

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

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Abstract: Washroom cleanliness is a key influence on our positive attitude towards public spaces. Recently, interactive technology has been introduced. While the role of physical cleanliness is obvious, interactive technology may affect perception of cleanliness. This study investigates whether the most recent washroom service time displayed on a touchscreen influences the perception of washroom cleanliness. Participants leaving a washroom were asked to rate the cleanliness of the washroom. The touchscreen that showed the service time was visible for the experimental group and covered for the control group. Results showed that participants who noticed the most recent washroom service time in the experimental group perceived the washroom as cleaner than the control group. In addition, the touchscreen was preferred as an interface for washroom service request, compared with telephone calls and text messaging. The results suggest interactive technology has potential to enhance attitudes towards public space.

Keywords: bathroom cleanliness; touch screen; public perception; bathroom management; hospitality

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 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

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this line of thought, it is hypothesized that visual presentation of the most recent washroom service time could influence perception of cleanliness. It suggests that 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, the study use WANDA (<http://visionstate.com/wanda>), a 15.6 inch 16:10 aspect ratio 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. The study asks participants to rate the cleanliness of the washroom, while the touchscreen is either visible or hidden from participants' sight. In addition, we also ask participants' preferred methods of requesting service to evaluate whether it is related to perception of washroom cleanliness

2. Methods

2.1 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

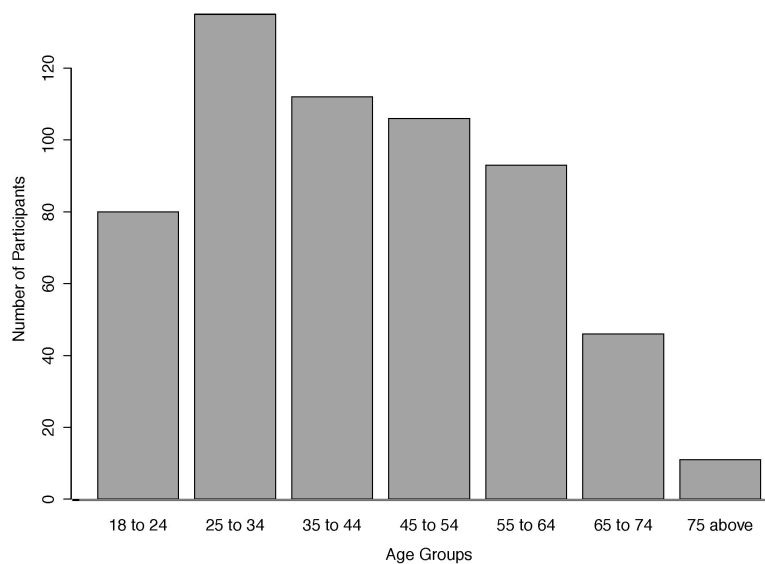


Figure 1. Age distribution of participants.

2.2 Materials and procedure

The questionnaire was 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 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.

2.3 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. LME analysis was used 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 'Screen Unnoticed', 'Service Unaware', '18 to 24', 'Female', were used 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, Davidson, & Bates, 2008). LMERConvenienceFunctions (Tremblay, 2013) library were used to conduct fitting of fixed effects systematically. In this approach, each condition started with a model that included all factor combinations and higher-order interactions.

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).

3. 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 they have 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 prevents caretakers from using the touchscreen to report the most recent washroom service time consistently. For those reasons, experimental group were analyzed first with Service Lag included as a factor, followed by analysis of the full dataset without Service Lag included as a factor.

| | 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)

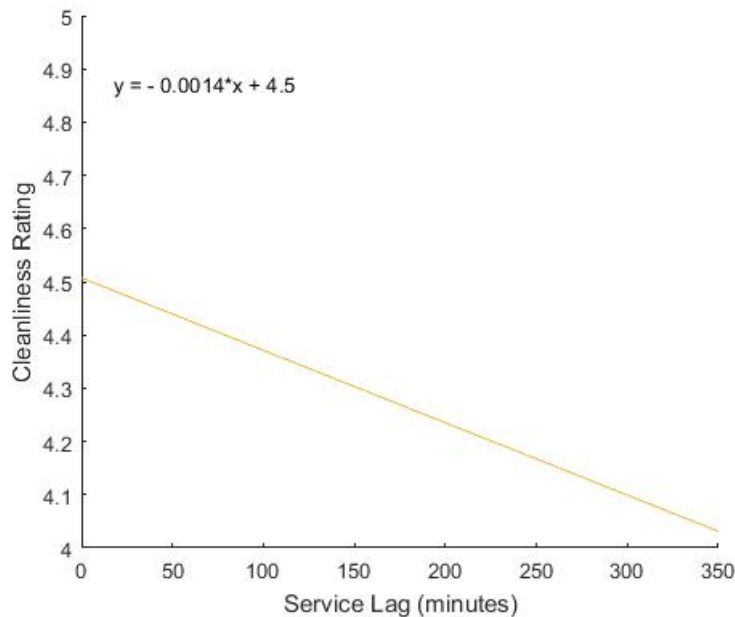


Figure 2. Cleanliness rating as a function of the Recent Service Lag, the solid line is the best linear fit of the data.

