Visual Prompts for Sorting Waste: Specificity of Contents

Dasol Kim, Jason Wang, Mary Kim, Senjae Zhou, Wai Keit Tham

University of British Columbia

PSYC 321

May 29, 2017

Visual Prompts for Sorting Waste: Specificity of Contents

BFFO Environment: Dasol Kim, Mary Kim, Wai Keit Tham, Jason Wang, Senjae Edward Zhou

University of British Columbia

April 5, 2017

Executive Summary

Past studies have demonstrated that visual prompts, such as display bins, can improve an individual's waste sorting behaviors. We conducted a study to examine whether or not changing the design and/or contents of the current Sort-It-Out 3D displays can be more effective in promoting waste sorting accuracy. Firstly, we tested for a control condition to find a baseline measure. Secondly, we tested for a condition which involved changing the contents of the bin by removing some items to make the contents more visible. Finally, we changed the background colour of the bins to red in accordance to results from a past study which found that red was the most attractive and noticeable colour in the spectrum (Kuniecki et al., 2015). In all three conditions, each participant's waste sorting response time and accuracy were recorded. Our results show that our conditions had a significant effect that improved waste sorting behaviors primarily at waste bins at the Pie R Squared in the UBC Nest.

Research question

Can the design and/or contents of the current Sort-It-Out 3D display bins be changed to make them more effective in promoting waste sorting accuracy?

Hypothesis

For our first experimental condition, we hypothesized that rearranging the contents in the display bin with fewer items would increase 3D enclosure visibility, and thus would increase waste sorting accuracy by causing participants to sort waste in a faster and more accurate manner compared to the control condition where the enclosure was messy and cluttered.

Our second experimental condition was based off a previous study which found that "the colour red attracted attention in an emotional context" (Kuniecki et al. in 2015). Thus, we hypothesized that changing the white-coloured backgrounds to red would improve waste sorting accuracy by increasing the visibility of the 3D enclosure. Therefore, we hypothesized that participants would take less time to sort their waste and would also sort it in a more precise manner compared to the other conditions.

Methods

Participants

The participants in this study were visitors of the Pie R Squared pizza shop in the AMS Student Nest. Participants consisted of UBC students, UBC faculty and staff as well as general visitors to the AMS Student Nest. There were a total of 422 participants.

Conditions

There were three conditions in the study, one control condition and two experimental conditions.

Control condition We used the prior arrangement of items in the 3D display bins as our control condition. The purpose of this condition was to provide a baseline for comparison with the results from the two other conditions and determine whether a noticeable effect from our two conditions exists. Moreover, the control condition allowed us to determine whether our results would be consistent with results from previous studies. This control condition consisted of 3-5 unsorted items per 3D enclosure, backed by a white piece of paper (See **Figure** 6.1).

Condition 2 In this condition, we rearranged the items in the 3D display bins so that the items would look more distinguishable (see **Figure** 6.2). We accomplished this by sorting and removing items in each bin so that there would only be 1 to 2 items per bin. The backgrounds of the bin in this condition were also white. The purpose of this condition was to determine whether there was an effect of having less items in the bin (1-2 items) on participants' waste sorting behaviours. The independent variable in this condition was the number of items in the 3D display bins and our dependent variable was the time and accuracy of participants' waste sorting behaviours.

Condition 3 We continued with the arrangement of the items from our second condition, but we changed the colours of the 3D enclosure by switching the white paper background to red (See **Figure** 6.3). This condition tested if red backgrounds would increase the visibility of the 3D display bins, improving participants' waste sorting behaviours. The independent variable in this condition was the red coloured background and our dependent variable was the time and accuracy of participants' waste sorting behaviours.

Measures

To measure the time it took for each participant to sort their waste, we used a stopwatch to measure their response times. We used a paper tally to record whether participants' waste sorting behaviours were accurate by including either a check mark to indicate accurate waste sorting behaviour or a cross to indicate incorrect waste sorting behaviours. The results from these paper tallies were then posted onto an Excel spreadsheet and then transferred to tables (See **Figure 5**).

Procedure

We collected data on Tuesdays and Fridays for three weeks during the month of March, 2017 for thirty minutes each session at 12pm, 3pm and 6pm on both days. For accuracy of the data collected, we ensured that there were at least two group members collecting data at the same time. Data collection was conducted entirely within the Pie R Squared area in the AMS student nest at UBC.

For the first condition, we left everything in the 3D enclosure as is, and sat at the table directly in front of the bins. We collected our time data by starting the stopwatch as soon as a participant reaches the bins, and stopped the watch as soon as the participant completed his or her waste disposal. We collected our accuracy data by looking at what participants had in their hands, and writing a check mark on our tally for an accurate throw, and writing a cross on our tally for an inaccurate throw.

