The Effectiveness of 3D Displays on Sorting Behaviour in Post-Secondary Institutions

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Project 3D

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Executive Summary

Visual processing has shown to improve greater conceptual understanding and how visual cues are situated spatially can also increase cognition processes (Gozli, Chasteen & Pratt, 2013). Another aspect of visual processing of a target is described by Bardy & Laurent (1991) as the time-to-contact parameter (T_c), which determines what information an individual can visually absorb. Spatial representation alongside the dilation rate of the target on the retina can help garner individuals' attention before they dispose of their items through their respective bins (Gozli, Chasteen & Pratt, 2013; Bardy & Laurent, 1991). With the addition of 3D displays, it is possible to implement findings on visual acuity to improve sorting behaviours at UBC's Stir It Up Café in the Buchanan A building.

Research Question

Does the presence of 3D displays change waste sorting behaviours at UBC's Stir It Up Cafe in Buchanan A building?

Hypothesis

The presence of 3D displays will provide a clear and visual assist for users to improve their sorting accuracy.

Methods

Subjects

The participants for this study included students, staff, employees and visitors using the waste sorting station by the Stir It Up Cade in the Buchanan A building on weekdays. Since the experiment was not conducted in a controlled environment, every individual passing by the waste sorting station had an equal chance of participating in the study. The subjects for the qualitative survey in Condition 2 consisted of 100 disposal bin users (Mean = 19.37 years; S.D. = ±1.055035544).

Conditions

In this study, there were two conditions: the control condition and the experimental condition. Aesthetically, the control condition had waste bins without 3D displays mounted onto the backboard, and the experimental condition had waste bins with 3D displays attached to the backboard. The 3D displays are therefore the independent variables in this study.

The control condition ran for 1 week, with the sorting station located by the stairs in Buchanan A building, beside Stir It Up Cafe. The experimental condition lasted for 1 week as well, with the same bins in the same location, but with 3D display boxes installed onto the backboard. The sorting behavior and accuracy of the participants are the dependent variable in this study.

Measures

In this study we incorporated both a quantitative and a qualitative measure component. As a quantitative measure we primarily observed and recorded the weight of trash collected at the end of each day at the sorting station located outside the Stir It Up Cafe in the Buchanan A building. Using an electronic scale, we measured the weight in kilograms of each of the four types of

disposables, namely: paper, recycling, organics and garbage. The weight was measured at the same time each day to maintain consistency and we aimed to observe the difference in each stream in comparison with the other days of the week. As part of our qualitative measure, we conducted a brief survey to record to presumed effectiveness of our experimental condition, the addition of the 3D display case. This survey consisted of a single question delivered to a random selection of participants, aiming to observe the effectiveness of the 3D display. The participants were asked if the presence of the 3D display aided them in their sorting decision making process and their answers were recorded with the help of a straightforward nominal scale consisting of two options: yes or no.

Procedure

The object of this study was to determine whether or not 3D displays affected the sorting behavior in participants using the four waste bins: garbage, paper, organics and recycling. The initial steps involved obtaining the equipment needed for the experiment, which included an electronic scale for measuring the waste bins in the Buchanan A building, beside Stir It Up Cafe as well as a key for access to the waste bins. These were obtained through contacting Ivana, a staff with the Institute for Resources, Environment and Sustainability. A schedule was also worked out with the janitor to leave the waste bins untouched until they were weighed. The bins were then weighed every day from Feb 29th to Mar 4th at 5pm for the control condition. The weight of each bin was recorded and the tops of each bin were searched by eye through 80% of the bin from the top for any contaminants. Weight was calculated by an electronic scale by placing each of the bins on top of the scale and subtracting the weight of the bin. The compost, paper, and recycling bins all weighed 12.00kg while the garbage bin weighed 3.60kg. For each stream, the ratio of contaminants per kilogram was created to compare how heavily polluted each stream was. Four one-tailed t-tests were conducted to determine whether on average, the results were consistent with the hypothesis that contaminants would decrease with displays. For each stream, the t-score was generated to determine the significance of the 3D displays between the control and experimental condition. There was also reason to believe that there may be certain days where the contamination rates would be significantly higher, either due to higher traffic or greater consumption. Therefore, four one-tailed T-tests were conducted for each stream to compare the conditions with the respective day of the week, Monday through Friday.

The 3D displays were then installed onto the backboard and the same procedures were run from March 7th to March 11th at 5pm for the experimental condition as well. A qualitative study was also used every day during the experimental condition to determine the effectiveness of the 3D displays; these surveys were run between 11am-2pm. 100 students were surveyed, 20 per day. Participants were asked whether they used the display case to dispose of their items and answers were recorded. The electronic scale and key were returned to the original owners and the results were organized and analyzed for indications of the study.

