Informal Learning Spaces; Impacts on Cognitive Functioning and Environmental Perception

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Executive Summary:

The goal of this research was to identify the relationship between informal learning spaces on campus and students' well-being, cognitive function and environmental perceptions. In order to collect this information surveys were distributed across four different locations on the University of British Columbia Vancouver Campus. The locations included Douglas Kenny (Kenny) building, Engineering Student Centre (ESC), Forest Science Centre (Forestry) and Centre for Interactive Research on Sustainability (CIRS) buildings. To measure participant's cognitive performance, we used a spatial working memory task (working memory span), cognitive control task (executive function) and Raven's matrices (fluid intelligence). Furthermore, an additional measure for self-authenticity, affective states (using PANAS) and environmental perception were assessed through a survey via computers. Findings for cognitive performance and affective states were insignificant with environmental perceptions showing the only significant results. Kenny was perceived to be uglier than all other buildings, dirtier than CIRS and Forestry, and quieter than ESC showing that Kenny was perceived to be a less environmentally stimulating building. Regardless of significance, Kenny had the longest reaction times in cognitive control tests leading us to believe that there could be a correlation between low environmental stimulation and cognitive control reaction times.

Introduction:

The research question of this paper was, "How do informal learning spaces on campus influence students' well-being, cognitive function and environmental perceptions?" In this paper well-being will be used as a blanket term that encompasses self-authenticity and affective states. We hypothesized that participant's performance (cognitive and affective) and environmental perceptions would be worse in the Douglas Kenny (Kenny) building than in the Engineering Student Centre (ESC), Forest Science Centre (Forestry) or Centre for Interactive Research on Sustainability (CIRS) buildings (Figures 1-4). We hypothesized that Kenny would have the worst results on cognition, affect and environmental perceptions because it is the oldest and least updated building of the four as it was built in 1984 and all other buildings were built within the last 20 years.

Methods:

Participant Population and Procedure:

The participant population consisted of mainly students who utilized either the CIRS, ESC, Forestry or Kenny buildings. The total number of participants was N=100 (male=39, female=60, other=1) with n=25 per building and the average age of 20.9 years old. The largest reported faculty was Arts (n=36), with Engineering (n=31), Science (n=19) and Forestry (n=9) following and the lowest reported faculties being Land-Food-Systems (n=3), Kinesiology (n=1) and Commerce (n=1).

The data was collected between February 27th, 2017 and March 24th, 2017 between the hours of 9:00AM and 5:00PM on Monday-Friday. Distributions of the surveys were preceded by verbal consent from the participants. A reward of a treat and the opportunity to enter a raffle to win a Starbucks gift certificate was given upon completion of the survey.

Conditions:

The four conditions in this study are the informal learning spaces in the four buildings previously outlined (CIRS, ESC, Forestry and Kenny). Images outlining the specifics of these ILSs can be found in Appendix A.

Measures:

This study has a correlational design investigating the relationship between the informal learning spaces and the participants cognitive and affective performance as well as environmental perception. To measure participant's cognitive performance, we used a spatial working memory task (working memory span), cognitive control task (executive function) and Raven's matrices (fluid intelligence). Furthermore, an additional measure for self- authenticity, affective states (using PANAS) and environmental perception was assessed through a 1-7 likert scale on a survey via computers. The survey questions can be found in Appendix B.

Results:

Cognitive Testing:

The finding of the cognitive tests were statistically insignificant. The Raven's Matrices' to test fluid intelligence had insignificant results, $F(3, 96) = 0.69$, $p = 0.56$, $\eta_p^2 = .021$, and due to participant error the findings of the reaction times for the Raven's Matrices' are unreliable. The Forestry building had the lowest average of correct answers for the Raven's Matrices' tests (M=2.4, SD = 1.96) (Figure 5). Spatial working memory tasks to test working memory span showed insignificant results, $F(3, 96) = 0.56$, $p = 0.64$, $\eta_p^2 = .64$, with CIRS having the lowest

average spatial working memory capacity (M=6.48, SD = 1.87) (Figure 6). Cognitive control tasks to test executive function showed insignificant results, $F(3, 96) = 1.40$, $p = 0.25$, $\eta_p^2 = .04$, (Figure 7), as well as the reaction times for the cognitive control tasks were insignificant, $F(3, 96) = 1.33$, $p = 0.27$, $\eta_p^2 = .04$, with Kenny holding the longest average response time for any given correct answer (M = 4558.69 ms, SD = 2761.47) (Figure 8).

Affective Testing:

The results for affective testing were found to be insignificant for both positive, $F(3, 96) = 0.59$, $p = 0.62$, ηp2 = .02) and negative, $F(3,96) = 0.25$, $p = 0.86$, $\eta_p^2 = .0080$, affective states (Figure 9). Findings showed that participants in ESC had the greatest negative affective state (M =1.96, SD = 0.60**)** as well as had the highest positive affective states (M = 2.89, SD = 0.72). Furthermore, the findings of self-authenticity were insignificant, $F(3, 96) = 1.37$, $p = 0.25$, $\eta_p^2 = .041$ with the least self-authentic building being CIRS (M = 4.73, SD = 1.15) (Figure 10).

Environmental Perceptions:

The findings for three of the six environmental perceptions scales were found to be statistically significant. The ugly-beautiful scale had significant results, $F(3, 96) = 12.385$, $p < 0.05$, $\eta_p^2 = .28$, with the Kenny building perceived as less beautiful (M= 3.56, SD = 1.56) (Figure 11). A post hoc comparison using the Tukey HSD test indicated that the Kenny building is statistically different with a p-value of $p < 0.05$, than all other buildings. The dirty-clean scale also had significant results, $F(3, 96) = 7.39$, $p = 0.00010$, $\eta_p^2 = .19$, with the Kenny building being perceived as less clean by its patrons (M = 4.64, SD = 1.52) (Figure 12). The post hoc Tukey HSD test indicated that the Kenny building is statistically different than the FSC (p = 0.004) and CIRS (p = 0.00010). However, the Kenny building was not statistically significant from the ESC (p = 0.11). Additionally, the loud-quiet scale had significant results as well,$F(3, 96) = 3.15$, $p = 0.029$, $\eta_p^2 = .090$, with the Kenny building being perceived as the most quiet (M = 5.60, SD = 1.26). The post hoc Tukey HSD test revealed that the Kenny building was statistically significant from the ESC with a p-value of $p = 0.050$ (Figure 13). The other three variables tested, which yielded insignificant results were scales of crowded-spacious, $F(3, 96) = 0.66$, $p = 0.58$, $\eta_p^2 = .020$, with the most perceived crowded building being Forestry (M = 5.00, SD = 1.41) (Figure 14), unsafe-safe, $F(3, 96) = 0.52$, $p = 0.67$, $\eta_p^2 = .016$, with the most perceived unsafe building being the Kenny building (M = 6.08, SD = 1.35) (Figure 15), and uncomfortable-comfortable, $F(3, 96) = 0.48$, $p = 0.54$, $\eta_p^2 = .015$, with the most perceived uncomfortable building being Kenny (M = 5.24, SD = 1.54) (Figure 16).

