Effects of dynamic information display on the perception of public washroom cleanliness

Yang S. Liu

Department of Psychology, University of Alberta, Edmonton, Alberta

1

Introduction

Cleanliness is highly valued in our society and has a direct influence on our positive attitude towards public spaces such as hotels (Lockyer, 2003; Prayukvong, Sophon, Hongpukdee, & Charupas, 2007; Stringam, Gerdes, & Vanleeuwen, 2010), restaurants (Aksoydan, 2007; Barber, Goodman, & Goh, 2011; Barber & Scarcelli, 2009; Choi, Almanza, Neal, & Sirsat, 2014; Henson et al., 2006), and hospitals (Whitehead, May, & Agahi, 2007). It is often impractical for people to interact with every aspect of a facility to objectively evaluate its overall cleanliness due to limited access of information. For example, a hotel guest does not have access to every room, a diner often has no access to kitchens in restaurants, and a patient visits limited areas in hospitals. Thus, the perception of cleanliness may depend on an inference-based heuristic, where some factors influence the perception more than others. The cleanliness of the washroom and toilet has been shown as a key factor driving the overall perception of cleanliness (Lockyer, 2003; Prayukvong et al., 2007; Barber & Scarcelli, 2009; Whitehead et al., 2007). If the washroom is dirty, people may infer other areas of the facility are also dirty.

The obvious solution to encourage an overall clean impression of a facility is to improve the quality of restroom maintenance and to improve promptness of service when requested. In addition, behavioural intervention, such as giving visual prompts to users could also enhance the

[1]We acknowledge Dr. Jeremy Caplan and Dr. Elena Nicoladis for study consultation, Dr. Eric Loo, Visionstate Inc., and the MITACS Accelerate Internship for funding support, and the Edmonton International Airport for research site provision and onsite support. Correspondence concerning this article should be addressed to Y. S. Liu, Department of Psychology, University of Alberta, Edmonton, AB, T6G 2E9 Canada (e-mail: ly6@ualberta.ca)

washroom's physical cleanliness (Clayton & Blaskewicz, 2012). However, physical cleanliness may not be the only factor determining the impression of cleanliness. Presenting relevant information could affect people's preferences and behaviour. For instance, nutrition labels on food products can affect people's preference and their purchasing behaviour (for a review see Drichoutis, Lazaridis, & Nayga, 2006). Following this line of thought, we hypothesize that visual presentation of the most recent washroom service time could influence perception of cleanliness. We suggest the impression of cleanliness could be inferred from online update of the most recent maintenance time: a recently serviced washroom should be perceived as cleaner than a washroom serviced long time ago, when all other factors are controlled. The awareness of the most recent washroom service time should also promote a feeling of cleanliness.

To test this hypothesis, we use WANDA (*http://visionstate.com/wanda*, 2015), an interactive touchscreen device that displays the most recent washroom service time and handles service requests by a touch interface. As soon as the washroom is serviced, the caretaker could immediately upload the service information via the touch interface. We ask participants to rate the cleanliness of the washroom, while the touchscreen is either visible or hidden from participants' sight. In addition, we also ask participant's preferred methods of requesting service to evaluate whether it is related to perception of washroom cleanliness.

Methods

Setting and participants

The study took place at the Edmonton International Airport, Alberta, Canada. 583 participants (279 female, 304 male) participated the study. Participants were over 18 years old and gave informed consent to participate. The ages of participants are summarized in Figure 1

Materials and procedure

The questionnaires are composed of 6 questions. 1) On a scale from 1 (very dirty) to 5 (very clean), what is your rating of the cleanliness of the washroom? 2) If you find the washroom need serving (e.g., out of toilet paper, out of paper towels), from the following options choose your most preferred methods of requesting washroom service (you may check multiple boxes): (a) request washroom service from a bacterial resistant LCD touchscreen; (b) make a telephone call to the