For the second condition, we first decided how many items we wanted to use in the 3D display bins, and we ultimately decided to reduce the amount of items in the bin to 1 or 2 items. We also attempted to make the contents in the bin look palatable by rearranging the contents in the bins (straightening up cups, making sure items don't touch) to ensure that it looked neater than the control condition. The data collection methods were the same as in the control condition.

For the third condition, we changed the background colour of the bins by removing the white-coloured paper background and replacing it with a red-coloured paper background to test whether using red as a background colour had an effect on participants' waste sorting behaviours. The data collection methods were the same as in both the control and the second condition.

As this was an observational study, we did not require consent from the participants.

Results

Since we were interested in whether the changes in bins will lead to faster sorting behaviour, independent samples t-tests (one-tailed) were conducted to determine consistency of our results with our hypothesis. Thus, t-scores were generated to determine the significance of the 3D displays in bins between the control and experimental group.

Figure 3 in the appendix shows the mean reaction time of sorting behaviour for each of the three conditions. For the control group, people's average reaction time of sorting behaviour was 3.0391 seconds (S.D. = 4.31447 seconds). The condition with less items and red-background in the bin had average reaction time of 3.7285 seconds (S.D. = 3.25194 seconds) and 3.9269 seconds (S.D. = 3.69192 seconds) respectively.

In order to determine the significance of the effect of different displays on sorting time, we ran independent sample t-tests with alpha level of .05 (1 tailed), to determine whether the means of the control group and experimental group differ significantly. The critical t-value used to determine significance of the results is 1.895 ($p < 0.05$). An one-tailed independent samples t-test revealed that less items group sorted garbage significantly faster than the control group, $t(7)= 1.74$, $p=.06$. As for the differences between control group and red-background bin, an one-tailed independent samples t-test revealed that red-background group sorted garbage significantly faster than the control group, $t(7)= 0.25$, $p=.43$.

Another part of the studies measured the sorting accuracy on different conditions, which was conducted with a qualitative method. As shown in Figure 4, numbers of accurately waste sorting for the control group, the less items group, and red-background groups were 119, 86, and 89 times respectively. Converted to percentage (N = 158 for control group, N = 121 for less items group, and N = 109 for red-background group), we had found that control group had an accuracy of 75%, less items group had accuracy of an 79%, and red-background group had an accuracy of 82% in correctly sorting out the garbage.

Another part of the studies measured the sorting accuracy on different conditions, which was conducted with a qualitative method. As shown in Figure 4, numbers of accurately sorting garbage for control group, less items group, and red-background groups were 119, 86, and 89 times respectively. Converted to percentage (N = 158 for control group, N = 121 for less items group, and N = 109 for red-background group), we had found that control group had an accuracy of 75%, less items group had accuracy of an 79%, and red-background group had an accuracy of 82% in correctly sorting out the garbage.

Discussion

The results from the independent sample t-test were consistent with our hypothesis that the interaction between the number of items and colour of the background in the bins would increase both speed of sorting the items and accuracy of sorting behaviour. We have found that sorted 3D bins with red backgrounds had the most accuracy for sorting garbage. 1-2 item 3D bins with white backgrounds also had increased accuracy, but not as much as the red background bin. As for the sorting time, we have found that 3D bins with red background took the most time among people to sort out their garbage. Red-background 3D bin was the slowest for people to sort out.

Possible inter-rater reliability is a major flaw within this study. Each member may have recorded data slightly differently as we did not set up a proper baseline for data collection, and thus our data may be unreliable. In addition to this, due to some participants having their back facing us, sometimes we could clearly not identify the items that participants threw into each bin. We also failed to determine whether if changing the red background improved participant's waste sorting behaviours, or removing items improved participants' waste sorting behaviours, since we manipulated two different variables for the third condition. If we were to rerun the study, we would test each condition separately, by testing for a red background, cluttered arrangement condition to find whether an effect exists. We would also find a better location to observe participants' waste sorting behaviours, as sometimes we would not be able to identify what participants were holding.

In addition, the fact that we conducted our study exclusively in the Pie R Squared restaurant, meant that most of the waste that participants were sorting was waste from the Pie R Squared. This meant that the majority of the items being thrown out were paper plates, and thus damages the external validity of our study since our results only apply to the Pie R Squared. Moreover, because there are red bars behind the Sort-It-Out waste bins, it camouflaged the red background of the display bins. This could be another limitation to our results since it could potentially prevent the red background from being appealing and lessen the effect.

