application in the future [7]. In view of this, understanding customers' needs and considerations and further developing an effective LBA push strategy are essential for the popularization of LBA services in the future.

The purpose of this study is to explore the key factors customers would concern about while they decide whether to turn on Bluetooth on their mobile devices to receive LBA services. With multi-layered considerations, this decision problem is a typical multi-criteria decision making (MCDM) problem. Among those popular MCDM methods, the analytic hierarchy process (AHP) is commonly applied to solve decision-making methods with multiple evaluation dimensions and factors ([8–10]). However, the AHP method has several limitations. First, in real life, people normally do not rely on an absolute standard to compare and consider the priorities among various factors. To solve this concern, when using AHP to evaluate the initial data from surveys, it is suggested combining with the concept of fuzzy theory to avoid the problem of surveyed participants being over-subjective and extreme while considering the priorities among various factors [11]. Second, although AHP can find out the weights of each consideration factor on the overall decision-making problem, the considerations under different dimensions are independent. In other words, the AHP method cannot verify the existence of interrelationships between the consideration factors under different dimensions. Therefore, the decision-making trial and evaluation laboratory (DEMATEL) can find out the possible interrelationships between the factors in the evaluation hierarchy and calculate the degree of impact through the matrix operation method [12, 13].

In summary, this study uses Fuzzy AHP in conjunction with DEMATEL to explore the key factors customers would concern about while they decide to use Bluetooth on their mobile devices to receive LBA services and proposes suggestions to advertisers and businesses based on the analysis results.

2 Research Methodology

For the customers who are willing to receive the LBA, it is necessary to turn on the location-identifying function on their mobile device to allow businesses and advertisers to find the current location of customers more accurately. But not all customers would turn on Bluetooth just for receiving LBA. As a result, this study uses Fuzzy AHP and DEMATEL methods to analyze the decision-making factors involving customers turning on the Bluetooth function on the mobile device to receive the LBA, and the interrelationships and cross-impacts between factors.

2.1 Selection of Evaluation Dimensions and Factors

Based on consumption value theory [14], fashion theory [15], and the characteristics of location-based service [16], this study categorizes customers' considerations about turning on Bluetooth to receive LBA as two dimensions, which are "functional value" and "popularity value." In addition, since customers may try to use LBA services because of curiosity or the desires to get notices about store events in their nearby area, the dimension of "psychological value" is also included [17]. Meanwhile, to receive LBA, it is required that users' mobile devices are well supported by decent software and hardware to get the most instant personalized LBA. This may also cause the issue of leaking the user's current location and personal privacy information [18, 19]. The study also adds the dimensions of "mobile device support" and "privacy considerations." In total, five dimensions are evaluated in this study.

2.2 Establishment of Hierarchical Evaluation Framework

Based on the dimensions described above and the characteristics of the LBA service, this study selects a total of 18 consideration factors under dimensions, defines each factor, and establishes the evaluation hierarchy, as shown in Table 1.

2.3 Analysis Approach Operation

According to the evaluation hierarchy from Table 1, this study designs and distributes an AHP interview questionnaire, and applies the Fuzzy AHP method to analyze the importance weight of each consideration factor. After that, a DEMATEL questionnaire based on matrix operation method is distributed to participants to find out the interrelationships between the consideration factors and how much they

Table 1 Definition of evaluation dimensions and factors

Dimension	Factor	Definition
D1 Functional value	**F1.1** Get ads at right time and right place	Through LBA services, customers can access a variety of products/services/brand information provided by surrounding businesses, such as experience, trial, sales.
	F1.2 Get information about saving money at right time and right place	Through LBA services, customers can obtain various discounts/discounts/free information provided by surrounding businesses, such as coupons, free parking, promotions, card discounts, etc., to save money.
	F1.3 Time saving	Through LBA services, customers can save time searching for daily supplies information, such as planning a route to a nearby store or finding a local restaurant for dining.
	F1.4 Convenience for decision-making	Through LBA services, customers can have more precise choices that meet personal preferences and the highest cost performance (CP value) when making consumption decisions.
D2 Popularity value	**F2.1** Popularity	Customers use LBA service because it has been highly accepted by users and gets a large number of positive reviews.
	F2.2 Following social network	Customers use LBA service because many of their friends and family have used LBA service.
	F2.3 Showing personal style	Customers want to show their unique choice and personal style by using LBA service.
	F2.4 Following the trend	Customers want to experience fashionable and cutting-edge services by using LBA.
D3 Psychological value	**F3.1** Early adopting	Customers choose to use LBA as earlier adopters because they are curious about how they may receive advertisements at right time and place.
	F3.2 Exploration	Customers choose to use LBA because they want to explore and learn about unfamiliar shops, product/service experiences, and promotions around their location.
	F3.3 Perceived playfulness	Customers choose to use LBA because they expect to be able to obtain more information, videos, or interactive games from surrounding stores, thereby enhancing the pleasure and satisfaction of shopping experience.
D4 Mobile device support	**F4.1** Push stability	LBA provides customers with stable pushing and receiving advertisement services.
	F4.2 User-friendly interface	LBA provides customers with user-friendly and plain interactional surface for clicking advertisement.
	F4.3 Response time	LBA provides quick response to customers' clicks without taking much page loading time.
	F4.4 Battery durability	Customers' mobile devices have durable battery power that keep Bluetooth/GPS to consistently receive LBA.
	F4.5 Screen size	Customer's mobile devices come with ideal screen sizes which are able to well present the information from LBA.
D5 Privacy considerations	**F5.1** Personal preference privacy	Customers are concerned about leaking their shopping history related to promotion, purchased products, and visiting stores by using LBA.
	F5.2 Personal location privacy	Customers are concerned about leaking their present locations to stores through LBA.

