Incentivizing Children's Fruit and Vegetable Consumption: Evaluation and Modification of the Food Dudes Program for Sustainable Use in U. S. Elementary Schools

Brooke A. Jones
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INCENTIVIZING CHILDREN’S FRUIT AND VEGETABLE CONSUMPTION:
EVALUATION AND MODIFICATION OF THE FOOD DUDES PROGRAM
FOR SUSTAINABLE USE IN U.S. ELEMENTARY SCHOOLS

by

Brooke A. Jones

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Psychology

Approved:

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Gregory Madden    Amy Odum
Major Professor    Committee Member

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                  Dean of the School of Graduate Studies

UTAH STATE UNIVERSITY
Logan, Utah

2014
ABSTRACT

Incentivizing Children’s Fruit and Vegetable Consumption: Evaluation and Modification of the Food Dudes Program for Sustainable Use in U.S. Elementary Schools

by

Brooke A. Jones, Doctor of Philosophy

Utah State University, 2014

Major Professor: Dr. Gregory Madden
Department: Psychology

Despite the well-known health benefits of consuming fruits and vegetables (FV), most children do not consume recommended daily levels. Incentive-based interventions like the Food Dudes (FD) program have shown generally robust effects but are limited by their labor and material costs that may be prohibitive to schools given current times of economic austerity. This series of studies aimed to address these limitations by evaluating praise (Chapter 2) and game-based consequences (Chapters 3 and 4) as rewards for objectively measured FV consumption. In Chapter 2, we conducted a randomized-controlled trial to evaluate the effects of the FD program using tangible prizes versus praise rewards. The FD program significantly increased consumption above Control-school levels during the intervention, with larger increases observed in the Prize than Praise schools when rewards were given daily. At follow-up, only Prize schools were
consuming slightly more FV than Control schools (0.12 cups per child). Because of weak long-term effects and that praise proved an inadequate substitute for tangible prizes, Chapter 3 evaluated a behaviorally based gamification approach using virtual, game-based rewards while maintaining a contingency on objectively measured FV consumption. During the intervention, the school played a cooperative game in which school-level goals were met by consuming higher than normal amounts of either fruit or vegetables. Game-based rewards were provided to heroic characters within a fictional narrative read by teachers. School-level consumption was quantified using a weight-based waste measure in the cafeteria. Over a period of 13 school days, fruit consumption increased by 66% and vegetable consumption by 44% above baseline levels. In Chapter 4, we modified the gamification intervention to increase its duration and external validity. Termed the FIT game, the intervention increased fruit and vegetable consumption by 39% and 33%, respectively, on intervention days. Results from Chapters 3 and 4 show that this game-based intervention provides a promising step towards developing a low-cost, effective FV intervention that schools could implement without outside assistance. In Chapter 5, we discuss overall results, additional analyses conducted to further explore intervention effects, and conclusions regarding the use of incentives in children’s in-school FV consumption interventions.
Researchers in the Psychology Department and the Nutrition, Dietetics, and Food Sciences Department sought to improve elementary school children’s in-school fruit and vegetable (FV) consumption. To achieve this goal, a program that has proven effective in the UK called the Food Dudes (FD) program was implemented in six local schools. Schools were assigned to either experience the traditional FD program (with prize rewards, such as pencil cases and bubbles), a modified version of the FD program (with praise rewards replacing the prize rewards), or no FD program (the control group). Students who consumed a pre-specified amount of FV each day during the intervention earned a reward according to the program’s schedule. Results showed that students in the Prize schools were consuming more FV than students in the Praise schools and the Control schools at follow-up when the intervention had been removed for six months.

While the success of the FD program with prize rewards (i.e., incentives) was encouraging, many teachers reported issues with its implementation. An incentive-based
intervention may be difficult for schools to implement due to high labor and material costs, especially without outside assistance. Therefore, we aimed to reduce these costs while maintaining the use of incentives. We developed an intervention based on the principles of gamification in which students earned in-game, virtual rewards for meeting their FV consumption goals each day at school. This intervention was rated favorably by teachers and parents and showed significant increases in school-wide and individual FV consumption in two schools in Logan, UT, but long-term increases were not obtained.

Improving children’s dietary decisions, namely FV consumption, is an important goal that can positively impact future health. Sustainable, incentive-based interventions, like the school-wide gamification model developed in this project, represent a promising step toward achieving this goal.
“Training is everything. The peach was once a bitter almond; cauliflower is nothing but cabbage with a college education.”

Mark Twain, The Tragedy of Pudd’nhead Wilson
and the Comedy of the Extraordinary Twins
ACKNOWLEDGMENTS

Funding for this research was generously provided by the United States Department of Agriculture (USDA; ERS 59-5000-1-0033 and ERS 59-5000-0-0065), without whom these studies would not have been possible.

I would like to thank Dr. Gregory Madden for his mentorship throughout my entire graduate career. His perpetual patience, fair and factual feedback, and multifaceted mentoring have coaxed me out of the bitter-almond stage, both professionally and personally. I would also like to thank my committee members, Drs. Amy Odum, Jamison Fargo, Michael Twohig, and Heidi Wengreen, along with research dietician Sheryl Aguilar, for their support, assistance, and feedback throughout the learning processes that are research and writing.

Finally, I am honored to give special thanks to my family, friends, and colleagues. Throughout my tumultuous graduate career, they managed to maintain relationships with me (or, in the case of my Daniel, chose to start a relationship with me that has transformed into the beginning of a lifelong journey). Neither these studies, nor this document, nor this doctoral degree would have come to fruition without their unconditional love, support, and encouragement.

Brooke A. Jones
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CHAPTER 1
INTRODUCTION TO THE PROBLEM AND RATIONALE FOR INVESTIGATION

In the U.S., most individuals do not consume the recommended daily amounts of fruits and vegetables (FV; Centers for Disease Control and Prevention [CDC], 2013). As a result, Americans are at an elevated risk of developing hypertension, heart disease, stroke, and cancer (Boeing et al., 2012) and perhaps becoming obese (Hill & Peters, 1998), though the relationship between FV consumption and obesity is complex and not well understood (Ledoux, Hingle, & Baranowski, 2011). Deficient consumption of high-nutrient foods like FV, in combination with excess consumption of low-nutrient foods in American dietary patterns, has contributed to a public health crisis that must be addressed. Although high-nutrient foods like FV should comprise a large proportion of the human diet (Freeland-Graves & Nitzke, 2013; National Center for Chronic Disease Prevention and Health Promotion, Division of Nutrition, Physical Activity, and Obesity, [NCCDPHP], 2011) and recommendations consistent with this are routinely provided by governmental organizations (e.g., U.S. Department of Agriculture and U.S. Department of Health and Human Services [USDA & USDHHS], 2010), very few children follow these recommendations (Keast, Fulgoni, Nicklas, & O’Neil, 2013). Though the 63-81% of children who do not consume enough fruit may be slightly less worrisome than the 92-96% of children who do not consume enough vegetables, both deficiencies must be addressed to promote public health (Krebs-Smith, Guenther, Subar, Kirkpatrick, & Dodd, 2010).

Given that dietary choices developed during childhood tend to continue into
adulthood (Lake, Mathers, Rugg-Gunn, & Adamson, 2006; Lien, Lytle, & Klepp, 2001; Lytle, Seifert, Greenstein, & McGovern, 2000), addressing this public health crisis might best focus on childhood dietary decision-making. One prevention strategy introduced in the U.S. has been to focus the attention of federally funded programs on improving American health, which includes recent updates to the USDA’s National School Lunch Program Guidelines (NSLP; Byker, Pinard, Yaroch, & Serrano, 2013; U.S. Department of Agriculture Food and Nutrition Service, 2012). Though this effort to change school meals should be applauded, and there is some econometric estimates suggesting that these guidelines will decrease body mass index over time (Taber, Chriqui, Powell, & Chaloupka, 2013), experimental studies that provide more FV to children have not increased consumption of these foods (e.g., Cooke et al., 2011; Upton, Upton, & Taylor, 2012). Instead, increased provision appears to substantially increase food waste (e.g., > 400% in Just & Price, 2013), estimated at a cost of $100,000 in wasted food per day in the Los Angeles Unified School District (Watanabe, 2014). At the same time, the new nutrition standards may be responsible for the recent 6.79% decrease in the number of children purchasing school lunch (School Nutrition Association, 2014). When fewer children purchase lunch at school, the cost to a school of providing the NSLP meal increases. These increased costs have played a role in states requesting to opt out of some or all of the NSLP guidelines (Associated Press, 2013).

