UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Main Mall Safety: An Evaluation of the Traffic Warning Sign Colors

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Main Mall Safety:
An Evaluation of the Traffic Warning Sign Colors

SEEDERS

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Abstract

The purpose of this study was to evaluate the effectiveness of current bicycle traffic signs (BTS) implemented to encourage safe behavior between different modal-users on Main Mall at The University of British Columbia. The study sought to examine how different colors on traffic warning signs influence people's interpretation of speed. It was hypothesized that colors with socially constructed meanings of precaution and attention to detail such as yellow and red respectively will yield more accurate interpretations of speed in regards to traffic warning signs. A structured survey comprising a fictitious scenario with color manipulated traffic warning signs measured interpretation of speed at which a fictitious character will ride his/her bicycle after encountering the sign. A numerical trend emerged demonstrating red, relative to green, complied lower perceptions of speed than the control, though not statistically significant. The results infer recommendations to UBC regarding how to elicit more precaution on Main Mall through established operations.

Keywords: Perception of speed, bicycle traffic sign (BTS),

Introduction

To investigate *what types of interventions would encourage safe behavior between different modal-users (e.g., pedestrian, cyclists, skateboarders) on Main Mall* we began by examining what measures are currently being taken at the University of British Columbia (UBC) and consequently explored the effectiveness of such interventions.

Main Mall is the pedestrian core of UBC Vancouver campus. Stretching from the Institute for Computing, Information, and Cognitive Systems/Computer Science (ICICS/CS) to the Flag Pole Plaza, Main Mall is classified as a pedestrian priority route (Campus + Community Planning, n.d., p. 1). In lines with UBC's public realm plan and its goal to create a vibrant and sustainable community UBC continues to advocate for alternative modes of transport. Through a range of programs UBC has managed to discourage the use of single occupancy vehicles, and instead has promoted the use of alternative modes of transport ranging from public transit, carpooling/sharing, cycling on campus, shuttles, Safewalk emergency ride home programs, amid other sustainable transport initiatives. UBC's continuing growth with such prospective did not come without tradeoffs. In other words reducing one form of transportation results in the increase of other forms. The densification of Main Mall is becoming a growing concern, which is indicative of our aforementioned notion regarding safety on Main Mall.

An Australian report examining the frequency and magnitude of injuries resulting from collisions between pedestrians and cyclists found that pedestrian-cyclist collisions result in equally serious, non-fatal injuries in relation to pedestrian-motor vehicle accidents (Chong et al., 2009) Understandably this sheds light as to why growing congestion on Main Mall can be problematic without appropriate interventions. To address such concerns, UBC has attempted to control Main Mall traffic by implementing traffic-warning signs for cyclists. Currently, there are 7 bicycle traffic signs (BTS) that read "slow - pedestrian priority zone" (Appendix A) on all principal entrances of Main Mall (Appendix B) with plans to install 3 more.

This paper sought to investigate UBC's current interventions to encourage safe behavior between cyclists and pedestrians on Main Mall. First and foremost, we evaluated the current traffic warning signs, with particular interest regarding its effectiveness and prevalence.

Present literature has extensively examined the multitude of variables that constitute to making a warning label salient. Colored warning labels have shown to elicit higher perceived hazard and readability than achromatic warning labels. (Kline et al., 1993) Moreover, warning labels printed in red yield higher perceptions of hazard than warning labels printed in black, orange, or green. As well, research examining the prevalence of warning signs found that red labels yielded faster detection than black labels.

As the aforementioned literature suggests, color, specifically red, is a key component of making a warning label more salient and precautionary. The purpose of the BTS is to communicate to cyclists a precaution, yet these signs are located on corners just before entering Main Mall making them easy to go unnoticed for someone traveling at high speeds.

Additionally, the current BTS is depicted by a green ring, which not only adds to the concern of their prevalence, but it may also cause ambiguities in the message it is trying to convey. Given that the color green is often associated with socially constructed meanings of “proceed” and red “yield”, we sought to investigate how different colors on traffic warning signs influence people’s interpretation of speed. We first hypothesized that colors with socially constructed meanings of precaution and attention to detail such as yellow and red respectively, will yield more accurate interpretations of speed in regards to traffic warning signs. Additionally, as a secondary measure, we predicted that the red and yellow conditions would be the more associated with appropriate adjectives such as caution and attention.

Method

Subjects

N=103 participants were originally recruited. After checking for color blindness 3 participants were excluded, and another 14 were excluded for failing a comprehension check, resulting in an end total of *N*=84 (45 females, 39 males, aged 18-35). All participants were recruited on Main Mall through convenient sampling and 75 were UBC students whilst 9 were not UBC affiliated. All participants were recruited on the basis of willingness to volunteer, gave informed consent, were orally debriefed, and received a small chocolate treat in exchange for their participation. A random generator (Appendix C) was used to ensure random assignment across all conditions.

Conditions

Our independent variable (IV) was the color of the sign, which we operationally defined by manipulating the color of the existing ring on the BTS to fully colored yellow, red, or green, with the original sign as the control (Appendix D).

A between-subjects field experimental design with a structured survey (Appendix E) consisting of 16 questions ranging from demographics, color-blindness, additional data collection, filler questions, target questions, and a comprehension check was given to all participants. All components of the survey were identical across condition except for the color of the BTS sign.

Measure

Our dependent variable (DV) was the interpretation of speed at which the fictitious character Sam will ride his/her bicycle after encountering the BTS, which we operationally defined by a 5-point rating scale ranging from 5 km/h to 25 km/h (Appendix F) to gather quantitative data. Additionally, a legend (Appendix G) was provided to show average speed measures of pedestrian walking and cycling speed to assist the comprehension of velocity in this context. Also a mph conversion accompanied each option to avoid confounds for participants not used to the km/h metric. To augment the study’s internal validity, a comprehension check asking participants the destination of the fictitious character controlled against response sets and/or lack of comprehension.