Discussion:

Our findings showed that Kenny was perceived to be a less environmentally stimulating or pleasing environment in a variety of ways. A key part of this environmental perception that could be linked to lower health and therefore lower cognitive-executive functioning is the significantly dirtier appearance of the Kenny building. While it was not statistically significant, Kenny had the longest reaction times in cognitive control tests in comparison to the other buildings and this could point to a potential relationship between environmental perception and cognitive functioning (Figure 17 and 18). This implies that there could be a connection between executive functioning and environmental perception of dirtiness and ugliness. One way that this could happen is via perceived health. When people perceive that they are being exposed to poorer environmental conditions, even if they actually are not, their health symptoms reflect that of a person in an unhealthy environment (specifically increase in CO_2 levels) (MacNaughton et. al., 2016). Perceived health and executive functioning is a relationship worth further

examination and could likely help explain why executive functioning was slower in Kenny. This can be attributed to the Sick Building Syndrome (SBS), in which individuals who reported any SBS symptoms took 7% longer to finish a computerized neurobehavioral test, and had 30% higher error rate on another test (Fisk, 2000).

Research has also found that styles that are perceived as more aesthetically pleasing are associated with increased central executive processing and more positive emotional response (Cheung, Law, & Yip, 2014). In this study,we found that that the Kenny building was rated as significantly uglier. The low aesthetic appeal of Kenny can be associated with the longer reaction time of the participants from the Kenny building on cognitive tasks. In other words, it could be possible that the perception of Kenny as less aesthetically pleasing affected the cognitive performance on executive control tasks (Cheung, Law, & Yip, 2014). This connection between perceived aesthetics of Kenny and performance on executive control task should be furthered studied via an experimental study. A previous study examined the relationship between cognitive states and aesthetics in the field of neuroaesthetics and evidence from neuroimages and brain damage illustrated that perception of aesthetics "arise from" neural networks that are responsible for cognitive tasks such as sensory-motor and meaning-knowledge processing (Pearce, Zaidel, Vartanian, Skov, Leder, Chatterjee & Nadal, 2016).

Further, "greenness" of a building (better ventilation, lighting and reduced humidity levels) is associated with physical well-being (Thatcher & Milner, 2013). Kenny lacks the perceived "greenness" factor, and is ill-ventilated and dim lit. Therefore, it could be that, due to lack of perceived "greenness" in Kenny, participants demonstrated lower self-reported well-being.

Additionally, our findings are echoed in a case study investigating the effect of improved indoor environmental quality on perceived health (Singh et al, 2010). In their study, Singh et al. examined occupants who moved from conventional to green office buildings and found that an improvement in indoor environmental quality contributed to reductions in perceived absenteeism and work hours affected by asthma, respiratory allergies, depression, stress and more importantly, self-reported improvements in productivity. In relation to our findings of the low perception of aesthetics and cleanliness in the building, this case study would suggest that cognitive performance of participants in Kenny is related to their less than ideal perception of their environment.

There are several limitations to our study. One of the limitations of this study is that it is a natural correlation. Hence, no causal inference can be drawn from it. Potentially, future research can attempt to test if there are any causal relationships between perceived cleanliness, aesthetic appeal of the building, and cognitive performance. Another limitation of this study was researcher's time constraints and technical issues (discussed in detail in Appendix D) that did not allow for large data collection. Therefore, it is hard to say whether the results were insignificant because of lack of correlation among the variables or due to lack of participants in each conditions. Thus, the survey needs to be conducted for a longer amount of time (more than three weeks), in order to obtain more participants, and to rule out the possibility that lack of any significant results were due to small participant size.

Furthermore, The survey was quite lengthy as it took approximately 25 minutes to finish the survey. Poor performance of the participants on the cognitive tasks could have been the result of a lack of motivation due to lack of incentive and/or length of the survey causing fatigue. An experimental design will be needed to test out whether the participants are performing poorly in these buildings due to building factors or due to lack of incentivisation and/or length of the

survey, that may have caused fatigue in the participants.

There could also be a selection bias in the sample because some students who were utilising the informal learning space for relaxation purposes and not for studying purposes agreed to fill the survey as well. There could be a potential response bias in the self-reported survey part of the study. This is a limitation as it hinders us from knowing the true response of the participants specially for questions related to authenticity, connectedness, and affective questions. Therefore, this low reliability results in an untrustworthy representation of whether or not self-authenticity in these locations has an impact on cognitive functioning.

Recommendations for UBC:

Based on our findings we recommend that UBC improve the aesthetic quality of the Douglas Kenny building as it was perceived to be most ugly. Though the differences in cognitive abilities did not statistically differ from building to building, the correlation we observed in Figure 17, shows that there could be a correlation between perception of aesthetics and cognitive functioning, suggesting that the Kenny building has the most to gain after renovations. Furthermore, expanding on the correlation we found between perception of aesthetics, cleanliness and participant cognitive control ability, it might be worthwhile for UBC to conduct additional studies to look closely at the relationship between these two variables. Findings on the correlation between the two could serve as a potential benefit or cost in deciding whether huge investments or superficial changes are better suited for the optimization of student cognitive control.

To this extent, we recommend that UBC start improving the aesthetics of the Kenny building in small increments at first. For example, an initial step to improving the perception of aesthetics is by purchasing and placing superficial items to make the building prettier; plants, change of furniture etc. As results from the suggestions we have proposed become more prevalent, UBC can then potentially make investments in creating a more aesthetically appealing informal learning space in the Kenny building by either modifying the structure of the first-floor Informal Learning Space or creating a different Informal Learning Space within the Kenny building.

As we mentioned in our discussion, we found that there were no significant differences between buildings for the correct number of responses in the Raven's matrices (Figure 5). This could be due to multiple reasons such as there might not be an effect. Also, due to the restricted and unequal sample size across all locations, around 3 students on average were excluded from this analysis because they were not able to do the task at all from the 8 different trials. The Raven's test as we come to understand is a universal measure of fluid intelligence and therefore, students should be able to do it. An alternative explanation is the lack of incentive to do the study, which can explain the many times people decided to say no to participating. We also think UBC should also conduct more studies into why students across all buildings struggled with the Raven's Matrices.