**Literature Review**

In a review of school-based interventions designed to modify children’s lunchtime
eating habits, Evans, Christian, Cleghorn, Greenwood, and Cade (2012) categorized studies as single-component (e.g., simply providing more FV at mealtimes per national regulations) or multi-component interventions. Based on their review, the authors suggest that multi-component interventions are a more effective way to increase FV consumption in schools than single-component interventions, though therapeutic effects were often limited to fruit consumption and not vegetable consumption. Before considering the characteristics of the interventions that Evans et al. (2012) identified as most effective, one must recognize a drawback of the Evans et al. review – the authors did not distinguish between studies that objectively and subjectively measured children’s FV consumption.

Self-reported health measures are often used in health research because of convenience, but their accuracy has been frequently questioned (e.g., Baranowski, 1985). Though children’s self-reported food consumption (sometimes assisted by parents) remains common, this subjective measurement approach is inadequate as they are subject to systematic reporting errors (Schoeller et al., 2013) that are likely due to the social desirability bias (Hebert, Clemow, Pbert, Ockene, & Ockene, 1995), also known as the Hawthorne effect (McCarney et al., 2007). That is, when participating in a study on dietary decision-making, individuals may be prone to report food choices that they think will be viewed as favorable by the experimenter. For example, Schoeller, Bandini, and Dietz (1990) reported that obese individuals were the most likely to under-report their daily energy intake when self-reports were compared to objectively measured energy intake. Likewise, children and parents, subjected as they are to frequent messages about
the health benefits of FV consumption may be biased to over-report FV consumption, particularly in intervention studies in which the purpose of the intervention is clear to the child or parent.

Concerns about this potential for bias prompted a new literature review to identify studies that objectively measured the effects of a school-based intervention on FV consumption. The following inclusion criteria were employed: the peer-reviewed paper (a) objectively measured in-school fruit, vegetable, or combined FV consumption (e.g., digital photography, waste weight, direct observation with inter-observer agreement scores reported); (b) employed either a between-subject (with a control/comparison group) or within-subject (with a control/comparison condition) experimental research design; (c) was conducted with elementary school-aged participants (i.e., kindergarten-5th grade); and (d) included at least one school-based intervention component that was designed to increase FV consumption. Tables 1-1 and 1-2 summarize the studies that met these criteria ($n = 19$), including intervention components, measurement system, results, effect sizes (when calculable), and post-intervention interval at which follow-up data were collected (where applicable).

**Single-component Interventions**

Table 1-1 summarizes the six single-component interventions that met the inclusion criteria, three of which were published in the same year or after the Evans et al. (2012) review. Consistent with the conclusion reached by Evans et al., two studies reported that simply providing access to (Adams, Pelletier, Zive, & Sallis, 2005) or default provision of (Upton et al., 2012) FV did not significantly increase FV
Table 1-1

Single-component Interventions Evaluating Children’s Objectively Measured Fruit, Vegetable, or Combined FV Consumption in School

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Intervention Component(s)</th>
<th>Measurement Type</th>
<th>Results&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Effect Size&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams et al.</td>
<td>2005</td>
<td>salad bar</td>
<td>weighted plate waste</td>
<td>FV: NS</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
| Getlinger et al.   | 1996 | recess before vs. after lunch | total food weight per food type | F: -6% g when recess before lunch  
V: +46% g when recess before lunch | F: 0.07  
V: 0.27    | NA        |
| Just & Price       | 2013 | default provision          | post-lunch visual estimations | Combined FV: Study 1: 1.8 percentage points more likely to consume FV  
Study 2: 7.7 percentage points more likely to consume FV | could not be calculated | NA        |
| McCool et al.      | 2005 | whole vs. pre-sliced apples | total food weight per food type | F: +47% sliced vs. whole across phases; +87% sliced vs. whole when available concurrently | 1.35  
2.23       | NA        |
| Upton et al.       | 2012 | default provision          | weighted plate waste   | F: NS  
V: NS                                                                               | could not be calculated | NA        |
| Wansink et al.     | 2012 | vegetable was given a fun name | weighted plate waste   | V: +50% from control                                                                     | F: NA  
V: 0.34     | NA        |

<sup>a</sup>Outcomes are reported as percentage increases above control-group or baseline levels. Where values are not reported in the original reports, we used Web Plot Digitizer to obtain estimates (<http://arohatgi.info/WebPlotDigitizer/app/>).

<sup>b</sup>Cohen’s d is reported when sufficient data were provided in the original manuscript(s) to complete the calculations.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Intervention Component(s)</th>
<th>Incentive Type</th>
<th>Measurement Type</th>
<th>Results&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Effect Size (Cohen's d)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Follow up</th>
</tr>
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<tbody>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auld et al.</td>
<td>1998</td>
<td>integrated education (classroom, cafeteria, parent, community)</td>
<td></td>
<td>post-lunch visual estimations</td>
<td><strong>Year 4:</strong> F: +41% servings from control V: +41% servings from control FV: +46% servings from control</td>
<td>could not be calculated</td>
<td>NA</td>
</tr>
<tr>
<td>Auld et al.</td>
<td>1999</td>
<td>integrated education (classroom, cafeteria, parent, community)</td>
<td></td>
<td>post-lunch visual estimations</td>
<td>F: +26% servings from control V: +31% servings from control FV: +46% servings from control</td>
<td>could not be calculated</td>
<td>NA</td>
</tr>
<tr>
<td>Reynolds et al.</td>
<td>2000</td>
<td>classroom, parent, &amp; food service education; environmental cues</td>
<td></td>
<td>post-lunch visual estimations</td>
<td>F: NS V: NS FV: NS</td>
<td>could not be calculated</td>
<td>1 year</td>
</tr>
</tbody>
</table>

*(table continued)*
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Intervention Component(s)</th>
<th>Incentive Type</th>
<th>Measurement Type</th>
<th>Results(^a)</th>
<th>Effect Size (Cohen's (d))(^b)</th>
<th>Follow up</th>
</tr>
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<td><strong>Incentives</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blom-Hoffman &amp; DuPaul</td>
<td>2003</td>
<td>education (all grades) &amp; incentives (K-1st grade only)</td>
<td>praise &amp; stickers</td>
<td>post-lunch visual estimations</td>
<td><strong>F:</strong> NS \n <strong>V:</strong> NS</td>
<td>could not be calculated</td>
<td>1 mo NS</td>
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<tr>
<td>Blom-Hoffman et al.</td>
<td>2004</td>
<td>role modeling, education, &amp; incentives</td>
<td>praise &amp; stickers</td>
<td>post-lunch visual estimations</td>
<td><strong>V:</strong> Exp Group: NS \n Waitlist Control Group: +43% from pre-test</td>
<td>Waitlist control group: 0.61</td>
<td>7 mo NS</td>
</tr>
<tr>
<td>Hendy et al.</td>
<td>2005</td>
<td>incentives, choice, peer participation</td>
<td>tokens exchanged for prizes</td>
<td>during-lunch visual estimations</td>
<td><strong>F:</strong> +36% in % meals in which students consumed F \n <strong>V:</strong> +51% in % meals in which students consumed V</td>
<td><strong>F:</strong> 1.21 \n <strong>V:</strong> 1.29</td>
<td>NA</td>
</tr>
<tr>
<td>Hoffman et al.</td>
<td>2011(^c)</td>
<td>role modeling, education, &amp; incentives</td>
<td>stickers</td>
<td>post-lunch visual estimations</td>
<td><strong>F:</strong> year 1: +50% from control \n year 2: +39% from control \n year 3: NS \n <strong>V:</strong> year 1: +72% from control \n year 2: +61% from control \n year 3: +37% from control</td>
<td><strong>F:</strong> year 1: 0.69 \n year 2: 0.49 \n year 3: NS \n <strong>V:</strong> year 1: 0.47 \n year 2: 0.24 \n year 3: 0.28</td>
<td>12 mo \n (table continued)</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Intervention Component(s)</td>
<td>Incentive Type</td>
<td>Measurement Type</td>
<td>Results&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Effect Size (Cohen's d)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Follow up</td>
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<tr>
<td>Horne et al.</td>
<td>2004</td>
<td>FD (default provision of FV, role modeling, &amp; incentives)</td>
<td>tangible prizes</td>
<td>post-lunch visual estimations; weighted measure for snacks</td>
<td>F: +131-151% from control V: +93-161% from control</td>
<td>F: 2.1-3.5 V: 1.5-2.5</td>
<td>NA</td>
</tr>
<tr>
<td>Horne et al.</td>
<td>2009</td>
<td>FD (default provision of FV, role modeling, &amp; incentives)</td>
<td>tangible prizes</td>
<td>weighted lunchbox waste</td>
<td>F: +61% from control V: +120% from control</td>
<td>could not be calculated</td>
<td>12 mo FV: +41% over control</td>
</tr>
<tr>
<td>Just &amp; Price</td>
<td>2013 (Study 3)</td>
<td>default provision of FV &amp; incentives</td>
<td>tangible prizes or $</td>
<td>post-lunch visual estimations</td>
<td>Combined FV: +48-60% in proportion of students consuming either</td>
<td>could not be calculated</td>
<td>NA</td>
</tr>
<tr>
<td>Lowe et al.</td>
<td>2004</td>
<td>FD (default provision of FV, role modeling, &amp; incentives)</td>
<td>tangible prizes</td>
<td>post-lunch visual estimations; weighted plate waste validation</td>
<td>F: +50-75% servings consumed from BL V: +91-137% servings consumed from BL</td>
<td>could not be calculated</td>
<td>NA</td>
</tr>
</tbody>
</table>