The fictitious scenario (Appendix H) was used to measure our target question as it was assumed that individual's response to a fictitious character's behavior is analogous to the participant's conceptualization of the BTS.

Additionally, to examine whether a relationship between the color condition and specific adjectives existed, a secondary measure was conducted. Particularly, the secondary measure investigated which of the adjectives STOP, CAUTION, BEWARE, and ATTENTION, was most associated to each condition in order to see whether the message the sign is trying to convey varied by the color the participant was exposed to.

Procedure

Participants were recruited at 4 designated locations on weekdays between the hours of 1:00-4:00pm at W. Robert Wyman Plaza, Agricultural road and Main Mall intersection, Marta Piper Plaza, and Agronomy road and Main Mall intersection (Appendix I) based on the position of existing signs. Participants were asked if they would like to partake in a survey in exchange for a piece of chocolate. Upon receiving informed consent, participants were randomly assigned to one of the four conditions using a random generator and given a tablet to complete the survey. To ensure ethical considerations were abided by, participants were informed that if at any moment they wished to withdrawal from the survey, they could do so and all their data would be deleted.

Results

A one-way between subjects analysis of variance (ANOVA) was conducted to examine whether there was a main effect between the four conditions (control, yellow, red, green) and the perceived speed of the fictitious character Sam. A main effect revealed no significant difference between color condition and perceived speed of Sam $F(3,80) = 1.97$, $p=0.12$. Given the p value was higher than the .05 alpha levels originally set, it is likely that the results obtained were due to chance. However, the descriptive statistics did show a numerical trend where the yellow (M=9.0, SD=3.08) and red (M=8.86, SD=3.76) conditions complied lower perceptions of speed than the control (M=10.28, SD=4.69) and green (M=11.25, SD=3.69) condition, though only marginally significant. As shown in the graph (Appendix J) the general pattern gives us reason to speculate that the insignificant results may be owing to the smaller than expected sample size obtained.

To measure whether there were any specific significant interactions between all the conditions and the perceived speed, a Tukey's honestly significant difference test (HSD) was conducted. Again, the post-hoc comparison yielded no significant relationships between the variables. Although non-significant, the mean difference between condition red and green varied the most (Appendix K).

To analyze the results of the secondary measure, a chi-square test of independence was performed examining the relation between the adjectives and the color conditions. However, no significant relationships emerged between adjectives and conditions (9, N=84 = 10.55 $p=0.31$) (Appendix L). Interestingly, every condition associated *caution* as the most fitting adjective describing the message the sign is trying to convey, followed by attention. Nonetheless, the lack of statistical significance prevents any conclusive remarks to be drawn.

Discussion

There are a number of concerns to be addressed regarding our experimental design. Firstly, the exclusion of 14 participants following the failure of the comprehension check gives us reason to believe that the fictitious scenario may not have been clear. It is possible that participants did not comprehend the scenario thoroughly. Though perhaps a more likely explanation is that participants may not have been engaged or incentivized enough in the survey as it was on the basis of volunteering, which may have led to response sets. Adding to the previous concern, the use of convenient sampling is susceptible to reducing external validity. As the recruitment of the sample was based on volunteers, it is subject to sampling bias, further reducing the generalizability of the results. Furthermore, we have reason to believe the study overlooked peoples understanding of speed measures. Objectively visualizing speed, even in the presence of a legend, is very difficult to conceptualize. It is possible that participants may have just been performing an anchoring bias to the scale that was given. To address such limitations, pilot studies can be conducted to see what facilitates participants understanding of speed, eliminating the need for a legend, so as to alleviate such confines. Previous studies have demonstrated that numerical ranges, accompanied by verbal terms facilitate the understanding of concepts (Budescu, 2014), thus such measures can be taken into consideration for future studies.

The secondary measure was introduced to serve as a manipulation check. Specifically, we were interested in seeing whether the different conditions elicited any variation in terms of conceptualization of the sign as a whole. In other words, we were interested to see whether different conditions provoked any difference in how the sign's message was interpreted. Nonetheless, the results yielded were insignificant, and there was an over association to the adjective *caution* relative to the others, demonstrating a possible ceiling effect. This phenomenon may be explained by the work of Klein et al (1993), where it was found that *caution* induced higher perceived readability in warning labels. Henceforth the adjective choices should be reconsidered as the use of *caution* may have masked any significant interactions.

As mentioned before, the primary results were marginally significant, therefore our primary hypothesis should not be fully rejected as the numerical trend does show a general pattern. It is imperative that the current results be replicated, perhaps with a bigger sample and addressing the aforementioned limitations, before any conclusions can be drawn. Nevertheless, our secondary hypothesis was rejected as no salient trends emerged and the manipulation was not reliable.

Interestingly, our additional data collection revealed that 81% (Appendix M) of the participants had never encountered the BTS prior to the experiment. Such findings are imperative as there are currently plans to implement 3 more BTS onto Main Mall. It appears that these signs are going unnoticed by the general public therefore UBC should be taking into consideration that perhaps the placement of these signs are ineffective.

Recommendations to UBC

Encompassing all the aforementioned notions, we believe there are certain measures UBC can make to improve safety on Main Mall. First and foremost, as we did find a numerical trend for red being more behaviorally compliant than green or the control, we propose UBC to redesign the current BTS into red signs, similar to the ones in our manipulation, as it may serve to elicit more precaution. Also, to further discourse how effective UBC's current interventions on Main Mall safety are, future studies can take the direction of analyzing not just the color as we have, but the size, placement, font, and illustration to measure what characteristics make the sign more salient.