In the future, when conducting this or similar studies, the study could be an HSP study instead allowing for more participants who are eager to improve their learning to complete this study, which are the students who are actually using informal learning spaces for studying. It would also allow for more control over what students are doing before completing the survey, for instance, forcing participants to study for 20 minutes prior to completing the survey.

Appendix A: Informal Learning Spaces

Figure 1*:

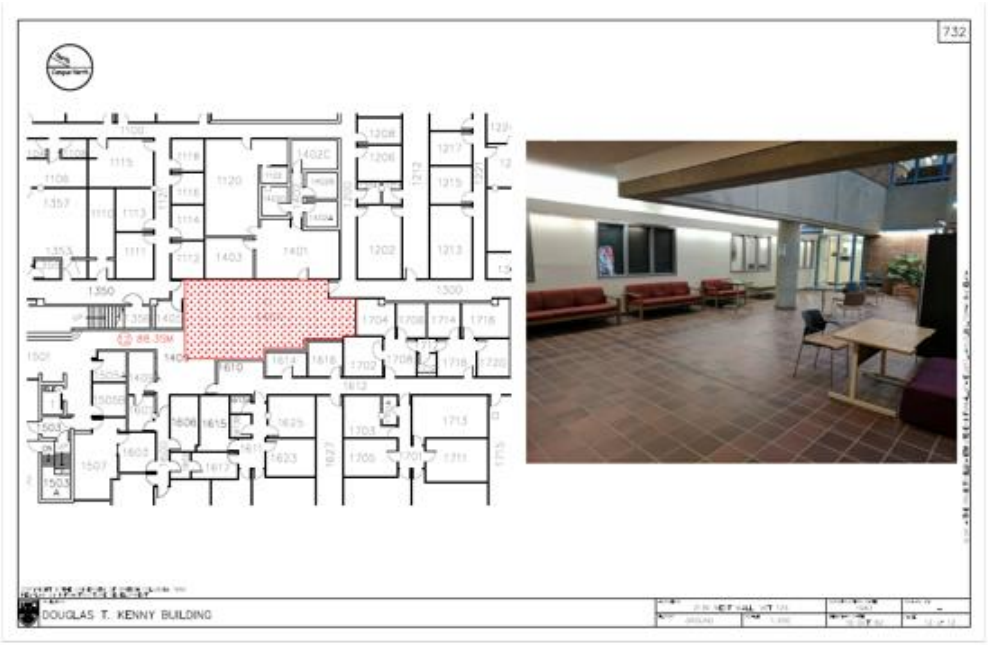


Figure 2*:

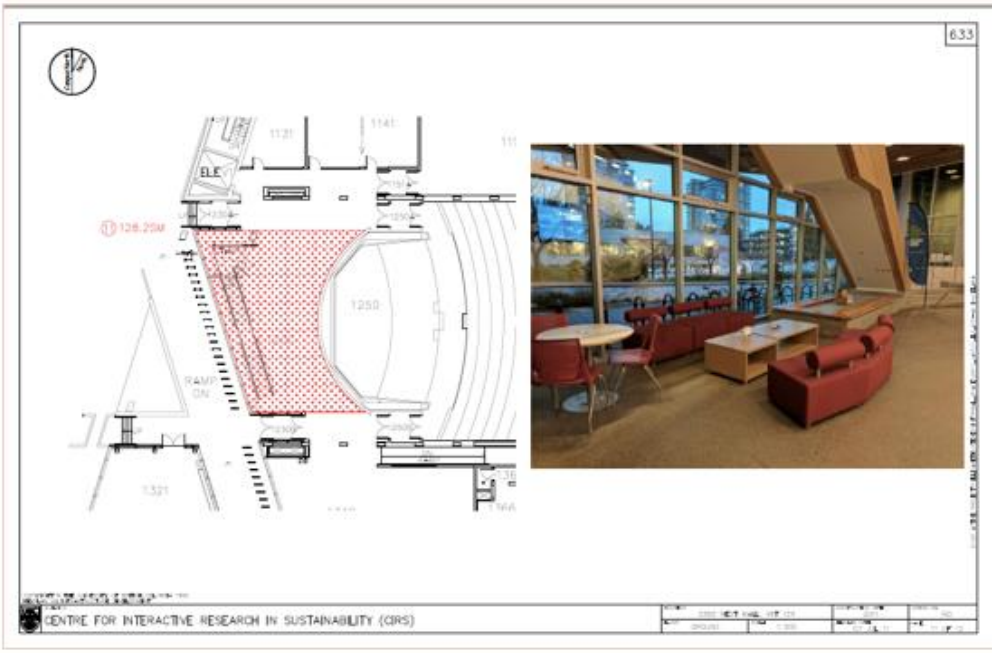


Figure 3*:

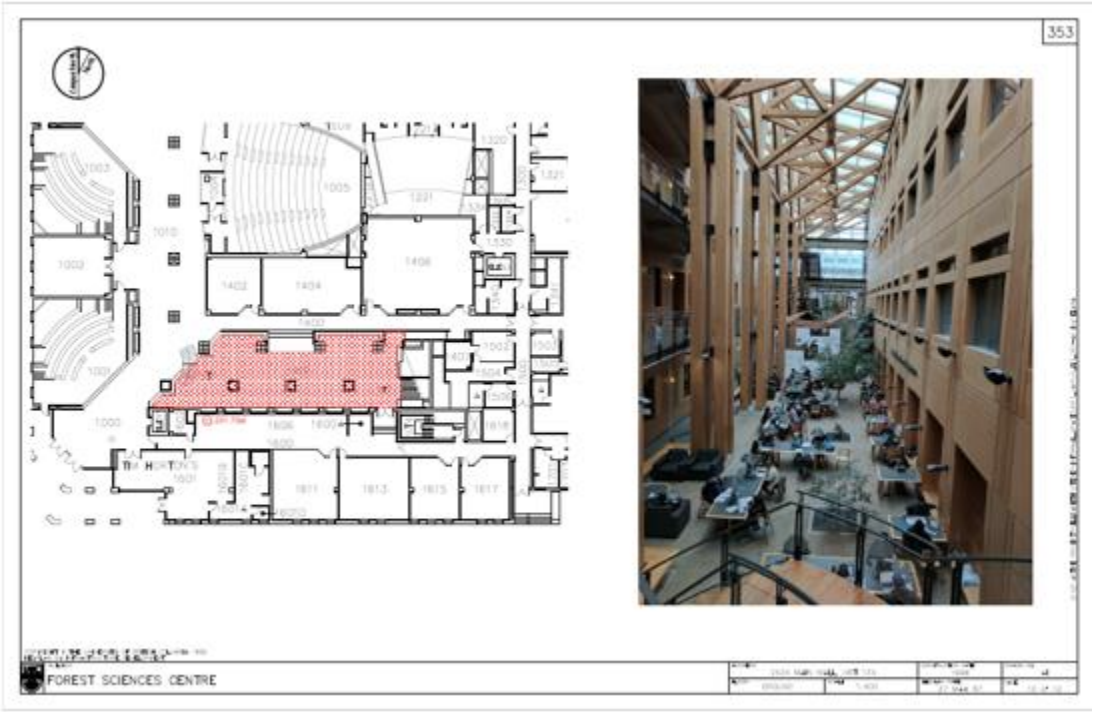
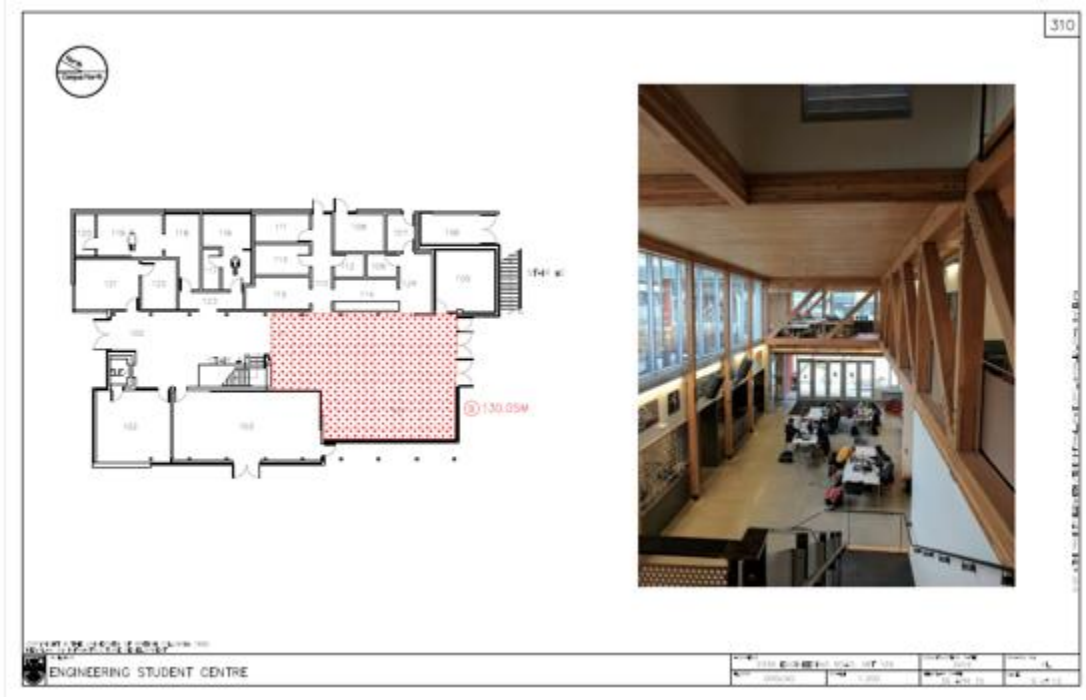


Figure 4*:



* Areas surveyed are marked in red

Appendix B: Survey Design

Self-authenticity questions:

1. Right now…

o (1) I feel inauthentic	(7) I feel authentic
o (1) I feel like I cannot be my true self	(7) I feel like I can be my true self
o (1) I feel like I don't "fit" in this space	(7) I feel like I "fit" in this space

2. How frequently do you visit this space during the academic year?

- o 0 = never
- o 1 = once a year
- o 2 = 2-6 times per year
- o 3 = once a month
- o 4 = twice a month
- o 5 = once a week
- o 6 = 2-5 days a week
- o 7 = every day

3. When you visit this space, is it by choice or by obligation (sliding scale)?

- o 1 = completely by choice
- o 4 = both by choice and by obligation
- o 7 = completely by obligation

4. This space is for general learning/studying or with a specific subject/department

(1) general learning/studying / (7) Specific subject/department

5. What have you come to this space to do today? _____

5A. Do you associate this space with a specific department, class, or subject area at UBC?

Yes or NO

5B. If yes, what is the name you would use to most clearly identify the department, class topic, or subject area that you associate this space with? _____

5C. If you do associate this space with a specific subject or department, to what extent do you associate yourself with this subject or department? Specifically, imagine two circles with various degrees of overlap between them. Circle 1 represents YOU (i.e., your sense of self), while circle 2 represents the SUBJECT AREA you associate with this space. Keeping this image in mind, which pair of circles most accurately represents the distance between You and the SUBJECT? The two Circles are...

1: extremely overlapping
2: moderately overlapping
3: slightly overlapping
4: touching, but not overlapping
5: slightly separated
6: moderately separated
7: extremely separated

PANAS (affective questions):

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to **what extent you feel this way right now, that is, at the present moment**.

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

Interested _____
Distressed _____
Excited _____
Upset _____
Strong _____
Guilty _____
Scared _____
Hostile _____
Enthusiastic _____
Proud_____
Irritable _____
Alert _____
Ashamed _____
Inspired _____
Nervous _____
Determined _____
Attentive _____
Afraid _____
Happy _____
Energetic _____
Relaxed _____
Confident _____
Stressed _____
Anxious _____
Tired _____

Environmental perception:

How do you rate your current environment?

