No Effect of Sugar Sweetened or Diet Beverages on Performance of a Battery of Cognitive Assessment Tests

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Introduction

- Dietary sugar has been alleged to contribute to the obesity epidemic.
- As a primary source of sugar in the American diet Sugar Sweetened Beverages (SSB) have been specifically targeted for caution.
- It has been argued that it is not just an issue of calories or metabolic products, but also sweetness of beverages as both SSB and diet beverages may produce changes in cerebral activity and associated cognitive impairment under experimental conditions.
- However, few data exists on how typical consumption of these beverages may affect cognitive function.

Methods

- For six months all participants (n=50) followed the ADA Exchange Diet, individually tailored according to each participant's caloric needs.
- Participants were required to incorporate 2 servings (12oz) per day of a Sugar Sweetened Beverage (SSB) or Diet Beverage (Diet), both caffeine free. A third group who drank only water were also included as a control.
- Before and after the intervention participants were assessed on a battery of tests that measure a wide variety of cognitive functions (CANTAB).
  - Spatial Working Memory (SWM), Intra-Extra Dimensional Set Shift (IED), Stop Signal Task (SST), Delayed Matching to Sample (DMS), Paired Associates Learning (PAL), and Rapid Visual Information Processing (RVP).
  - In addition, participants also performed the Iowa Gambling Test (IGT).
- Data presented are means ± SD.

Description of Tests and Results

Spatial Working Memory
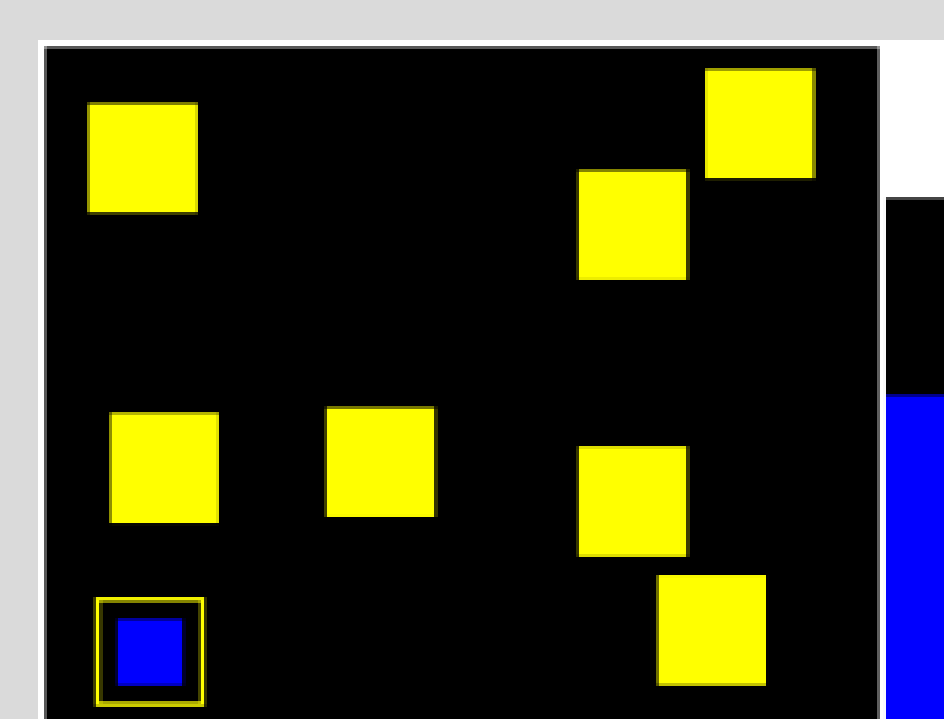
- A test of the subject's ability to retain spatial information and to manipulate remembered items in working memory.
- The subject must touch each box until a blue token is found. A new search will then commence with the token located in a box in which it has not yet been found. This will continue until the token has been successfully found in each of the boxes.