The placement of the signs should also be reconsidered. As noted before, they are going unnoticed by the general population. Currently the signs are all located on key turning points into Main Mall. As the signs are intended for cyclists, placing the signs on corners is impractical, as they would likely not enter the peripheral vision of the cyclists travelling at high speeds. Instead the signs should be placed before turning into Main Mall and along Main Mall for cyclists to have time to perceive and interpret them appropriately.

However, if amended signs are not feasible in the near future, we propose alternative solutions to work with the existing signs. Main Mall safety is not a commonly addressed problem, thus emphasizing its importance can make students and faculty more aware that such problems exist. UBC can implement campaigns introducing Main Mall safety and instill a frequency illusion in which students and faculty may begin to notice the signs more often if they are aware of its purpose.

References

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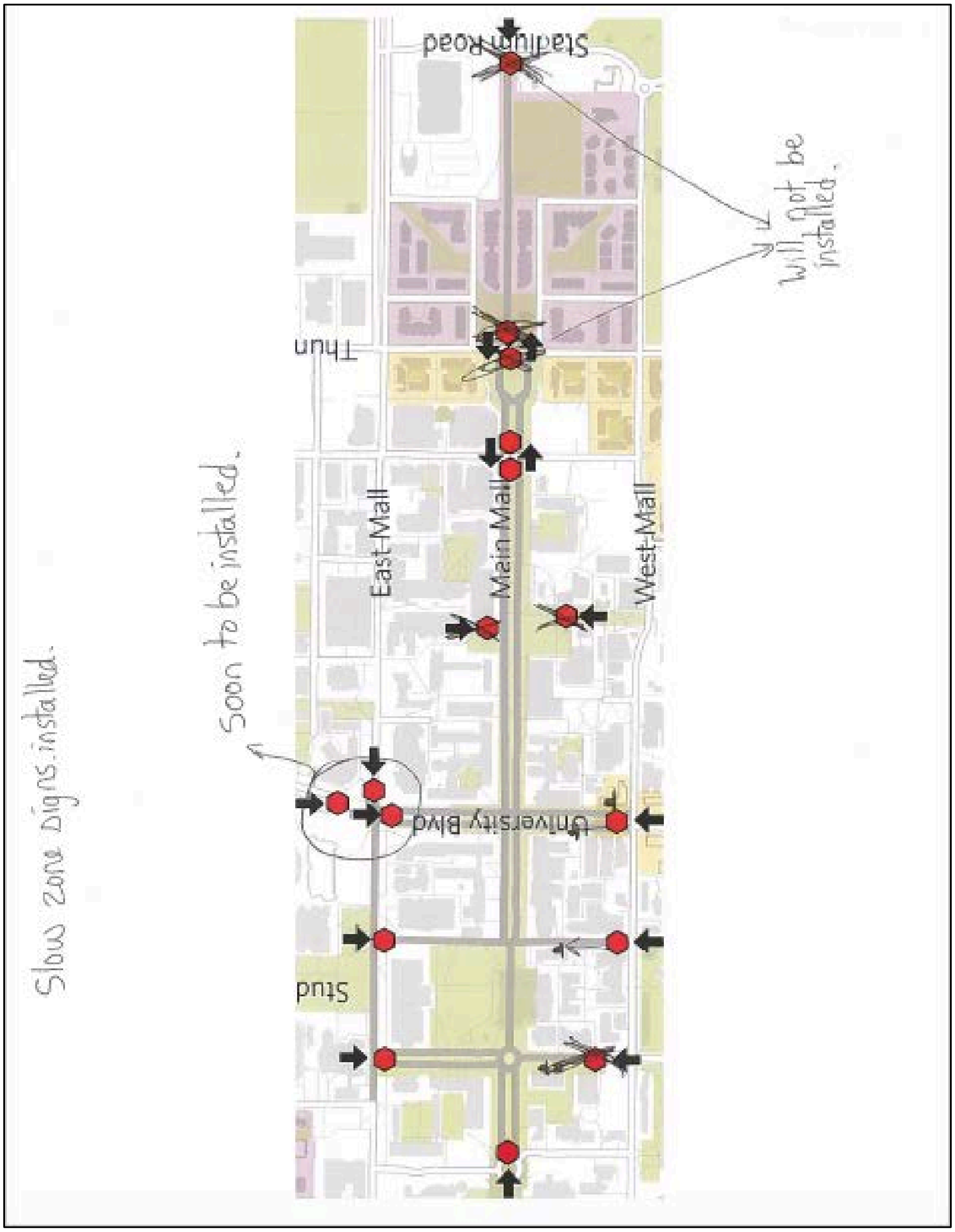
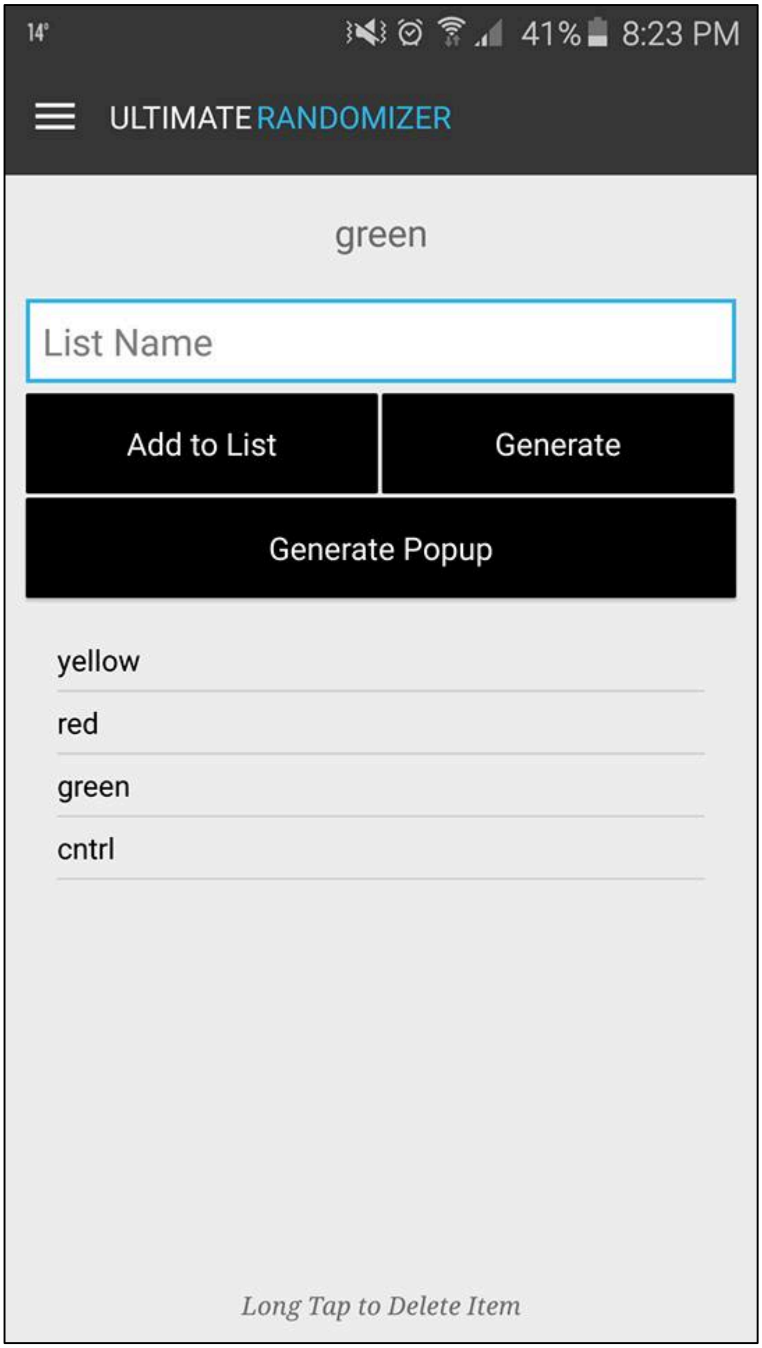
Appendices