0=ugly to 10=beautiful
0=dirty to 10=clean
0=loud to 10=quiet
0=crowded to 10=spacious
0=unsafe to 10=safe
0=uncomfortable to 10=comfortable

How much do you like your current environment? (0=not at all, 10=very much)

Demographics:

What gender do you identify with? (female, male, other)
What is your age?
What best describes your current status at UBC? (undergrad student, grad student, faculty, staff, visitor, other)
Which department or faculty are you in? (open ended, text-box)
How long have you been at UBC? (0 to 30 years)
How busy are you at this moment? (scale, from 1=not busy at all, 10=very busy)
How much financial stress do you feel on a day-by-day basis? (scale, from 1=no stress at all, 10=a lot of stress)
What were you doing just before taking the survey? (open ended, text-box)
Are you here by yourself or with friends? (choice, by yourself, with friends)
What is your major? (open ended, text-box)

Appendix C: Results

Figure 5:

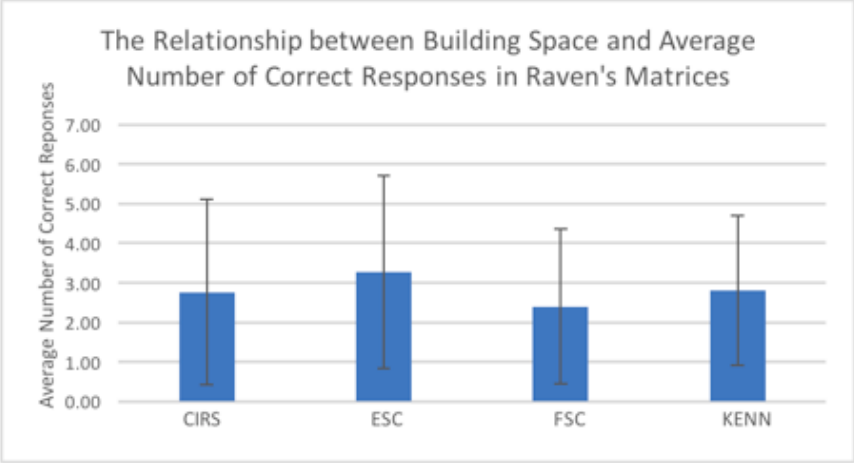
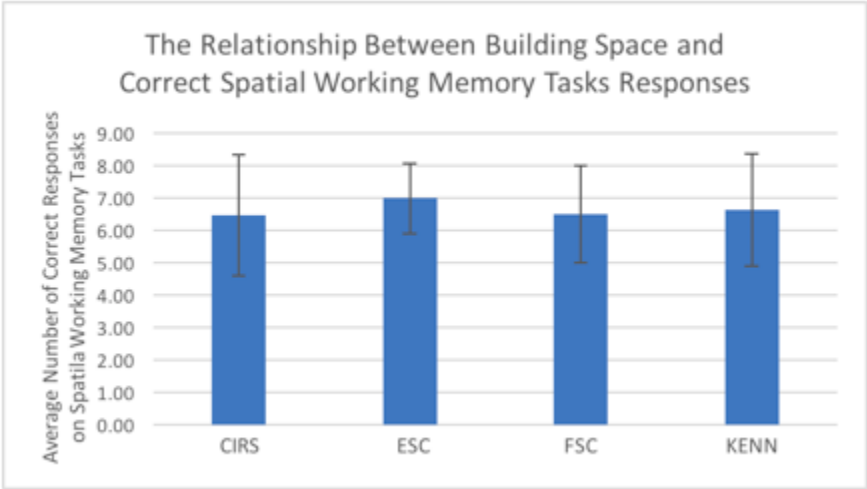


Figure 6:



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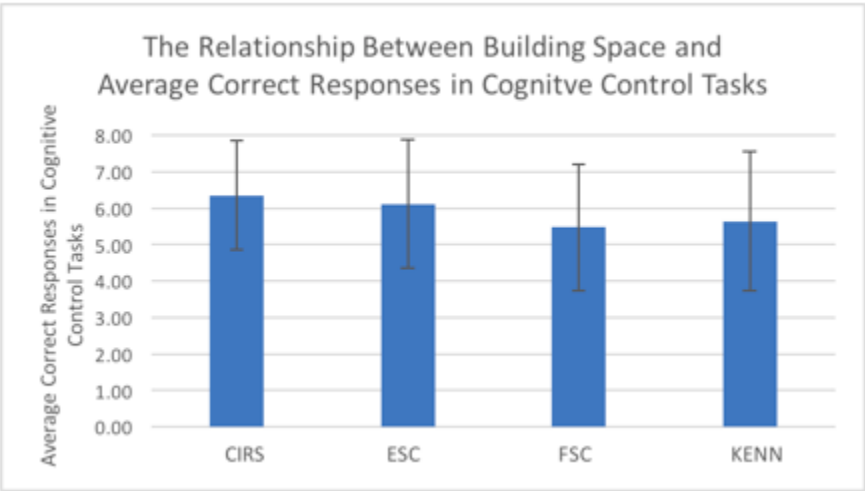


Figure 8:

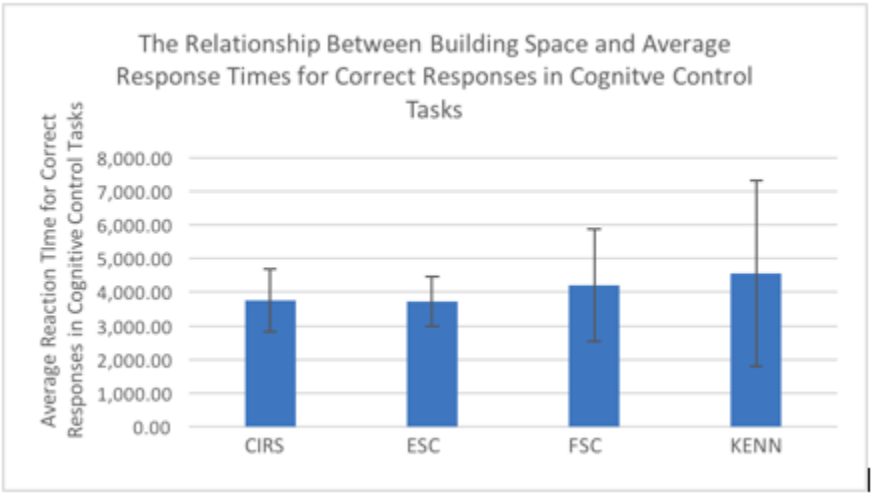
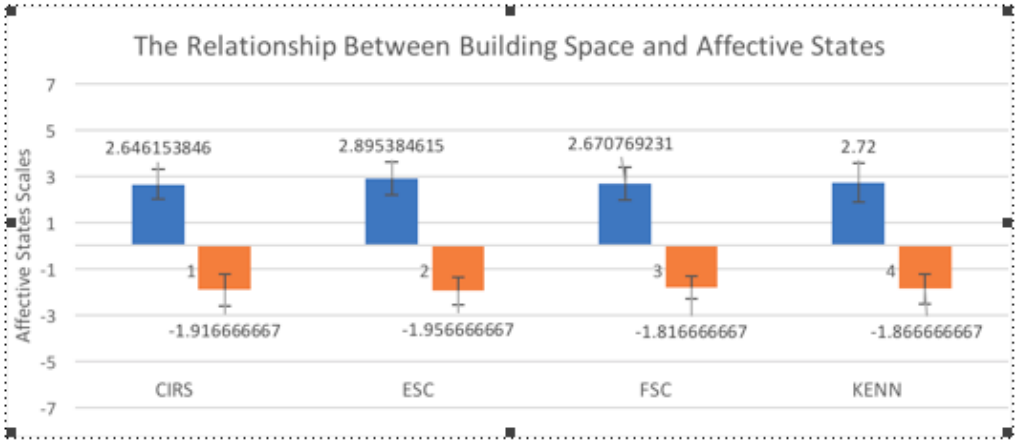