Results

The effects of 3D displays in the Buchanan A building, were shown by the ratio of contaminants per kilogram was created to compare how heavily polluted each stream was. Four one-tailed t-tests were conducted to determine whether on average, the results were consistent with the hypothesis that contaminants would decrease with displays. For each stream, the t-score was generated to determine the significance of the 3D displays between the control and experimental condition. There was also a reason to believe that there may be certain days where the

contamination rates would be significantly higher, either due to higher traffic or greater consumption. Therefore, four one-tailed t-tests were conducted for each stream to compare the conditions with the respective day of the week, Monday through Friday.

The results of Figure 1 show the average ratio of contaminants per kilogram for each condition. For Condition 1, the organics stream has an average contaminant per kilogram ratio of 1.33982 (S.D. = 0.306455) compared to Condition 2 whose average was 1.2073 (S.D. = 0.248294). For the recycling stream, Condition 1 had an average ratio of 7.799379 (S.D. = 0.189465) and Condition 2 had an average ratio of 6.73884 (S.D. = 0.650874). With the paper stream, Condition 1 had an average ratio of 0.281557 (S.D. = 0.172694) and Condition 2 had a ratio of 0.46631 (S.D. = 0.259521). Garbage contaminant ratios for Conditions 1 and 2 are 5.512791 (S.D. = 0.467185) and 5.66205 (S.D. = 0.247207) respectively.

The t-tests run to determine the significance of the four streams in the two conditions were one-tailed because of the expected decrease in contaminants in Condition 2. Therefore, the critical t value is 2.132. The organics t-score was 1.06748 which was deemed insignificant ($p<0.05$). The recycling t-score, 3.2588 ($p<0.05$), was the only score that was significant which was likely the result of a decreased number of contaminants and a high standard deviation. This is shown through both Figure 1 and Table 1. Figure 1 shows the average contaminants per kilogram in each stream and Table 1 shows the raw data collected from the disposal bins. The paper and garbage t-scores were 1.423791 and 1.033752 respectively and were insignificant at an alpha value of $p<0.05$.

Since this study is a between-groups study due to the fact that it is impossible to determine who used the sorting stations at certain days and certain times, it would be beneficial to see if there were significant results between conditions for various days of the week. This analysis was to see whether there was a stronger effect on the user based on the day of the week. There were five t-tests to determine whether there were significant differences between days for both the control condition and the intervention condition. Figures 2.1.1 and 2.1.2 shows the weight of each stream and the contaminants per kilogram respectively. The critical t-value used to determine significance is 6.314 ($p<0.05$). The Monday t-values for organics, recycling, paper, and garbage are 0.836510973, 1.380976915, 0.804171283, and 0.475968134 respectively, which are all insignificant at $p<0.05$. Tuesday t-values for organics, recycling, paper, and garbage are 1.197952297, 1.376813463, 1.405853557, and 0.262677567 respectively, and are all insignificant at $p<0.05$. Wednesday t-values for organics, recycling, paper, and garbage are 1.068131459, 0.201689983, 0.333935373, and 1.329230781 respectively, and are also insignificant at $p<0.05$. Thursday t-values are no different for organics, recycling, paper, and garbage with 0.390915301, 1.376237444, 1.175829393, and 1.412127177 respectively, which are all insignificant at $p<0.05$. The Friday t-values yielded similar results for organics, recycling, paper, and garbage with 1.384628874, 1.40866342, 1.377455362, and 1.266522038 respectively, as all are insignificant at $p<0.05$. This shows there were no differences in sorting behaviour between days for both the control and experimental conditions.

A qualitative survey was conducted during the experimental week to see if there was a significant change in sorting behaviour at the Buchanan A building's disposal bins. A simple

yes-no survey was conducted to examine whether the user had utilized the 3D displays to sort their items. The survey (see Table 2 in Appendix) was conducted every day and each day had 20 individuals surveyed. The effect of the 3D displays on sorting behaviour were not as anticipated as most days less than 50% of individuals had used the displays to sort their items. On Monday and Wednesday, only 8 individuals per day stated they used the 3D displays to sort their items, compared to 12 individuals per day who used another method to sort their items. On Tuesday and Thursday, 9 individuals on both days stated they used the 3D displays to sort their items compared to 11 individuals on both days who said they did not. Friday was the only day in which individuals who used the 3D displays equaled the individuals who did not at 10 individuals a piece.

Discussion

It is important to measure the contaminants in each of the four streams to determine which bins confuse bin users the most. Therefore, any visual cue that can assist the sorting of items into their appropriate bins are useful. Figure 1 shows Condition 2 has more contaminants per kilogram for both the garbage and paper streams but less contaminants in the organics and recycling streams when compared to Condition 1. This is an expected variation between different weeks on a busy college campus as there are many confounding variables that may affect human traffic in the Buchanan A building. These confounding variables would include the classes in session that day, whether individuals would purchase or bring any food items, or if they would dispose their items in the sorting station being observed. The general trend was there were more items on average in each of the streams in Condition 2, represented by all the Figure 2 graphs which may be due to heavier human traffic, heavier items being disposed, or another confound that has not been researched. When looking at Figure 3.1 compared to Figure 3.2, at the end of the day, the recycling and compost streams are overflowing already (as seen in Figure 3.1) so individuals may feel less motivated to sort their items as a result. Also based on Figure 1, the recycling stream had the greatest difference in contaminant per kilogram ratio as Condition 1 was 7.799379 (S.D. = 0.189465) and Condition 2 was 6.73884 (S.D. = 0.650874). Not only was the greatest difference between the two conditions in ratios, but also standard deviation as well, which was another factor in the recycling stream being the only significant difference between conditions.