		SSB	Diet	Water	Pooled Population
Total Errors	Pre	29.8 ± 27.6	27.9 ± 18.7	22.1 ± 15.8	26.0 ± 20.2
	Post	28.7 ± 21.0	17.8 ± 13.8	19.3 ± 13.1	21.3 ± 16.0*
Latency	Pre	931.1 ± 323.1	936.3 ± 341.8	937.5 ± 325.4	935.5 ± 323.4
	Post	944.8 ± 408.8	868.6 ± 298.0	831.2 ± 169.5	872.7 ± 286.3
Strategy	Pre	33.5 ± 5.5	32.6 ± 6.2	31.8 ± 5.6	32.5 ± 5.7
	Post	32.7 ± 6.2	29.3 ± 6.5	30.9 ± 6.7	30.8 ± 6.5*

* Different than Baseline, p<0.05

Measures
- Total Errors – The number of times a box is selected that is certain not to contain a token
- Latency – Mean time taken between token-search touches.
- Strategy – The most efficient strategy for completing the task is to follow a predetermined sequence for all searches. This is a measure of the number of times a subject begins a new search with a different box (scores range from 1-56). A lower score is better.

Rapid Visual Processing

- A sequence of numbers will be presented to the participant eg 3-5-7.
- Numbers from 2-9 will appear in the white box in the center of the screen and cycle at a rate of 100/minute.
- Participants are required to detect the target sequence, registering the identification on the keypad.
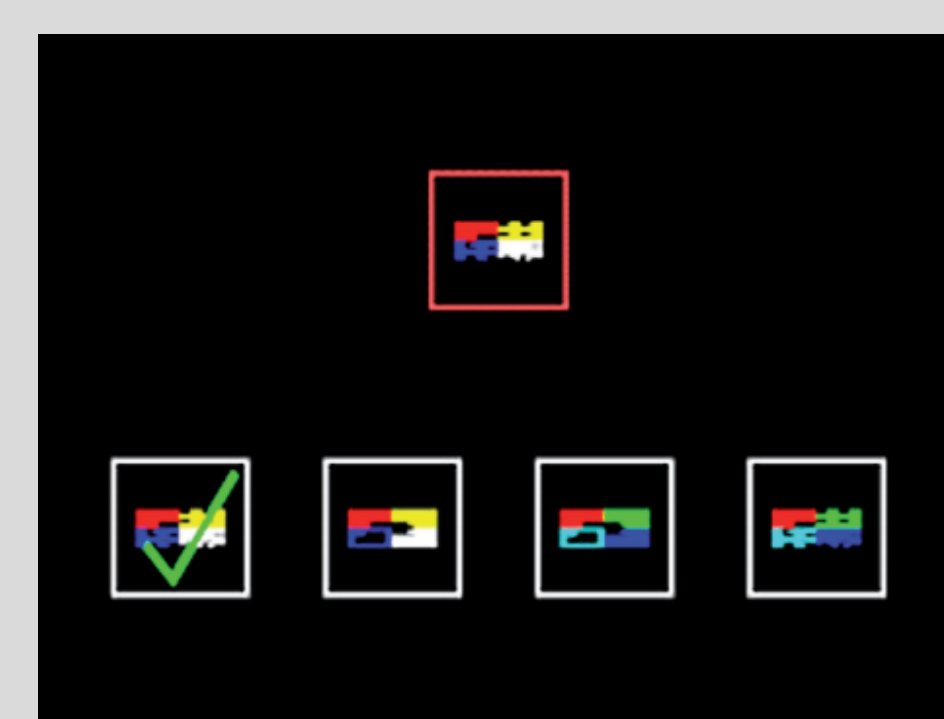
		SSB	Diet	Water	Pooled Population
Latency (ms)	Pre	432.8 ± 111.5	395.9 ± 99.6	392.9 ± 104.5	404.2 ± 104.1
	Post	431.9 ± 141.6	404.3 ± 104.5	382.6 ± 104.3	402.8 ± 114.6
A'	Pre	0.89 ± 0.08	0.91 ± 0.06	0.91 ± 0.05	0.90 ± 0.06
	Post	0.90 ± 0.05	0.93 ± 0.04	0.93 ± 0.05	0.92 ± 0.5*

* Different than Baseline, p<0.05

Measures
- Latency – Time taken to respond when correctly detecting the target sequence
- A' – The total measure of sensitivity to identifying the correct sequence, taking into account the probability of correctly identifying the sequence and the probability of a false positive identification.