Figure 9:



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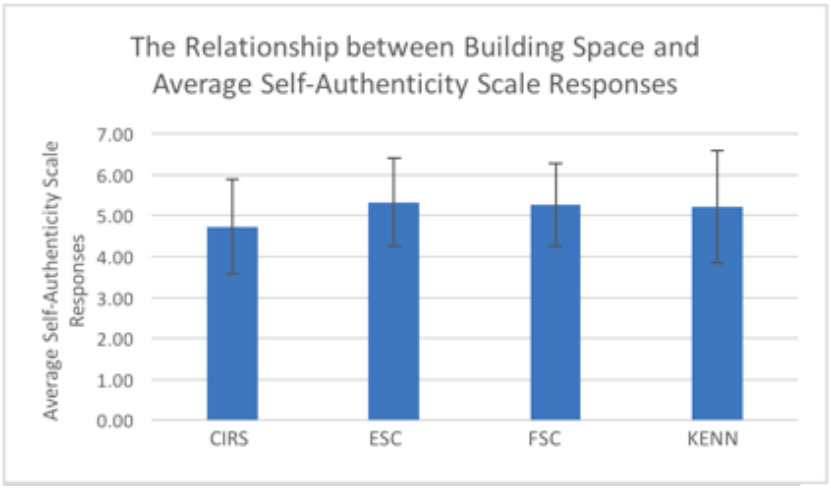

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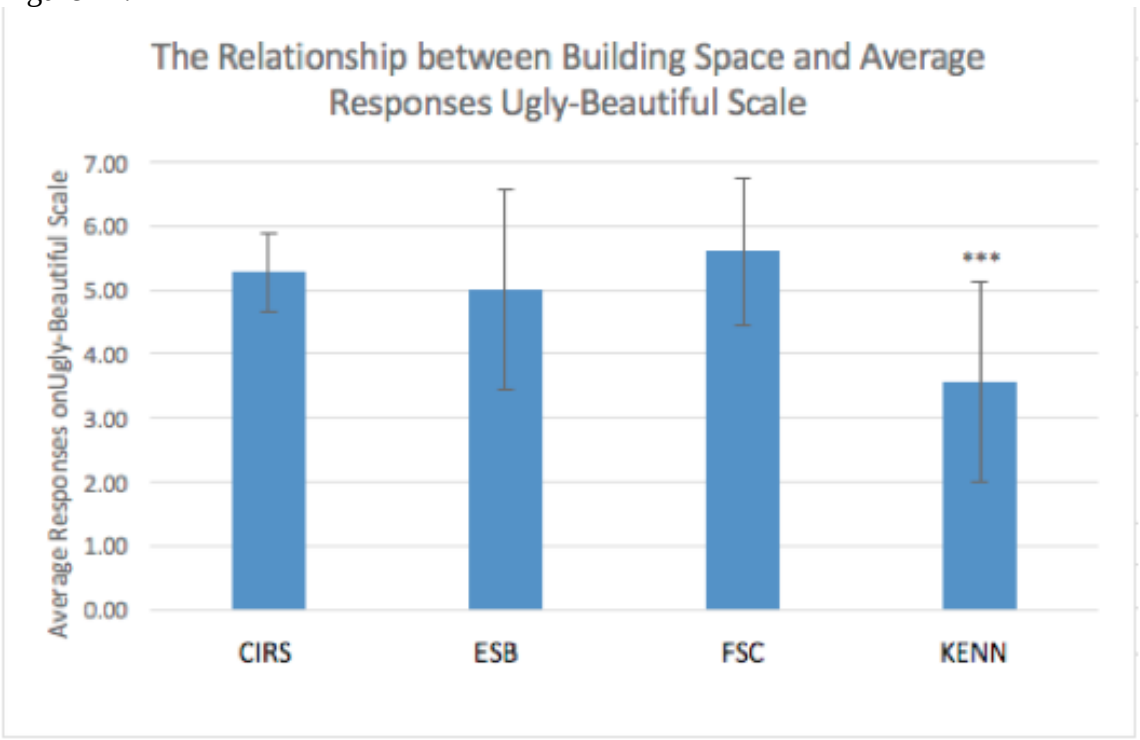

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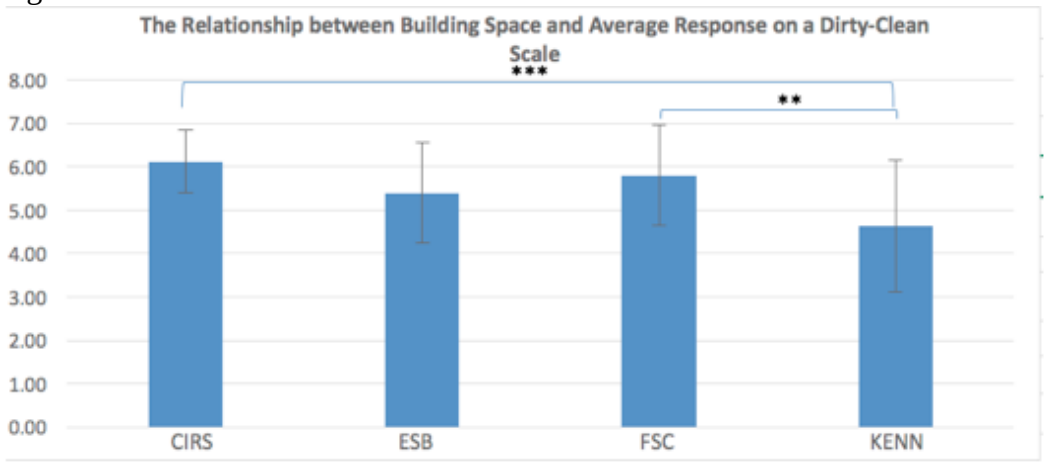