<sup>a</sup> Results indicate the percentage increase from control conditions.
<sup>b</sup> Effect size values suggest medium to large effects.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Intervention Component(s)</th>
<th>Incentive Type</th>
<th>Measurement Type</th>
<th>Results&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Effect Size (Cohen's &lt;sup&gt;d&lt;/sup&gt;)&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upton et al.</td>
<td>2013</td>
<td>FD (role modeling &amp; incentives)</td>
<td>tangible prizes</td>
<td>weighted plate waste</td>
<td>Combined FV: +14% from BL</td>
<td>could not be calculated</td>
<td>12 mo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FD (default provision of FV, role modeling, &amp; incentives)</td>
<td>tangible prizes</td>
<td>visual estimation of lunch-tray photo analysis</td>
<td>F: +27-35% from BL V: +32-63% from BL</td>
<td>F: 0.32-0.34 V: 0.29-0.65</td>
<td>NA</td>
</tr>
</tbody>
</table>

<sup>a</sup>Outcomes are reported as percentage increases above control-group or baseline levels. Where values are not reported in the original reports, we used Web Plot Digitizer to obtain estimates ([http://arohatgi.info/WebPlotDigitizer/app/](http://arohatgi.info/WebPlotDigitizer/app/)).

<sup>b</sup>Cohen's <i>d</i> effect sizes are reported when sufficient data were provided in the original manuscript(s) to complete the calculations.

<sup>c</sup>Hoffman et al. (2010) was excluded from this table because Hoffman et al. (2011) provides a more complete analysis of the same data reported by Hoffman et al. (2010).

<sup>d</sup>Upton, Taylor, and Upton (in press) was excluded from this table because those authors reported data on a subset of participants from Upton et al. (2013). The Upton et al. (2014) follow-up data are included here in the Upton et al. (2013) table entry.
consumption. On the other hand, Just & Price (2013) reported small but significant increases in the likelihood that students would consume a serving of either fruit or vegetable when FV were provided by default (1.8% increase in Study 1, 7.7% increase in Study 2). In another study, Getlinger et al. (1996) hypothesized that children would eat more FV if they were not rushing through lunch so that they could go out to the playground. Moving recess from after to before lunch modestly increased fruit (effect size $[ES] = 0.07$) and vegetable ($ES = 0.27$) consumption.

Wansink and colleagues (2012) reported that labeling vegetables with a fun name (x-ray vision carrots) increased vegetable consumption ($ES = 0.34$), although the lasting effects of the intervention are unknown as the effects of this labeling were investigated for only a few days. The most effective single-component intervention was to serve pre-sliced instead of whole apples on the cafeteria line ($ES = 1.35$; McCool, Myung, & Chien, 2005). This is an impressive effect because of the duration of the study, 6 weeks of whole apples and 6 weeks of sliced. From an economic perspective, slicing the apples decreases their handling costs; i.e., it is easier and less messy for a child to obtain a bite from a sliced apple than from a whole apple. Whether similar increases in consumption could be obtained by reducing the handling costs of other FV is worthy of investigation. A shortcoming of the other single-component interventions summarized in Table 1-1 is that their intervention intervals were comparatively brief. Therefore, whether longer versions of these interventions could produce continued effects on FV consumption is unknown.
Multi-component Interventions

Table 1-2 summarizes the school-based multi-component interventions in which FV consumption was objectively measured. Within the table these studies are separated into studies that focused primarily on educating children and parents about the health benefits of FV consumption and studies that incentivized FV consumption. Education-based interventions have produced mixed results, ranging from moderate increases in FV consumption (Auld, Romaniello, Heimendinger, Hambidge, & Hambidge, 1998, 1999) to nonsignificant effects (Reynolds et al., 2000). Only Reynolds et al. collected follow-up data, but their intervention was not successful in producing short-term effects so it is not surprising that they observed no lasting effects on FV consumption.

The second category of multi-component interventions shown in Table 1-2 includes ten studies that have incentivized the consumption of FV. These programs have produced more consistently positive outcomes than education-based interventions. Default provision of FV plus either tangible prize or monetary incentives yielded a 48-60% increase in the proportion of students consuming either fruit or vegetables (Just & Price, 2013). When incentives were combined with food choice and peer participation they increased the percentage of meals during which students consumed fruit \((ES = 1.21)\) and vegetables \((ES = 1.29; Hendy et al., 2005)\). In an evolving series of studies, education (Blom-Hoffman & DuPaul, 2003) then role modeling and education (Blom-Hoffman, Kelleher, Power, & Leff, 2004; Hoffman, Franko, Thompson, Power, & Stallings, 2010; Hoffman et al., 2011) were combined with tangible incentives (stickers) for FV consumption. Though Blom-Hoffman et al., (2003, 2004) did not show significant
increases in FV consumption, these pilot studies led to the development of a successful program featuring incentives, educational/peer-modeling videos, and take-home materials (Hoffman et al., 2010, 2011). The latter program increased FV consumption in Year 1 ($ES = 0.69$ for fruit and $0.47$ for vegetables) and Year 2 ($ES = 0.49$ for fruit and $0.24$ for vegetables) and increased vegetable consumption only in Year 3 ($d = 0.28$).

Five of the studies shown in Table 1-2 investigated the effects of the Food Dudes (FD) program on FV consumption. The FD program includes default provision to encourage repeated tasting of FV, video role-modeling of FV consumption, and tangible rewards for FV consumption. In the UK, this program has increased fruit consumption by 61-245% ($d = 2.1-3.5$) and increased vegetable consumption by 23-120% ($d = 1.5-2.5$) when compared to a control group (Horne et al., 2004; 2009; Lowe, Horne, Tapper, Bowdery, & Egerton, 2004). In one within-group pilot study of FD in the U.S., fruit consumption increased by 27-35% ($d = 0.23-0.34$) and vegetable consumption increased by 32-63% ($d = 0.29-0.65$) throughout the intervention (Wengreen, Madden, Aguilar, Smits, & Jones, 2013). One research trial conducted in the UK showed less-robust effects of the FD program (14% increase in combined FV from baseline; Upton, Upton, & Taylor, 2013). At least two factors may have contributed to these differences. First, Upton et al. employed an ecological design in which they aimed to be as non-intrusive as possible to the school. As such, they excluded the repeated-tasting component of the FD program. Second, the ecological design may have yielded less than ideal treatment fidelity (the extent to which a program is implemented as intended; Durlak & DuPre, 2008) by teachers. That is, if researchers held the view that the program must be
conducted daily but only insomuch as it does not interfere with the typical schedule, they may have trained teachers to do so in a less-precise way than ideal.

**Long-term Effects**

Six of the 10 studies from Table 1-2 conducted follow-up assessments after the intervention had ended. In three of these studies, the intervention was effective while implemented and, therefore, one might expect significantly more FV consumption at follow-up. In the Hoffman et al. (2011) report there was a gradual decline in the efficacy of the intervention over its three years of implementation and, therefore, it is somewhat unsurprising that it produced no long-term increase in FV consumption when assessed at follow-up one year later. Horne et al. (2009) reported that the FD program produced elevated FV consumption at a one-year follow-up, whereas Upton et al. (2013) reported the opposite. Although the latter post-intervention decrease in FV consumption is predicted by self-determination theory (see Ryan & Deci, 2000), no other study reporting follow-up data reported a comparable decline. As noted above, the latter decline in FV consumption is likely due to intervention integrity issues surrounding the Upton et al. (2013) and Upton, Taylor, & Upton (in press) studies.

**Obstacles to Incentive-based Interventions**

As a whole, the results of this literature review indicate that multi-component incentive-based programs are the most effective currently available intervention for increasing children’s in-school FV consumption. The mechanism by which incentives produce their effect is not well understood. They may motivate children to repeatedly
taste FV until they increase their liking of these foods (e.g., Birch & Marlin, 1982; Birch, Marlin, & Rotter, 1984; Birch, McPhee, Shoba, Pirok, & Steinberg, 1987), and repeated tasting has been incorporated into the FD program. Incentivizing the consumption of FV may also expose children to new FV that they had not previously tasted. Expanding the variety of FV tasted increases the probability that the child will find a fruit or vegetable that they enjoy eating, and they may increase their consumption of FV as a result. Whatever the mechanism, future researchers should include incentives in their interventions.

