UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Sort It Out: Providing Immediate Game Feedback on Waste-Sorting Accuracy and its Effect on Sorting Behaviour

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Executive Summary

The current study investigates how sorting behaviour is influenced when residents play an interactive online game with feedback compared to no feedback. *n* = 17 Acadia Residents were recruited to play the Waste Sorting Game; among 8 were assigned to receive feedback, while the other 9 did not receive feedback. The study was conducted over a 5-day baseline phase followed by the introduction of the Waste Sorting Game, after which a 24-day post-intervention measure was performed. We predicted that providing immediate feedback would significantly help decrease the contamination rate in compost bins than without feedback. The results revealed that with immediate feedback, contamination rate is significantly lower than without feedback.

Introduction

One of the greatest challenges faced by campus compost initiatives is the contamination of the green compost bins. Items such as styrofoam, plastic bags and plastic cutlery cause downstream problems at the composting facility (Paradelo, 2009). Previous research show that teaching the basics of waste sorting for both adults and kids can be beneficial for the environment and the economy (Lotfi, Amine & Mohammed, 2014). Education and interactive waste sorting games are currently being designed, with the objective of making users become more aware of the issue, i.e. how to avoid misplacing plastics into green bins (Stolte, 2016). Many studies have shown that it is possible to promote deeper learning with the presence of features such as feedback (Moreno & Valdez, 2005). Feedback refers to receiving information after a given performance. Feedback in educational games appear to reduce redundant cognitive processes, while supplying learners with schemas to help them correct their comprehension errors (Clark & Mayer, 2008). With the importance of waste sorting games and the benefits of game feedback, we aim to investigate how providing immediate feedback - informing whether an item was sorted correctly or not, and which bin it should actually go towards, influence the waste sorting behaviour of residents of Acadia Residence.

Research Question

How is sorting behaviour influenced when participants play an interactive online game with feedback compared to no feedback?

Hypothesis

Providing Waste Sorting Game with feedback to residents would significantly help decrease the contamination rate in compost bins than without feedback.

Methods

Participants
Seventeen University of British Columbia students living in Acadia Residence (7 male, 10 female), from age 23 to 46 years old (M = 32, SD = 7.18), were assigned to the feedback group (n = 8) and the no-feedback group (n = 9) to play the Waste Sorting Game. There are 96 units in our study separated into two designated areas: the feedback area (47 units) and the no-feedback area(49 units) (Appendix C).

Conditions
There are two conditions within the independent variable: the feedback condition (experimental) and the no-feedback (control) condition. Once the participant sorts out a waste item, the feedback condition in the waste sorting game immediately informs the participant whether their answer is correct or incorrect. If the item is sorted incorrectly, the feedback condition provides corrective feedback, indicating what the correct answer would be. In the end, the participant receives a final score out of 100%. On the contrary, the no-feedback condition gives no indication of correct or incorrect sorting, however it does proceed to show a final percentage score at the end of the game.

Measures
We measured the effect of giving feedback to participants through measuring the waste contamination rate in the assigned compost bins within the two conditions (Appendix C).

To calculate the rate of contamination accurately, we primed ourselves by being familiar with the contaminants in the waste sorting game. We then counted the number of contaminants on the surface layer of each compost bin divided by the percentage volume of compost in the bin. There were four bins in each assigned area, so we calculated the mean of the four bins to get a fair distribution at each point.

Procedure
We visited Acadia Residence according to the designated control area and the experimental condition area. We had 1-2 experimenters to conduct a visual inspection of the compost bins to increase inter-rater reliability for a pre-measure (baseline phase) from February 28 to March 5, and 8 post-measures (intervention phase) on March 12, 14, 15, 16, 21, 23, and 27 (Appendix D). We ensured to conduct the inspection with the weekly garbage pick-up in mind, scheduled every Thursday from 8:00AM to 2:00PM, by collecting the data several days prior or after Thursday. On the day we measured on Thursday, we did our measures before 8AM.

After our pre-measure, participants were recruited by an email notification by Acadia's Residence Life Manager. We included a poster (Appendix B) marketing an incentive of a $25 Starbucks gift card to encourage participation. Due to the low participation rate, we physically went to the 2 designated Acadia residences to recruit participants by common areas to play the Waste Sorting Game (Appendix A). The game requires participants to select which bin a waste item should be correctly sorted in, from recyclables, paper, compost, and garbage. In total there are 28 items.