Finally, despite its implications, the study is generally quite weak in determining whether or not changing the appearance of the 3D enclosures has a major effect on the waste sorting behaviours of UBC members since it only tests for a single colour and a single item arrangement. It is merely a stepping stone in exploring the viability of the 3D enclosures for UBC member waste sorting behaviours.

Even though we found a significant effect in condition 2 and 3, our results should be taken with a grain of salt due to the reliability issues and external validity issues that were present when we conducted our study. However, the attractiveness of the colour red for object visibility is clear in our study.

Recommendations for UBC clients

Based on the results of our study, we recommend that the 3D display bins be organized to 1-2 items to allow users to view the contents in the display bin better. When many items are scattered in a messy order, it is hard for users to clearly see the contents in the 3D display bin which could negatively affect their sorting accuracy. In addition, we also recommend that the 3D

display bins be placed with red backgrounds in order to increase the likelihood that the users are aware of the items in the 3D display bins. As noted in a previous study, researchers found that colours can guide attention towards important objects as they are powerful signal in nature and culture (Kuniecki, et. al., 2015). Another study found that "viewing red immediately before or during a motor response increases the response's strength and velocity" (Elliot and Aarts, 2011). These studies indicate the powerful effects of the colour red in terms of attention and motor responses. By allowing users to view the contents of the 3D display bins more clearly, it can promote better sorting accuracy leading to an ecologically friendly UBC. One of the challenges we had when conducting this study was that some people took a longer time to open and close the lids on the garbage bins which may have affected their sorting time accuracy. Therefore, we recommend that future studies should remove the lids when replicating this study. We also recommend that future studies should find better locations to conduct the study as we had trouble viewing what the participants were holding when throwing away their trash. Replicating the results to other locations can be especially helpful as our results applied specifically to Pie R Squared.

Appendix

Figure 1 Statistical Tests

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Control group	8.854	157	.000	3.03911	2.3611	3.7171

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Less items	12.612	120	.000	3.72851	3.1432	4.3138

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Red-background	12.719	142	.000	3.92692	3.3166	4.5372

Figure 2

	N	Mean	Std. Deviation
Control group	158	3.0391	4.31447
Less items	121	3.7285	3.25194
Red-background	143	3.9269	3.69192