This was supported by the t-test following as the t-value for the recycling was considered significant 3.2588 was greater than the critical t-value of 2.132 at an alpha value of $p<0.05$. Majority of the contaminants in the recycling stream were the cup sleeves as individuals had not properly sorted the items. It cannot be said that the 3D displays and the decrease in contaminants in the recycling stream in Condition 2 are cause-and-effect as more data points are needed to test its reliability. The significance of this result may be the result the 3D displays but is not the exclusive reason as there may be confounding variables that will affect this result. These confounds may include individuals either purchasing coffee from shops that did not provide cup sleeves in Condition 2, they happened to sort the sleeve into the paper stream that week or even the amount of coffee consumed that week was lower than in Condition 1. It is difficult to control these confounds affecting the results as this is a weeklong study that begins when the Buchanan

A building opens until the contents are emptied each day by the custodian. Another week of the experimental condition would test for the reliability of results (see Table 3 in Appendix). This is a major limitation of the study as it cannot be confirmed whether the significant t-value in the recycling stream was due to the 3D displays or random chance.

There were no significant differences between days for both conditions because majority of users would be the same and would react the same of different days of the week. This would be supported by the qualitative survey conducted to measure the effectiveness of the 3D displays as only 44 individuals admitted to using the 3D displays to sort their items (see Table 2 in Appendix). There is a similar trend as only 8 users used the 3D displays on Monday and Wednesday and there were 9 users on Tuesday and Thursday as there may be similarities in the individuals attending class and how they dispose of their items. Friday was the only day that did not support this trend as 10 individuals said they used the 3D displays and 10 said they did not.

Recommendations

Many individuals are constantly in a hurry so they are unable to pay close attention to fine detail in their surroundings. Bardy & Laurent (1991) stated an alternative method to calculating time-to-contact as distance from target over walking speed. So as people are walking faster past the sorting station, they will have a decreased spatial awareness of the disposal target in sight and may increase in incorrect sorting as their conceptual understanding of the sorting station decreases (Gozli et al., 2013). The suggestions for the client to either draw attention of users to the 3D display cases would be to attach another cue such as a motion detected light to cause the user to focus the 3D display box in their retina for a greater comprehension of the sorting process. Currently, only 44% of individuals use the 3D display cases which is low since this is the only intervention available to increase sorting behaviour. It can also be paired with another intervention such as a mirror, Emily from Emily Sorting, or the sorting game to be combined to use one another's strengths and to resolve each intervention's weakness.

This study shows there may be simpler and more effective ways to improve sorting behaviours for the sorting stations as the 3D display cases may not be the visual cue individuals identify with most. Since individuals who did not use the 3D display cases stated they used the pictures above the sorting stations instead, it would be valuable to compare the 3D display cases to pictures in future studies.

References

Bardy, B. G. & Laurent, M. (1991). Visual Cues and Attention Demand in Locomotor Positioning. *Perceptual and Motor Skills, 72*(3), 915-926. doi: 10.2466/pms.1991.72.3.915

Gozli, D. G., Chasteen, A. L., & Pratt, J. (2013). The Cost and Benefit of Implicit Spatial Cues for Visual Attention. *Journal of Experimental Psychology: General, 142*(4), 1028-1046. doi: 10.1037/a0030362

