The Effect of Bin Order on Waste Sorting Behaviour

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EXECUTIVE SUMMARY

To test how the order of bins at waste disposal stations impacts sorting behaviour, 180 participants were observed disposing waste at a restaurant in three conditions of different bin orders, with 60 participants in each condition. The first condition had the bin order of: Compost, Garbage, and Recycle. The second condition had the bin order of: Garbage, Compost, and Recycle. The third condition had the bin order: Recycle, Compost, and Garbage. Waste sorting accuracy was measured as the percentage of the total number of items that each participant sorted into the correct bins, recorded independently by three observers. The means of the three conditions were 60.43% for condition 1, 66.50% for condition 2, and 59.76% for condition 3. Inter-rater reliability was high, with 81% of data collected in agreement. A one-way ANOVA was used to find any significant differences between the three means and independent samples t-tests were used to find any significant differences between any two conditions. All statistical tests found no significant differences, suggesting that the position of the garbage bin at waste disposal stations does not matter, and that future studies are needed to further explore the impact of bin order on waste sorting behaviour.

Keywords

waste disposal, waste sorting behaviour, recycling, garbage, compost, bin order, environmental psychology

Research Question and Hypothesis

The research question being asked in this study is: How does the order of bins impact sorting? This questions aims to determine if changing the bin order from left to right will affect the waste sorting behaviour of people when they throw their trash. The hypothesis is that sorting accuracy (the percentage of correct disposals per participant) will be highest when the bin order from left to right is: Recycle, Compost, then Garbage (Condition 1). We hypothesized that this bin order would produce the best results because it is the traditional way of organizing the bins. It was the original bin order in that location, and the most commonly used bin order around the university campus. We believed that people were accustomed to this bin order; therefore it would be easiest for them to sort out the trash in this condition.

METHOD

Participants

The participant population included students, faculty, visitors, and staff of the University of British Columbia who ate in Mercante Restaurant (an Italian Restaurant) at the Ponderosa Building (Appendix D). There were a total of 180 participants in the study (n = 180). It is assumed that Mercante restaurant provided a neutral environment (unlike the CIRS building) with no potential biases towards positive recycling behaviour because of the

fact that it is a restaurant open to everyone. It was also ideal because the garbage, recycling, and compost bins of the waste disposal station had no identifying characteristics, such as colour or shape of the bin, aside from the signs themselves (Appendix A).

Conditions

There were three conditions in this study. The first condition had the bin order of: Compost, Garbage, and Recycle. The second condition had the bin order of: Garbage, Compost, and Recycle. The third condition had the bin order: Recycle, Compost, and Garbage. The labels of each bin were changed (as seen in Appendix A) based on the condition being tested. The three conditions were observed on three consecutive days in a single location (Mercante Restaurant in the Ponderosa Building). The only factor that changed throughout the conditions was the label of the bins. Everything else, including the location of the waste station in the restaurant, the shape of the bins, and the colour of the bins remained constant. There were a total of 60 participants in each condition.

Measures

This is an experimental study, with the independent variable being the order of bins and the dependent variable being the sorting accuracy (percentage of correct disposals per participant) in each condition. For each participant, we calculated the number of correct throws he/she had divided by his/her total amount of throws (Appendix E). We therefore had 60 individual percentages for each condition (Appendix B). The experimenters compared their observations for inter-rater reliability. Since it was an observational study that had no potential risks to participants, no oral consent was needed from participants. A One-way ANOVA was used to determine if there are any significant differences between the three means (Appendix C). In addition to this, we tested if there were any significant differences between any of the two conditions using the Independent Samples t-test (Appendix C).

Procedure

The study was conducted during three separate days in the month of March, between the times of 12pm and 3pm. Waste sorting accuracy was measured as the percentage of the total number of items that each participant sorted into the correct bins.

In order to discern the optimal bin order, in each of the three separate days, the researchers rearranged the bin order. On the first day, from left to right, the bins were ordered recycle, followed by compost, then garbage. This was the default bin order, the usual order the bins in the restaurant, without us making any changes. On the second day, the bins were rearranged with garbage occupying the leftmost bin, followed by compost, and then recycle. On the last day, the compost bin occupied the leftmost spot, followed by garbage, and then recycle bin.

