Measurement of the Degree of Brand Purchase Intention by Using Reaction Time

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Abstract. Most brand managers are interested in measuring the degree of purchase intention of their brands. Purchase intention is useful to predict the future earnings of a brand. However, previous research has not measured brand purchase intention to <u>learn the state of the brand</u>. Therefore, this research proposes a method to measure the degree of brand purchase intention by using respondents' reaction time between reading and answering a query about a brand. An original survey method to collect reaction time was developed and the results of this survey were analyzed by GLMM. The random parameters were estimated by the MCMC method. Because the respondents' reactions are influenced by their past purchase experiences, the model in this research is developed for not only reaction time but also past purchase experience as an explanatory variable. Thus, the proposed model enables the measurement of purchase intention except for the influence of past purchase experience. The estimated parameter results clearly show the difference among brands and the present state of each brand.

Keywords: brand power, reaction time, GLMM, MCMC

1. INTRODUCTION

It is important for brand managers to understand both the current and future state of their brands to achieve their business objectives. Brand loyalty and brand equity are utilized to manage a brand because they indicate the current state of the brand. However, loyalty and equity do not indicate the future state of the brand. Brand purchase intention is one of the methods to understand the future state of the brand. If consumers have strong purchase intentions for a certain brand, they will buy that brand in the future. Thus, brand managers can assess the future state of their brands by understanding the degree of consumers' purchase intentions.

To understand the degree of purchase intentions, brand managers usually conduct marketing research with ordinal scale alternatives (e.g., strongly agree, somewhat agree, somewhat disagree, and strongly disagree). Such ordered scale alternatives are useful for business, but they are not able to measure consumers' attitudes accurately because ordered scale alternatives do not have regular intervals. This research employs reaction time to measure the brand purchase intention instead of using ordered alternatives.

Reaction time reveals the strength of the connection in a consumer's memory (Mulligan, Grant, Mockabee and Monson, 2003). If consumers have a strong connection between purchase intentions and a certain brand, they reveal the purchase intention faster when they are asked "Would you like to buy this brand?" Therefore, we understand the degree of purchase intentions by measuring reaction time. However, previous research has not proposed methods to collect and analyze reaction time in order to measure brand purchase intention. This current research proposes a method using reaction time to understand consumers' purchase intentions as the future state of the brand.

The rest of this article is organized as follows. The second section presents the novelty of this research through a literature review. In the third section, the data and the analysis method are described. Next are the results of the analysis. The last section discusses the conclusions of this study.

2. Research Review

The objective of this section is to show the reason for measuring brand intention and collecting reaction time to measure purchase intention. Additionally, the positioning and novelty of this research are clarified by reviewing previous related literature.

2.1 Measurement of Brand State

Many kinds of methods to understand the state of a brand have been proposed, including brand loyalty brand equity. Brand loyalty is defined as biased consumers' choice behavior (Tucker, 1964) and is measured by the ratio of the purchase amount of a particular brand to the purchase amount in the category that includes that brand. Brand loyalty is often used in business, because it is easy to calculate and understand. However, brand loyalty has the disadvantage of excluding consumers who purchase few items (i.e., one or two) in a category in order to hedge the risk of overestimation of brand loyalty.

Methods to measure brand equity have been proposed in previous research can be classified into three types. One type of method is to apply behavior data. Kamakura and Russell (1993) developed a brand choice model based on scanner panel data. They measured brand equity as the intercept estimated by the choice model. Another type of method is to apply experimental data. Swaif, Erdem, Louviere and Dubelaar (1993) conducted a brand choice experiment to measure brand equity. Brand equity is the intercept of a choice model, such as that by Kamakura and Russell (1993). The third type of method is to apply attitude data collected by questionnaire. Yoo and Donthu (2001) applied the sum of the scores of questionnaire answers for measuring brand equity. Additionally, Forbes, a press and marketing research company, proposed the original surveys, e.g., The World's Most Valuable Brands.

The methods mentioned above only measure the current state of the brand and do not estimate the future state.

2.2 Purchase Intention and Reaction Time

One of the methods to understand the future state of a brand is to measure the degree of purchase intention. In the present research, purchase intention is measured by the reaction time between asking and answering a question about the purchase intention for a certain brand. Reaction time is applied for two reasons. One reason is that reaction time reveals how strongly a consumer intends to purchase it. If a respondent has a strong mental connection between an item and purchase intention, he/she shows the purchase intention with a fast reaction time. Conversely, if a respondent has a weak mental connection between an item and purchase intention, he/she hesitates to show the intention to purchase, and therefore the reaction time is slow. Thus, a fast or slow reaction time clarifies the degree of purchase intention.