Appendix

Figure 1

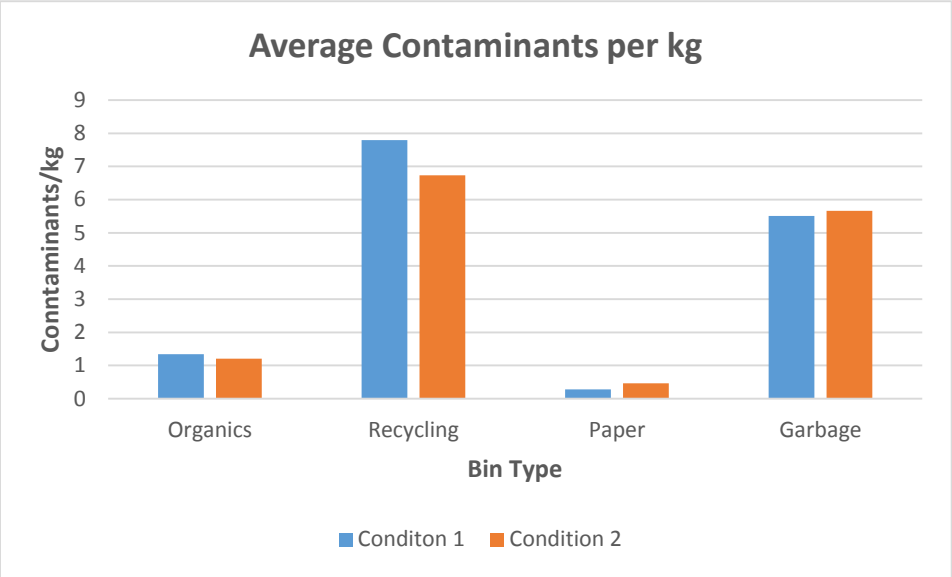

Figure 2.1.1

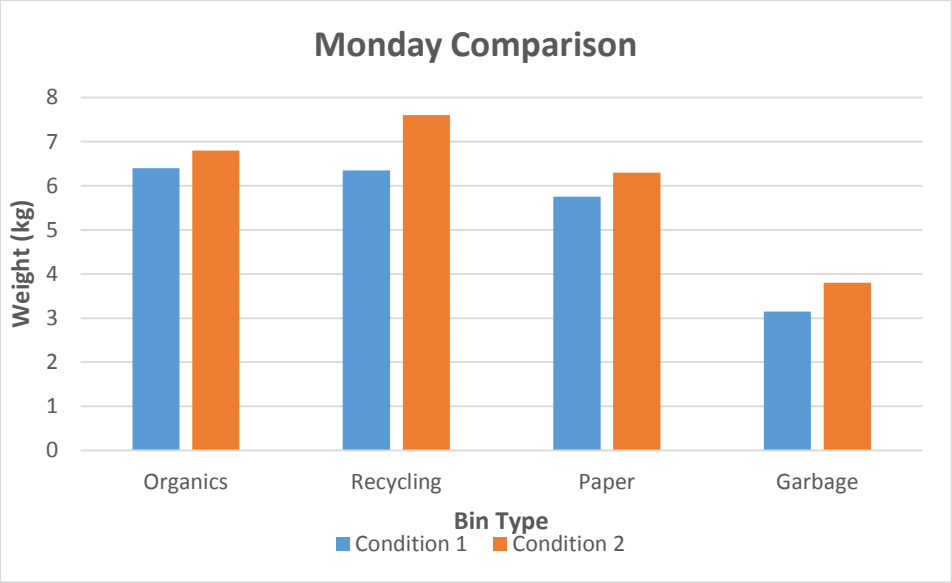

Figure 2.1.2

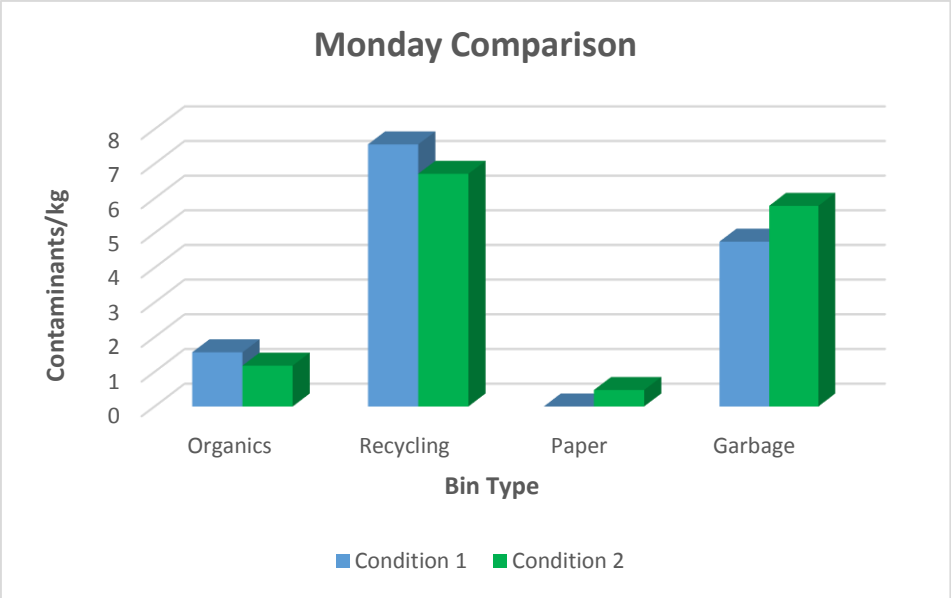

Figure 2.2.1

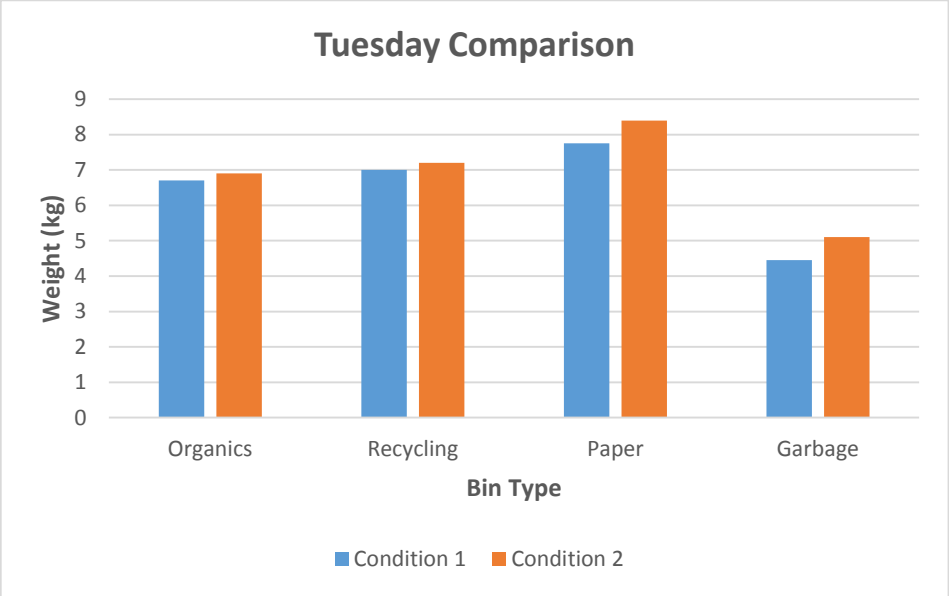

Figure 2.2.2

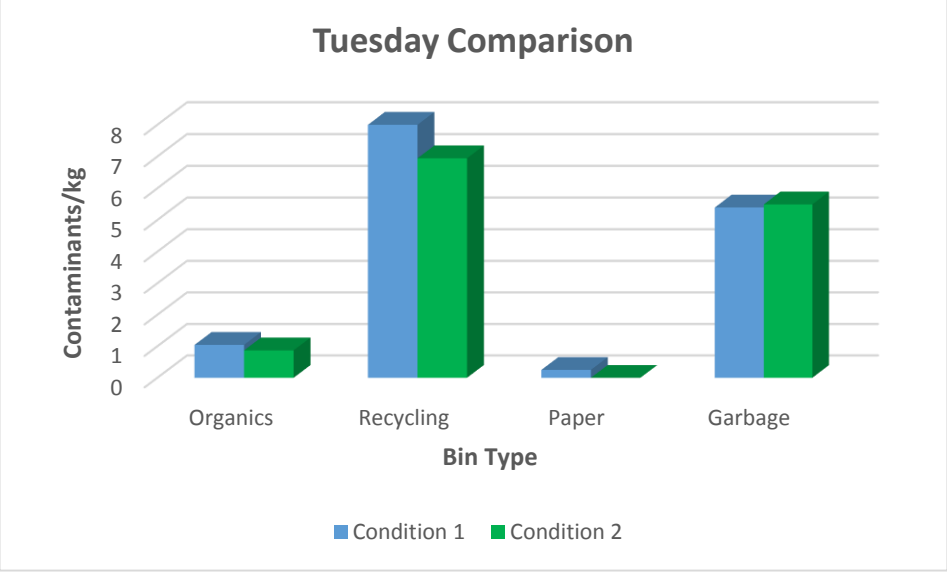

Figure 2.3.1

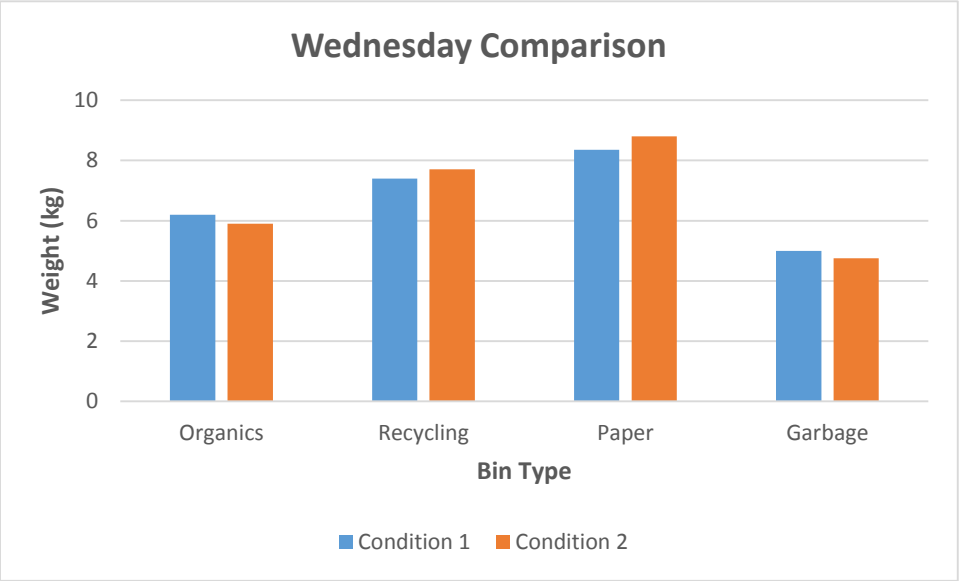

Figure 2.3.2

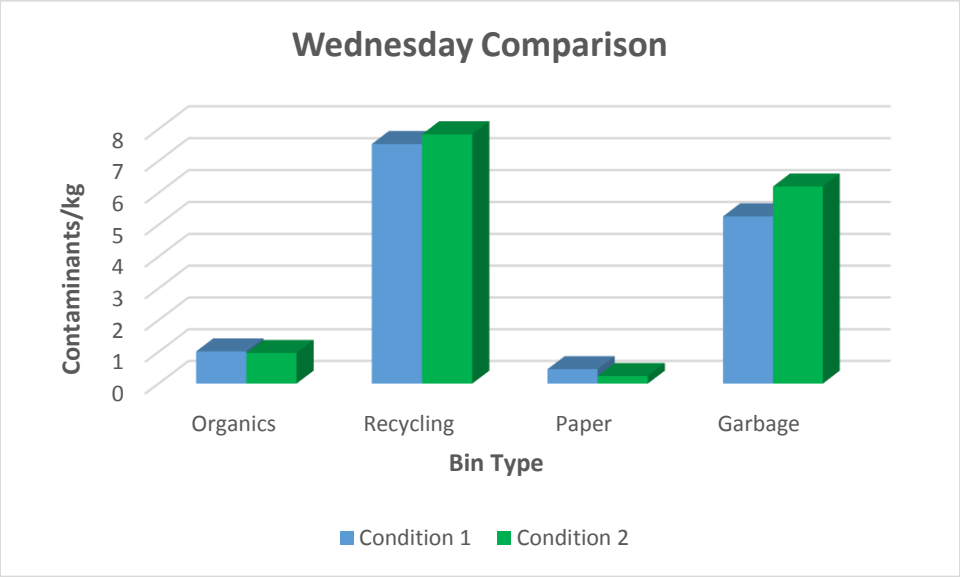

Figure 2.4.1

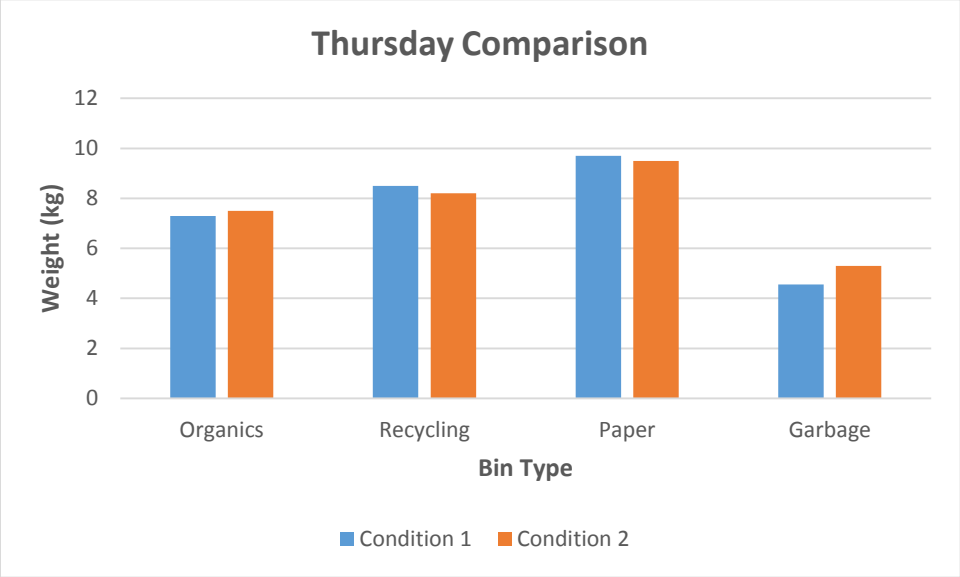

Figure 2.4.1

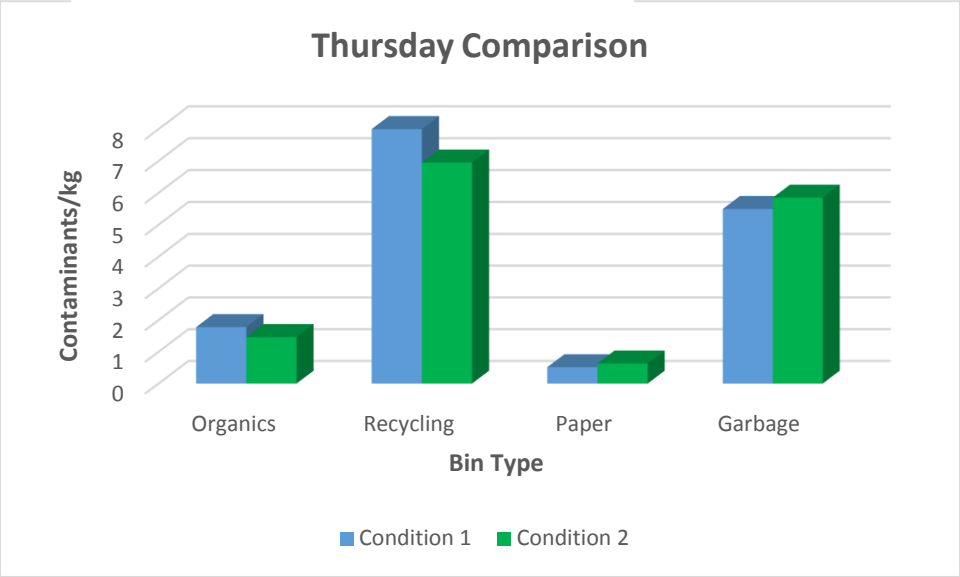

Figure 2.5.1

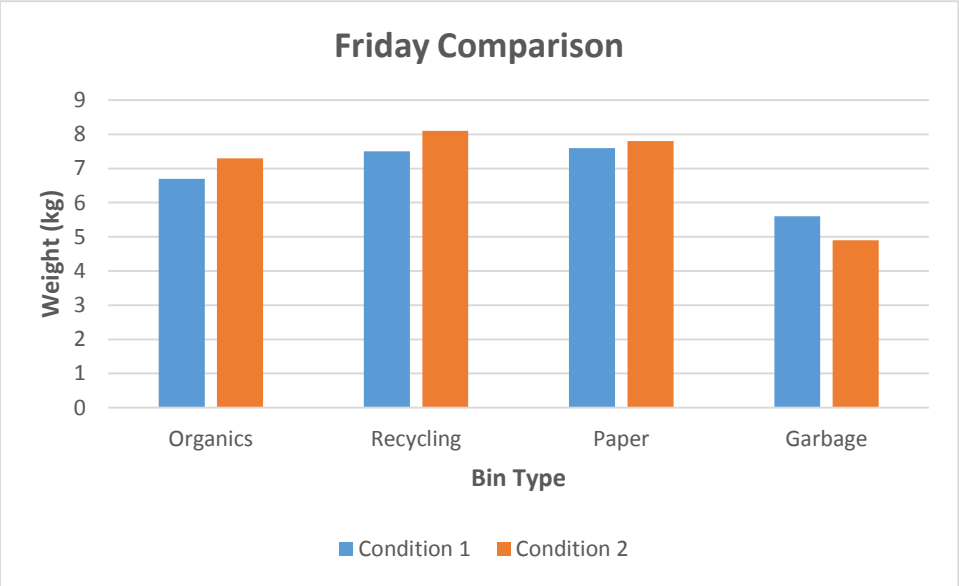

Figure 2.5.2

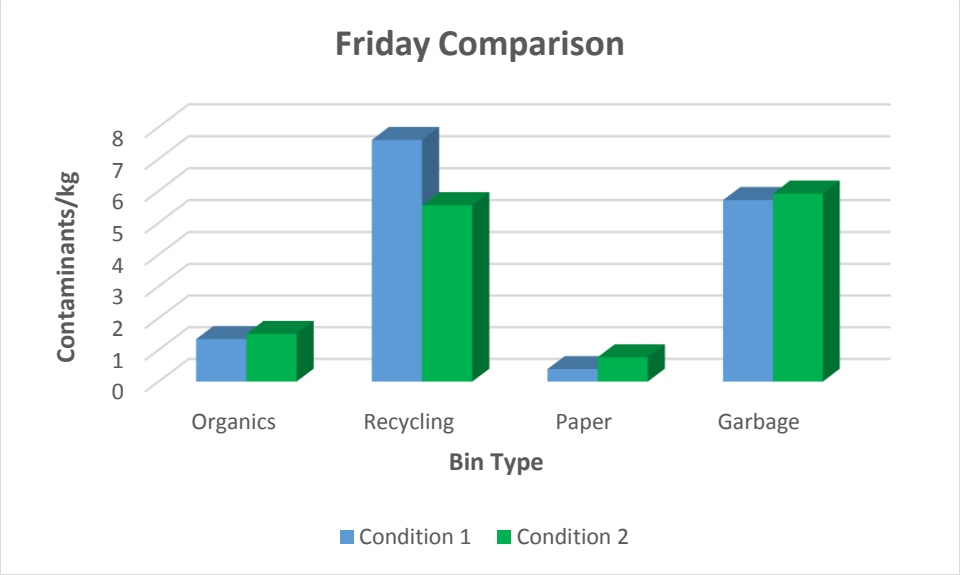

Figure 3.1

Figure 3.2

Table 1

Date	Bin Location & Condition	Bin Type	Weight Kg	Fullness of Bin % 0-100	# of Contaminants	# of Plastic Containers & Cups	# of Soft Plastics (bags, etc)	# of Cutlery Pieces	Other (Describe)
Feb 29th	Buchanan A - Condition 1	Organics	6.40	95	10	0	0	0	Styrofoam containers