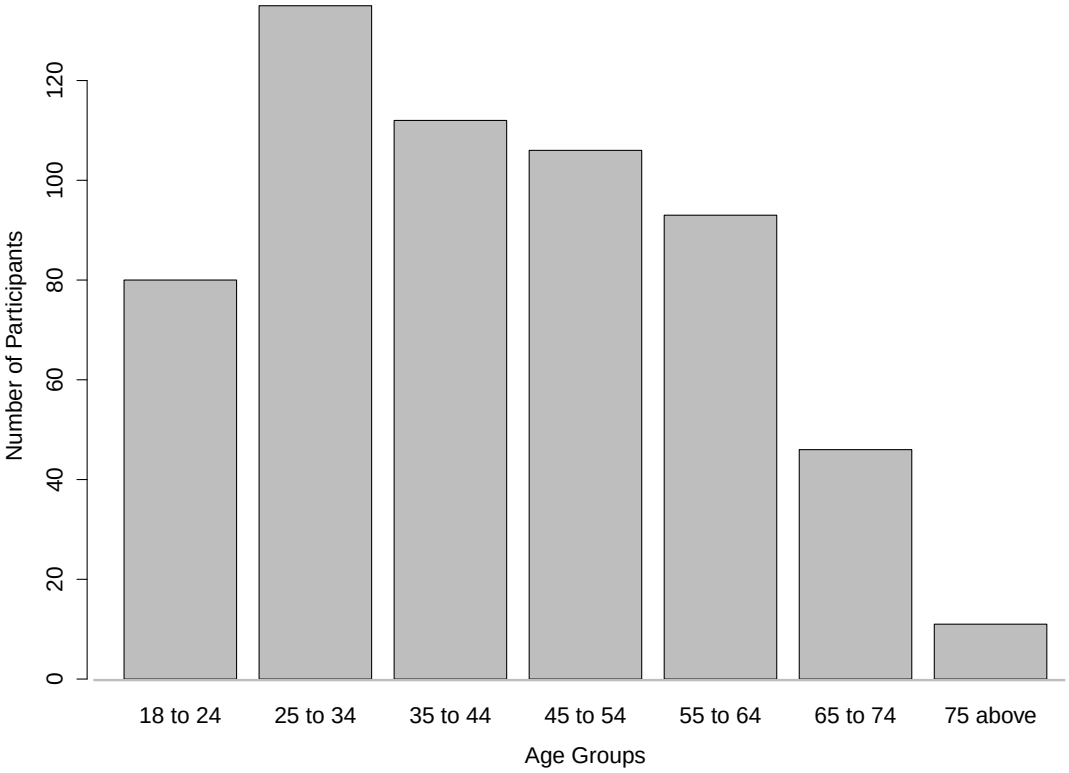

Figure 1. Age distribution of participants.

washroom service number; (c) send a text message to the washroom service number; and (d) prefer not to request washroom service. 3) Have you noticed there is a LCD touchscreen installed near the entrance of the washroom? (YES/NO) 4) Have you noticed when is the most recent washroom service time? (YES/NO) 5) What is your age? (18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 or older) 6) What is your gender? (Male/Female) The researcher also recorded the time and date of participation. The participation times were later compared to the recorded washroom service logged on the computer server to determine the lag between the most recent service and participation time. The questionnaire was either administered in paper format or from a HP Stream 7 tablet using Survey Monkey (http://www.surveymonkey.com). The WANDA touchscreen device was installed at the wall near the Men's washroom door, opposite to the Women's washroom door. The touchscreen was fully visible for the experimental condition, and was covered for the control condition. The control condition was tested during the first week, alternated with the experimental condition. During testing, the researcher approached participants near the end of an L-shaped

corridor after they just exited the washroom, and administered the questionnaire after they gave informed consent to participate.

Data analysis

A linear mixed effects (LME) model (Baayen, Davidson, & Bates, 2008; Bates, 2005) was used to analyze our data. LME is an extension of linear regression models, with the addition of modelling random factors. We adopted LME analysis because compared to ANOVA, LME handles unbalanced designs, and protects against type II error due to increased power (Baayen et al., 2008; Baayen & Milin, 2010). LME analyses were conducted in R (Bates, 2005), using the LME4 (Bates & Sarkar, 2007), LanguageR (Baayen, 2007) and LMERConvenienceFunctions (Tremblay, 2013) libraries. The "lmer" function was used to fit the LME model. The "pamer.fnc" function was used to calculate the p values of model parameters.