Delayed Matching Sample

- The participant is shown a complex visual pattern (the sample), then after a brief delay, four similar patterns
- The participant must then touch the pattern that exactly matches the sample

		SSB	Diet	Water	Pooled Population
Percent Correct	Pre	84.2 ±7.3	92.7 ± 8.2	90.8 ± 6.6	89.7 ± 8.0
	Post	85.8 ± 6.6	91.7 ± 5.3	87.7 ± 10.5	88.5 ± 8.4
Latency on Correct (ms)	Pre	3057.4 ± 792.0	3024.3 ± 902.3	2835.4 ± 804.3	2953.6 ± 823.0
	Post	2906.1 ± 843.9	3268.3 ± 812.5	2732.6 ± 734.5	2949.1 ± 806.6

Measures
- Percent Correct – Percent of trials in which the correct response was selected on the first attempt
- Latency on Correct – The time taken to make a selection on trials in which the correct options was selected.

Paired Association Learning
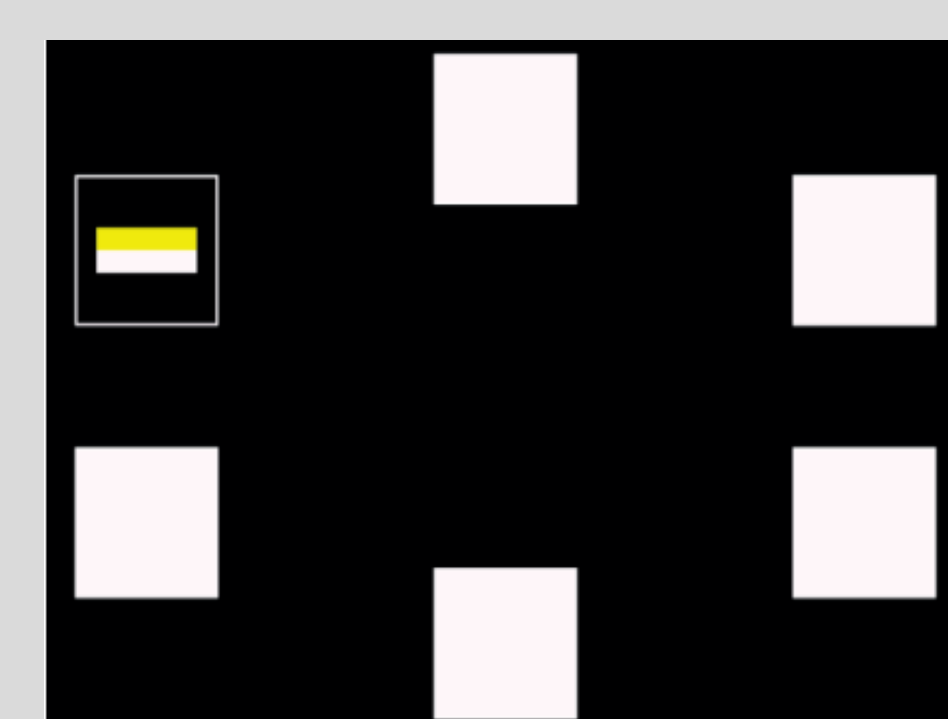
- Boxes are displayed on the screen and are opened in a randomised order.
- One or more of them will contain a pattern.
- The patterns are then displayed in the middle of the screen, one at a time, and the participant must touch the box where the pattern was originally located.
- If the participant makes an error, the patterns are re-presented to remind the participant of their locations.
- The difficulty level increases through the test

		SSB	Diet	Water	Pooled Population
Total Errors	Pre	15.3 ± 19.5	11.1 ± 10.7	5.3 ± 4.3	9.8 ± 12.4
	Post	11.6 ± 11.5	6.4 ± 5.1	6.1 ± 3.3	7.6 ± 7.1
First Trial Memory	Pre	20.6 ± 3.8	19.9 ± 3.9	21.9 ± 3.2	20.9 ± 3.6
	Post	20.5 ± 3.6	21.8 ± 2.8†	20.0 ± 4.6	20.7 ± 3.8
Stages Completed	Pre	7.9 ± 0.3	8.0 ± 0.0	8.0 ± 0.0	8.0 ± 0.1
	Post	8.0 ± 0.0	8.0 ± 0.0	8.0 ± 0.0	8.0 ± 0.0

Measures
- Total Errors – Total errors across all 8 stages
- Memory Scores – The number of patterns located after the first trial summed across all 8 stages (range from 0-26).
- Stages Completed – How many of the 8 stages were completed