	Buchanan A - Condition 1	Recycling	6.35	100	48	76	5	46	Cup holders
	Buchanan A - Condition 1	Paper	5.75	50	0	0	0	0	N/A
	Buchanan A - Condition 1	Garbage	3.15	35	15	12	20	14	
March 1st	Buchanan A - Condition 1	Organics	6.7	97	7	0	0	0	Styrofoam
	Buchanan A - Condition 1	Recycling	7	110	56	85	2	52	Cup holders, straws
	Buchanan A - Condition 1	Paper	7.75	80	2	0	0	0	Milk carton
	Buchanan A - Condition 1	Garbage	4.45	65	24	20	18	19	Forks, spoons, cup lids
March 2nd	Buchanan A - Condition 1	Organics	6.2	94	6	0	2	14	Styrofoam, plastic utensils
	Buchanan A - Condition 1	Recycling	7.4	115	58	92	5	57	Straws, cup holders
	Buchanan A - Condition 1	Paper	8.35	90	2	2	0	0	Juice box
	Buchanan A - Condition 1	Garbage	5	70	31	22	37	16	Compostable boxes, compost, utensils
March 3rd	Buchanan A - Condition 1	Organics	7.3	100	13	0	6	18	Styrofoam, plastic utensils
	Buchanan A - Condition 1	Recycling	8.5	120	68	103	9	70	Straws, cup holders