Following the last day of observation, the researchers then compared and contrasted each individual data collected, and subsequently tested for inter-rater reliability. The inter-rater reliability between the three data sets were high, with 81% of the data gathered agreeing with each other. The dissimilar data was then discarded, and filled with additional observations in order to achieve the desired total of 180 agreed-upon observations.

RESULTS

Based on our observations, we found that the second condition (garbage, compost, recycle) yielded the highest sorting accuracy of 66.50%. This was followed by the first condition (recycle, compost, garbage), which yielded a sorting accuracy of 60.43%, while the third condition (compost, garbage, recycle) generated the lowest sorting accuracy of 59.76% (Appendix F). Conducting a one-way ANOVA between the three conditions yielded an F statistic of 0.434, with a p-value of 0.655, as well as having two degrees of freedom. Furthermore, the one-way ANOVA led to the conclusion that the group means did not yield any statistically significant differences, because the p-value was greater than 0.05. As such, post hoc ANOVA tests are not required, since the results are not statistically significant.

From conducting independent samples t-tests, we determined that though the second condition yielded the best results, when compared to the first condition, the difference is not statistically significant, with a p-value of 0.448. Similarly, comparing the second condition to the third one yielded a p-value of 0.410, which means the difference is also not statistically significant. Lastly, the difference between the first and third conditions was also not statistically significant, with a p-value of 0.934. Because the p-values were not less than or equal to 0.05, in all three conditions we concluded that there are no significant differences. These findings further support the conclusions drawn up by the one-way ANOVA, in that there are no statistically significant differences between any of the three conditions.

Due to the nature of the way in which our observations were coded, where one correct throw out of one yielded a score of 100%, and where one correct throw out of two would similarly yield a score of 50%, the standard deviation between points were high. The first condition yielded a standard deviation of 43.38, the second condition, a standard deviation of 44.47, and the third condition, a standard deviation of 45.18 (Appendix F). This shows that the differences between each observation were large, with the third condition producing the largest differences between correct throws. The researchers would like to note that though the standard deviation between points may be large, it does not disrupt the data, as it is a natural occurrence due to the way the data was coded.

DISCUSSION

While the second condition yielded the best sorting accuracy, and therefore seemed to be optimal order for waste sorting, further analysis of the results revealed that none of the three conditions are any better than the others in terms of statistically significance, as neither one produced a p-value less than or equal to 0.05. This was determined through the use of three separate t-tests, as well as the use of a One-way ANOVA between subjects. As such, though the second condition produced the best sorting accuracy relative to the other two conditions, we cannot make recommendations to use this order due to the lack of statistical significance.

One underlying reason for this may the lack of observations. As we only observed a total of three conditions over three days, increasing the number of observations and conditions may strengthen the reliability of our results. Although this may increase the study's reliability, we predict that significant results may not yield any significant differences even with more participants. This is due to the law of small and large numbers. Because the statistical difference with a small set of conditions is not high, using a larger set of observations would likely just amplify the effect of averages converging into a smaller

range of numbers. In the end, this would strengthen the reliability of our study, but would most likely not produce any more significant results, as per the law of large numbers.

Although we tried to minimize possible confounding variables that may affect our results in conducting our study, we recognize some that may still have skewed our observations. The first possible confounding variable is that people may have noticed that we were observing them throwing trash, generating an observer's effect. Because of the nature of our study, we had to observe our subjects relatively closely in order to discern how accurate each individual throws were. This may have made us too obvious to the individuals we were observing, and thus, made them more mindful of how they dispose of their garbage. This may be remedied by observing from a further distance, but may reduce the observers' ability to collect accurate results. A second possible limitation to our study is that because our study entailed switching bin positions around, it may have created a shock-and-awe effect, in that people may have become keenly aware that bin positions have been changed, thus drawing more attention to it. Because UBC arranges bins throughout campus in a certain order, people may have become accustomed to throwing trash in certain bins without paying much attention to it. This practice effect may be the biggest limitation to our study, because there is little that may be done to curb this effect. Lastly, a third possible limitation to our study may be that people are simply uninformed as to which bins certain objects belong to. From what we have observed, a common example of this is the coffee cup. The coffee cups offered in Mercante are made up of three main components, the cup itself, its lid, and its sleeve. Though the sleeve should be disposed of in the compost bin, the lid and the cup should be disposed of in the recycling bin. From our observations, we noticed that most people either separated the lid only, and disposed of the cup and sleeve into the compost bin, or outright disposed of the whole thing into the compost bin. In this example, it may be due to a lack of knowledge rather that blatant disregard for sorting trash that people incorrectly dispose of coffee cups. In order to limit this effect, we suggest that signs be erected to make people more aware of these details regarding waste disposal.