Intra-Extra Dimensional Set Shift
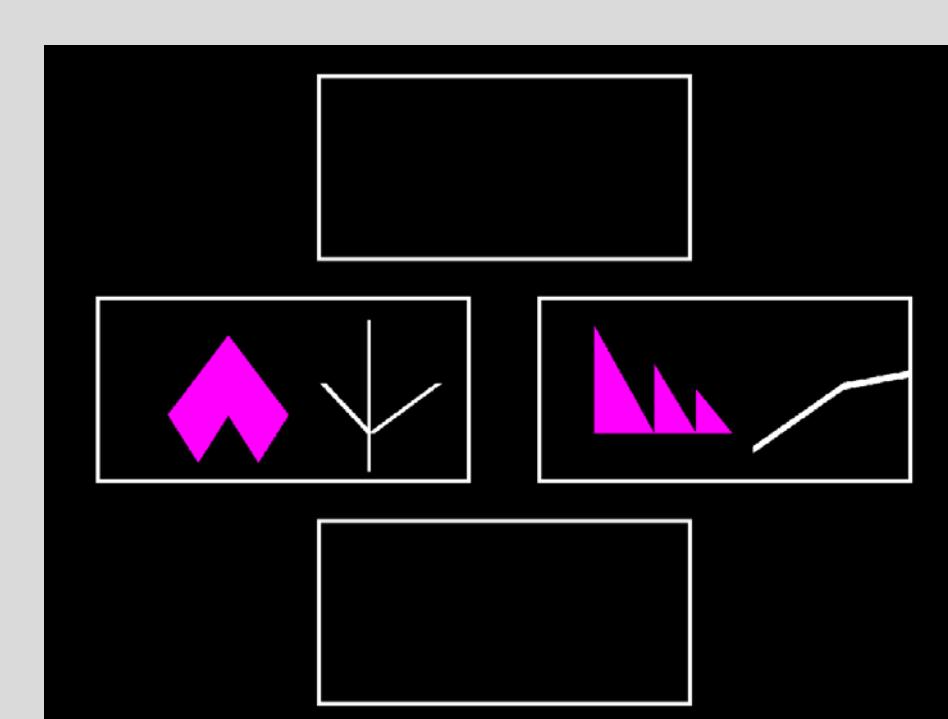
- The participant starts by seeing two simple color-filled shapes, and must learn which one is correct by touching it.
- Feedback teaches the participant which stimulus is correct, and after six correct responses, the stimuli and/or rules are changed.
- Participants progress through the test by satisfying a set criterion of learning at each stage (six consecutive correct responses).
- If at any stage the participant fails to reach this criterion after 50 trials, the test terminates

		SSB	Diet	Water	Pooled Population
Errors (Adjusted)	Pre	32.6 ± 22.3	23.3 ± 21.1	27.0 ± 38.1	27.3 ± 29.4
	Post	29.3 ± 22.9	19.8 ± 16.7	26.1 ± 35.3	24.9 ± 27.1
Stages Completed	Pre	8.4 ± 1.0	8.6 ± 0.8	8.4 ± 1.6	8.5 ± 1.2
	Post	8.2 ± 1.0	8.7 ± 0.7	8.5 ± 1.4	8.5 ± 1.1
Total Trials (Adjusted)	Pre	109.3 ± 38.5	92.8 ± 35.6	100.0 ± 66.9	100.1 ± 51.2
	Post	101.5 ± 38.8	89.5 ± 38.8	89.9 ± 32.0	96.3 ± 61.4