Two obstacles to the use of incentives in school-based interventions will need to be addressed before they are likely to be adopted on a large scale in U.S. schools. First, the material costs of tangible incentives may be an adoption barrier, particularly among low-income school districts. Hoffman et al. (2011) addressed this by using low-cost stickers that their K-1st graders appeared to enjoy. Identifying a low-cost tangible reward for older children is an as-of-yet unmet challenge. Second, the labor costs of an incentive-based program are an obstacle that must be overcome. In the Hoffman et al. study, for example, each day in the cafeteria, a 1:30 staff to child ratio was required to observe and reward FV consumption.

A different strategy for reducing the materials costs of an incentive-based program would be to substitute social praise for a tangible reward. In a laboratory-type investigation, Cooke et al. (2011) found that children who earned praise for consuming a moderately disliked vegetable had 26% higher levels of consumption of that vegetable than the control group at a 3-month follow-up. Importantly, children in the same study
who earned a tangible prize did not consume a statistically significantly more of the vegetable at follow-up than the children provided only with verbal praise ($p > 0.11$). Thus, praise may be a viable option to replace tangible items in an incentive-based intervention. Indeed, there may be other advantages to using praise over prizes. Praise can be delivered anywhere by the teacher and does not involve organizing and maintaining a physical supply of rewards. Though some labor costs would remain (e.g., identifying children who are deserving of praise), delivering verbal praise may be less effortful and is certainly less costly than delivering tangible prizes.

In Chapter 2, we conducted a randomized-controlled trial in which we evaluated the effects of the FD program (with either tangible-prize rewards or praise rewards) on children’s lunchtime FV consumption in U.S. public school cafeterias. Given concerns about the effects of program implementation fidelity in the Upton et al. (2013) study (see also Lowe, 2013), and that no published studies have evaluated the impact of FD implementation fidelity on short- or long-term outcomes, in the present study we evaluated levels of treatment fidelity and evaluated its impact on FV consumption.

Throughout the investigation, we found that teachers often did not implement the FD program as intended, and this failure affected children’s consumption outcomes. We also found that some teachers rated the FD program poorly because, for example, it diverted classroom time away from academics. Finally, we observed several instances in which children cheated in order to obtain tangible prizes that they did not deserve. Thus, we questioned whether the FD program, as implemented in our study, was appropriate for US schools. Based on the literature review of interventions designed to impact children’s
in-school FV consumption, we considered incentives to be a crucial component for program success. The remaining question was how to incentivize FV consumption in a low-effort, low-cost way. In an attempt to answer this question, we employed principles of gamification in Chapters III and IV to develop a school-based intervention featuring incentives that had lower materials and labor costs than FD.

Gamification

Gamification describes the application of video game design elements to encourage socially relevant behaviors (Reeves & Read, 2009; Salen & Zimmerman, 2004). Gamification is surging in popularity (Morford, Witts, Killingsworth, & Alavosius, 2014) and its elements have been used in business, education, and health-promotion contexts (Deterding, 2012).

Unfortunately, very few peer-reviewed, controlled empirical studies have been conducted on the effects of gamification interventions on dietary decision-making (Baranowski, Buday, Thompson, & Baranowski, 2008). Instead, health-based gamification researchers have given greater attention to physical activity. In one category of the latter studies, individuals play active video games (AVG) in which game-based outcomes are tied directly to physical movement (e.g., Staiano & Calvert, 2011). The effects of these AVGs are mixed with important control conditions sometimes omitted (see Baranowski et al., 2012). Further, AVGs are limited by the technology needed to play them (typically a large television and a video game console). Installing AVGs on mobile devices can increase their availability and reduce their expense (Boulos & Yang,
2013) but to date no peer-reviewed studies have evaluated the effects of these portable games on physical activity.

Gamification interventions that target dietary decision-making have focused more on changing mediators of target behavior than healthy eating itself (e.g., Cerin, Barnett, & Baranowski, 2009). For example, Squire’s Quest is a multimedia computer game in which children help a fictional king and queen by completing challenges that focus on FV selection and consumption goals and/or skills related to FV consumption (e.g., Baranowski et al., 2003). The 25-min sessions involve skills (e.g., identifying a healthy dessert), knowledge (e.g., identifying the appropriate size of a serving of vegetables), recipes (e.g., fruit smoothie), a goal (e.g., ask for ingredients for a recipe), and other miscellaneous components, all of which are hypothesized by the authors to help increase FV consumption (see also Ferrera, 2013).

I will discuss three shortcomings of the gamification studies that have focused on dietary decision-making. First, the time-course of target behavior and mediator change is not documented such that it is impossible to determine which behavior (target or mediator) the intervention actually changed. Second, these interventions have relied solely on children’s self-reports of attitudes toward FV, knowledge of FV, and/or FV consumption (e.g., Baranowski et al., 2003, 2011; Ferrara, 2013). These self-report measures, though convenient, suffer from the limitations of subjective measures of FV consumption as outlined earlier in this chapter. Third, gamification studies focused on dietary decision-making have been high-tech interventions that require computer equipment and require time that schools would otherwise use for academic activities.
(Baranowski & Frankel, 2012; Baranowski et al., 2013). While the gamification research described in Chapters 3 and 4 does not conduct mediator analyses, they objectively measure FV consumption and require less classroom time that other interventions like Squire’s Quest.

Principles of gamification may be used in low-tech, less-expensive applications, as well, which may be appealing to schools that have limited resources and, thus, be more sustainable. Reeves and Read (2009) outlined ten ingredients of great games, some of which are applicable only to high-tech situations. Of those design elements that are not tied to high-tech, Reeves and Read suggested that great games include a compelling narrative, character autonomy within the narrative, feedback, reputation/competition, marketplace/economy, and time pressure. We sought to design a school-based game in Chapters III and IV in which these elements could be combined with the elements of the FD program – role modeling, repeated tasting, and rewards from Chapter II.

Our gamification-based intervention was designed to lower labor costs, material costs, and replace tangible incentives with game-based rewards. In the FD program in U.S. schools, video role models are shown prior to children’s food decision-making situations (like lunch) and tangible rewards are given after target food consumption to encourage the repeated tasting and consumption of FV (see Lowe et al., 2004 for additional details). During each of the six video episodes and 10 letters, the four FD characters are engaged in battles with the Junk Punks, who are trying to destroy all FV on planet Earth, and the FD are able to foil the Junk Punks’ evil plots by consuming FV. Teachers show these episodes to students prior to lunchtime, and children who consume
criterion amounts of featured FV during lunch earn tangible rewards over a period of 16 days (Phase 1). In a second phase, the episodes are no longer shown and FV consumption is rewarded according to a progressively leaner schedule. As children repeatedly taste FV, they discover some that they like and are apt to continue to consume them even when the tangible rewards are no longer available.

In the gamification intervention, a similar “heroes versus villains” narrative was maintained. The four heroic characters (the FITs) battle to prevent the evil villains from ridding the universe of all vegetation. As in the FD program, teachers present the role models to the students prior to lunch each day via a brief narrative story (< 3 min). To develop the remainder of the game, the ingredients of great games (Reeves & Read, 2009) that are applicable to low-tech games were integrated. The school, as a group, worked to meet consumption goals by “eating a little more FV than they normally do,” as prompted within the game narrative. Waste-based weight measures of FV were collected in the cafeteria each day to objectively determine the quantity of FV consumed as a group. Game-based rewards were delivered for the whole group based on group-level consumption. Rewards consisted of both progressing in the story (as provided via the narrative episode) and earning currency to use to purchase in-game equipment that is used to aid in the quest to capture the VAT.