Nine fixed factors were used as predictors: Screen Awareness (Screen Noticed vs. Screen Unnoticed), Recent Service Awareness ('Service Aware' vs. 'Service Unaware'), Age ('18 to 24', '25 to 34', '35 to 44', '45 to 54', '55 to 64', '65 to 74', '75 or older'), Gender ('Male' vs. 'Female') were treated as categorical factors, where we use 'Screen Unnoticed', 'Service Unaware', '18 to 24', 'Female', as the default level for those factors respectively for the purpose of reporting the results. Each of the method of requesting washroom service ('Touchscreen', 'Phone Call', 'Text Message', 'No Request') were treated as separate factors, with two levels (TRUE vs. FALSE). Service Lag, the time difference between the most recent washroom service and questionnaire completion in minutes, was used as a continuous factor. The date of data collection, coded as a categorical vector was used as a random factor affecting the intercept. LME estimated random effects first, followed by fixed effects. In the results tables, the "Estimate" column reported the corresponding regression coefficients, along with their standard errors.

The best fits of LME models were obtained by conducting a series of iterative tests comparing progressively simpler models with more complex models using the Akaike Information Criterion (AIC). This approach was adopted to remove interactions and variables that do not explain significant amount of variance (Baayen et al., 2008). We used LMERConvenienceFunctions (Tremblay, 2013) library to conduct fitting of fixed effects systematically. In this approach, for each condition we started with a model that included all factor combinations and two-way interactions.

	Screen Noticed	Screen Unnoticed	Service Aware	Service Unaware	Totals
Experimental	157	319	118	358	476
Control	12	95	11	96	107
Totals	169	414	129	454	583

Table 1
Number of participants in each group, grouped by whether the participants noticed the touchscreen (Screen Noticed vs. Screen Unnoticed) and whether the participants were aware of the most recent washroom service time (Service Aware vs. Service Unaware)

Starting with the complete model, the highest-order terms were considered first, progressing to the lowest-order terms. At each stage, considering a given order of interaction, the term with the lowest p value was identified and a model without this term was compared with the original model using AIC. The term was kept if it improves AIC based on a threshold of 2 or if the term was also contained within a higher-order interaction. When all terms were tested for the highest-order interaction, the comparison process continued to the term with lowest p value in the next highest-order interaction, and so on. The process iterated until all interaction terms were tested, ending with main effects (Tremblay, 2013).

Results

The number of participants and whether they have noticed the touchscreen and washroom service time is summarized in table 1. Note that when the touchscreen was covered, some participants still report noticed the most recent service; this is likely because they noticed the caretakers actually cleaning inside the washroom. In addition, when the touchscreen was covered, not only the most recent washroom service time was not visible to the participants, but it also prevent caretakers from using the touchscreen to report the most recent washroom service time consistently. For those reasons, we analyzed the experimental group first with Service Lag included as a factor, followed by analyzing the full dataset without Service Lag included as a factor.

The LME model was first fitted to the experimental condition. The best fitting LME is summarized in Table 2a. We found main effects of Recent Service Awareness, Gender and Service Lag. Participants who were aware of the most recent service time gave higher cleanliness ratings than participants who were unaware of the most recent service time. Female participants gave higher cleanliness ratings than male. The cleanliness ratings were also lower with increased Service

a)

		Estimate (SE)
Main effects - Experimental group		
	Intercept	4.61 (0.077)*
	Recent Service Awareness	0.319 (0.079)*
	Gender	-0.28 (0.069)*
	Service Lag	-0.0020 (0.0009)*
b)		
Main effects - Both groups		
	Intercept	4.54 (0.057)*
	Recent Service Awareness	0.29 (0.073)*
	Gender	-0.23 (0.061)*

Table 2

The best-fitting LME model for the experimental group (panel a) and for both groups, with the Service Lag factor removed from the model (panel b). The "Estimate" column reports the corresponding regression coefficient, along with its SE (standard error). Significant effects are denoted * - $p < 0.05$.

Lag (see Figure 2). The Screen Awareness, Age and Method of Requesting Service factors did not show any significant effects. We further tested whether the correlation between cleanliness rating and service lag were driven by the Service Unaware group. LME analysis found that lower service lag predict higher cleanliness rating in the Service Unaware group (Table 3a), but both Gender and Service Lag were not significant predictors of the cleanliness rating (Table 3b). The null finding of the gender effect for the Service Aware group could be because of a ceiling effect, where all participants noticed the most recent washroom service time rated the cleanliness to be close to the highest end of the scale. We could not draw any conclusion on the Service Lag effect based on the Service Aware data due to limited number of data points. Those results suggested the physical cleanliness of the washroom had a significant influence on the washroom cleanliness.