Measures
- Errors (Adjusted) – Total number of errors including penalty points for stages not reached due to early termination of the test.
- Stages Completed – Maximum of 9
- Total Trials (adjusted) - Total number of trials across all stages, including penalty points for stages not reached due to early termination of the test
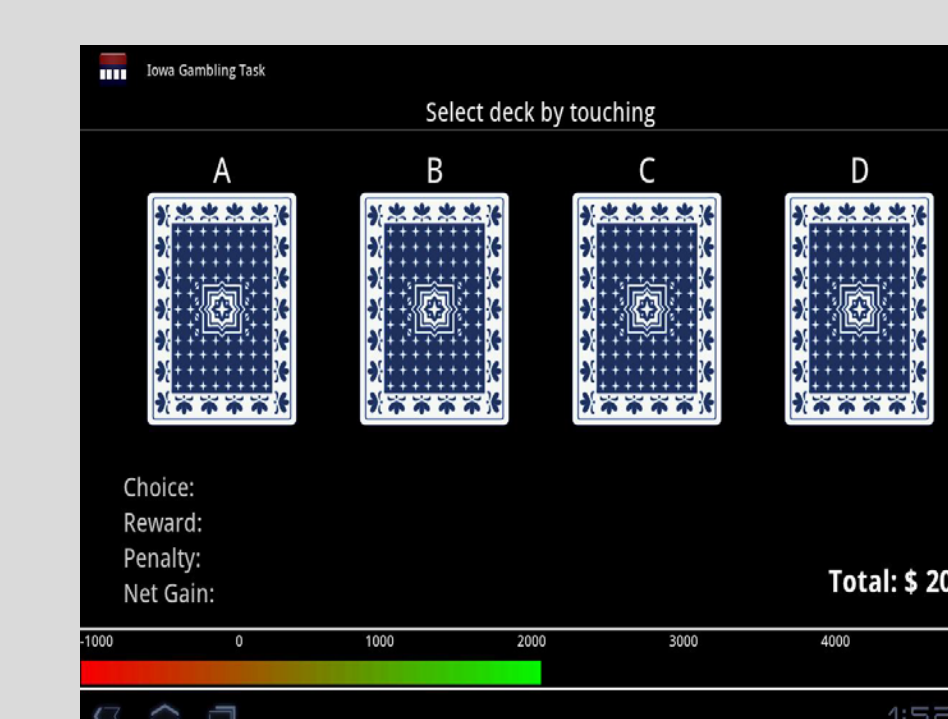
Stop Signal Task
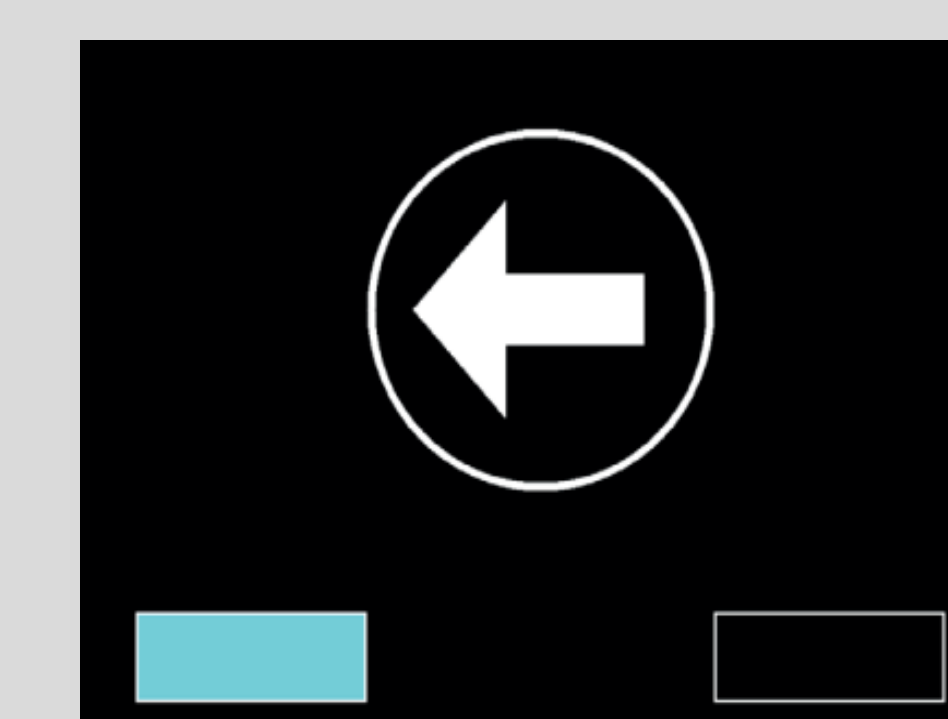
- An arrow will appear in the circle in the center of the screen
- Participants have a key pad with 2 buttons and are instructed to the button that corresponds with the direction of the arrow (Go).
- In the second half of the test a beep will sometimes follow the appearance of the arrow and participants are instructed to refrain from pressing the button on these trials (Stop).