impact one another. By cross-checking the results from these two methods, we made some conclusions.

3 Analysis Results

3.1 Descriptive Statistics Analysis

The targeted survey participants in this study are college students who have been currently using LBA applications. A total of ten participants were interviewed. Five of them are male college student and the other five are female college students. In addition, the study also obtained participants' relevant experience and habits of using LBA services, as described in Table 2.

3.2 AHP Analysis

This study developed questionnaires based on AHP and interviewed participants by using 1–9 scale pairwise comparisons developed by Saaty [10]. Each interview result was reviewed to make sure that the C.I. and C.R. values of each question are less than or equal to 0.1 so that the responded answers are in accordance with

Table 2 Interviewees' experiences in using LBA

Item	Sub-items	Count	Percent
Motivations to turn on Bluetooth on mobile device	Get directions	3	30.0%
	Sending files	9	90.0%
	Search for stores	2	20.0%
	Connect accessories	6	60.0%
	Others	1	10.0%
Types of frequently used LBA applications	Food and restaurant	7	70.0%
	Tea parlor/coffee shop	8	80.0%
	Hotels	2	20.0%
	Transportations	1	10.0%
	Shopping	2	20.0%
	Others	1	10.0%
Frequency of using cellphone to receive LBA ads weekly	1–5 times	4	40.0%
	6–10 times	2	20.0%
	11–15 times	1	10.0%
	More than 15 times	3	30.0%

consistency. If a question fails the inconsistency test, the participant was requested to take the survey again and the responded answers were adjusted.

After all valid questionnaires are analyzed by Fuzzy AHP, the local fuzzy weights (LW) of each evaluation factors are obtained. Further, by multiplying the LW of the dimension levels and the factor levels, the global fuzzy weight (GW) of each consideration factor in the overall evaluation hierarchy can be calculated, and according to the weight value, the importance ranking of each consideration factors is created. The results of the analysis are shown in Table 3. It indicates that the GW of the top three key consideration factors (F5.2 "personal location privacy," F1.2 "get information about saving money at right time and right place," F5.1 "personal preference privacy") takes more than 40% of the overall GW. It can be seen that these evaluation factors have a great influence on the customers when considering whether to turn on Bluetooth on the mobile device to receive the LBA services.

3.3 DEMATEL Analysis

This study further explores the interrelationships and impacts between consideration factors through the DEMATEL method. This study first established a correlation matrix between consideration factors, as an interview questionnaire for the DEMATEL analysis, and then conducted a questionnaire interview for the selected ten respondents. The scale of the questionnaire is based on the 0–3 scale proposed by

Table 3 Fuzzy weight of dimensions and factors

Dimension	LW	Factor	LW	GW
D1Functional value	0.338 (1)	F1.1	0.138 (4)	0.047 (9)
		F1.2	0.460 (1)	0.156 (2)
		F1.3	0.210 (2)	0.071 (4)
		F1.4	0.192 (3)	0.065 (5)
D2Popularity value	0.059 (5)	F2.1	0.389 (1)	0.023 (14)
		F2.2	0.265 (2)	0.016 (15)
		F2.3	0.208 (3)	0.012 (17)
		F2.4	0.138 (4)	0.018 (18)
D3Psychological value	0.152 (4)	F3.1	0.414 (1)	0.063 (6)
		F3.2	0.285 (3)	0.043 (11)
		F3.3	0.301 (2)	0.046 (10)
D4Mobile device support	0.185 (3)	F4.1	0.192 (3)	0.036 (12)
		F4.2	0.333 (1)	0.062 (7)
		F4.3	0.255 (2)	0.047 (8)
		F4.4	0.151 (4)	0.028 (13)
		F4.5	0.069 (5)	0.013 (16)
D5Privacy considerations	0.266 (2)	F5.1	0.358 (2)	0.095 (3)
		F5.2	0.642 (1)	0.171 (1)