Figure 3 Mean reaction time of sorting behaviour

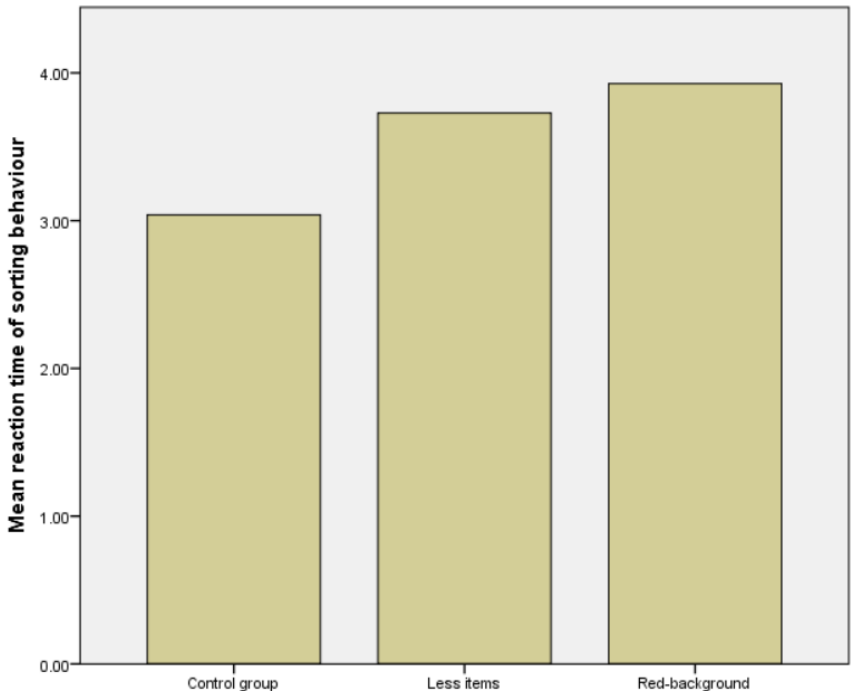

Figure 4 Percentage of accurately throwing away trash

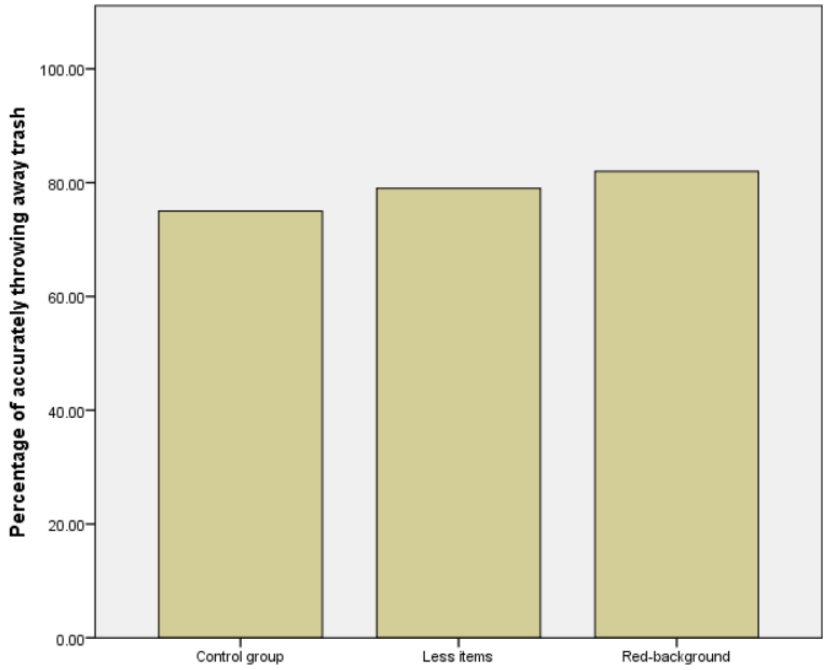

Figure 5 Data collection

Date / Time	March 7th Tuesday Condition 1: control			March 10th Friday Condition 1: control			March 14th Tuesday Condition 2: less items			March 17th Friday Condition 2: less items			March 21st Tuesday Condition 3: red			March 24th Friday Condition 3: red		
12:00pm	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	0.360 0.460 0.920 0.210 0.116 0.802 0.232 0.361 1.541 1.6219 .0	✓ ✓ ✓ ✓ X ✓ X ✓ ✓ ✓ ✓ X ✓ ✓ X ✓ X X ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	4.480 0.80 0.923 3.053 .074 .784 4.054 .320 0.710 0.86	X ✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	2.451 1.341 .7812 .349 .432 .341 .456 .564 .452 .37	✓ ✓ ✓ ✓ ✓ X X ✓ ✓ X ✓ ✓ ✓ X ✓ ✓ X ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	1.893. 033. 023. 022. 354. 898. 331. 314. 451. 451. 16	X ✓ X X ✓ ✓ ✓ ✓X ✓X ✓ ✓X ✓ ✓ ✓ ✓ X X ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	19.2 15.5 91. 072. 983. 326. 052. 212. 542. 854. 21	✓ ✓ X ✓ ✓ ✓ X ✓ ✓ ✓X X ✓ ✓ ✓ ✓ ✓ X ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	12:00 11.09 13.57 3.220. 672. 564. 10. 925. 95	✓ ✓ X X ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ X ✓ ✓ ✓

	23 24 25 26 27 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48	1. 38 3. 2 0. 16 0. 17 3. 82 1. 72 1. 23 1. 31 5. 21 3. 98 4. 75 10 .0 1. 39 0. 99 0. 31 1. 56 1. 28 1. 97 2. 34 0. 84 1. 33 1. 58 0. 67 0. 74 0. 17 0. 16 2. 3 1. 95 1. 03 1. 21 1. 85 3. 03 1. 55 0. 52 3. 53	✓ ✓ ✓ X X ✓ ✓ ✓ X ✓ ✓ ✓ X X ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓	23 24 25 26 27 29 30 31 32 33 34	4. 6 0. 4 0. 8 7. 42 0. 18 11 .8 7 12 2. 76 0. 81 0. 58 1. 71 0. 9 0. 98 0. 65 2. 46 0. 5 0. 65 4. 7 6. 72 7. 57 5	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓	23 24 25 26 27 29 30 31 32 33 34 35 36 37	1. 23 3. 63 3. 67 2. 34 2. 89 1. 23 1. 28 3. 98 10 .2 9 5. 68 2. 14 1. 35 2. 38 5. 99 1. 28 3. 56 2. 3 4. 56 4. 85 12 .6 8 1. 97 2. 37 8. 76	✓ ✓ ✓ X ✓ ✓ ✓ X ✓ ✓ ✓ X ✓ ✓	23 24 25 26 27 29 30 31 32	15 .7 2 7. 42 1 1. 18 3. 63 3. 53 1. 73 1. 06 0. 86 8. 28 1. 2 6. 43 1. 51 5. 1 5. 1 3. 13 1. 02 0. 68 0. 98	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	23 24 25 26 27 29 30 31 32 33 34	2. 82 0. 55 6. 76 7. 76 1. 05 3. 93 1. 22 1. 2 1. 99 1. 27 6. 22 3. 53 1. 41 1. 16 4. 72 1. 52 3. 27 0. 97 4. 06 3. 93 3. 06 3. 08	✓ ✓ ✓ X X ✓ ✓ ✓ ✓ ✓ ✓ X	23 24 25 26 27 29 30 31 32 33 34 35	2. 45 1. 24 12 .5 5 6. 15 1. 51 7. 87 5. 15 0. 77 0. 61 9. 91 1. 56 3. 87 11 .1 3. 69 2. 36 0. 15 1. 96 6. 61 7. 51 4. 12 1. 98 0. 14 5. 62 1. 99	✓ ✓ ✓ ✓ X ✓ ✓ ✓ X ✓ X ✓ ✓