Another advantage of utilizing reaction time is the accuracy of measurement. Purchase intention is often measured by the Likert scale of alternatives (e.g., definitely buy, probably buy, probably not buy, and definitely not buy). The Likert scale is a convenient scale to deal with the ordinal scale as a ratio scale. However, the Likert scale has the problem that it cannot measure a respondent's reaction accurately because it does not have equal intervals. Reaction time is a ratio scale that has equal intervals, as noted in a previous study (Tyebjee, 1979b).

In marketing, several studies revealed that reaction times can support understanding consumers' behavior. Tyebjee (1979a) identified that brand choice time is influenced by the respondent's preference. Tyebjee (1979b) showed that reaction time is suitable for measuring brand preference with brand choice experience. Aaker, Bagozzi, Carman and MacLachlan (1980) noted that a stronger preference for a brand induced a fast time for choosing a brand. Haaijer, Kamakura and Wedel (2000) developed a choice model that included reaction time as an explanatory variable. They identified the negative relation between the choice and the reaction time. In consideration of these studies, reaction time is related with choice behavior and a fast reaction time means strong choice intention.

Because it is considered that the choice intention and the purchase intention are substantially the same, it is sufficient to measure the reaction time for the brand purchase in order to measure the purchase intent of a certain brand. The shorter the reaction time a consumer reveals, the stronger the brand purchase intention he/she has. Therefore, it is necessary to develop a method for measuring the purchase intention of a brand by reaction time. In previous studies, no specific methods for measuring the purchase intention of a brand were proposed. Thus, this study was conducted.

3. Method

3.1 Data and Variables

To obtain both purchase intention (Yes/No) and reaction time data, a questionnaire was set up on a Web browser (e.g., Internet Explorer) as shown in Figure 1. This system obtains both purchase intention and reaction time by operation of a mouse. Reaction time data are collected in units of 0.001 seconds.

Nine brands of the Japanese tea "Nihon-cha" and barley tea "Mugi-cha" categories are selected for analysis in this research. The two reasons for selecting them are as follows. One reason is that respondents are found easily because Nihon-cha and Mugi-cha are familiar to Japanese people. The other reason is that the Nihon-cha and Mugi-cha categories consist of several brands that include both a national brand (NB) and a private brand (PB). The individual NB and PB do not have the same brand powers.

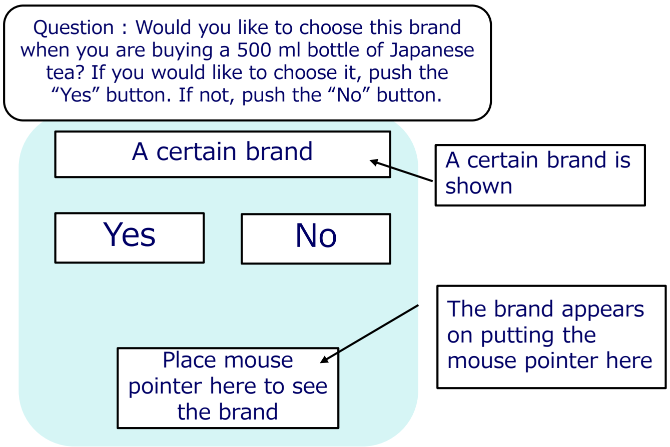

Figure 1: The Image of Questionnaire in This Research

It is reasonable to assume that purchase intention is influenced by past purchase experience. Therefore, this research requires that we know what the respondents purchased before. This was achieved by choosing shopping monitors for a Japanese internet research company (Macromill Inc.) as the respondents. Shopping monitors keep shopping records by scanning the barcode on food or daily goods which they purchased. By checking their scanned shopping records, we could confirm the brands they purchased.

The respondents were chosen first according to their past purchase amounts of Nihon-cha and Mugi-cha, and then by their reaction times. It is better to measure the user's purchase intention of each brand in the Nihon-cha and Mugi-cha categories, because those with no purchase intentions do not generate reliable results. Respondents who bought more than four items in the Nihon-cha and Mugi-cha categories during the sample period from November 1, 2013 to January 31, 2014 were chosen. The number of respondents in this research was 420. The research period was from March 4 to March 17, 2014. Also, if a respondent makes a mistake in operating the mouse or if his/her reaction time is exceedingly long, for example, the respondent's answer (reaction time) must be discarded to maintain the quality of the reaction time data for the analysis. In this research, the maximum reaction time of each respondent is calculated and checked. Only one respondent, whose maximum reaction time was longer than one minute, was excluded from the analysis.