For future studies, we first recommend, exploring all six possible bin combinations. For our study, we only explored three conditions, as we had only sought to manipulate the garbage bin, placing it in every possible position. Exploring all six possible bin combinations would likely discern the optimal bin sorting order. Another recommendation is to record the waste disposal accuracy of each bin. In our study, we only observed whether an individual disposed of anything into the corresponding correct bin, then totalled his/her score to give us the overall waste sorting accuracy percentage. Recording waste disposal accuracy for each bin would further the understanding of waste disposal, and may also give an indication as to where or how most people dispose of waste incorrectly.

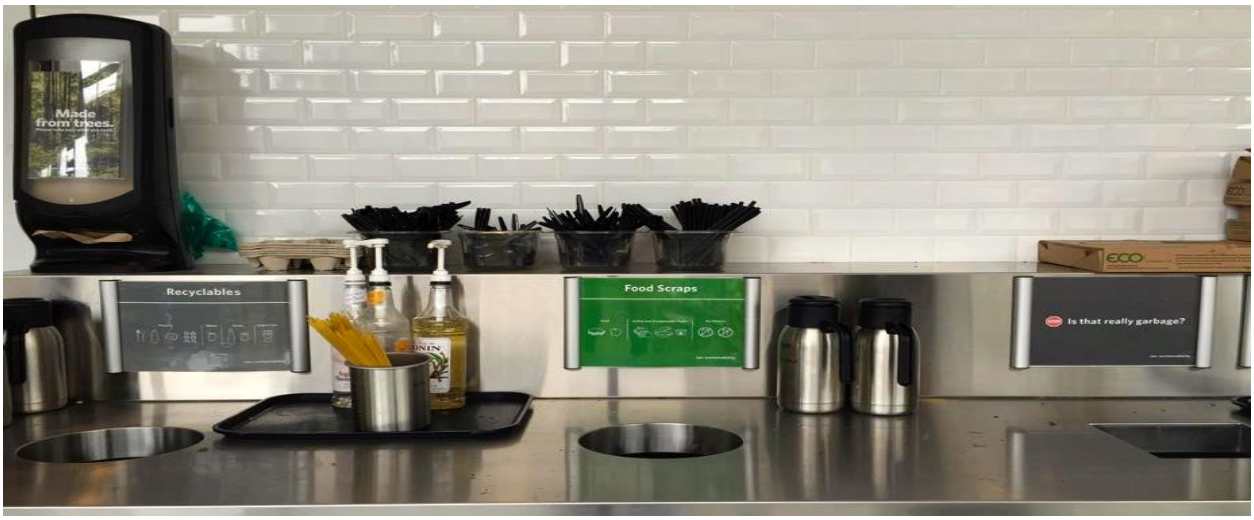
Recommendations for UBC

Because we found no significant differences between the three bin orders we tested, we can only recommend for UBC to conduct further studies, exploring all six possible bin orders. Since our study looked at the three possible positions of the garbage bin and found no significant differences, we can suggest that the position of the garbage bin does not matter for optimizing waste sorting behaviour. Therefore, future studies should focus more on how the positions of the recycling and compost bins affect sorting behaviour. Another

