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Human Behaviour Change Based on Nudge Theory: An Empirical Test at an Expressway Rest Area in Japan

Abstract

Nudge theory is an approach that uses behavioural science findings and theories to 'gently push' people into acting. This paper focuses on the possibility of using nudges to improve the satisfaction of highway rest area users. We set up a mechanism for users of highway parking rest areas to engage not only in functional behaviour but also free behaviour and to conduct a demonstration experiment based on nudge theory.

Previous studies have focused on whether or not the nudge theory approach is effective or not and have come to fairly uniform conclusions. In this study, we measured whether the effectiveness of the nudges varied according to 'subject demographics' and 'location'. The data were examined using the two-way analysis of variance (ANOVA) method. Results of the experiment, we were able to detect significant differences between attributes (adults and parents with children) due to the nudge mechanism.

Key words

Nudge theory, Human behaviour, Behavioural economics, Highway parking rest areas, ANOVA

1. Introduction

On highways in Japan, parking lots and related facilities are provided at certain intervals, with the main purpose of allowing drivers to take a rest. More specifically, the objective of these facilities is to respond to ‘functional behaviour’, such as satisfying the physiological needs of drivers (e.g. using the toilet) or relieving driving fatigue.

These parking rest areas are equipped with shops and convenience stores that sell souvenirs featuring local products from the nearby area, as well as restaurants and cafes that serve a variety of meals and beverages. Since the use of these facilities is not essentially necessary for drivers, we refer to this use as ‘free behaviour’ in this paper.

In Japan, the highways were managed by the Japan Highway Public Corporation, a national agency, from 1956 to 2005. Since then, the company has been divided into three regions. Following privatisation, the use of expressways has been focused not only on efficiency and functionality but also on the enhancement of services from the viewpoint of user satisfaction.

The "free behaviour" option will also increase user satisfaction with the rest area. Not only that, but it is assumed that the increase in users' free behaviour will increase sales at rest area stores and restaurants. In other words, "free behaviour" leads to consumption behaviour in business, and the application of nudge theory to such consumption behaviour is considered beneficial.

Specifically, we will use nudges that focus on "dinosaurs," a unique feature of Fukui Prefecture. This initiative aims to demonstrate the effect of using dinosaur footprints to arouse interest in tourists and users. This is expected to help users understand the characteristics of the region and increase their interest in local products and tourism resources.

This paper focuses on the possibility of using nudges – part of an experimental theory in changing human behaviour – to improve the satisfaction of highway rest area users. Traditionally, nudges have been used to change the behaviour of citizens in terms of policy; however, it can be argued that nudges may also be applicable to business. With this in mind, the Innovation and Management Engineering Laboratory, Graduate School of Engineering, University of Fukui worked together with Central Nippon Expressway Company Limited (NEXCO Central Japan Limited) – which manages the highways – to set up a mechanism for users of highway parking rest areas to engage not only in functional behaviour but also free behaviour and to conduct a demonstration experiment based on nudge theory.

2. Theory and Prior Reseacher

Nudge theory is an approach that uses behavioural science findings and theories to ‘gently push’ people into acting. Thaler and Sunstein (2008) define ‘nudging’ as predictably changing people's behaviour without prohibiting choice or significantly changing economic incentives. In

other words, it pertains to the concept behind libertarian paternalism, which, as the name suggests, is a fusion of paternalism and libertarianism. It involves the induction of 'better outcomes' while not allowing the powers that be to interfere with an individual's freedom of action and choice.

To confirm previous studies using the notion of nudges, Ishikura et al. (2021) categorised the presence or absence of nudge effects for each tool to identify the nudges used in a series of facilitating physical activity (tools). The results showed that the nudge elements, 'priming', 'ego', 'norms', and 'commitments', are used more frequently. On the other hand, the authors argue that in terms of Japanese implementation, there are few of these elements, with most categorised as 'incentives', that is, economic rewards.

Van der Meiden (2018) investigated how nudge interventions affect employee use of stairs in an office environment. To determine whether nudge interventions are effective in stimulating stair use by office workers, the study was divided into a period where posters were placed in front of the elevators, a period with footprints on the stairs and a period with no footprints, with the nudge effects compared and verified before and after each installation. The results showed a significant increase (p=0.1345; +3.67%) in the use of the stairs only after the footprints were incorporated. After the footprints were removed, the stair use clearly decreased again (p=0.0305; −5.76%). This suggests that nudge interventions are more effective when they entail fun, engaging, and creative visuals rather than simple plain text.