Richards and James (1963) indicated that reaction time differed between a young group and an old group. Therefore, because reaction time has a different baseline for each respondent, the individual reaction time was standardized by mean and standard deviation and transformed Z-score (Fazio, 1990). Past purchase experience is expressed as a dummy variable. If a respondent purchased the brand shown during the sample period mentioned above, the dummy variable takes the value of 1; if a respondent had not purchased the brand shown on the internet browser, the variable is 0. The experimental variables in this study are reaction time and past purchase experience (dichotomous variable), which is the dependent variable with a Yes/No answer.

3.2 Model

To account for the consumers' different reactions to a brand, the model allows for heterogeneity in the intercept, reaction time, and past purchase experience for each brand. To measure the purchase intention of each brand in this research, the generalized liner mixed model (GLMM), which is a binary logit mixed model, is applied with the random effect of intercept, reaction time (T_{ib}), and past purchase experience (E_{ib}), as follows:

$$y_{ib} = (\alpha_f + \alpha_r) + (\beta_f + \beta_r)T_{ib} + (\gamma_f + \gamma_r)E_{ib} + \varepsilon_{ib} \quad (1)$$

y_{ib}: respondent i answered with purchase intention of brand b (b=1, 2, 3, ..., 9) as Yes/No (y_{ib} is a dichotomous variable)
T_{ib}: Z-score of reaction time to brand b for respondent i
E_{ib}: purchase experience of brand b for respondent i (E_{ib} is a dichotomous variable)
ε_{ib}: error term in choice of brand b for respondent i
α_f/α_r: fixed effect/random effect parameter of intercept
β_f/β_r: fixed effect/random effect parameter of reaction time
γ_f/γ_r: fixed effect/random effect parameter of past purchase experience

The parameters in Eq. (1) are estimated by the Markov chain Monte Carlo method (MCMC). Specifically, the MCMC procedure with SAS9.4 is applied in this research. The reason for estimating by MCMC is that the proposed model is complex; namely, the model includes three random effects of nine brands (Goldstein, 2010). The prior distribution of each parameter is assumed as below (where N indicates a normal distribution). Noninformative priors are used to estimate these parameters as follows.

α_f~ N (0, 10000)
β_f~ N (0, 10000)
γ_f~ N (0, 10000)
α_r~ N (0, sa1)
β_r~ N (0, sb1)
γ_r~ N (0, sc1)
sa1~ Inverse-Gamma (0.01, 0.01)
sb1~ Inverse-Gamma (0.01, 0.01)
sc1~ Inverse-Gamma (0.01, 0.01)

The MCMC steps are repeated for 300,000 iterations. The first 150,000 iterations are the burn-in period, and the last

150,000 are used to estimate the posterior distribution of the parameters. The thinning interval is 30. Convergences are checked with a plot and the Geweke Test (Geweke, 1992).

4. Results

The convergence is monitored visually and confirmed by the results of the Geweke Test, which shows that the absolute Z-scores of all estimated parameters are below 1.96.

Figure 2 is a scatter plot of the purchase intention rate vs. the average standardized reaction time. The purchase intention rate is the number of people who answered "Yes" divided by the total number of respondents. The average standardized reaction time is the total Z-score of the brand divided by the total number of people who answered "Yes" for the brand.

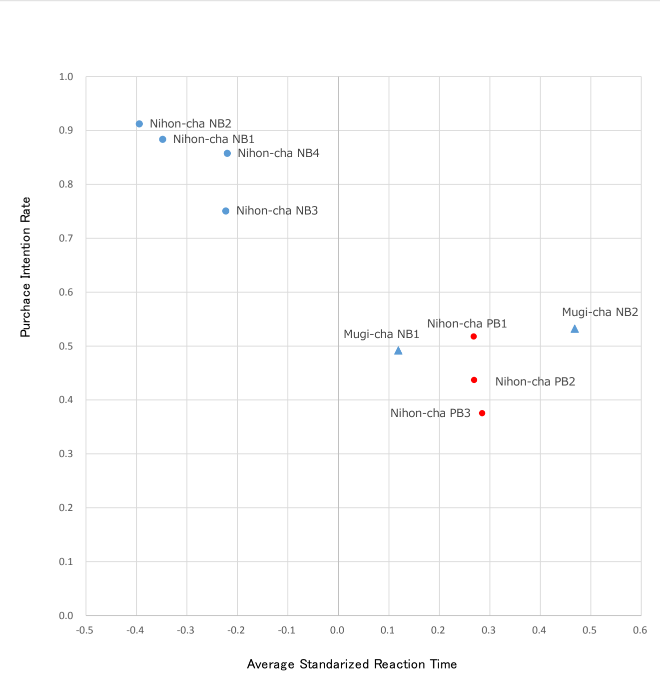

Figure 2: Scatter Plot of Purchase Intention Rate and Average Standardization Reaction Time

If respondents have a tendency to push the "Yes" button too fast for a certain brand, the average standardized reaction time shows a negative value. Because the reaction time is transformed to the Z-score, a reaction time below the mean (i.e., the reaction time is faster than the mean reaction time) shows a negative value. Respondents tend to have a fast reaction for the brand on the left side of Figure 2.