Table 1-3 shows the components of the FD Program, the components of the gamification intervention, and the estimated amount of time (in minutes per day) each component takes to implement. Labor- and material-costs were reduced in the gamification intervention by requesting that teachers present the role models and rewards
Table 1-3

*Estimated Time and Staff Required to Implement the FD Program and the Gamification Intervention for 4 Months*

<table>
<thead>
<tr>
<th>Component</th>
<th>Staff</th>
<th>min/day</th>
<th># days</th>
<th>Total</th>
<th>Component</th>
<th>Staff</th>
<th>min/day</th>
<th># days</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classroom Time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Letters &amp; Show Videos*</td>
<td>Teachers**</td>
<td>70</td>
<td>16</td>
<td>1120</td>
<td>Pre-lunch Episode</td>
<td>Teachers</td>
<td>30</td>
<td>80</td>
<td>2400</td>
</tr>
<tr>
<td>Deliver Rewards</td>
<td>Teachers</td>
<td>5</td>
<td>80</td>
<td>4000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cafeteria Time</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portioning FD FV*</td>
<td>Cafeteria Staff</td>
<td>20</td>
<td>16</td>
<td>320</td>
<td>Updating Cafeteria Game Board</td>
<td>Staff</td>
<td>5</td>
<td>80</td>
<td>400</td>
</tr>
<tr>
<td>Observing FV consumption</td>
<td>1 staff per 30 students (8 per cafeteria***)</td>
<td>480</td>
<td>80</td>
<td>38400</td>
<td>Observing FV consumption</td>
<td>Cafeteria Staff</td>
<td>70</td>
<td>80</td>
<td>5600</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>575</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43840</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8400</td>
</tr>
</tbody>
</table>

*Phase 1 (3 weeks) only.*

**All teacher estimates were calculated based on 10 teachers per school**

***Cafeteria estimates were calculated based on a cafeteria with a 240-student capacity and a 60-min total lunch period***
within a single entity: a short narrative read aloud before lunch each day. All other game components for the gamification intervention noted above were completed in the cafeteria, including FV consumption observation and updating the students’ status in the game (i.e., the game board). These components functioned like the tangible rewards for criterion levels of FV consumption as do the tangible rewards in the FD program but were only based in the game and were provided to all students simultaneously. Lower labor costs than the FD program were also achieved by using a group-based contingency: instead of staff being required to watch individual students consume FV and subsequently provide individual rewards. Students sorted their FV waste into separate bins to assist in calculating an overall waste-based measure, representing a potentially sustainable behavior-measurement system that a school staff could implement in the absence of a research team that takes less time than observing individual children. Overall, this gamification intervention represents a potentially sustainable model that addresses the limitations of previous research on incentive-based interventions.

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http://dx.doi.org/10.1016/j.ypmed.2012.07.012


CHAPTER 2

A RANDOMIZED-CONTROLLED TRIAL OF THE FOOD DUDES PROGRAM:
TANGIBLE REWARDS ARE MORE EFFECTIVE THAN SOCIAL REWARDS
FOR INCREASING SHORT- AND LONG-TERM FRUIT AND
VEGETABLE CONSUMPTION\textsuperscript{a}

Consuming a diet rich in fruit and vegetables (FV) decreases the risk of
developing hypertension, coronary heart disease, some types of cancer, and stroke,\textsuperscript{1} yet
children and adolescents do not consume the recommended daily amounts.\textsuperscript{2,3} Various
types of school-based interventions aimed at increasing children’s FV consumption have
been evaluated, but results have been mixed. Evans and colleagues\textsuperscript{4} reported that simply
providing FV produces no improvement in healthy eating whereas multi-component
interventions produce the best effects.

One multi-component intervention that has shown the most consistent increases in
children’s FV consumption at school is the Food Dudes (FD) program.\textsuperscript{5-8} The FD
program uses role modeling, repeated tasting, and rewards and typically increases fruit
(27-164\% increases) and vegetable (32-51\% increases) consumption during the 4-month
intervention period. Two long-term evaluations of FD have been conducted.\textsuperscript{6,9} At a 12-
month follow-up, Horne and colleagues\textsuperscript{6} showed that consumption of fruit, vegetables,
colleagues\textsuperscript{9} reported at the same follow-up interval that FV consumption decreased
by 9-17\% below baseline levels.

\textsuperscript{a}This chapter is prepared for submission to the Journal of the Academy of Nutrition and
Dietetics and is formatted based on the journal’s requirements (AMA Manual of Style,
10\textsuperscript{th} edition).
Lowe\textsuperscript{10} suggested that poor program implementation fidelity might be responsible for the Upton and colleagues\textsuperscript{9} outcomes. That is, if their teachers did not implement the FD program as designed, good long-term outcomes should not be expected. Neither Horne and colleagues\textsuperscript{6} nor Upton and colleagues\textsuperscript{9} measured treatment fidelity, but the weak effects of FD during the implementation phase of the Upton and colleagues\textsuperscript{9} study (a modest 14% increase in FV consumption) offer reason to question their implementation fidelity and to be skeptical that their long-term results are representative of FD. Thus, one rationale for conducting the present study was to evaluate the relation between fidelity of implementing the FD program and its long-term effects on FV consumption.

A second rationale for conducting the present study was to evaluate the effects of FD when the tangible rewards provided for FV consumption are replaced with social praise from teachers. The cost of tangible rewards may be an adoption barrier to schools concerned about their students’ healthy eating, so evaluating the efficacy of a less-expensive version of FD was of interest. If substituting teacher praise for a tangible prize produces the same long-term benefits, then this less-expensive version of FD might be more successfully disseminated. Cooke and colleagues\textsuperscript{11} reported that providing young children with tangible rewards or praise for consuming a vegetable increased consumption at a 3-month follow up relative to a control group that was given repeated tasting opportunities. Although tangible rewards produced about twice the effect of praise at follow-up, the fact that social praise maintained elevated long-term vegetable consumption suggests that this model of rewarding FV consumption in schools could
prove to be a cost-effective approach to improving public health.

A randomized-controlled trial was conducted in which incentive type (tangible reward vs. praise) was compared to a no-treatment control. Based on previous research, we hypothesized that tangible rewards and praise would increase FV consumption relative to the control condition, with tangible prizes being more effective than praise. We also hypothesized that the effects of each intervention at follow-up would not be as robust as initial effects, but that both incentive groups (Prize and Praise) would have significantly higher FV consumption at follow-up than the Control group. The effects of group (Prize, Praise, or Control) and the effects of teacher implementation fidelity on children’s FV consumption were evaluated with hierarchical linear modeling.

**METHOD**

**Participants and Setting**

Recruitment for this study began in early 2011 at the end of the 2010/2011 academic year. All students attending one of six public elementary schools from one school district in northern Utah during the 2011/2012 and 2012/2013 academic years were invited to participate. The only eligibility requirement was that students were enrolled in 1st through 5th grade during the 2011/2012 academic year. Required sample size was calculated via a power analysis for cluster-randomized designs. A passive, opt-out consent yielded a minimum of 92% participation (range 92%-97%, n = 2,292), with 29, 26, and 69 students opting out of participation in the Prize, Praise, and Control groups, respectively. All teachers (n = 63) agreed to participate in the treatment fidelity analyses and were assured anonymity. The study was conducted during the 2011/2012
academic year and follow-up measurements took place during 2012/2013 academic year. The research protocol, including the passive consent procedure, was reviewed and approved by the Institutional Review Board at Utah State University.

Schools were randomly assigned to one of three groups (two schools per group) while matching for the percentage of students qualifying for free or reduced lunch (a measure of SES). Group assignment was completed by the 2nd and 5th authors by randomly drawing each school’s assignment from a hat. The grant coordinator (5th author) enrolled participants. Baseline demographics of the Prize, Praise, and Control groups are shown in Table 2-1. No programmatic changes were made after the trial commenced. Student’s FV consumption data were collected during school lunch periods, and teacher fidelity data were collected during school lunch periods or teacher free periods.

**Materials**

Student identification (ID) numbers were printed on 1.5 x 6.7 cm white adhesive labels and were placed on lunch trays for child identification in pre- and post-lunch tray photos, which were taken with handheld digital cameras with 10.1 megapixel resolution (Canon Power Shot SD 1300 IS). Portions of FV were served in plastic cups with cup size (2-4 oz) determined by the FV portion programmed by the FD program. Food Dudes media (videos, letters) were obtained from Food Dudes Health Ltd. (FDHL; Cheshire, UK). A custom website was used by teachers to access these media. Four types of self-inking stamps were used to place marks on students’ hands: two pre-consumption hand-stamps when a serving of fruit (open red circle) and vegetable (open green circle) was on
Table 2-1

Baseline Demographic Characteristics by Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prize (N=852)</th>
<th>Praise (N=635)</th>
<th>Control (N=770)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>356</td>
<td>41.8</td>
<td>290</td>
</tr>
<tr>
<td>3-5</td>
<td>496</td>
<td>58.2</td>
<td>345</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>381</td>
<td>44.7</td>
<td>316</td>
</tr>
<tr>
<td>Female</td>
<td>395</td>
<td>46.3</td>
<td>300</td>
</tr>
<tr>
<td>Unknown</td>
<td>76</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>Qualified for Free or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced Lunch</td>
<td>337</td>
<td>37</td>
<td>254</td>
</tr>
<tr>
<td>Opted Out of Study</td>
<td>29</td>
<td>3</td>
<td>26</td>
</tr>
</tbody>
</table>

the child’s tray and two post-consumption hand-stamps when the fruit (cherry shaped) and vegetables (carrot shaped) were consumed. Prizes for use in the Prize group were small toys or gadgets (e.g., notepad, whistle, etc.) obtained from various vendors (e.g., Oriental Trading Company); 64% of the prizes were branded with the “Food Dudes” logo. The 46 x 61 cm wall charts used for self-reported FV consumption were posted on a classroom wall at the beginning of Phase II. Briefly, the wall charts contained a grid with separate rows for the name of each child in the class. Columns corresponded to days on which children consumed fruit and vegetables (separate cells for the latter two). The placement of “goal” cells in each row indicated the number of days of FV consumption required prior to earning a prize/praise; these inter-reward intervals increased each time a prize/praise was obtained.
Procedure

**Teacher Training.** Prior to the start of the study, a research assistant experienced in implementing the FD program conducted a training session with teachers in which they were instructed on procedures for prize or praise delivery, how and when to present the FD media, and how to assist students in placing their ID labels on their cafeteria trays. Training materials provided by FDHL were discussed and distributed to teachers.

