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Effects of Junk Food Diet and High Fat Diet Manipulation on Working Memory of Sprague Dawley Rats

Derrick Obiri-Yeboah

Catherine Wingrove

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Derrick Obiri-Yeboah, Catherine L. Wingrove and Peter J. Vollbrecht
Department of Biology, Hope College, Holland, MI

Introduction

Obesity has become not only a nationwide problem, but a cause for worldwide concern as the prevalence of processed junk-food is currently on the rise. Along with numerous physical ailments induced by obesity, emerging evidence suggests that consumption of a high-fat diet has negative neurological implications. The prefrontal cortex (PFC), known to play an important role in mediating "executive" functions such as inhibitory control, working memory, and decision-making is one region that appears to be affected by consumption of a junk food diet. In this study, we explored the effects of a junk-food diet and a high fat diet on PFC function. Rats were fed either a junk-food diet (19.6% fat) intended to mimic a typical Western diet, a high fat diet (60% fat), or a standard chow diet. Behavioral tests were then conducted following a 4 week exposure to the diets and included the Egocentric Morris Water Maze, Spontaneous Alternation, Novel Object Recognition and Attentional Set Shift. These behavioral tests were performed in order to identify any differences in working memory or attention between groups.

Protein expression differences in the PFC following diet exposure were explored via western blot. BDNF is a neuropeptide that aids in neurogenesis and synaptic plasticity, therefore playing an important role in working memory and other PFC functions. Another protein of interest is the astrocytic glutamate transporter GLT-1. GLT-1 is credited with over 90% of glutamate uptake from the synapse and deficits in its proper functioning is known to cause excitotoxicity and eventual neuronal death. Biochemical and behavioral analysis of our data will aid in the determination of the effects of junk-food on the PFC.

Methods

Animals: An outbred population of thirty adult male Sprague-Dawley rats were fed one of three treatments: a standard lab chow diet (n=10) or a junk food diet (n=10; Chips Ahoy, potato chips, Nesquik, peanut butter, and LabDiet #5012), or a high-fat lab diet (n=10). Weight and food consumption were measured daily throughout the study.

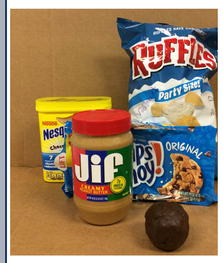
Egocentric Morris Water Maze: Each animal was placed in the Morris Water Maze and given 90 seconds to locate the platform. Each animal completed a training session followed by six test sessions that each consisted of four trials. The platform location remained constant for the training session while the location of the platform was randomly assigned for each test trial. The animal was always placed in the pool in the same location ***relative*** to the platform. Distance traveled and latency to escape were measured.

Novel Object Recognition: Each animal was placed in an arena containing four objects (ring, styrofoam cup, legos, beaker) and explored for five minutes. During a five minute intertrial period, two of the objects were switched. The animal was placed back in the arena for three minutes. Time spent exploring the novel objects was compared to the time spent exploring the original objects.

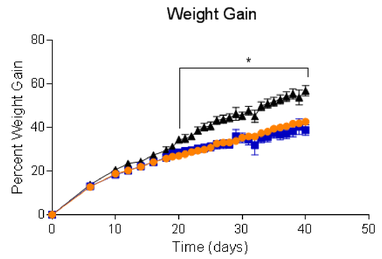
Spontaneous Alternation: Each animal was placed in the T-maze and given 90 seconds to enter an arm. After a 50 second intertrial period, the animal was placed back in the maze and given 90 seconds to enter an arm. If the animal chose a different arm the second trial, this was considered an alternation. 3-5 sessions were completed for each animal.