Figure 2 shows the feature of each brand chosen in this study. Though Mugi-cha NB1 and Mugi-cha NB2 are different in average standardized reaction time, they have almost the same purchase intention rates. Similarly, the average standardized reaction time of Nihon-cha NB3 is the same as that of Nihon-cha NB4, though the purchase intention rates are different. The numbers of respondents who reveal their purchase intentions differ; however, in regard to the degree of purchase intention, Nihon-cha NB3 has almost the same value as Nihon-cha NB4.

Equation (1) has a fixed effect and a random effect. The fixed effect shows the tendency of the whole brand and the random effect shows the tendency of each brand.

The estimated fixed effect is as shown in Table 1. β_f has a negative value, which shows the reaction time has a negative relation to pushing the "Yes" button (to show purchase intention), and γ_f has a positive value, which shows a positive relation to past purchase experience.

Table 1: Estimated Fixed Effect Parameter

	α_f	β_f	γ_f
Fixed Effect	0.331	-0.188	1.333

The estimated random effects are shown in Table 2. In this table, β_r is the difference of the degree of purchase intention between brands. All four Nihon-cha NBs have negative β_r values, but all other NBs (Mugi-cha) and PBs (Nihon-cha) are positive. A negative value means that respondents have a tendency to push the "Yes" button fast. Nihon-cha NB2 has the smallest parameter, -0.505, of the nine brands and so shows the strongest purchase intention. According to Figure 2, Nihon-cha NB1 and Nihon-cha NB4 have almost the same purchase intention rate; however, the reaction time of Nihon-cha NB1 is shorter than that of Nihon-cha NB4. Nihon-cha NB1 has a shorter average standardized reaction time than does Nihon-cha NB4. Table 2 shows a similar result to Figure 2, in that parameter β_r of Nihon-cha NB1 is larger than Nihon-cha NB4.

The Nihon-cha NBs tend to have a short reaction time. In contrast, among the Nihon-cha PB brands, the respondents show a long reaction time to push the "Yes" button. This result of PB brands means respondents hesitate to push the "Yes" button, indicating low purchase intentions. This suggests that the future state of the Nihon-cha PBs is not good.

In Table 2, γ_r shows the degree of the past experience effect on the brand selected in this research. Three Nihon-cha NBs and one Nihon-cha PB are negative and the other, Nihon-cha PB2, is positive. This result shows that some brands provided in this research are affected by past purchase experience more strongly. Nihon-cha PB3, which has the largest value of γ_r, is most influenced by past purchase experience to push the "Yes" button.

Table 2: Estimated Random Effect Parameters

	α_r	β_r	γ_r
Nihon-cha NB1	0.747	-0.404	-0.162
Nihon-cha NB2	1.094	-0.504	-0.159
Nihon-cha NB3	0.357	-0.278	-0.008
Nihon-cha NB4	0.831	-0.300	0.040
Mugi-cha NB1	-0.462	0.132	0.117
Mugi-cha NB2	-0.426	0.238	0.092
Nihon-cha PB1	-0.607	0.281	0.108
Nihon-cha PB2	-1.104	0.559	-0.144
Nihon-cha PB3	-0.823	0.366	0.132

5. Discussion

If respondents have a strong purchase intention to a certain brand, they push the "Yes" button fast (showing s short reaction time) and so β_r shows a negative value. The β_r parameters in Nihon-cha NBs are negative; however, β_r of the Mugi-cha NBs are positive. These positive values are caused by the consumers' purchase behavior. Mugi-cha is a drink suited to summer. The demand of the Mugi-cha category was lower in this research period (March). Therefore, the β_r parameters of the Mugi-cha NBs are negative.