Appendix A
Bicycle Traffic Sign

Appendix B
Map of existing signs provided by the client



Appendix C
Random Generator App



Appendix D

Manipulated signs (IV conditions)

Figure 3 Green Condition

Figure 2 Red Condition

Figure 1 Yellow Condition

Figure 4 Control Condition

Appendix E
Survey

Survey links by condition:

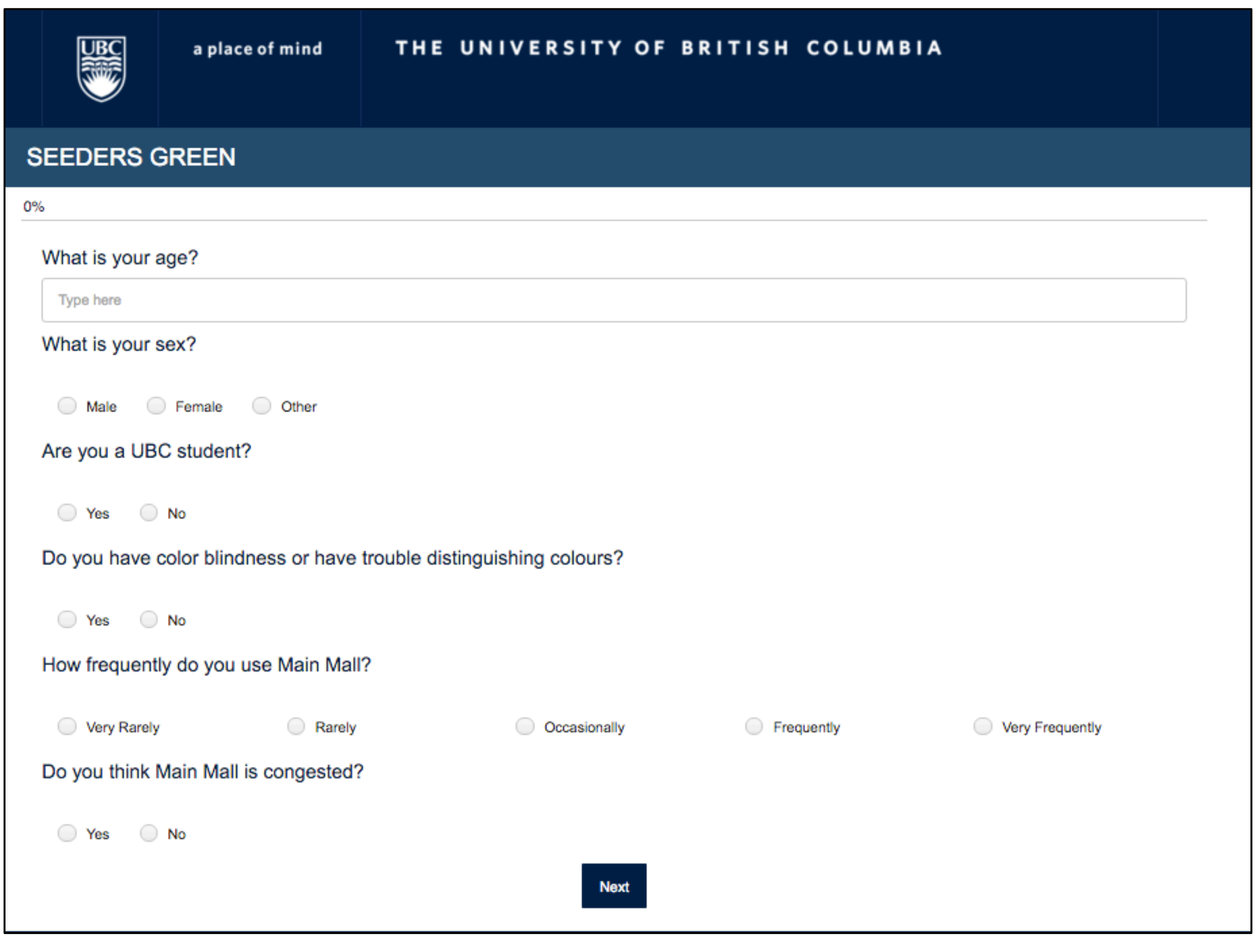
GREEN CONDITION:
https://survey.ubc.ca/surveys/joconde/seeders/