Weghorst (2016) tested the nudge effect among elevator users and stair users, adopting a combination of posters encouraging stair use and the installation of green footprints. The chi-square test method was used to evaluate the results among the building users before and after the intervention. The results showed a significant increase in stair users regardless of individual/group attributes. However, it cannot be verified that the posters were effective, nor can it be stated that placing green footprints on the floor is a simple and inexpensive nudge intervention.

Dreibelbis et al. (2016) tested the potential of a nudge-based intervention to improve handwashing behaviour after toilet use among rural elementary school children in Bangladesh. The authors experimented with the provision of traditional handwashing infrastructure, the installation of footprint markers and the incorporation of handprint painting at the finish line to encourage handwashing with soap after toilet use in two elementary school in a rural area. The results showed that strategic environmental nudges could have a positive and lasting impact on the handwashing behaviour of school-aged children.

Mamede et al. (2021) investigated how a gamified digital app intervention affects "increased activity" and "decreased seating time" among office workers in the Netherlands. Results showed that in terms of objectively measured daily steps, the intervention group took 634 more steps per day than the control group. The study showed that a gamified digital app intervention was

effective in increasing the number of steps taken by office workers, while at the same time pointing out that general prompting in the workplace is insufficient to sustain behavior change.

Meeusen et al. (2023) found that a combination of nudge strategies led to healthier purchasing behavior in the cafeteria of a Dutch hospital workplace. Purchasing data were collected using photographs of healthcare workers' lunch trays. Results showed that a combination of nudge strategies partially improved healthy choices at lunch in the Dutch healthcare setting.

Weijers et al. (2023) noted that while recognizing the importance of autonomous learning behaviors, students often do not learn them adequately. In this study, nudges were used to support three autonomous learning behaviors: planning, preparing for class, and questioning. The study showed that goal-setting nudges have potential as a facile and effective teaching strategy, especially with regard to the autonomous learning behavior of questioning.

Samaranayake et al. (2021) investigated the impact of nudges on individuals' attitudes toward and accuracy in waste sorting. Participants in the experiment were provided with nine different behavioral nudge strategies to improve their waste sorting behavior. Results showed that the nudge strategies improved accuracy. Furthermore, detailed labels and stickers were found to be more influential than color.

Franssens et al. (2021) tested whether nudges increase public transit use: an analysis of the number of rides per hour estimated that the nudge intervention led to 1.18 more rides on bus routes in the experimental group than in the control group.

Takemoto et al. (2022) collected data at highway rest areas that was obtained between 2021 and 2022 and analysed the data using structural equation modelling. In the process, customer behaviour was categorised into functional behaviour and free behaviour, and by analysing the impact of each on the amount of time spent at the facilities, the data provided useful information for improving the service at rest areas and attracting customers in the future. Specifically, among the functional behaviours, the authors found that the use of toilets had a significant impact and subsequently quantified the negative causal relationship between free behaviour and functional behaviour.

3. Hypothesis Formulation

Previous studies have focused on whether or not the nudge theory approach is effective or not and have come to fairly uniform conclusions. However, there exist no studies that have examined multiple elements separately. As mentioned in previous studies, these have revealed significant differences between the nudge intervention group and the control group, but have not clarified to which subjects the nudges are effective. On the other hand, while some studies have found that effects can be detected by multiple combinations of nudge strategies, this experiment focused on

nudge subjects rather than nudge combinations. Based on the results of my own previous studies, I designed an experiment – which is described in the following sections – to examine differences among the effects of the nudge device on locations and subjects, with a focus on the installation of footprints.

Hypothesis 1: The same nudge device will have different effects depending on its location.

Hypothesis 2: The same nudge device will have different effects on different subjects.

Hypothesis 3: Even if the same nudge device is used, a synergistic effect will be generated depending on the combination of the target audience at the installation site.

To clarify the above hypotheses, we conducted an experiment on nudges and collected the resultant data in December 2022.

4. Research Methodology

Based on the results and discussions of the previous studies, the experiment – which is outlined below – was conducted at a rest area in Nanjo on the Hokuriku Highway, a highway that runs through Fukui Prefecture, Japan. The overall aim was to ascertain whether or not nudge theory can be applied to business situations.

In this study, we decided to use "priming," which uses dinosaur content that evokes the image of the region, and "attractive," which emphasizes design, in response to a previous study that pointed out that most nudge experiments in Japan are related to "incentives.

(1) In December 2022, a ‘dinosaur footprint’ marker was installed on the sidewalk from the parking lot to the toilets (Figure 1). The reason behind the ‘dinosaur’ motif relates to how Fukui Prefecture is famous in Japan for its dinosaur fossil excavations.