Table 2 shows that brands are unequally influenced by past purchase experience; especially, Nihon-cha NB1, NB2, and NB3 have negative values of γ_r. This result can be interpreted as follows. Brand managers of national brands have huge budgets for consumer communications and they create more attractive advertising. Memorable advertisement leaves a good impression on consumers and induces them to purchase that brand. This is the reason for the small influence of purchase experience for these NBs. In contrast, the PBs tend to have a positive past purchase experience parameter. Because PBs seldom advertise, purchase experience has a big impact on purchase intention. However, Nihon-cha PB2 shows a negative value of γ_r. The following are possible reasons: Nihon-cha PB2 is the powerful retailer's PB, and most respondents know Nihon-cha PB2 to be like NBs that use attractive advertisement. Thus, past purchase experience only slightly influences purchase intention.

The academic contributions and the business contributions of the measurement method are summarized below. The academic contributions are the proposal of a method to measure the future state of a brand by reaction time and a method for analyzing purchase intention with GLMM. The results of the analysis show that the reaction of respondents is affected by past purchase experience. Many factors affect the reaction of respondents, according to the previous literature (e.g., Gal and Rucker, 2011). This research clarifies past purchase experience as a new factor. Hereafter, when marketing research in regard to purchase intention is conducted, past purchase experience should be confirmed by survey questions.

The business contributions are the understanding of the general state of a brand by using estimated parameters α_r and β_r. The γ_r is not considered here, since γ_r is a parameter representing the influence of past purchases, not the state of the brand. The α_r is the intercept of the random effect. This intercept in the brand choice model is considered as its attractiveness, which affects brand choice. It seems that attractiveness applies to the current state of the brand. Thus, parameter α_r shows the current state of the brand and β_r shows the future state of the brand. Utilizing these two parameters enables estimating brand power, as shown in Figure 3. Brand power is assumed to be a function of the current and future states of the brand, as shown in Eq. (2). It is possible to express brand power as the distance between a starting point and the point (β_r, α_r).

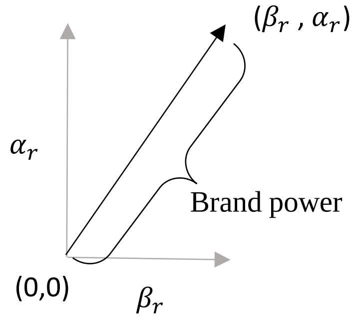

Figure 3: Illustration of brand power index

$$\text{Brand power}=\sqrt{(\beta_r - 0)^2+(\alpha_r - 0)^2} \quad (2)$$

Table 3 lists the results of the calculation of brand power for each of the four Nihon-cha NBs by using Eq. (2). Nihon-cha NB2 is the most powerful of the four brands, because it has the largest numerical value, 1.27. By applying the estimated parameters with GLMM (Eq. (1)), it is possible to quantify the brand power.

Table 3: Brand Power

	Brand Power
Nihon-cha NB1	0.91
Nihon-cha NB2	1.27
Nihon-cha NB3	0.51
Nihon-cha NB4	0.95

By utilizing both α_r and β_r values, brands can be divided into four segments on the plane with the vertical axis α_b and the horizontal axis β_r. The second quadrant ($\beta_r < 0,\ \alpha_r > 0$) indicates better current and future states and is a desirable position for the brands. $\beta_r < 0$ indicates a fast reaction time and high purchase intention. $\alpha_r > 0$ indicates a brand with high attractiveness. In contrast, the fourth quadrant ($\beta_r > 0,\ \alpha_r < 0$) is an undesirable position for brands.

Additionally, the results of this research have a significant implication for marketing research due to the diffusion of smartphones. Research devices are shifting from personal computers (PCs) to smartphones. Smartphones have smaller screens than PCs, and so it is difficult for respondents to answer on a scale of ordered alternatives, which need a large screen space. Dichotomous alternatives are better suited for smartphones, because they do not need a large screen space. However, dichotomous alternatives have the disadvantage that they collect varying levels of answers. Utilizing the reaction time prevents dichotomous alternatives from losing information.

Although this empirical study sheds light on several issues, the results are derived from only two categories, the Nihon-cha and Mugi-cha categories. Conducting empirical research in other categories would confirm the validity of these results.

This research clarifies the reaction to questionnaires affected by the past purchase experience of respondents. Thus, in order to measure the purchase intention in marketing research, researchers should confirm the past purchase experiences of respondents. The methods for confirming what respondents have purchased include using shopping records, such as barcode scanner records, or consumer surveys. It is not certain that the results of consumer surveys can be substituted for shopping records. Therefore, it is necessary to conduct new research to show the effect of consumer surveys.

ACKNOWLEDGMENTS

I would like to show my greatest appreciation to Dr Moriguchi, Professor of Waseda University and Macromill Inc. Prof. Prof. Moriguchi gives me insightful comments and suggestions. Macromill Inc. support to collect the research data.

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