To confirm the generality of the main effects, we re-fitted the full dataset to LME model, without adding Service Lag as a factor. We replicated the same main effect of Recent Service Awareness and Gender, with a null result for Screen Awareness and Age and each of the Method of Requesting Service factors (see Table 2b). To help visualize the data, the effect of Service Awareness and Screen Awareness collapsing across experimental conditions were plotted in Figure 3.

A limitation of the above analysis was that we were comparing participants' self-report of not noticing either the touchscreen or the most recent service time. It is possible that participants

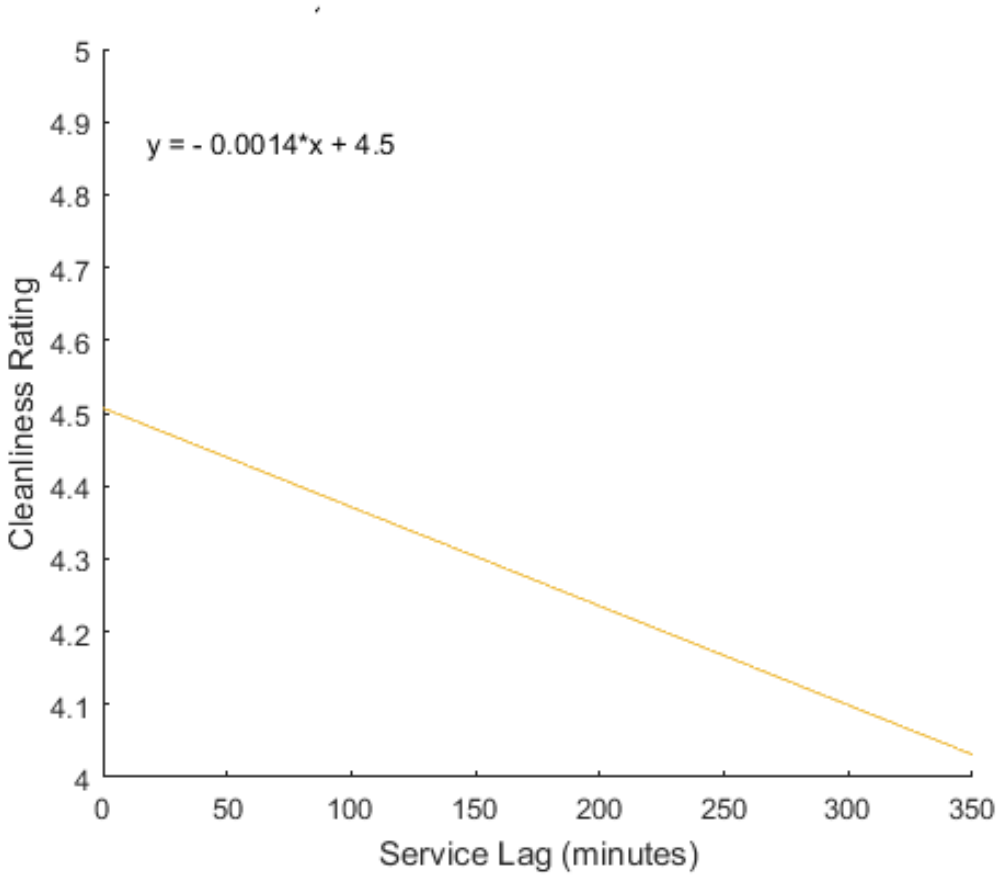

Figure 2. Cleanliness rating as a function of the Recent Service Lag, the solid line is the best linear fit of the data .

a)

		Estimate (SE)
Main effects - Service Unaware		
	Intercept	4.68 (0.097)*
	Gender	-0.34 (0.086)*
	Service Lag	-0.0026 (0.0011)*
b)		
Main effects - Service Aware		
	Intercept	4.76 (0.075)*
	Gender	-0.99 (0.084)
	Service Lag	-0.0.0005 (0.0013)