RED CONDITION:
https://survey.ubc.ca/surveys/joconde/seeders-red/

YELLOW CONDITION:
https://survey.ubc.ca/surveys/joconde/seeders-yellow/

CONTROL CONDITION:
https://survey.ubc.ca/surveys/joconde/seeders-ctrl/

Survey screenshots:


a place of mind THE UNIVERSITY OF BRITISH COLUMBIA

SEEDERS GREEN

0%

What is your age?

Type here

What is your sex?

Male Female Other

Are you a UBC student?

Yes No

Do you have color blindness or have trouble distinguishing colours?

Yes No

How frequently do you use Main Mall?

Very Rarely Rarely Occasionally Frequently Very Frequently

Do you think Main Mall is congested?

Yes No

Next

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

SEEDERS GREEN

33%

For the following questions please read the scenario carefully and answer accordingly.

Sam is cycling down Main Mall UBC from Buchanan (Arts) to the Forest Sciences Centre (Forestry) when Sam encounters the following sign:

What is Sam's destination?

- Buchanan
- Sauder
- Irving K. Barber
- Forest Sciences Centre

At what speed will Sam cycle at after seeing the sign?

(The average human walks at 5 km/h // The average cyclist cycles at 15 km/h)

- 5 km/h (3.1 mph)
- 10 km/h (6.2 mph)
- 15 km/h (9.3 mph)
- 20 km/h (12.4 mph)
- 25 km/h (15.5 mph)

On a rainy day how long will it take Sam to arrive to the destination?

- 4 Minutes
- 6 Minutes
- 8 Minutes
- 10 Minutes
- 12 Minutes

On a sunny day how long will it take Sam to arrive to the destination?

- 4 Minutes
- 6 Minutes
- 8 Minutes
- 10 Minutes
- 12 Minutes

Which of the following adjectives best describes the message the sign is trying to convey?

- Stop
- Caution
- Beware
- Attention

Sam will slow down upon seeing the sign

For this question rate how much you agree or disagree with the statement

- Strongly Disagree
- Disagree
- Neither Disagree / Agree
- Agree
- Strongly Agree

Sam will speed up upon seeing the sign

For this question rate how much you agree or disagree with the statement

- Strongly Disagree
- Disagree
- Neither Disagree / Agree
- Agree
- Strongly Agree

What is the likelihood that Sam will miss the sign if Sam was listening to music?

- Extremely Unlikely
- Unlikely
- Somewhat Likely
- Likely
- Extremely Likely

Back Next

UBC a place of mind THE UNIVERSITY OF BRITISH COLUMBIA

SEEDERS GREEN

66%

What type of transport system do you usually use on Main Mall?

- Walking
- Bicycling
- Skateboarding
- If other Please Specifcy Type here

Have you ever encountered this sign prior to conducting this survey?

Yes No

Back Submit

Appendix F
Dependent Variable

At what speed will Sam cycle at after seeing the sign?

(The average human walks at 5 km/h // The average cyclist cycles at 15 km/h)

- ○ 5 km/h (3.1 mph)
- ○ 10 km/h (6.2 mph)
- ○ 15 km/h (9.3 mph)
- ○ 20 km/h (12.4 mph)
- ○ 25 km/h (15.5 mph)

Dependent Variable 1 (Primary measure of speed perception)

Which of the following adjectives best describes the message the sign is trying to convey?

- ○ Stop
- ○ Caution
- ○ Beware
- ○ Attention

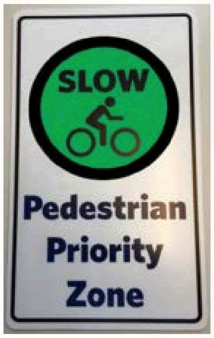
Appendix G
Legend

Dependent Variable 2 (Secondary Measure of adjective association)