At the end of the game, the participants' information was gathered, such as gender, age, ethnicity, and which Acadia building they live in.

Results

The descriptive statistics of the contamination rate of feedback and no-feedback condition are summarized in Table 1 and Table 2. To compare the mean scores of the two conditions, we have conducted an independent t-test (Table 3). Specifically, we sought to determine whether there is a statistical significant differences in the mean score for the two groups (i.e. whether residents who received immediate feedback have significantly lower contamination rates than those who did not).

The p-value of .015 shows that there is a significant difference in the mean scores of contamination rate between the feedback and non-feedback condition. The results support the hypothesis.

Discussion

In the current study, we tested how immediate feedback would influence waste sorting behaviour of residents of Acadia by manipulating the feedback of an online Waste Sorting Game, and subsequently measuring the contamination rate of compost bins over 4 weeks. Our results support our hypothesis; providing Waste Sorting Game with feedback to residents would significantly help decrease the contamination rate in compost bins than without feedback.

In light of Moreno & Valdez's (2005) study showing the possibility to promote deeper learning with feedback, we propose that immediate feedback from the Waste Sorting Game promotes deeper learning through operant conditioning. In theory of B.F. Skinner, operant condition refers to the learning process through which the strength of a behaviour is modified by positive or negative reinforcement. When participants selected the incorrect answer, a crossmark - a type of punishment is prompted; when participants selected the correct answer, a checkmark - a type of reinforcement is prompted. The immediate feedback, which is presented in a form of punishment or reinforcement promotes intentional and purposeful processing of the information, hence influence waste sorting behaviour.

This study was primarily limited by its small sample size. A larger sample size can better remove random error due to individual differences among participants, hence obtain a larger effect size. This has been greatly limited by Acadia's management in distributing our email campaigns. In addition, the two designated areas (for experimental and control condition respectively) were too close in distance. There is no way of knowing if there is cross-contamination between groups or from Acadia residents outside the study. The recruitment of participants also became more difficult, largely because the residents who live in other areas would spend time around these designated common areas. We can tackle this problem by allocating two areas that are further apart or separating them by physical barriers such as gates.

Moreover, recruiting the participants was challenging due to rainy conditions. It must also be noted, however, that the current study did not focus on the underlying attitudes or cultural norms of the resident populations as well as the residents' baseline composting knowledge. Lastly, the waste sorting game was simplistically designed for lab-based studies and did not have an user-friendly interface. Due to the field recruitment at the residences, we were limited to running the games on smartphones. A few participants were confused at the sorting function of the game, unsure of whether to tap or drag the items.

Recommendations for your client

For future studies, we recommend extending the research period to gather more data for both pre and post measures. Increased data collection would yield more robust results and gain greater insights on trends. Due to the limited number of game players, it's hard to justify that composting data reflects the behaviour of the entire Arcadia residences within our study.

There are varying types of feedback ranging in explanatory, length, specificity, timing, and complexity (Shute, 2008). Our current study uses corrective feedback, but studies prove that elaborative feedback may be a more effective technique in why a particular question item is answered correctly or not. For instance, when the player sorts the item incorrectly, the game can provide the player a reasoning behind the correct response. In a game study using corrective feedback like ours, Moreno and Mayer (2004) showed that the use of explanatory feedback improved learners' performance more than corrective feedback did. Thus, implementing explanatory feedback in future sorting games may yield enhanced learning.

A positive relationship was discovered between the level of intrinsic motivation and learning scores in a digital learning game (Liu, Horton, Olmanson, & Toprac, 2011). Intrinsic motivation refers to the behaviour driven by internal rewards out interest, amusement, or a good challenge. Charles, Bustard and Black (2008) identified forty engaging motivating aspects of game design that increases engagement in games, summarizing them into six core dimensions: structure, challenge, feedback, and fun. To increase motivation in future sorting game players, it should consider such factors to increase user engagement. For instance, UBC's Waste Sorting Game conducted by the SEEDS Sustainability Program and Department of Psychology could be put to the test. It includes many of the desired features such as improved graphics, levels, bonus points, and engaging fun facts (Appendix E).

In conclusion, the current evidence has important implications for campus waste management, environmental policy makers and interactive game designers to work towards making recycling and composting education more effective, with the ultimate goal of reducing waste destined for landfills and the costs associated with it.