Table 3

*The best-fitting LME model for the experimental group Service Unaware (panel a) and for the experimental group Service Aware (panel b). The "Estimate" column reports the corresponding regression coefficient, along with its SE (standard error). Significant effects are denoted * - $p < 0.05$.*

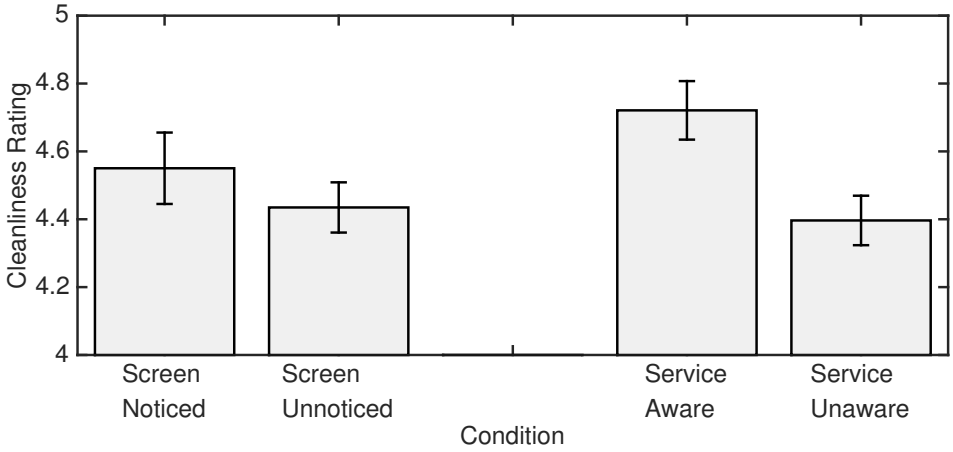

Figure 3. Mean cleanliness rating for Screen Awareness and Recent Service Awareness. The error bars were 95% confidence intervals.

may have noticed the the most recent service time subconsciously. It is also possible that some participants noticed the most recent washroom service from witnessing caretakers cleaning, not from the displayed information from the touchscreen. To address those issues, we looked at two groups: a) participants who noticed both the touchscreen and most recent washroom service time, and b) participants who did not notice the most recent service time in the control group. Those two groups were derived to minimize the chance that participants could have noticed the most recent washroom service time from other sources, such as unconscious awareness of the displayed service time, or witnessing the caretaker cleaning. A two-tailed Welch's t-test found the first group had a higher cleanliness rating than the second group, $t = 2.01, df = 144.21, p < 0.05$ (see Figure 4), further supporting the perception of washroom cleanliness could be influenced by the touchscreen display of the most recent washroom service time.

Although we have failed to find any significant effects of the preferred service requesting methods on the cleanliness ratings, the preference pattern clearly favoured the 'Touchscreen' method. Twelve participants who selected multiple responses were removed from the analysis to meet the assumption of independence of the z-test. The proportion of preferred methods of requesting service were shown in Figure 5. We first conducted a one-sample z-test between 'Touchscreen' and 'No Request', where 'Touchscreen' and 'No Request' had the highest number of responses among the four methods, and found that the proportion prefer 'Touchscreen' was significantly higher than 50% ($z = -11.9, p < 0.05$). Thus, we can conclude that the most preferred method was to use