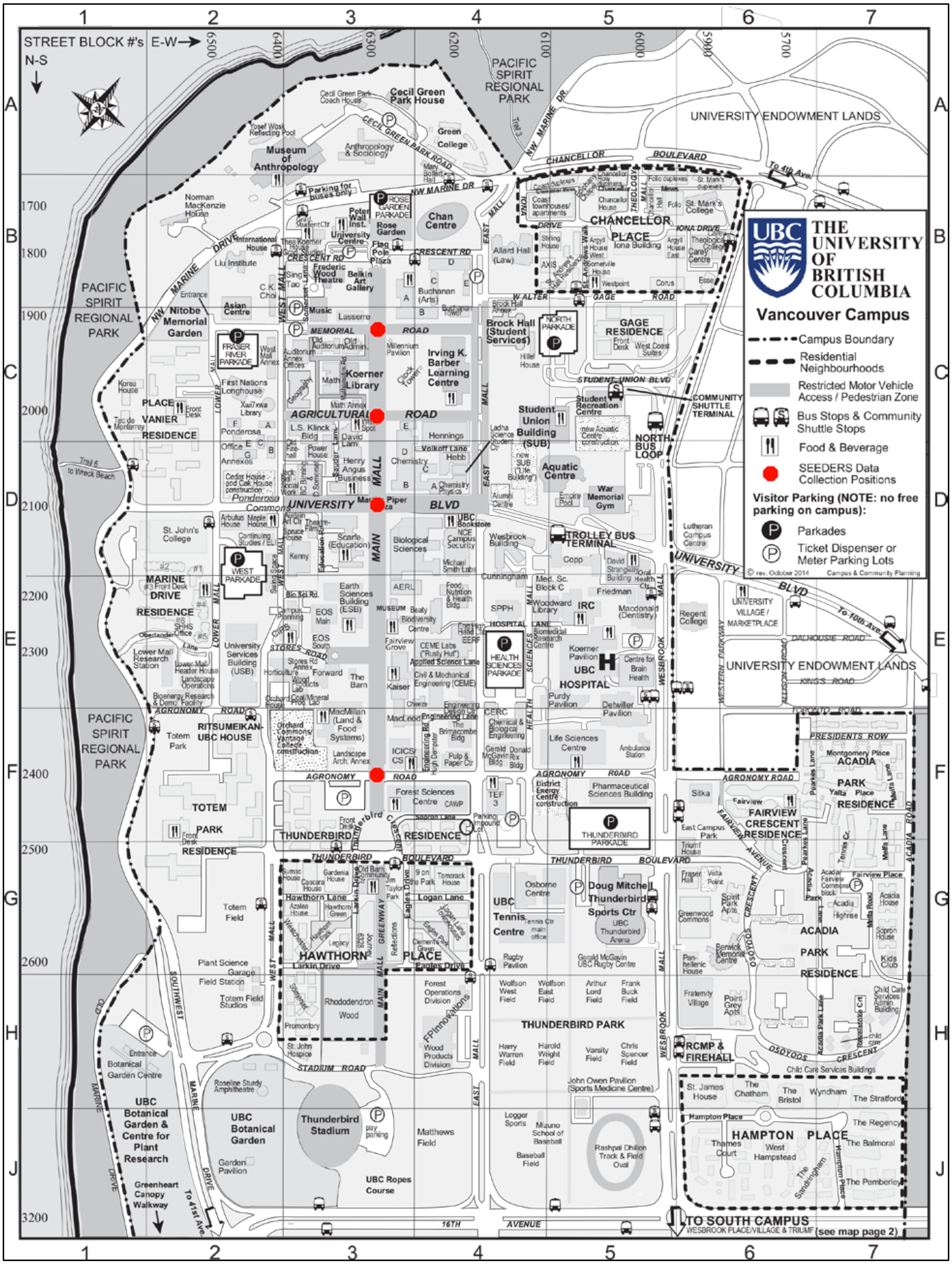
(The average human walks at 5 km/h // The average cyclist cycles at 15 km/h)

Appendix H
Fictitious Scenerio

Sam is cycling down Main Mall UBC from Buchanan (Arts) to the Forest Sciences Centre (Forestry) when Sam encounters the following sign:

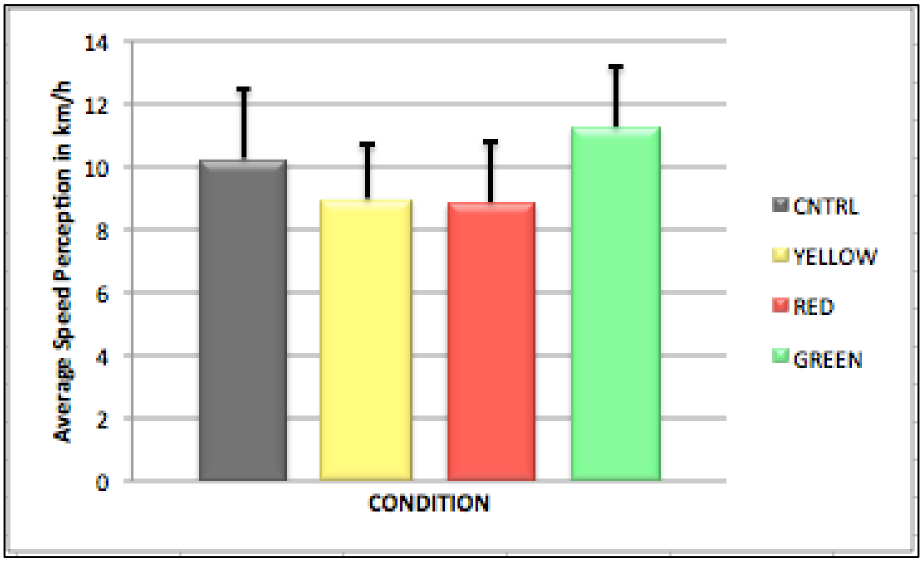


Appendix I
Map of where data was collected


THE UNIVERSITY OF BRITISH COLUMBIA
Vancouver Campus
Campus Boundary
Residential Neighbourhoods
Restricted Motor Vehicle Access / Pedestrian Zone
Bus Stops & Community Shuttle Stops
Food & Beverage
SEEDERS Data Collection Positions
Visitor Parking (NOTE: no free parking on campus):
Parkades
Ticket Dispenser or Meter Parking Lots
STREET BLOCK #'s E-W
N-S
PACIFIC SPIRIT REGIONAL PARK
UNIVERSITY ENDOWMENT LANDS
Museum of Anthropology
Cecil Green Park House
CHANCELLOR PLACE
Chan Centre
Koerner Library
Irving K. Barber Learning Centre
Brock Hall (Student Services)
GAGE RESIDENCE
Student Union Building (SUB)
Aquatic Centre
War Memorial Gym
NORTH BUS LOOP
COMMUNITY SHUTTLE TERMINAL
TROLLEY BUS TERMINAL
MEMORIAL ROAD
AGRICULTURAL ROAD
UNIVERSITY BLVD
AGRONOMY ROAD
MAIN MALL
EAST MALL
WEST MALL
LOWER MALL
WESBROOK MALL
THUNDERBIRD BOULEVARD
NW MARINE DRIVE
CHANCELLOR BOULEVARD
PLACE VANIER RESIDENCE
MARINE DRIVE RESIDENCE
TOTEM PARK RESIDENCE
THUNDERBIRD RESIDENCE
HAWTHORN PLACE
UBC HOSPITAL
FAIRVIEW CRESCENT RESIDENCE
ACADIA PARK RESIDENCE
Doug Mitchell Thunderbird Sports Ctr
THUNDERBIRD PARK
UBC Botanical Garden
Thunderbird Stadium
HAMPTON PLACE
RCMP & FIREHALL
16TH AVENUE
TO SOUTH CAMPUS
To 41st Ave.
To 10th Ave.
To 4th Ave.

Appendix J

Graph and SPSS output



Graph 1 Speed Perception Graph

Tests of Between-Subjects Effects

Dependent Variable: SP

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	86.108[a]	3	28.703	1.975	.124	.069
Intercept	8053.298	1	8053.298	554.109	.000	.874
CONDITION	86.108	3	28.703	1.975	.124	.069
Error	1162.702	80	14.534			
Total	9450.000	84				
Corrected Total	1248.810	83				

a. R Squared = .069 (Adjusted R Squared = .034)

Table 1 SPSS ANOVA output

Descriptive Statistics

Dependent Variable: SP

CONDITION	Mean	Std. Deviation	N
CTRL	10.2778	4.68798	18
YELLOW	9.0000	3.07794	20
RED	8.8636	3.75811	22
GREEN	11.2500	3.68605	24
Total	9.8810	3.87890	84

Table 2 Descriptive Statistics of Speed Perception

Appendix K
Post-hoc Tukey Table

Multiple Comparisons

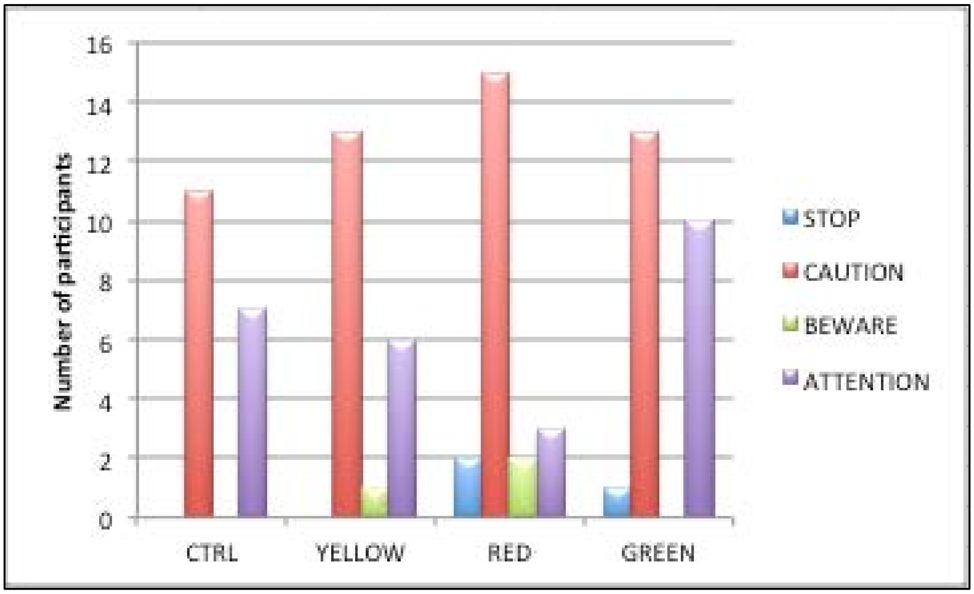
Dependent Variable: SP

	(I) CONDITION	(J) CONDITION	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	CTRL	YELLOW	1.2778	1.23860	.731	-1.9721	4.5277
		RED	1.4141	1.21163	.649	-1.7650	4.5933
		GREEN	-.9722	1.18870	.846	-4.0912	2.1468
	YELLOW	CTRL	-1.2778	1.23860	.731	-4.5277	1.9721
		RED	.1364	1.17784	.999	-2.9541	3.2269
		GREEN	-2.2500	1.15424	.216	-5.2786	.7786
	RED	CTRL	-1.4141	1.21163	.649	-4.5933	1.7650
		YELLOW	-.1364	1.17784	.999	-3.2269	2.9541
		GREEN	-2.3864	1.12526	.155	-5.3389	.5662
	GREEN	CTRL	.9722	1.18870	.846	-2.1468	4.0912
		YELLOW	2.2500	1.15424	.216	-.7786	5.2786
		RED	2.3864	1.12526	.155	-.5662	5.3389