Figure 1: Installation of footprints

(2) In terms of location, focal points include a convenience store and a store selling souvenirs located at the halfway point between the parking lot and the toilets (Figure 2).

Figure 2: Location of parking lots, stores, and toilets
(Source: NEXCO Central Japan Limited web page site map, English translation added by the author)

(3) We measured whether the effectiveness of the nudges varied according to 'subject demographics' and 'location'. The data were collected at highway rest areas using the field observation method and were examined using the two-way analysis of variance (ANOVA) method.

The target group was divided into three groups: adults; parents and children; and others. The location groups were divided into i) parking⟶shop⟶toilet, ii) toilet⟶shop⟶parking, and iii) parking⟶toilet.

The effects of the nudges were classified according to the degree of response (to the dinosaur footprints) as follows: 1 point was given for little or no interest, 2 points for changes such as looking, pointing or talking about the footprints, and 3 points for actions such as intentionally stepping on the footprints.

Table 3: Details of weekday data (December 21, 2022)

Attribute	①parking→shop→toilet	②toilet→shop→parking	③parking→toilet
Adult	561	360	343
Parent–child	21	11	4
Other	203	141	69
Total	785	512	416

Table 4: Weekday data aggregation times (December 21, 2022)

Attribute	①parking→shop→toilet	②toilet→shop→parking	③parking→toilet
12:00–13:00	260	167	115
13:00–14:00	272	176	164
14:00–15:00	253	169	137
Total	785	512	416

Table 5: Details of holidays data (January 8, 2023)

Attribute	①parking→shop→toilet	②toilet→shop→parking	③parking→toilet
Adult	365	299	331
Parent–child	67	46	24
Other	320	196	107
Total	752	541	462

Table 6: Holiday data aggregation times (January 8, 2023)

Attribute	①parking→shop→toilet	②toilet→shop→parking	③parking→toilet
12:00–13:00	165	172	161
13:00–14:00	270	203	155
14:00–15:00	317	166	146
Total	752	541	462

5. Results

As shown in Table 7, the p-values between attributes (rows) and between locations (columns) were both above 5% for the weekday data, at 0.16 and 0.44, respectively. As such, it can be stated that no significant differences exist. On the other hand, as shown in Table 8, the p-values between attributes (rows) and between locations (columns) for the holiday data showed a highly significant difference of 9.81E-14 between attributes. However, the p-value between locations was 0.34, indicating no significant difference. The results of the analysis showed that Hypothesis 1 was rejected, but Hypothesis 2 was supported for the holidays.

The two interactions (synergies) between location and attributes revealed a p-value of 0.14, which does not necessarily mean that a significant difference exists (Figure 9). Hypothesis 3 was also rejected in this experiment.

Table 7: Results of two-way ANOVA for weekdays

Variation Factors	Variation	Degrees of freedom	Variance	P-value	F boundary value
Attributes	2.00	2	1.00	0.16	6.94
Location	0.67	2	0.33	0.44	6.94
Error	1.33	4	0.33		
Total	4.00	8			

Table 8: Results of two-way ANOVA for holidays

Variation Factors	Variation	Degrees of freedom	Variance	P-value	F boundary value
Attributes	22.87	2	11.43	**9.81E-14**	3.03
Location	0.72	2	0.36	0.34	3.03
Interaction	2.37	4	0.9	0.14	2.41
Repeatability error	81.79	243	0.34		
Total	107.75	251			

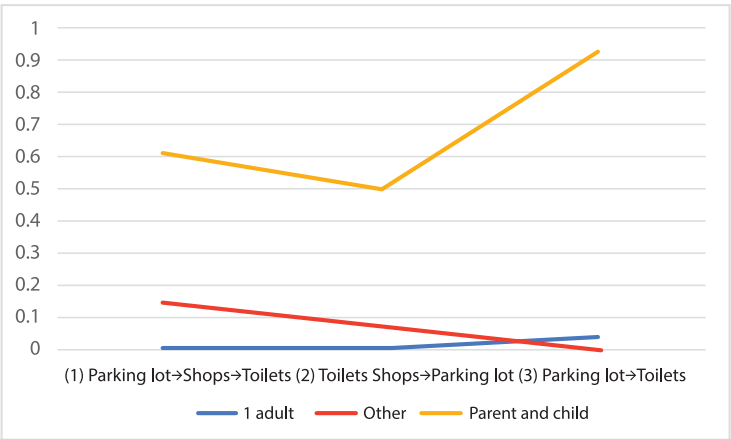

Figure 9: Graph representing the interaction

The results of the chi-square test were checked using the same holiday data used in the ANOVA to see if there was a significant difference between the attributes (rows). Indeed, the p-value between attributes (rows) was 4.09512E-11 for all locations combined, and the p-values for each of the three locations measured were 0.018253947 for (1) parking⟶shop⟶toilet, 0.006579819 for (2) toilet⟶shop⟶parking, and 2.65349E-11 for (3) The results were all significant, albeit with some strength.