References

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Appendices

Table 1: Descriptive Statistics - Mean Contamination Rate Across Conditions

Mean Contamination Rate (# of contaminants / total percentage volume of compost)		
Condition	Period	Compost Bin
Feedback	Intervention	1.07
	Baseline	1.59
Non-feedback	Intervention	5.03
	Baseline	1.20

Table 2: Descriptive Statistics Output

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
Contamination	Feedback	8	.6264	.65099	.23016
	Non-Feedback	9	3.9867	3.28029	1.09343

Table 3: Independent T-test Output

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Contamination	Equal variances assumed	12.783	.003	-2.838	15	.012	-3.36029	1.18393	-5.88378	-.83680
	Equal variances not assumed			-3.007	8.705	.015	-3.36029	1.11739	-5.90112	-.81947

Figure 1: Mean Contamination Rate of Feedback and Non-feedback Condition. Mean contamination rate is calculated as number of contaminants divided by percentage volume of compost. Standard error means do not overlap.

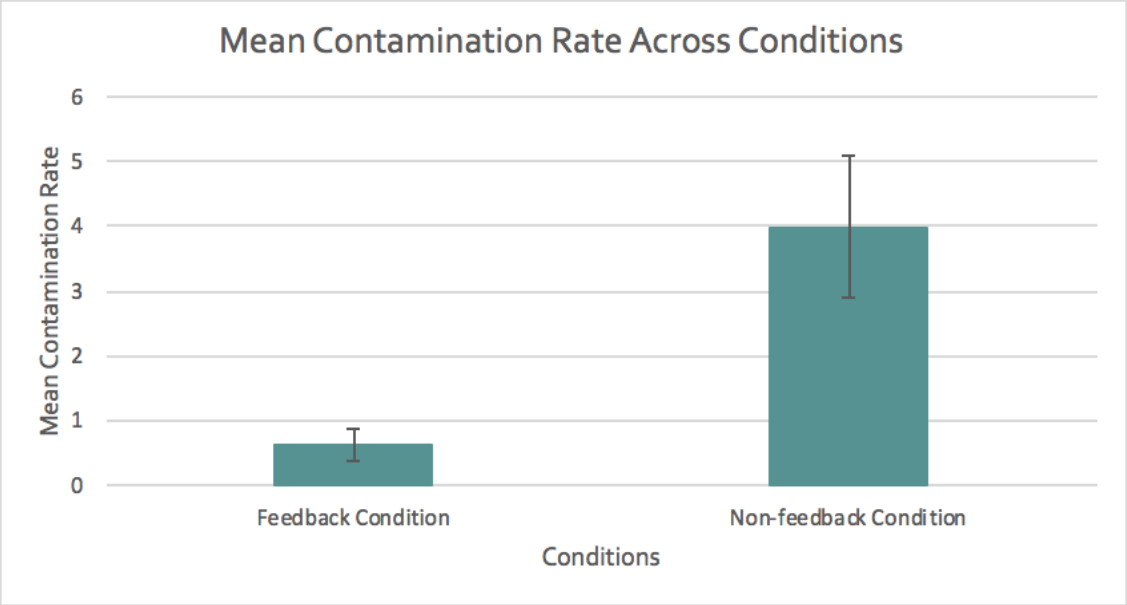


Figure 2A: Participation of Feedback Condition Over Time. Intervention is implemented on March 12.