Figure 13:

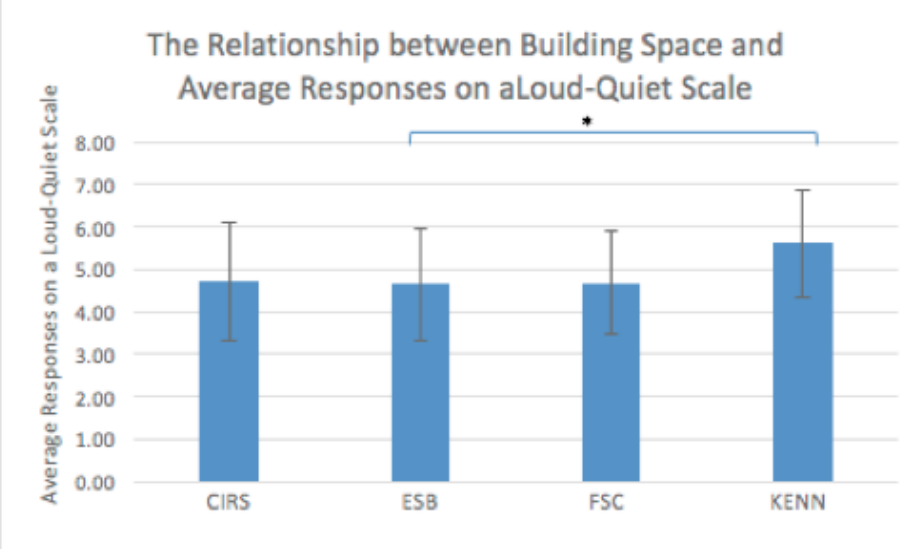
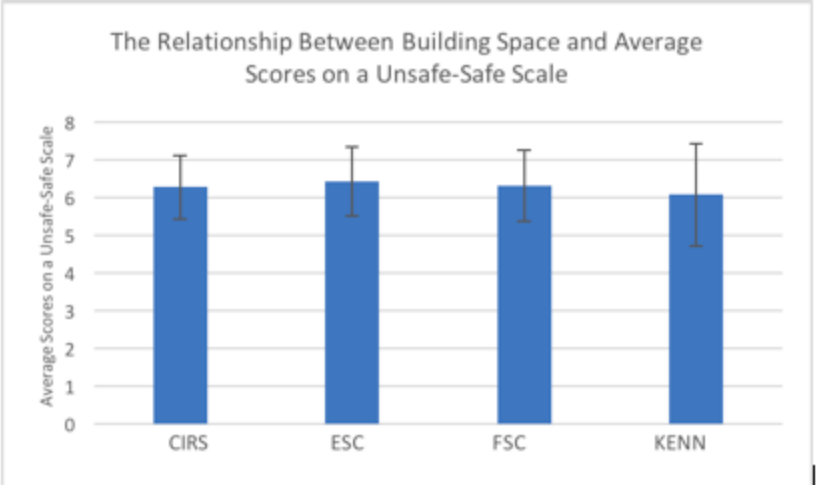


Figure 14:



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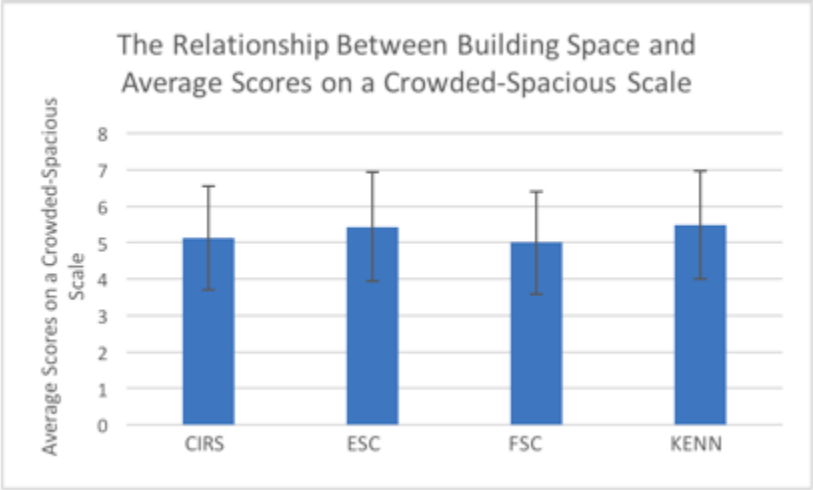