[20]. The larger the score is, the greater the mutual influence between each factors would be [21]. Finally, through a series of matrix calculation, the study compiles the results from all questionnaires and obtains a total influence-relation matrix (T) as shown in Table 4.

In addition, by summing the values from each column and row of the total influence-relation matrix (T), the sums of all columns (D_i value) and all rows (R_i value) pop out. The results of $D_i + R_i$ and $D_i - R_i$ are shown in Table 5.

Here, D_i represents the total influence of factor i on other factors, and R_i represents the total influenced intensity of factor i that is influenced by other factors. In addition, $D_i + R_i$ is called "prominence" that represents the sum of influences strength of factor i including both the strength influencing other factors and the influences from other factors. $D_i - R_i$ is called "relation" that divides factors into "cause group" and "effect group." If $D_i - R_i$ is positive, it means the factor i dispatches the influence to other factors more than it receives; thus, factor i belongs to the "cause group." On the other hand, if $D_i - R_i$ is negative, it means the factor i receives the influence from other factors more than it dispatched; thus factor i belongs to the "effect group" [21].

4 Conclusions

Identifying the locations of potential customers, mobile advertising can send useful advertisements to them. Many studies have indicated that it can effectively stimulate consumers' purchasing intentions [22]. However, for pushing the advertisements to customers accurately, the first condition is that they are willing to turn on the positioning service on their mobile devices. This study applies the FAHP and DEMATEL methods to analyze the consideration factors of customers while making the decision whether to turn on Bluetooth on mobile devices to receive the LBA service.

The analysis results generated in this study indicate that "Functional Value" (D1, weight 0.338) is the most important consideration dimension for customers while considering turning on Bluetooth to receive LBA services, followed by "privacy considerations" (D5, weight 0.266). As to ranking of consideration factors, "personal location privacy" (F5.2, weight 0.171), "get information about saving money at right time and right place" (F1.2, weight 0.156), and "personal preference privacy" (F5.1, weight 0.095) are the top three consideration factors. In addition, the results from DEMATEL analysis show that "exploration (F3.2)," "get ads at right time and right place (F1.1)," and "convenience for decision-making (F1.4)" are ranked as the top three consideration factors with highest prominence among all decision-making questions in this study.

According to the above analysis results, it can be found that when customers are willing to turn on Bluetooth to get LBA, one of their major consideration factors is to get chance of saving money anytime, anywhere. The study also finds that although "exploration" (F3.2) and "get ads at right time and right place" (F1.1)