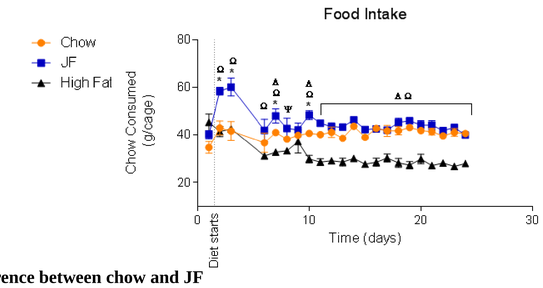
Results

1. Diet, Weight Gain and Food Intake.



Junk Food Diet

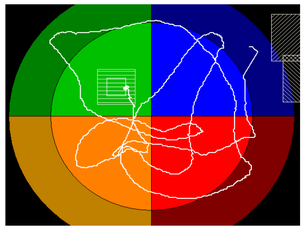


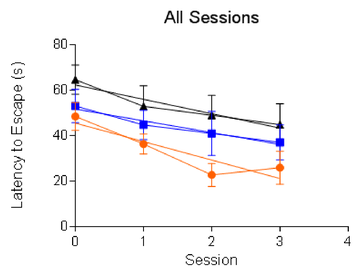


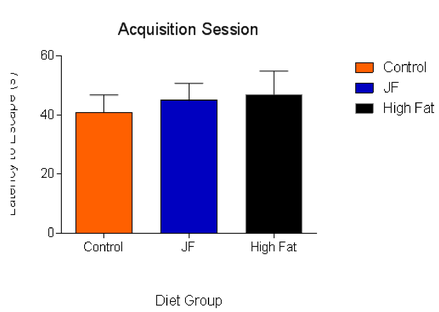
*** indicates difference between chow and JF**
Ω indicates difference between high fat and JF
Δ indicates difference between high fat and chow

2. Slower escape latency but no significant difference in acquisition time between groups in Egocentric Morris Water Maze.

EMWM Tracking Program:

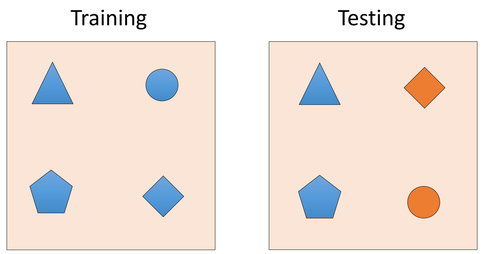


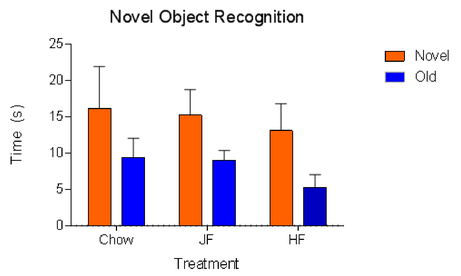




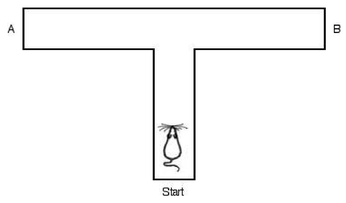
$F_{(2, 23)} = 3.632$, $p=0.0426$

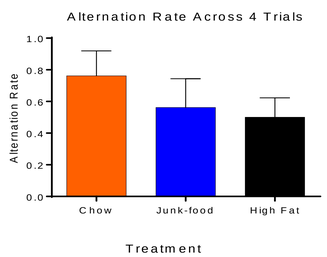
3. No significant difference between JF, HF, or chow animals in time spent exploring novel objects.





4. A trend towards a reduced spontaneous alternation rate in High Fat fed animals

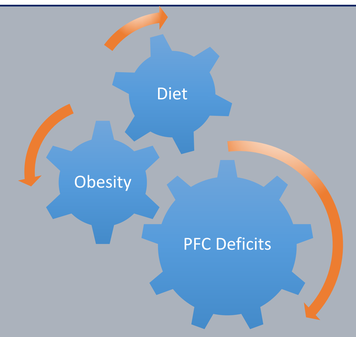




Discussion

Exposure to the junk food diet resulted in a significant increase in the food intake relative to those fed the standard rat chow. This increase was transient however, and returned to a level similar to that of the chow rats for the remainder of the study. Rats on the high-fat diet ate significantly less food than the other groups. Due to the caloric density of the diet, the animals consumed a smaller amount, however it was enough to induce significant weight gain.

Our behavioral results presented here represent the effects of diet manipulation and/or weight gain and its effect on cognition and working memory. Working memory (PFC mediated) tasks explored here included novel object recognition and Egocentric Morris Water Maze (EMWM). In the EMWM there were no significant differences in the distance travelled, however the latency to escape data suggest that high fat fed animals are learning the task more slowly than their chow fed counterparts The Novel Object Recognition task showed a significant difference between directed interest towards the novel object and that towards the old object across the treatment groups. While there was no significant difference between the groups in time spent exploring the novel object, there, the JF and HF show a downward trend, suggesting some difference. These data suggest that short-term exposure to a junk food diet or a high fat diet is not in itself sufficient to induce changes in PFC mediated behaviors, however with a larger sample size differences may become apparent.



Conclusions/Future Directions:

- **Behavioral tasks exploring prefrontal cortex function suggest that junk food exposure in the absence of obesity may not lead to prefrontal cortex deficits.**
- **Perform Attentional Set Shift Task to identify the effect of the diet manipulation on attention**
- **Western blots to determine protein levels of mGluR2/3, BDNF, GLT-1.**
- **Expression of mGluR2/3, BDNF, GLT-1 in test animals will guide further research on the development of obesity and its effects on PFC function.**

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