recommendation is to record the waste disposal accuracy of each bin, to see if people dispose of waste most incorrectly to any of the bins in particular. Knowing the most conducive order of bins for accurate recycling behaviour will contribute to the University's sustainability goals of becoming a "Zero Waste" campus. Furthermore, while making our observations, we noticed that the UBC waste disposal staff themselves did not separate the compost, recycling, and garbage from one another when changing the garbage bags from the bins we were observing, but rather mixed everything together. For UBC to reach its goals of diverting more and more waste from the landfill, it needs to ensure the Waste Management Staff themselves are practicing good waste sorting behaviour through training and education. We recommend that the education be extended also to students, to both promote and educate about proper waste disposal, because it was evident, as in the coffee cup example, that many students, while trying to correctly sort their waste, simply did not know what kind of waste belongs in which bin. Education programs can help address this problem and move UBC towards becoming a truly "Zero Waste" campus.

<u>Appendix A.</u> Images of the Three Conditions in the Study (Mercante Restaurant)

Condition 1. Bin order from left to right: Recyclables, Compost, then Garbage.



Condition 2. Bin order from left to right: Garbage, Compost, then Recyclables.

Condition 3: Bin order from left to right: Compost, Garbage, then Recyclables.

<u>Appendix B.</u> Observational Data Recorded via Microsoft Excel during the experiment
(An 'x' represents a wrong throw, while a 'c' represents a right throw.)

Condition 1. Bin order from left to right: Recyclables, Compost, then Garbage.

Condition 1		
Participant	Right/Wrong	Percentages
1	xx	0
2	xx	0
3	x	0
4	c	100
5	c	100
6	c	100
7	c	100
8	x	0
9	x	0
10	xx	0
11	x	0
12	c	100
13	xx	0
14	c	100
15	c	100
16	ccx	66
17	xx	0
18	x	0
19	c	100
20	cc	100
21	xx	0
22	x	0
23	c	100
24	c	100
25	c	100
26	c	100
27	c	100
28	cx	50
29	x	100
30	x	100
31	ccx	66
32	cx	50
33	cx	50
34	xx	0
35	x	0
36	c	100
37	x	0
38	x	100
39	xxc	33
40	cxxxx	20
41	cx	50
42	cx	50
43	x	0
44	ccc	100
45	cc	100
46	c	100
47	cx	50
48	c	100
49	x	50
50	cx	50
51	ccx	66
52	cccx	75
53	x	0
54	c	100
55	c	100
56	c	100
57	ccc	100
58	c	100
59	c	100
60	c	100
	Average	60.4333333

Condition 2. Bin order from left to right: Garbage, Compost, then Recyclables.

G	H	I
Condition 2		
Participant	Right/Wrong	Percentages
1	x	0
2	xc	50
3	c	100
4	x	0
5	x	0
6	ccc	100
7	x	0
8	cc	100
9	c	100
10	c	100
11	c	100
12	cccc	100
13	xc	50
14	cc	100
15	x	0
16	cc	100
17	xc	50
18	x	0
19	cc	100
20	ccx	66
21	c	100
22	c	100
23	xc	50
24	c	100
25	x	0
26	cc	100
27	c	100
28	xx	0
29	x	0
30	x	0
31	xxccc	60
32	c	100
33	c	100
34	xx	0
35	c	100
36	c	100
37	c	100
38	c	100
39	c	100
40	cc	100
41	cc	100
42	xcc	66
43	cc	100
44	c	100
45	xx	0
46	x	0
47	cc	100
48	xx	0
49	c	100
50	c	100
51	cc	100
52	x	0
53	c	100
54	x	0
55	cc	100
56	c	100
57	x	0
58	c	100
59	c	100
60	ccc	100
	Average	66.5333333

Condition 3. Bin order from left to right: Compost, Garbage, then Recyclables.