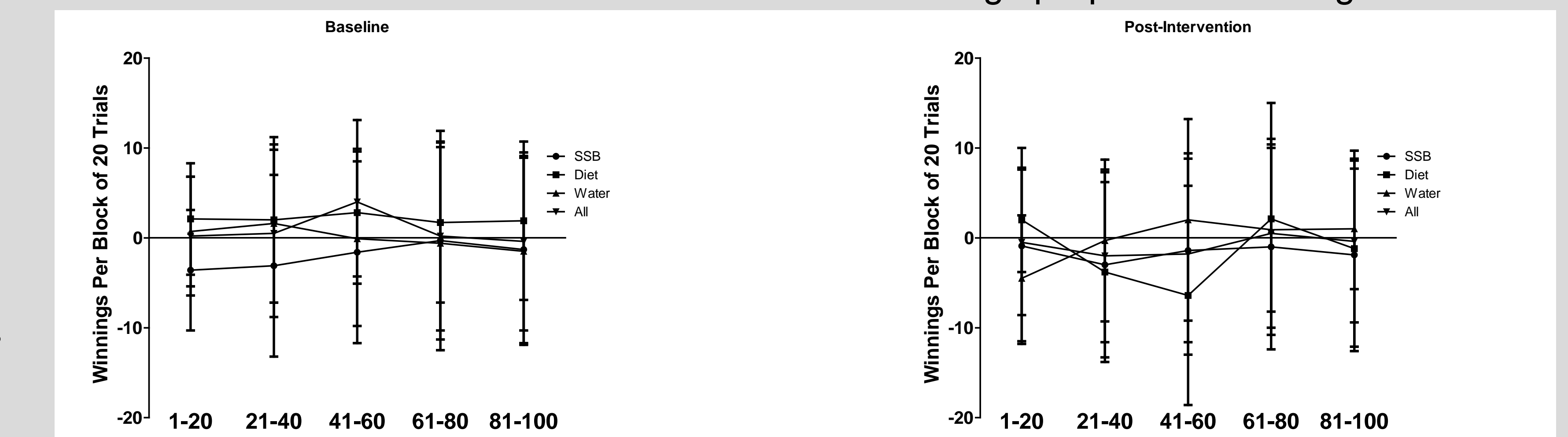|		SSB	Diet	Water	Pooled Population
RT (ms)	Pre	201.4 ± 63.6	156.3 ± 39.9	185.8 ± 97.5	180.3 ± 74.8
	Post	177.8 ± 65.4	165.5 ± 72.7	174.8 ± 80.1	172.5 ± 72.7
Successful Stops (%)	Pre	51.9 ± 9.8	51.1 ± 9.2	50.8 ± 13.0	51.2 ± 10.8
	Post	54.7 ± 7.6	50.0 ± 15.8	48.5 ± 5.5	50.5 ± 10.4
RT on Go (ms)	Pre	510.0 ± 177.8	449.4 ± 141.9	385.9 ± 80.4	439.5 ± 139.0
	Post	511.5 ± 152.2	424.6 ± 136.1	387.4 ± 88.0	432.5 ± 131.2

Measures
- RT– Reaction Time (ms). This is an estimate of the length of the time between the go and stop stimuli that allows the participant to successfully inhibit pressing the button on 50% of the Stop trials.
- Successful stops – The percent success rate for participants correctly inhibiting the pressing of the button on a Stop trial.
- RT on Go – Mean Reaction time for pressing the button on Go trials.

Iowa Gambling Test

- There are 4 decks of cards placed face down. Participants will select a card from one of the 4 decks on each of 100 trials.
- On each trial the selected card will either win or lose the participant "money"
- They are told that some decks are more profitable than others and the object is to earn as much money as possible over the 100 trials.
- Decks containing cards that win a high amount of money are located in decks with a high proportion of losing cards.

Measures
- [chart: Winnings Per Block of 20 Trials vs trial blocks 1-20, 21-40, 41-60, 61-80, 81-100 for Baseline and Post-Intervention, groups SSB, Diet, Water, All]

Discussion & Conclusion

- These data do not support the theory that regular consumption of sweet beverages, either SSB or diet, cause cognitive changes that have previously been associated with the development of obesity.

RLI
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