**Phased Roll-out.** The program was rolled out sequentially into five schools in the Fall 2011 semester and the sixth school at the start of the Spring 2012 semester. The order of roll out was randomly determined to be as follows: Praise school 1, Prize school 1, Control school 1, Praise school 2, Control school 2, Prize school 2. An average of 11 days separated the start dates for each school.

**Naturalistic Baseline (all groups; days 1-3).** During the Naturalistic Baseline, the cafeteria adhered to the pre-planned menu following the U.S. National School Lunch Program (NSLP) guidelines. Observers took top-down pictures of individual lunch trays as students exited the serving line and again after lunch was eaten. Photos were taken of all trays, including those of students who brought lunch from home. There were no programmed consequences for FV consumption in the cafeteria or in the classroom during this phase.

**Default-provision Baseline (all groups; days 4-7).** During the Default-provision Baseline, volume-measured servings of FV (henceforth, targeted FV) were provided by default to every participant, including students who brought lunch from home. First and second graders received ¼-cup servings each of the targeted FV, and
third through fifth graders received 1/3-cup servings. A different targeted FV pairing was provided each day (a serving each of apples & black bean salad, pineapple & carrots, grapes & cucumber, oranges & blanched broccoli). Targeted FV replaced one fruit and one vegetable variety served on the salad bar. Pre- and post-lunch tray photo data were collected in the same way as during the Naturalistic Baseline phase. There were no programmed consequences for FV consumption during this phase.

**Phase I (days 8-23). Prize Schools.** During Phase I teachers showed FD video episodes and read FD letters according to the schedule provided by FDHL. In the cafeteria, default provisions of the same targeted FVs from the preceding phase were served on a rotating basis (four times each) throughout the 16 days of Phase I. Bite-sized tasting portions were served on days 8-11, 2 tablespoons of targeted FV were served on days 12-15, ¼ cup of targeted FV were served on days 16-19, and full portions (¼ or 1/3 cup, depending on grade) were served on days 20-23. The gradually increasing portion size is a deviation from the FD procedure of transitioning from four days of tasting-sized portions to 12 days of full-sized portions. This procedure change was based on a pilot study in which children struggled to consume full portions following 4 days of tasting-sized portions.8

When students accepted the portions of FV, they received the appropriate pre-consumption hand-stamps on the back of their hand. Research assistants identified students who consumed all of their targeted FV and gave them the appropriate post-consumption hand-stamps. Other FV were available as part of the purchased school lunch, but consequences were provided only for consuming the targeted FV. After lunch,
classroom teachers provided a prize to each child who had all four hand-stamps. During the final 4 days of Phase I, pre- and post-tray photo data were collected as above.

**Praise Schools.** All procedures were identical to those employed in the prize schools except that teachers rewarded FV consumption with social praise. Teachers were instructed to praise their students in a way that felt most natural and genuine.

**Control Schools.** No intervention was provided during Phase I but FV consumption was measured during the final 4 days, as in the other groups.

**Phase II (days 24-93/96). Prize Schools.** During Phase II, the cafeteria returned to serving school lunch as in the Naturalistic Baseline phase. Research assistants provided hand-stamps in the cafeteria one day per week; stamps were provided for taking and consuming full portions of FV served in the cafeteria or brought from home as in Phase I. Otherwise, students self-reported daily FV consumption after lunch on the wall chart posted in the classroom. Students wrote their names in a cell to the left of a row of cells corresponding to days in which they consumed FV. When students completed all cells to the left of and including a pre-marked “goal” cell, teachers delivered a prize in accord with the sequence provided by FDHL. During the final 3 days of Phase II, lunch tray photo data were collected as above.

**Praise Schools.** All procedures were as in the Prize schools except that when a wall chart “goal” was met, teachers provided social praise instead of a tangible prize.

**Control Schools.** Lunch tray photo data were collected on the final 3 days of Phase II.

**Follow-up (All Groups).** Follow-up lunch-tray data were collected over 3 days in
all schools approximately 6 months following the end of Phase II. Procedures were identical to those used in the Naturalistic Baseline phase. FV consumption of students who had matriculated into the sixth grade was evaluated in the middle-school cafeteria following the same procedures. No consequences were provided for taking or consuming FV.

Assessing Treatment Fidelity. Two types of treatment fidelity data were collected in Phase I: FD media use (antecedent) and incentive delivery (consequence). Antecedent treatment fidelity was tracked automatically by the study website from which teachers accessed the FD videos and letters. The website recorded the times and dates each teacher accessed these media. In the Prize schools, a research assistant visited teachers weekly to assess consequence fidelity. The number of prizes delivered was recorded during Phase I and compared to the number of the teacher’s students who consumed full portions of FV (the latter obtained from the lunch-tray photo data). Errors of omission (failing to deliver an earned prize) and commission (delivering an unearned prize) were treated identically. Proportion of errors (i.e., omission and commission errors divided by prize events) was calculated over the course of Phase I, and teachers were coded for fidelity on a 1-5 scale where ≤ 20% fidelity = 1 and > 80% fidelity = 5. For Praise schools, research assistants visited teachers on the same schedule and asked them to self-report the number of days (out of the past five) that they delivered praise to deserving students. These were converted to the same 1-5 scale using the same percentage cutoffs (e.g., a teacher who reported delivering praise on 75% of the Phase I days was given a score of 4). During these observations and also monthly in Phase II,
teachers in both groups were asked to respond orally to a brief Likert-scale survey indicating their current (a) opinion of the FD program (1=very negative, 3=neutral, 5=very positive) and (b) level of stress (1=extreme, 3=neutral, 5=none).

**Data Preparation.** Two trained observers who were blind to study group and phase independently coded each pre- and post-lunch tray photo, recording the amount of each fruit and vegetable consumed. The scale used ranged from 0 to 1 cups in 0.13-cup increments (2 child bite-sized pieces of fruit or vegetable). The mean of the two estimations was taken as the final estimate. If the first two observers did not obtain agreement within 0.13 cup of each other, a third observer (blinded as above) coded the photo pair. If this third observer’s estimation did not match either of the other two, a registered dietitian coded the photo pair to make the final estimation. The fourth observer was needed for 5% of the estimations.

**Statistical Analyses**

Descriptive statistics for demographic characteristics (Table 2-1), children’s FV consumption, and teacher’s treatment fidelity were calculated by group and phase. The FV consumption of students who ate school lunch and those who brought lunch from home were combined in the statistical analyses. All assumptions of the statistical analyses that follow were met, and analyses were conducted in R (with one exception, noted below). First, the effects of group (Prize, Praise, or Control) on FV consumption were examined within twelve linear mixed-effects models: one model for each outcome measure, including (a) fruit, (b) vegetable, or (c) combined FV consumption at (i) Phase I controlling for Default-Provision Baseline consumption, (ii) Phase II controlling for
Naturalistic Baseline consumption, (iii) Follow-up controlling for Naturalistic Baseline consumption, and (iv) Follow-Up controlling for Default-Provision Baseline consumption. Because students were clustered within classrooms at their respective schools, the mixed-effects models used classroom as a random (slope) effect. School was not included as an additional cluster variable because intervention group accounted for it (i.e., the intervention was school-based and thus synonymous with treatment group). Both FV consumption level at the corresponding baseline (as noted above) and intervention group served as predictor variables in each model. Preliminary statistical tests were conducted to determine group equality, and results indicated that third through fifth grade students comprised the majority of each group. Additionally, two differences emerged between the Prize group and the Praise and Control groups: the Prize group had a larger percentage of older participants (grades 3-5; $x^2=18.67$, $p < .001$) and significantly fewer participants whose gender was unknown (not coded; $x^2=27.93$, $p < .001$). Because of the differences in these characteristics, grade level and gender were included as covariates in each model. Two-way interactions between group and both gender and grade level were also evaluated in each model.

The effects of treatment fidelity on FV consumption were examined within a second set of twelve models. The models were identical to those above except that (a) the Control group was excluded because there were no treatment fidelity data for this group and (b) both antecedent fidelity (i.e., showing videos and reading letters) and consequence fidelity (i.e., delivering rewards correctly) were added as predictor variables. Two- and three-way interactions between group and all predictor variables
were evaluated. Finally, teachers’ opinion of the FD program was examined with a 2 (Prize vs. Praise group) x 2 (Phase I vs. II) repeated-measures ANOVA conducted in SPSS. Each teacher’s opinion was averaged separately for Phase I and Phase II and subsequently analyzed.