Table 4 Total influence-relation matrix of each factor

	F1.1	F1.2	F1.3	F1.4	F2.1	F2.2	F2.3	F2.4	F3.1	F3.2	F3.3	F4.1	F4.2	F4.3	F4.4	F4.5	F5.1	F5.2
F1.1	0.158	0.178	0.143	0.174	0.164	0.151	0.126	0.186	0.221	0.211	0.168	0.175	0.145	0.148	0.132	0.076	0.172	0.188
F1.2	0.192	0.109	0.126	0.155	0.152	0.141	0.117	0.127	0.172	0.184	0.163	0.121	0.106	0.112	0.083	0.072	0.127	0.145
F1.3	0.147	0.111	0.081	0.121	0.112	0.117	0.106	0.134	0.134	0.124	0.103	0.111	0.105	0.131	0.076	0.058	0.080	0.103
F1.4	0.240	0.226	0.204	0.153	0.183	0.164	0.150	0.187	0.230	0.235	0.182	0.156	0.156	0.188	0.148	0.091	0.163	0.201
F2.1	0.137	0.109	0.079	0.131	0.088	0.114	0.098	0.124	0.132	0.136	0.106	0.114	0.094	0.100	0.054	0.034	0.114	0.116
F2.2	0.167	0.134	0.132	0.160	0.166	0.099	0.137	0.160	0.177	0.174	0.140	0.117	0.118	0.117	0.078	0.042	0.126	0.114
F2.3	0.152	0.113	0.118	0.146	0.153	0.136	0.091	0.168	0.191	0.173	0.140	0.103	0.091	0.088	0.059	0.037	0.135	0.115
F2.4	0.188	0.165	0.161	0.179	0.191	0.172	0.181	0.129	0.219	0.189	0.177	0.125	0.137	0.137	0.087	0.048	0.141	0.137
F3.1	0.168	0.134	0.144	0.166	0.158	0.167	0.159	0.174	0.136	0.195	0.145	0.108	0.107	0.101	0.069	0.042	0.152	0.167
F3.2	0.248	0.194	0.179	0.205	0.195	0.174	0.203	0.212	0.244	0.176	0.204	0.169	0.158	0.160	0.121	0.088	0.189	0.209
F3.3	0.190	0.173	0.149	0.186	0.190	0.151	0.153	0.171	0.218	0.216	0.122	0.140	0.139	0.132	0.096	0.064	0.128	0.147
F4.1	0.237	0.210	0.195	0.215	0.211	0.175	0.169	0.212	0.230	0.227	0.213	0.130	0.175	0.192	0.137	0.091	0.153	0.198
F4.2	0.206	0.176	0.171	0.181	0.184	0.165	0.153	0.166	0.192	0.183	0.160	0.137	0.099	0.162	0.107	0.094	0.127	0.153
F4.3	0.241	0.215	0.201	0.220	0.202	0.187	0.160	0.211	0.235	0.232	0.212	0.204	0.161	0.128	0.128	0.084	0.139	0.177
F4.4	0.278	0.247	0.202	0.232	0.226	0.209	0.176	0.222	0.256	0.260	0.231	0.208	0.162	0.218	0.105	0.133	0.161	0.214
F4.5	0.155	0.112	0.109	0.127	0.105	0.088	0.119	0.105	0.120	0.125	0.137	0.096	0.133	0.083	0.098	0.038	0.101	0.104
F5.1	0.218	0.193	0.160	0.173	0.206	0.179	0.182	0.194	0.229	0.219	0.186	0.132	0.116	0.129	0.099	0.065	0.113	0.152
F5.2	0.260	0.233	0.183	0.210	0.178	0.171	0.176	0.215	0.240	0.250	0.196	0.195	0.141	0.193	0.172	0.072	0.156	0.145

Table 5 Row and column operation in T matrix of each factor

Factor	D_i	R_i	$D_i + R_i$	$D_i - R_i$
F1.1	2.917	3.584	6.501	−0.666
F1.2	2.405	3.033	5.437	−0.628
F1.3	1.955	2.739	4.693	−0.784
F1.4	3.258	3.135	6.393	0.123
F2.1	1.880	3.063	4.943	−1.183
F2.2	2.357	2.763	5.119	−0.406
F2.3	2.209	2.657	4.865	−0.448
F2.4	2.764	3.098	5.862	−0.334
F3.1	2.492	3.577	6.070	−1.085
F3.2	3.328	3.508	6.836	−0.180
F3.3	2.765	2.985	5.751	−0.220
F4.1	3.370	2.540	5.910	0.830
F4.2	2.816	2.343	5.159	0.473
F4.3	3.338	2.517	5.855	0.820
F4.4	3.739	1.849	5.588	1.890
F4.5	1.956	1.230	3.186	0.726
F5.1	2.948	2.479	5.427	0.468
F5.2	3.388	2.785	6.173	0.603

are not ranked on the top of the importance ranking. However, they are highly prominent consideration factors in the whole evaluation framework. As a result, this study suggests that LBA advertisers could cooperate with various businesses and provide customers with LBA that contains activities of product/service experience, shopping promotion, and discount information from stores near customers' current location. In this way, customers might experience the shopping surprises when they use the LBA service. In addition, it can save customers' money, thereby stimulating consumption and increasing the profit for the businesses.

However, the analysis results also indicate that customers are concerned about giving out personal privacy information when considering turning on Bluetooth to use LBA services. This study suggests that LBA advertisers should not only design proper contents of advertisements, but also develop better strategies and implement fair practices to improve privacy protection, which might relieve the concerns of the customers while providing personal location information.

In addition, from Table 5, the DEMATEL analysis indicates that "battery durability" (F4.4) has the highest Di score; i.e., it would have the highest influence to other factors. It is noticed that many customers would turn off location positioning in order to save battery life. Thus, it is suggested that LBA advertisers could focus on more relevant and customized advertisements instead of pushing too many irrelevant advertisements to the users.

In the future, the evaluation hierarchy proposed by this study can be applied to analyze other customer groups with different work background and ages. In addition, it is expected to further explore the factors that may influence customers' decisions to click and watch advertisements after receiving LBA messages.

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