Table 3 Post-Hoc Tukey HSD test for Speed Perception

Appendix L

Chi-Square test output / adjective association graph



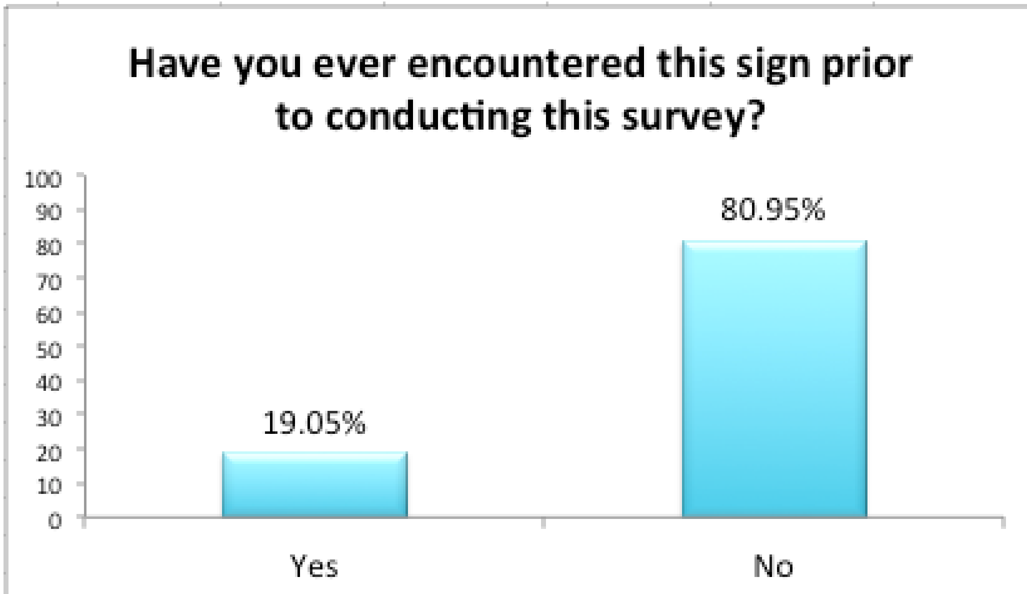
Graph 2 Adjective Association Graph

CONDITION * AA Crosstabulation

			AA				
			STOP	CAUTION	BEWARE	ATTENTION	Total
CONDITION	CTRL	Count	0	11	0	7	18
		% within CONDITION	0.0%	61.1%	0.0%	38.9%	100.0%
		% within AA	0.0%	21.2%	0.0%	26.9%	21.4%
		% of Total	0.0%	13.1%	0.0%	8.3%	21.4%
	YELLOW	Count	0	13	1	6	20
		% within CONDITION	0.0%	65.0%	5.0%	30.0%	100.0%
		% within AA	0.0%	25.0%	33.3%	23.1%	23.8%
		% of Total	0.0%	15.5%	1.2%	7.1%	23.8%
	RED	Count	2	15	2	3	22
		% within CONDITION	9.1%	68.2%	9.1%	13.6%	100.0%
		% within AA	66.7%	28.8%	66.7%	11.5%	26.2%
		% of Total	2.4%	17.9%	2.4%	3.6%	26.2%
	GREEN	Count	1	13	0	10	24
		% within CONDITION	4.2%	54.2%	0.0%	41.7%	100.0%
		% within AA	33.3%	25.0%	0.0%	38.5%	28.6%
		% of Total	1.2%	15.5%	0.0%	11.9%	28.6%
Total		Count	3	52	3	26	84
		% within CONDITION	3.6%	61.9%	3.6%	31.0%	100.0%
		% within AA	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	3.6%	61.9%	3.6%	31.0%	100.0%

Table 4 Chi-Square test of independence output

Appendix M
Number of people who have seen the sign



Graph 3 Percentage of people who have encountered the sign prior to conducting the survey

Appendix N

Raw Data of Speed Perception and Adjective Association

A	B	C	D	E
	CTRL (1)	YELLOW (2)	RED (3)	GREEN (4)
1	10	10	5	15
2	5	10	15	10
3	5	10	10	10
4	15	10	5	15
5	15	10	10	10
6	15	10	5	10
7	10	10	10	15
8	5	15	5	10
9	20	10	20	15
10	15	10	10	20
11	5	10	10	10
12	5	5	10	15
13	5	5	5	10
14	15	5	10	10
15	10	15	10	15
16	10	5	5	5
17	10	10	10	10
18	10	5	10	10
19		10	10	10
20		5	10	15
21			5	5
22			5	10
23				10
24				5
25				

At what speed will Sam cycle at after seeing the sign?

5 km/h
10 km/h
15 km/h
20 km/h
25 km/h

Table 5 Speed Perception Raw Data

A	B	C	D	E
	CTRL (1)	YELLOW (2)	RED (3)	GREEN (4)
1	2	2	4	2
2	2	2	2	2
3	2	2	2	2
4	2	4	2	1
5	4	2	2	2
6	4	4	2	2
7	2	2	2	2
8	2	4	4	2
9	4	4	2	4
10	4	4	2	4
11	4	2	2	4
12	2	2	3	4
13	4	2	4	4
14	2	2	2	2
15	2	3	3	4
16	2	2	1	2
17	2	2	2	2
18	4	4	2	4
19		2	1	4
20		2	2	2
21			2	2
22			2	4
23				2
24				4

Which of the following adjectives best describes the message the sign is trying to convey?

Stop =1
Caution =2
Beware =3
Attention =4

Table 6 Adjective Association Raw Data