	Buchanan A - Condition 1	Paper	9.7	100	5	5	0	0	Chocolate milk carton
	Buchanan A - Condition 1	Garbage	4.55	65	25	18	29	21	Compostable boxes, fruit

March 4th	Buchanan A - Condition 1	Organics	6.7	97	9	0	4	14	Styrofoam, plastic utensils
	Buchanan A - Condition 1	Recycling	7.5	115	57	89	6	61	Straws, cup holders
	Buchanan A - Condition 1	Paper	7.6	80	3	3	0	0	Juice boxes
	Buchanan A - Condition 1	Garbage	5.6	75	32	21	33	24	Compost
March 7th	Buchanan A - Condition 2	Organics	6.8	97	8	0	0	0	Styrofoam containers
	Buchanan A - Condition 2	Recycling	7.6	115	51	65	5	39	Straws, Cup holders
	Buchanan A - Condition 2	Paper	6.3	70	3	0	0	0	Juice boxes
	Buchanan A - Condition 2	Garbage	3.8	55	22	15	27	19	Compost
March 8th	Buchanan A - Condition 2	Organics	6.9	97	6	0	0	0	Styrofoam
	Buchanan A - Condition 2	Recycling	7.2	110	50	92	4	44	Cup holders, straws
	Buchanan A - Condition 2	Paper	8.4	85	0	0	0	0	N/A