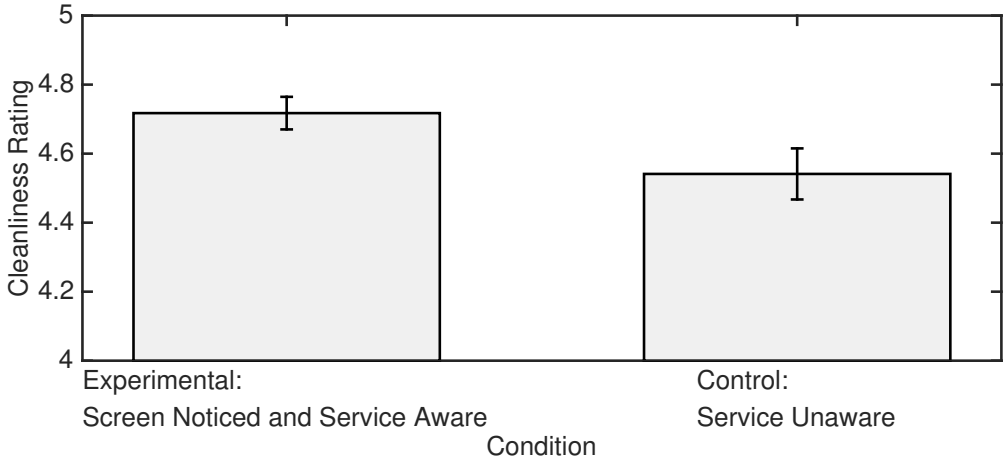

Figure 4. Mean cleanliness rating for participants in the experimental group that noticed both the touchscreen and service time, and for participants in the control group that did not notice the most recent washroom service time . The error bars were standard errors.

the touchscreen. Following the same logic, we found 'Phone' had a significantly lower proportion than 'Text Message' ($z = -6.47, p < 0.05$), and 'No Request' had a significantly higher proportion than 'Text Message' ($z = 9.74, p < 0.05$). The differences in proportion among four methods was significant.

Discussion

Our results showed the perceived cleanliness of public washrooms could be directly enhanced by visual updates of the most recent washroom service time alone, supporting our hypothesis

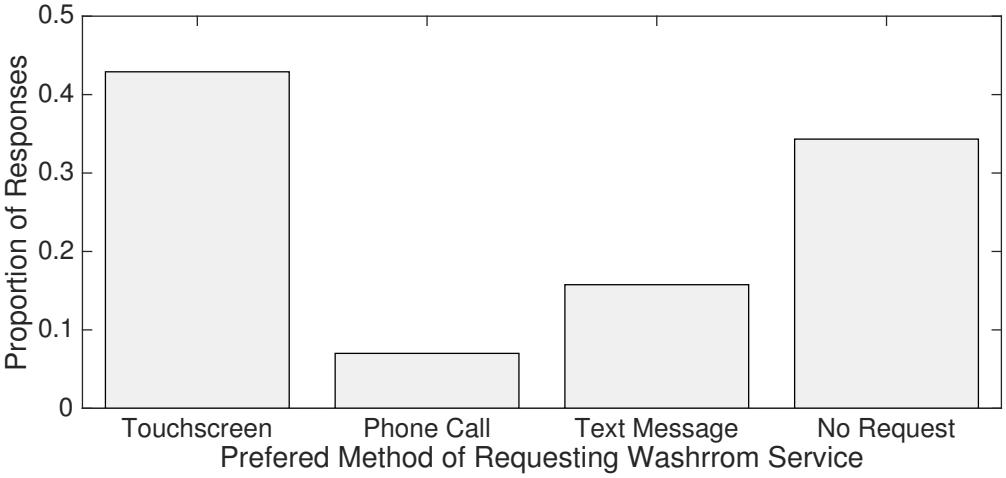

Figure 5. Proportion of each method of requesting washroom service.

that the cognitive component and physical cleanliness are equally important on influencing the subjective experiences of cleanliness, in line with research suggesting visually displayed information can influence preferences (Drichoutis et al., 2006). The results suggest that there is great potential to enhance the positive atmosphere of facilities such as hotels, restaurants, hospitals, public transit and tourist attractions, where washrooms were considered a key indicator of the overall cleanliness.

More importantly, the results could suggest practical applications that may help to further enhance the perceived cleanliness of public washrooms. First, our results suggests two thirds of participants in the experimental group did not notice the touchscreen, 33.0% of participants at the experimental group noticed the touchscreen, and within this 33.0%, 75% of participants noticed the most recent washroom service time. Thus, in order to enhance the effect of enhanced perception of cleanliness, service providers need to focus on increasing the visibility of the information displayed. This could be achieved by playing animated text, increasing font size, and carefully choose the installation location. However, further research is needed to evaluate the boundary conditions of this approach. The results also suggest the awareness of the most recent washroom service time could the key for enhanced perception of cleanliness, and the modality of information presentation may not be limited to visual, but could also to auditory. The awareness of the most recent washroom service time may have induced a inference-based process that changes the perception of cleanliness (e.g., a recently cleaned washroom is more likely to be clean). In addition, more than 40% of the participants prefer to use a touchscreen device to request washroom service than prefer to use a telephone call, to send a text message, or not to request service at all. This may reflect the public's preference of using an anonymous device to request service, rather than relying on their personal cell phone. However, the interpretation of the result is limited by the location of the study, where traveling participants could be roaming on their cellphone and may not have access to free text messages or free telephone, and this in turn promote the preference to use a touchscreen to request washroom service.