		1. 68																
3:00pm	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 29 30 31 32 33 34 35 36 37 38 39 40	1. 210. 522 1 1 1 2 0 0 1 0. 570. 977. 561 1. 68 1. 252 1. 2 13 .9 1 3 1 2. 585. 951. 351. 481. 221. 832. 782. 563. 9710 .1 4 1. 523. 32	X ✓ ✓ ✓ ✓ ✓ X X ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ X X ✓ ✓ ✓ X ✓ ✓ ✓X	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	22 .11 3. 361. 7633 .17 4. 072. 852. 121. 592. 523. 133. 914. 483. 8511 .32 3. 342. 294. 75	✓ ✓ ✓ ✓ ✓ ✓ ✓ ? ✓ ✓ ✓ ✓X X ✓X ✓ X ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	2. 415. 22. 53. 573. 382. 21. 766. 910 .79 1. 86. 233. 6910 .75 2. 861. 588. 783. 436. 596. 267. 35	X ✓X X ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓X ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26	1. 284. 311 .88 11 .55 3. 993. 511. 675. 3914 .93 1. 673. 224. 052. 621. 431. 891. 682. 824. 525. 763. 684. 382. 834. 46	✓ ✓ ✓ ✓ ✓ ✓ X ✓X ✓ ✓ X ✓ X X ✓ ✓ ✓ X X ✓ ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25	3. 264. 211. 311. 191. 560. 83. 637. 816. 71. 462. 493. 240. 981. 451. 924. 673. 231. 921. 41. 241. 381. 562. 655. 931. 23	✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	2. 32. 20. 9212 .63 1. 561. 2910 .48 0. 90. 765. 261. 121. 280. 6512 .73 5. 623. 351. 521. 533. 442. 353. 342. 113. 32	✓ ✓ ✓ ✓X ✓ ✓ ✓X X ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ ? ✓ ✓ ✓

		1.162.8713.36																
6:00pm	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy	Participant	Time (sec)	Accuracy
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	4.52.30.530.3616.560.131.843.590.150.210.170.539.490.13	✓ ✓ ✓ ✓ ✓ X X ✓ ✓ ✓ ✓ ✓ ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12	0.541.521.769.942.210.140.670.340.860.781.124.41	✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓	1 2 3 4 5 6 7 8 9	1.420.510.260.110.170.910.231.591.03	✓ ✓ X ✓ ✓ ✓ ✓ ✓ X ✓	1 2 3 4 5 6 7 8 9	2.391.011.090.780.650.270.950.860.49	✓ ✓ ✓ X X X ✓ ✓ ✓	1 2 3 4 5 6 7 8 9	1.891.092.564.415.183.484.760.110.15	✓ ✓ ✓ ✓ ✓ X X ✓ ✓	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	1.111.542.560.244.623.369.913.351.122.119.175.378.564.2416.629.983.920.893.89	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ X ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓

Figure 6 Pictures

Figure 6.1 - Condition: cluttered items, white background

Figure 6.2 - Condition 2: With less items: 1-2 items per bin and a white background

Figure 6.3 - Condition 3: With less items and a red background

References

Elliot, A. J., & Aarts, H. (2011). Perception of the color red enhances the force and velocity of motor output. *Emotion, 11*(2), 445-449. doi:10.1037/a0022599

Kuniecki, M., Pilarczyk, J., & Wichary, S. (2015). The color red attracts attention in an emotional context. An ERP study. *Frontiers in Human Neuroscience, 9*, 212. doi:10.3389/fnhum.2015.00212

Wexner, L. B., & Wexner, L. B. (1954). The degree to which colors (hues) are associated with mood-tones. *Journal of applied psychology, 38*(6), 432-435 , 432-435. doi:10.1037/h0062181