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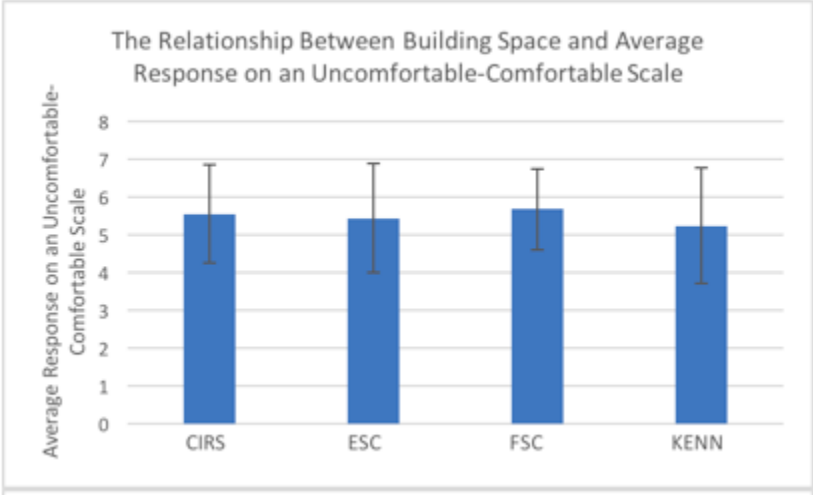
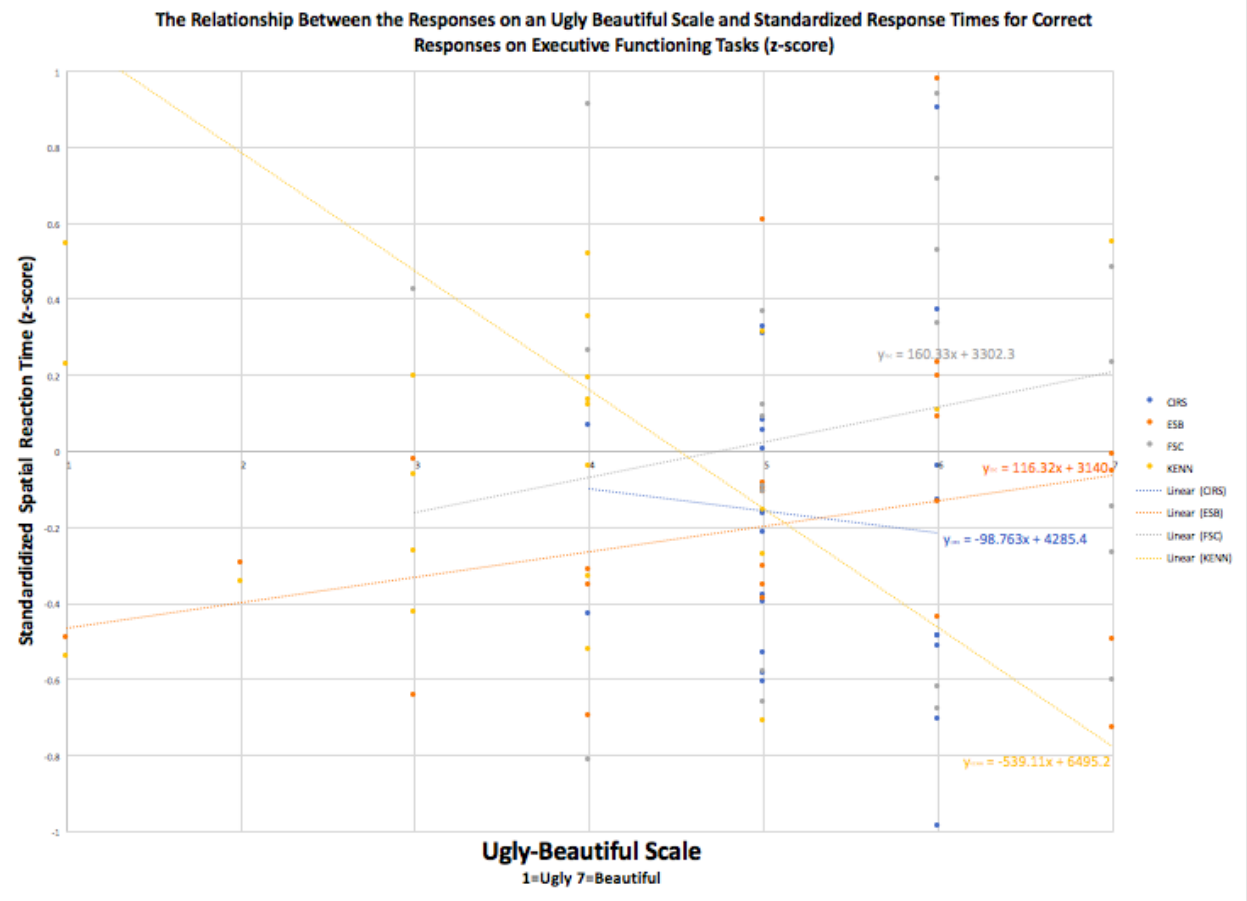


Figure 17:



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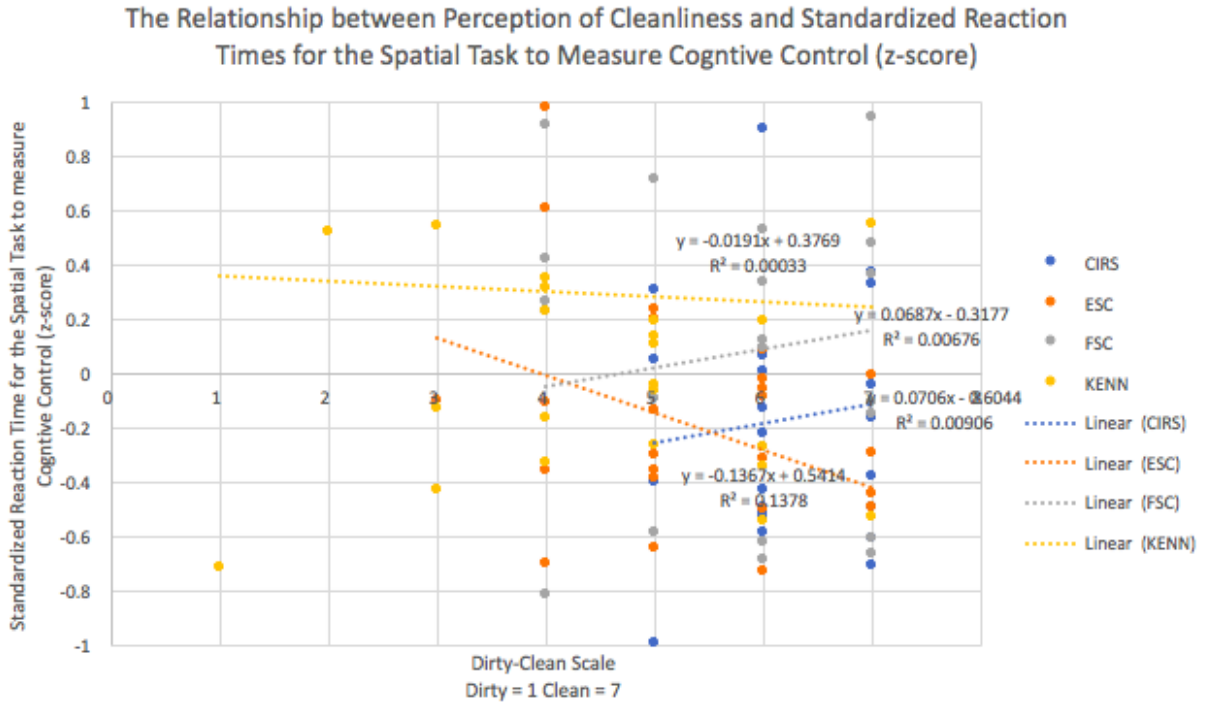
The Relationship between Perception of Cleanliness and Standardized Reaction Times for the Spatial Task to Measure Cogntive Control (z-score)
Standardized Reaction Time for the Spatial Task to measure Cogntive Control (z-score)
Dirty-Clean Scale
Dirty = 1 Clean = 7
y = -0.0191x + 0.3769
R² = 0.00033
y = 0.0687x - 0.3177
R² = 0.00676
y = 0.0706x - 0.6044
R² = 0.00906
y = -0.1367x + 0.5414
R² = 0.1378
CIRS
ESC
FSC
KENN
Linear (CIRS)
Linear (ESC)
Linear (FSC)
Linear (KENN)

Appendix G: References

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