Our large sample size yielded many statistically significant but small effects that were judged to be of no clinical or theoretical significance; therefore we highlight within the text only those effect sizes >0.18. Except as noted above, non-significant main effects and interactions remained in the model and are reported in the tables below.

RESULTS

Table 2-2 presents the mean amounts of FV (adjusted for baseline consumption) consumed by each group at Phase 1, Phase 2, and Follow-up. All graphical and in-text descriptions of results are based on the predicted values generated by each model, adjusted for baseline consumption level as outlined above.

Phase I

Table 2-3 shows that fruit, vegetable, and combined FV consumption were significantly higher in the Prize group than both the Praise and Control groups. Figure 2-1 shows between-group mean comparisons for each food type. Across groups, combined FV consumption increased by 0.21 cups (Control vs. Praise), 0.32 cups (Control vs. Prize), and 0.11 cups (Praise vs. Prize). Additionally, there were significant grade (older students consumed more FV than younger students) and gender (female students consumed more FV than male students) effects. Variance in FV consumption
Table 2-2

*Fruit and Vegetable Consumption (in cups) at Phase 1, Phase II, and Follow-up by Intervention Group, Adjusted for Baseline Consumption*

<table>
<thead>
<tr>
<th></th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prize</td>
</tr>
<tr>
<td></td>
<td>Fruit Veg FV</td>
</tr>
<tr>
<td>Phase I</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>836 836 836</td>
</tr>
<tr>
<td>M</td>
<td>0.39 0.34 0.73</td>
</tr>
<tr>
<td>SD</td>
<td>0.13 0.11 0.21</td>
</tr>
<tr>
<td>Mdn</td>
<td>0.37 0.32 0.7</td>
</tr>
<tr>
<td>Phase II</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>797 797 821</td>
</tr>
<tr>
<td>M</td>
<td>0.24 0.13 0.38</td>
</tr>
<tr>
<td>SD</td>
<td>0.08 0.08 0.35</td>
</tr>
<tr>
<td>Mdn</td>
<td>0.23 0.11 0.3</td>
</tr>
<tr>
<td>Follow-up</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>671 671 671</td>
</tr>
<tr>
<td>M</td>
<td>0.27 0.12 0.4</td>
</tr>
<tr>
<td>SD</td>
<td>0.09 0.04 0.12</td>
</tr>
<tr>
<td>Mdn</td>
<td>0.27 0.12 0.38</td>
</tr>
</tbody>
</table>

*N values decrease across phases due to participant school transfers and missing child observations.

accounted for by all predictor variables ranged from 37-46%. Figure 2-2 shows a significant interaction between group and consequence fidelity on fruit consumption. That is, when prizes were delivered correctly in Prize schools, students tended to consume more fruit in Phase I. However, when praise was delivered correctly in Praise schools, students tended to consume less fruit in Phase I.

**Phase II**

Figure 2-3 shows that fruit consumption was significantly higher in the Prize
Table 2-3. Results of Mixed-Effects Models of Fruit and Vegetable Consumption at End of Phases I, II, and Follow-up

<table>
<thead>
<tr>
<th></th>
<th>Fruit</th>
<th></th>
<th>Vegetable</th>
<th></th>
<th>Fruit + Vegetable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimator</td>
<td>95% CI</td>
<td>Estimator</td>
<td>95% CI</td>
<td>Estimator</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Phase I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.06</td>
<td>0.04 , 0.09</td>
<td>0.01</td>
<td>-0.02 , 0.03</td>
<td>0.06</td>
<td>0.03 , 0.10</td>
</tr>
<tr>
<td>Group (Control vs. Praise)</td>
<td>0.07*</td>
<td>0.04 , 0.09</td>
<td>0.14*</td>
<td>0.12 , 0.17</td>
<td>0.21*</td>
<td>0.17 , 0.25</td>
</tr>
<tr>
<td>Group (Control vs. Prize)</td>
<td>0.12*</td>
<td>0.09 , 0.14</td>
<td>0.20*</td>
<td>0.18 , 0.22</td>
<td>0.32*</td>
<td>0.28 , 0.35</td>
</tr>
<tr>
<td>Group (Praise vs. Prize)</td>
<td>0.05*</td>
<td>0.02 , 0.08</td>
<td>0.05*</td>
<td>0.04 , 0.08</td>
<td>0.11*</td>
<td>0.07 , 0.15</td>
</tr>
<tr>
<td>Grade (1-2 vs. 3-5)</td>
<td>0.05*</td>
<td>0.03 , 0.07</td>
<td>0.06*</td>
<td>0.04 , 0.07</td>
<td>0.09*</td>
<td>0.06 , 0.13</td>
</tr>
<tr>
<td>Gender (Male vs. Unknown)</td>
<td>0.02</td>
<td>-0.01 , 0.05</td>
<td>0.06*</td>
<td>0.02 , 0.09</td>
<td>0.07*</td>
<td>0.03 , 0.13</td>
</tr>
<tr>
<td>Gender (Male vs. Female)</td>
<td>0.02*</td>
<td>0.00 , 0.04</td>
<td>0.03*</td>
<td>0.02 , 0.05</td>
<td>0.05*</td>
<td>0.02 , 0.07</td>
</tr>
<tr>
<td>Default-Provision Baseline Consumption</td>
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<td>0.49 , 0.56</td>
<td>0.39*</td>
<td>0.35 , 0.42</td>
<td>0.50*</td>
<td>0.46 , 0.53</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.37</td>
<td></td>
<td>0.38</td>
<td></td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td><strong>Phase II</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.12</td>
<td>0.09 , 0.15</td>
<td>0.07</td>
<td>0.04 , 0.11</td>
<td>0.12</td>
<td>0.08 , 0.15</td>
</tr>
<tr>
<td>Group (Control vs. Praise)</td>
<td>-0.01</td>
<td>-0.05 , 0.02</td>
<td>0.06*</td>
<td>0.03 , 0.10</td>
<td>0.08*</td>
<td>0.03 , 0.12</td>
</tr>
<tr>
<td>Group (Control vs. Prize)</td>
<td>0.07*</td>
<td>0.04 , 0.10</td>
<td>0.06*</td>
<td>0.03 , 0.09</td>
<td>0.13*</td>
<td>0.09 , 0.17</td>
</tr>
<tr>
<td>Group (Praise vs. Prize)</td>
<td>0.05*</td>
<td>0.02 , 0.08</td>
<td>0.01</td>
<td>-0.03 , 0.03</td>
<td>0.01</td>
<td>0.01 , 0.10</td>
</tr>
<tr>
<td>Grade (1-2 vs. 3-5)</td>
<td>-0.01</td>
<td>-0.03 , 0.02</td>
<td>0.02</td>
<td>-0.01 , 0.04</td>
<td>0.01</td>
<td>-0.03 , 0.04</td>
</tr>
<tr>
<td>Gender (Male vs. Unknown)</td>
<td>-0.01</td>
<td>-0.05 , 0.04</td>
<td>-0.02</td>
<td>-0.05 , 0.02</td>
<td>-0.02</td>
<td>-0.07 , 0.04</td>
</tr>
<tr>
<td>Gender (Male vs. Female)</td>
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<td>-0.01 , 0.03</td>
<td>0.03*</td>
<td>0.01 , 0.05</td>
<td>0.04*</td>
<td>0.01 , 0.07</td>
</tr>
<tr>
<td>Naturalistic Baseline Consumption</td>
<td>0.31*</td>
<td>0.27 , 0.35</td>
<td>0.33*</td>
<td>0.29 , 0.36</td>
<td>0.33*</td>
<td>0.29 , 0.37</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.13</td>
<td></td>
<td>0.25</td>
<td></td>
<td>0.18</td>
<td></td>
</tr>
</tbody>
</table>