The LME model was first fitted to the experimental condition. The best fitting LME is summarized in Table 2a. The results showed 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 Lag (see Figure 2). The Screen Awareness, Age and Method of Requesting Service factors did not show any significant effects. The author 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 predicts 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. The Service Lag effect based on the Service Aware data was inconclusive due to limited number of data points. Those results suggested the physical cleanliness of the washroom had a significant influence on the washroom cleanliness.

| a) | | |
|-----------------------------------|--------------------------|--------------------|
| Main effects - Experimental group | | Estimate (SE) |
| | 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 * - $p < 0.05$.

| a) | | |
|--------------------------------|-------------|----------------------|
| Main effects - Service Unaware | | Estimate (SE) |
| | 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 * - $p < 0.05$.

To confirm the generality of the main effects, the full dataset was re-fitted to LME model, without adding Service Lag as a factor. Main effect of Recent Service Awareness and Gender were replicated, 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.

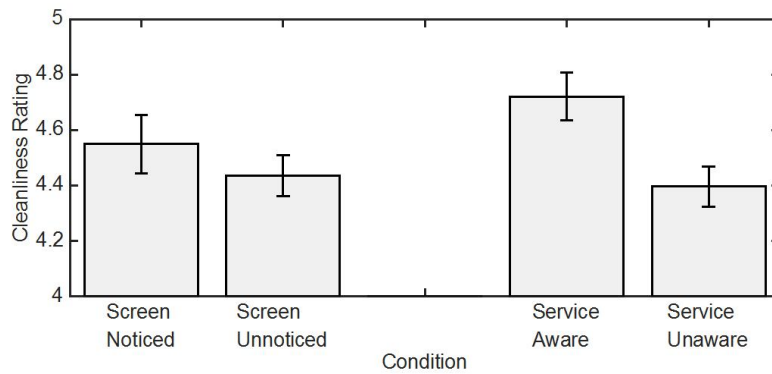


Figure 3. Mean cleanliness rating for Screen Awareness and Recent Service Awareness. The error bars were 95% confidence intervals.

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 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, two groups were further analyzed: 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

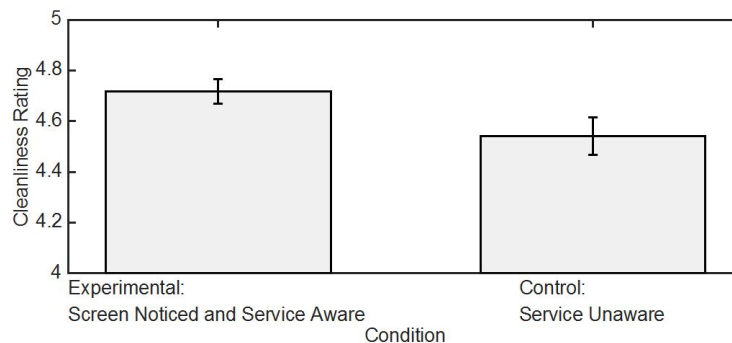


Figure 4. Mean cleanliness rating for participants in the experimental group that noticed both the touchscreen and service time, and for participants in the control group that did not notice the most recent washroom service time . The error bars were standard errors

Although the results 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, the results suggested that the most preferred method was to use the touchscreen. Following the same logic, '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.

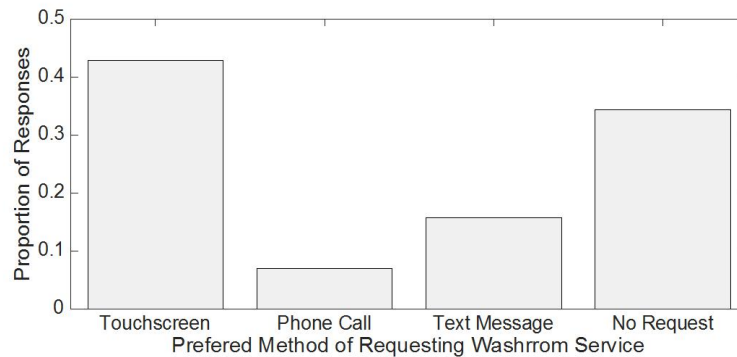


Figure 5. Proportion of each method of requesting washroom service

4. 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 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, Lazaridis, & Nayga, 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 suggest 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 be the key for enhanced perception of cleanliness, and the modality of information presentation may not be limited to visual, but could also be auditory. The awareness of the most recent washroom service time may have induced an 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 promotes the preference to use a touchscreen to request washroom service.

5. Future directions

Future research should focus on the generalizability of the current results. The public washrooms at the airport are 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.

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