Future directions

Future research should focus on the generalizability of the current results. The public washrooms at the airport is generally cleaned very frequently, and the obtained cleanliness ratings are towards the higher end of the scale; thus, the current results may not generalize to washrooms

that were not serviced frequently and rated in the lower end of the cleanliness scale. Information about timing may have a general effect on promoting positive mood. This may not be limited to the public space and maybe applicable in personal space. For example, knowing when was the last time of laundry, when was the last time cleaning the dishes may have a specific effect on mood.

In sum, the perception of public washroom cleanliness could be enhanced when participants are aware of the most recent washroom service time, and this enhancement could be achieved by interactive information update.

References

Aksoydan, E. (2007). Hygiene factors influencing customers' choice of dining-out units: findings from a study of university academic. *Journal of Food Safety*, *27*(3), 300-316.

Baayen, R. H. (2007). *LanguageR (R package on cran version 1.1).* `http://cran.r-project.org/web/packages/languageR/index.html`.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390-412.

Baayen, R. H., & Milin, P. (2010). Analyzing reaction times. *International Journal of Psychological Research*, *3*(2), 12-28.

Barber, N., Goodman, R. J., & Goh, B. K. (2011). Restaurant consumers repeat patronage: a service quality concern. *International Journal of Hospitality Management*, *30*, 329-336.

Barber, N., & Scarcelli, J. M. (2009). Clean restrooms: how important are they to restaurant consumers? *Journal of Foodservice*, *20*(6), 309-320.

Bates, D. M. (2005). Fitting linear mixed models in R. *R News*, *5*, 27-30.

Bates, D. M., & Sarkar, D. (2007). lme4: Linear mixed-effects models using s4 classes (version 0.999375-39) [Computer software and manual]. `http://cran.r-project.org/web/packages/lme4/`.

Choi, J., Almanza, B., Neal, J., & Sirsat, S. (2014). A strategic cleaning assessment program: menu cleanliness at restaurants. *Journal of Environmental Health*, *76*(10), 18-24.

Clayton, M. C., & Blaskewicz, J. (2012). The use of visual prompts to increase the cleanliness of restrooms on a college campus. *Journal of Organizational Behavior Management*, *32*(4), 329-337.

Drichoutis, A., Lazaridis, P., & Nayga, R. M., Jr. (2006). Consumers' use of nutritional labels: a review of research studies and issues. *Academy of Marketing Science Review*, *10*(9).

Henson, S., Majowicz, S., Masakure, O., Sockett, P., Jones, A., Hart, R., ... Knowles, L. (2006). Consumer assessment of the safety of restaurants: The role of inspection notices and other information cues. *Journal of Food Safety*, *26*(4), 275-301.

(2015, October). Retrieved October 8th 2015, from `http://visionstate.com/wanda`

Lockyer, T. (2003). Hotel cleanliness—how do guests view it? let us get specific. a new zealand study. *International Journal of Hospitality Management*, *22*(3), 297-305.

Prayukvong, W., Sophon, J., Hongpukdee, S., & Charupas, T. (2007). Customers' satisfaction with hotel guestrooms: a case study in ubon rachathani province, thailand. *Asia Pacific Journal of Tourism Research*, *12*(2), 119-126.

Stringam, B. B., Gerdes, J., & Vanleeuwen, D. M. (2010). Assessing the importance and relationships of ratings on user-generated traveler reviews. *Journal of Quality Assurance in Hospitality & Tourism*.

Tremblay, A. (2013). LMERConvenienceFunctions: a suite of functions to back-fit fixed effects and forward-fit random effects, as well as other miscellaneous functions (version 2.5) [Computer software and manual]. `http://cran.r-project.org/web/packages/LMERConvenienceFunctions/index.html`.

Whitehead, H., May, D., & Agahi, H. (2007). An exploratory study into the factors that influence patients' perceptions of cleanliness in an acute nhs trust hospital. *Journal of Facilities Management*, *5*(4), 275-289.