	Buchanan A - Condition 2	Garbage	5.1	70	28	17	24	27	Forks, spoons, cup lids
March 9th	Buchanan A - Condition 2	Organics	5.9	90	6	0	2	14	Styrofoam, plastic utensils
	Buchanan A - Condition 2	Recycling	7.7	110	58	92	5	57	Straws, cup holders
	Buchanan A - Condition 2	Paper	8.8	90	4	4	0	0	Juice box
	Buchanan A - Condition 2	Garbage	4.75	65	25	18	29	21	Compostable boxes, compost, utensils
March 10th	Buchanan A - Condition 2	Organics	7.5	100	11	0	4	15	Styrofoam, plastic utensils
	Buchanan A - Condition 2	Recycling	8.2	115	57	94	5	77	Straws, cup holders, utensils
	Buchanan A - Condition 2	Paper	9.5	100	6	6	0	0	Juice Boxes

	Buchanan A - Condition 2	Garbage	5.3	70	31	21	26	18	Compostable boxes, fruit
March 11th	Buchanan A - Condition 2	Organics	7.3	97	11	0	5	11	Styrofoam, plastic utensils
	Buchanan A - Condition 2	Recycling	8.1	115	45	91	4	57	Straws, cup holders
	Buchanan A - Condition 2	Paper	7.8	80	6	6	0	0	Juice boxes, cartons
	Buchanan A - Condition 2	Garbage	4.9	70	29	19	27	16	Compost

Table 2

3D Survey

	Yes	No
Monday	8	12
Tuesday	9	11
Wednesday	8	12
Thursday	9	11
Friday	10	10

Table 3

The scale used to measure the weight of the bins was stolen by a thief during the second proposed intervention week which resulted in the scrapping of that week. The recycling display case was also stolen a short time afterwards as well so there was an outside factor that disrupted the study in a major way. It was difficult to collect data and determine significance based on one baseline week compared to one intervention week. There was constant communication between Project 3D and the client but the client was unable to provide another scale for the study. The client also needed her 3D display cases returned to the CIRS building because there was a presentation one of the days during the study so another week might not have been applicable even with a scale.