Condition 3		
Participant	Right/Wrong	Percentages
1	c	100
2	x	0
3	xc	50
4	cc	100
5	xc	50
6	ccx	66
7	x	0
8	x	0
9	x	0
10	cccc	100
11	xc	50
12	x	0
13	x	0
14	xc	50
15	x	0
16	xxxxc	20
17	c	100
18	c	100
19	c	100
20	c	100
21	c	100
22	xc	50
23	c	100
24	c	100
25	cc	100
26	c	100
27	cc	100
28	xxxx	0
29	xc	50
30	c	100
31	x	0
32	cc	100
33	x	0
34	xxx	0
35	c	100
36	c	100
37	ccc	100
38	xc	50
39	c	100
40	c	100
41	x	0
42	cc	100
43	x	0
44	xc	50
45	x	0
46	c	100
47	xx	0
48	c	100
49	c	100
50	x	0
51	xxx	100
52	cc	100
53	c	100
54	x	0
55	xxx	0
56	xxx	0
57	cc	100
58	cccc	100
59	c	100
60	c	100
	Average	59.7666667

Appendix C. SPSS Statistical Data Analysis

Below is a One-Way ANOVA Analysis showing that there are no statistically significant differences between the means of the three conditions. No post-hoc analysis was done due to the fact that there were no statistically significant results.

Univariate Analysis of Variance

[DataSet2]

Between-Subjects Factors

		N
VAR00001	1.00	60
	2.00	60
	3.00	60

Descriptive Statistics

Dependent Variable: VAR00002

VAR00001	Mean	Std. Deviation	N
1.00	60.4333	43.38451	60
2.00	66.5333	44.47641	60
3.00	59.7667	45.18000	60
Total	62.2444	44.21022	180

Levene's Test of Equality of Error Variances[a]

Dependent Variable: VAR00002

F	df1	df2	Sig.
.314	2	177	.731

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + VAR00001

Tests of Between-Subjects Effects

Dependent Variable: VAR00002

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1668.844[a]	2	834.422	.424	.655	.005
Intercept	697386.756	1	697386.756	354.507	.000	.667
VAR00001	1668.844	2	834.422	.424	.655	.005
Error	348194.400	177	1967.200			
Total	1047250.00	180				
Corrected Total	349863.244	179				

a. R Squared = .005 (Adjusted R Squared = -.006)

Below is an Independent Samples t-test comparing between Condition 1 and Condition 2.

T-Test

[DataSet1]

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	1.00	60	60.4333	43.38451	5.60092
	2.00	60	66.5333	44.47641	5.74188

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
VAR00002	Equal variances assumed	.070	.792	-.760	118	.448	-6.10000	8.02119	-21.98414	9.78414
	Equal variances not assumed			-.760	117.927	.448	-6.10000	8.02119	-21.98424	9.78424

Below is an Independent Samples t-test comparing between Condition 2 and Condition 3.

T-Test

[DataSet1]

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	2.00	60	66.5333	44.47641	5.74188
	3.00	60	59.7667	45.18000	5.83271

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
VAR00002	Equal variances assumed	.261	.610	.827	118	.410	6.76667	8.18473	-9.44132	22.97465
	Equal variances not assumed			.827	117.971	.410	6.76667	8.18473	-9.44136	22.97469

Below is an Independent Samples t-test comparing between Condition 1 and Condition 3.

T-Test

[DataSet1]

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	1.00	60	60.4333	43.38451	5.60092
	3.00	60	59.7667	45.18000	5.83271

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
VAR00002	Equal variances assumed	.644	.424	.082	118	.934	.66667	8.08646	-15.34672	16.68006
	Equal variances not assumed			.082	117.806	.934	.66667	8.08646	-15.34700	16.68033

<u>Appendix D</u>. Full image of Mercante Restaurant in the Ponderosa Building at UBC

<u>Appendix E.</u> Summary of Independent and Dependent Variable

- **Independent Variable:** Order of bins from left to right *(e.g. Recycle, Compost, then Garbage)*

- **Dependent Variable:** Percentage of correct disposals per participant

= Number of correct throws per participant / Total amount of throws per participant
(e.g. Throwing a water bottle to Recyclables is 1 correct. Throwing a pizza crust to Garbage is 1 wrong. This hypothetical participant would get ½ or 50%.)

Appendix F. Summary of Statistical Results

	Mean	Standard Deviation	N
Condition 1	60.433	43.38	60
Condition 2	66.533	44.47	60
Condition 3	59.766	45.18	60
Total	62.244	44.21	180

Conditions:	1-2	1-3	2-3
P-value	.448	.934	.410