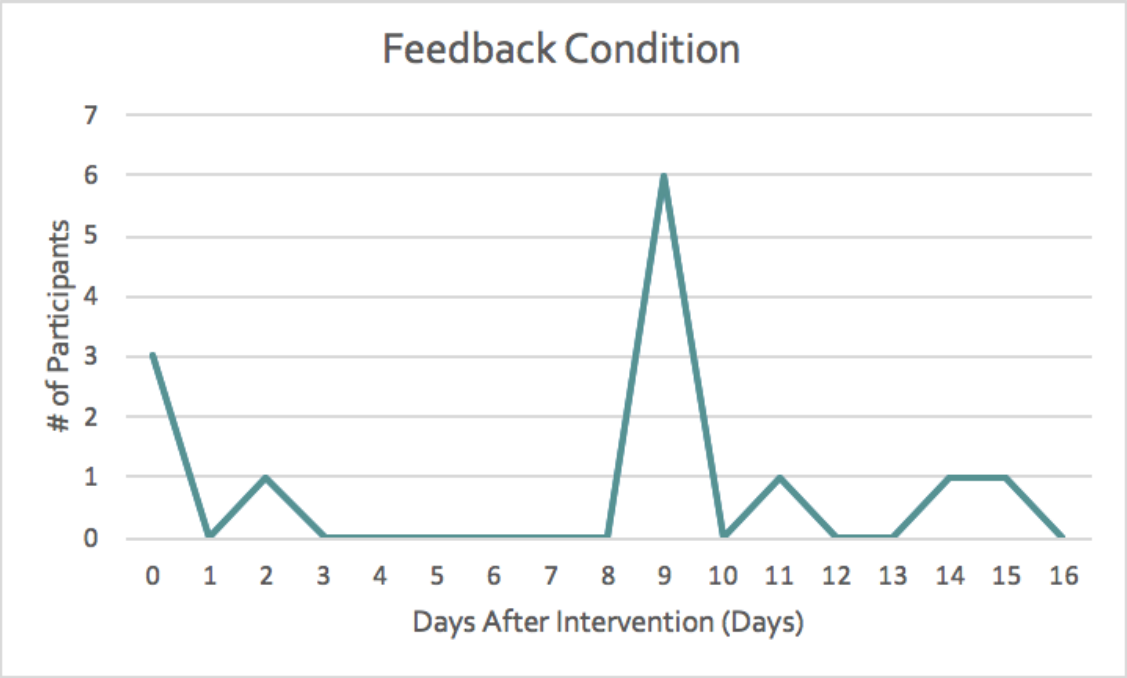
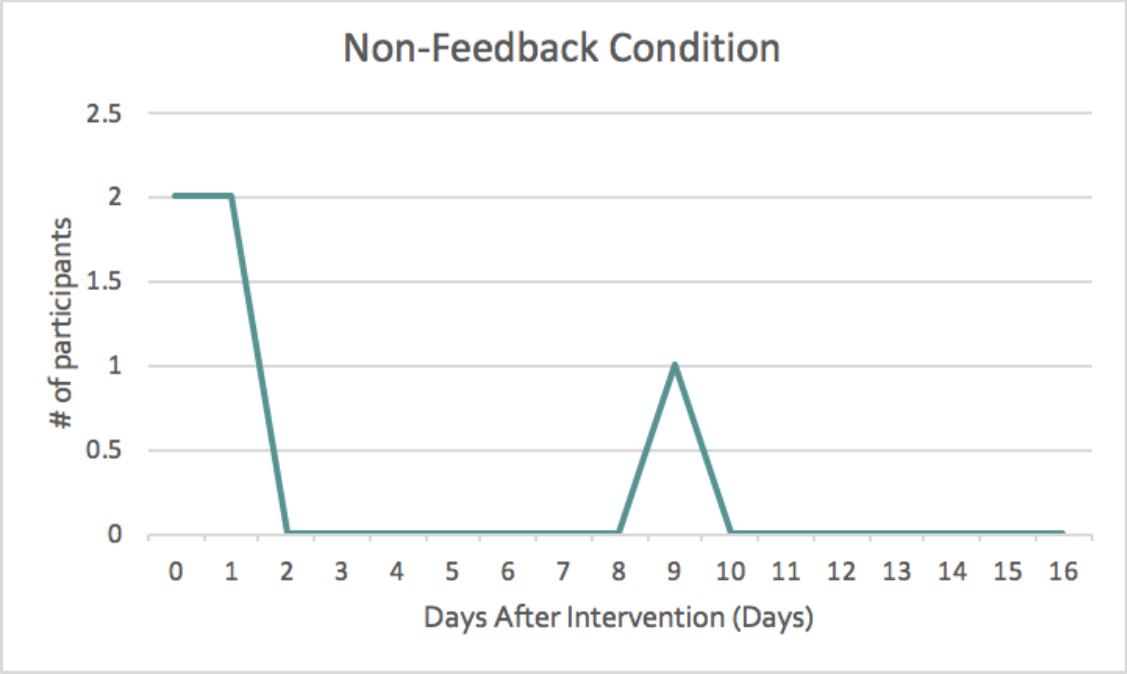
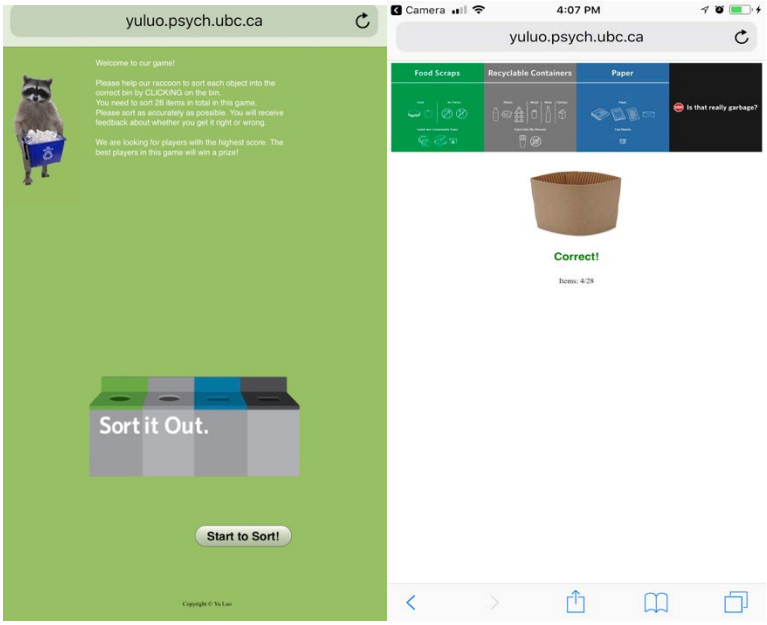