These results confirm that there are indeed differences in response to nudges among attributes.

6. Discussion

In this experiment, the effects of nudges were verified by installing dinosaur footprints at a rest stop on an expressway in Fukui Prefecture. The dinosaur footprints present a nudge intervention that includes elements of 'priming' and 'attractive', which are considered to be rare in Japan according to previous studies.

In the two-way ANOVA test for weekdays, the p-values between attributes and between locations showed no significant differences in either case. However, the ANOVA results for the holidays revealed significant differences between attributes, but not between locations. In other words, we were able to detect significant differences between attributes (adults and parents with children) due to the nudge mechanism. This indicates that the effect of the nudge measure acts on the attribute 'with children' (on holidays), and that the difference in the actions is not a coincidence.

The difference between the previous study and this study is that the study was conducted by attribute and by location, and the quantitative study showed the effects of the nudge intervention in more detail. While many of the previous studies targeted a subset of subjects and locations, the results of this study were conducted by three attributes and by location, resulting in a significant effect of the nudge intervention for those with children on holidays.

While collecting data and observing pedestrians, children were observed to be particularly interested in the nudge devices and in following the dinosaur footprints. Notably, close to the entrance to the concession stand, almost half of the parents were observed grabbing their children's hands and pulling them back without respecting their wishes.

In this experiment, the placement of dinosaur footprints on pedestrian pathways resulted in significant differences between adults and parents with children on holidays. Thus, the results are in line with the previous research that concluded that nudges are effective when the interventions are presented in the form of fun, engaging, and creative visuals rather than as simple text. However, while the results of this experiment certainly do not negate prior research, they also reveal that nudges are not necessarily effective for all attributes. This was the novel finding of this experiment.

On the other hand, a limitation of this study is that the results are subject differences regarding specific nudges. Previous studies have incorporated message and color differences in their strategies, tested nudge effects, and revealed significant differences. Some also conducted an experiment called nudge composites. Although we did not implement any policies that included messages or color differences in this study, we can propose to maximize nudge effects by combining them with dinosaur footprints in the future. It is also assumed that a composite nudge policy will allow for more behavioural scientific measurement, such as differences in the amount of nudge

effectiveness.

Prior research has shown that effects can be detected by multiple combinations of nudge strategies. A possible direction for future research is to combine the subject-specific differences in this study with the results of previous studies to verify which nudge elements are highly effective for which subjects. In this direction, we aim to maximize the nudge effect. There is also a possibility to further explore the importance of nudges in business. For example, it may be possible to analyse the free behaviour of visitors through nudge intervention and measure the difference in the amount of money spent at parking/rest areas.

7. Implications from Research Findings

The effect of nudges on users with children was observed during the holidays, which may lead to increased satisfaction with the parking/rest area. In other words, both functional and free behaviour are encouraged, which in turn contributes to increased user satisfaction in parking/rest areas.

The measurement location for this study was the Nanjo rest area of an expressway in Fukui Prefecture (average daily number of stopovers: 8,000 on weekdays and 16,000 on weekends), and this study used the "dinosaur" nudge that is characteristic of Fukui Prefecture. Therefore, generalizations in other regions and environments may not be clear. If a similar study is conducted in other regions, it is likely to be effective by intervening with nudges that are specific to those regions.

In addition, practical research on nudge theory has so far been conducted mainly by public agencies to motivate the citizens. In this sense, this study can suggest the application of nudge theory to business, including the possibility of inducing people to visit commercial facilities and purchase local products through priming and attractive elements. This study can suggest applications of nudge theory to business.

Acknowledgements

This research was conducted by Scientific Research (B), a Scientific Research-KAKENHI of the Japan Society for the Promotion of Science.

We would also like to express our deepest gratitude to NEXCO, the students at the Innovation and Management Engineering Laboratory, and all the people involved for kindly collaborating with us on this research.

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Received: 2023/09/27

Revised: 2023/10/31

Accepted: 2023/11/02