Figure 2B: Participation of Non-Feedback Condition Over Time. Intervention is implemented on March 12.



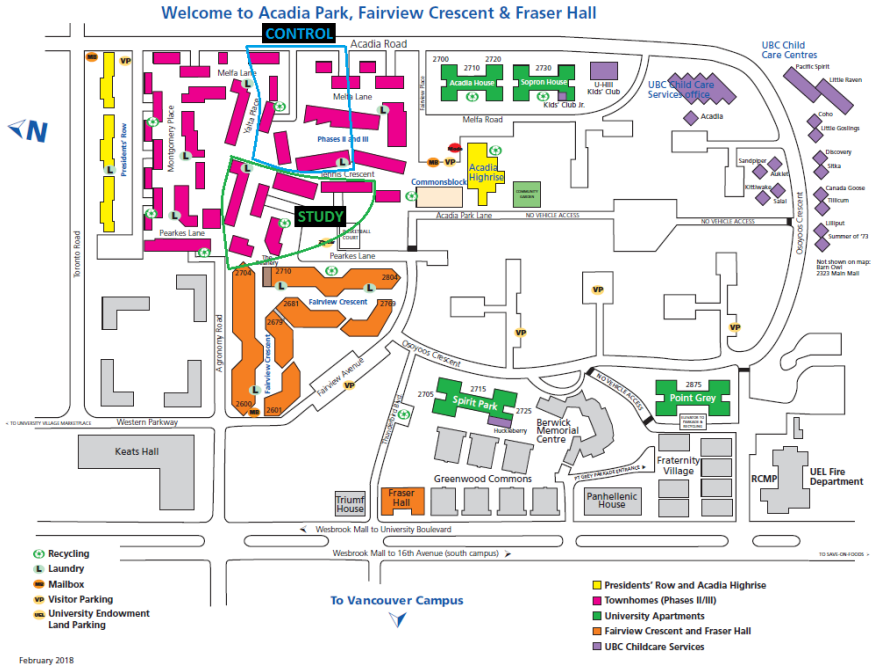
Appendix A: Waste Sorting Game (Screenshots)

http://yuluo.psych.ubc.ca/studies/Sorting_MD/task.php



Appendix B: Poster Design (Feedback and No-Feedback Posters)

Appendix C: Map of Acadia Residences



Appendix D:

Post-Measure: March 12, 14, 15, 16, 20 , 21, 23, 27

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				March 1	2	3
4	5	6	7	8	9	10
11	12	13	14	15 (Morning)	16	17
18	19	20	21	22	23	24
25	26	27	28	29	27	28

29	30	31				

Appendix E: UBC SEED's Sort It Out Game

http://www.ubcsortinggame.com