(table continued)
<table>
<thead>
<tr>
<th>Predictor</th>
<th>Fruit Estimator</th>
<th>95% CI</th>
<th>Vegetable Estimator</th>
<th>95% CI</th>
<th>Fruit + Vegetable Estimator</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.12</td>
<td>0.10 , 0.18</td>
<td>0.01</td>
<td>-0.01 , 0.03</td>
<td>0.14</td>
<td>0.08 , 0.18</td>
</tr>
<tr>
<td>Group (Control vs. Praise)</td>
<td>0.02</td>
<td>-0.06 , 0.03</td>
<td>-0.01</td>
<td>-0.01 , 0.03</td>
<td>-0.01</td>
<td>-0.05 , 0.06</td>
</tr>
<tr>
<td>Group (Control vs. Prize)</td>
<td>0.06*</td>
<td>0.02 , 0.10</td>
<td>0.05*</td>
<td>0.03 , 0.07</td>
<td>0.12*</td>
<td>0.07 , 0.17</td>
</tr>
<tr>
<td>Group (Praise vs. Prize)</td>
<td>0.05*</td>
<td>0.01 , 0.09</td>
<td>0.07*</td>
<td>0.05 , 0.09</td>
<td>0.13*</td>
<td>0.07 , 0.18</td>
</tr>
<tr>
<td>Grade (1-2 vs. 3-5)</td>
<td>0.01</td>
<td>-0.03 , 0.03</td>
<td>0.02*</td>
<td>0.01 , 0.03</td>
<td>0.01</td>
<td>-0.03 , 0.05</td>
</tr>
<tr>
<td>Gender (Male vs. Unknown)</td>
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<td>-0.14 , 0.03</td>
<td>0.01</td>
<td>-0.04 , 0.06</td>
<td>-0.04</td>
<td>-0.15 , 0.07</td>
</tr>
<tr>
<td>Gender (Male vs. Female)</td>
<td>0.03*</td>
<td>0.01 , 0.05</td>
<td>0.04*</td>
<td>0.03 , 0.05</td>
<td>0.06*</td>
<td>0.04 , 0.09</td>
</tr>
<tr>
<td>Naturalistic Baseline Consumption</td>
<td>0.26*</td>
<td>0.22 , 0.30</td>
<td>0.13*</td>
<td>0.11 , 0.16</td>
<td>0.26*</td>
<td>0.22 , 0.29</td>
</tr>
</tbody>
</table>

*R^2* 0.20 0.16 0.24

*p < .05*
Figure 2-1. The effect of the Food Dudes Program on predicted fruit, vegetable, and combined FV consumption at Phase I. These values are from the results of the mixed-effects model controlling for Baseline II consumption, grade, and gender.

Figure 2-2. Relationship between fruit consumption and Food Dudes Reward Fidelity at Phase I by Food Dudes Group. For each teacher’s consequence fidelity score (along the x-axis), their students’ mean fruit consumption is plotted (along the y-axis). Best-fit regression lines (one smoothed, one straight) are plotted for each group.

group than the Praise and control groups after Phase II. Additionally, vegetable and combined FV consumption were significantly higher in both intervention groups relative to the Control group, with no significant difference between the intervention groups.
Across groups, combined FV consumption increased by 0.08 cups (Control vs. Praise) and 0.13 cups (Control vs. Prize). A gender effect (females consumed more vegetables and combined FV than males) was evident, but there was no grade-level effect. Variance in FV consumption accounted for by all predictor variables ranged from 13-25%.

Table 2-4 shows that Phase I consequence treatment fidelity modestly affected fruit consumption in Phase II (see Figure 2-4). Variance in FV consumption accounted for by all predictor variables ranged from 14-28%.

The ANOVA analysis of teacher’s opinion of the FD program revealed a significant main effect of phase \(F[1,43]=11.464, p < .01\) and a phase x group interaction \(F[1,43]=8.541, p < .01\). Prize-group teachers’ opinion of the FD program declined from a mean of 4.02 (SD=0.57) in Phase I to 3.29 (SD=0.95) in Phase II, whereas Praise-group teachers’ opinion of FD did not change from Phase I (3.61 ± 0.81) to Phase II (3.56 ± 0.88).

![Figure 2-3](image-url)

Figure 2-3. The effect of the Food Dudes Program on predicted fruit, vegetable, and combined FV consumption at Phase II. These values are from the mixed-effects model controlling for Baseline I consumption, grade, and gender.
Table 2-4. Results of Mixed-Effects Models of Fruit and Vegetable Consumption at End of Phases I & II (two FD groups only)

<table>
<thead>
<tr>
<th></th>
<th>Fruit Estimator</th>
<th>95% CI</th>
<th>Vegetable Estimator</th>
<th>95% CI</th>
<th>Fruit + Vegetable Estimator</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase I</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.20</td>
<td>0.14 , 0.25</td>
<td>0.15</td>
<td>0.12 , 0.17</td>
<td>0.42</td>
<td>0.19 , 0.65</td>
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<tr>
<td>Group (Praise vs. Prize)</td>
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<td>-0.18 , -0.02</td>
<td>0.06*</td>
<td>0.03 , 0.08</td>
<td>-0.45*</td>
<td>-0.80 , -0.10</td>
</tr>
<tr>
<td>Reward</td>
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<td>-0.03 , 0.00</td>
<td>--</td>
<td>--</td>
<td>-0.05</td>
<td>-0.13 , 0.02</td>
</tr>
<tr>
<td>Stress</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-0.03</td>
<td>-0.10 , 0.00</td>
</tr>
<tr>
<td>Group x Reward</td>
<td>0.05*</td>
<td>0.03 , 0.08</td>
<td>--</td>
<td>--</td>
<td>0.18*</td>
<td>0.08 , 0.29</td>
</tr>
<tr>
<td>Group x Stress</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.13*</td>
<td>0.01 , 0.26</td>
</tr>
<tr>
<td>Reward x Stress</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.01</td>
<td>-0.01 , 0.03</td>
</tr>
<tr>
<td>Group x Reward x Stress</td>
<td>--</td>
<td>--</td>
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<td>-0.04*</td>
<td>-0.08 , -0.01</td>
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<td>0.03 , 0.11</td>
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<td>0.32 , 0.40</td>
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<td>0.27</td>
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<td>0.00 , 0.34</td>
<td>--</td>
<td>--</td>
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<td>--</td>
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<tr>
<td>Reward</td>
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(table continued)
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<th></th>
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<th>Vegetable Estimator</th>
<th>95% CI</th>
<th>Fruit + Vegetable Estimator</th>
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<td>-0.15, -0.01</td>
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<tr>
<td>Reward x Stress</td>
<td>--</td>
<td>--</td>
<td>0.04*</td>
<td>0.01, 0.07</td>
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<td>-0.01, 0.07</td>
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<tr>
<td>Group x Stress x Opinion</td>
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<td>0.01, 0.16</td>
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<td>--</td>
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<tr>
<td>Group x Reward x Stress</td>
<td>--</td>
<td>--</td>
<td>-0.06*</td>
<td>-0.11, -0.01</td>
<td>-0.08*</td>
<td>-0.13, -0.02</td>
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<td>0.03</td>
<td>-0.02, 0.07</td>
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<td>-0.04, 0.04</td>
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<td>-0.06, 0.05</td>
<td>-0.02</td>
<td>-0.08, 0.03</td>
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Follow-up

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<tr>
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<th>Fruit Estimator</th>
<th>95% CI</th>
<th>Vegetable Estimator</th>
<th>95% CI</th>
<th>Fruit + Vegetable Estimator</th>
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<tr>
<td>Interception</td>
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<td>-0.07, 0.03</td>
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<td>Group (Praise vs. Prize)</td>
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<td>0.07, 0.19</td>
<td>0.13*</td>
<td>0.07, 0.18</td>
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<tr>
<td>Stress</td>
<td>--</td>
<td>--</td>
<td>0.01</td>
<td>-0.01, 0.03</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Group*Stress</td>
<td>--</td>
<td>--</td>
<td>-0.03*</td>
<td>-0.06, -0.01</td>
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<td>Grade (1-2 vs. 3-5)</td>
<td>0.01</td>
<td>-0.03, 0.05</td>
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<td>-0.01, 0.04</td>
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<td>-0.27, 0.01</td>
<td>-0.03</td>
<td>-0.11, 0.06</td>
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<tr>
<td>Gender (Male vs. Female)</td>
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<td>0.04*</td>
<td>0.03, 0.06</td>
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<td>0.04, 0.10</td>
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<tr>
<td>Naturalistic Baseline Consumption</td>
<td>0.26*</td>
<td>0.20, 0.31</td>
<td>0.13*</td>
<td>0.10, 0.16</td>
<td>0.26*</td>
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<tr>
<td>$R^2$</td>
<td></td>
<td>0.18</td>
<td>0.17</td>
<td>0.23</td>
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*p < .05
Follow-Up

Although separate models were constructed controlling for consumption at each baseline (Naturalistic and Default Provision) the models were extremely similar so Table 2-3 shows only data from the model that controlled for Naturalistic Baseline consumption. Figure 2-5 shows that the Prize group consumed significantly more of each food than the Praise and Control groups, which were not significantly different from each other (see Tables 2-3 and 2-4). Across groups, combined FV consumption increased by 0.12 cups (Control vs. Prize), and 0.13 cups (Praise vs. Prize). There was again a gender effect (i.e., females consumed more FV than males) and a grade effect (older children consumed more vegetables than younger children). Variance in FV consumption accounted for by all predictor variables ranged from 16-24%.

DISCUSSION

When the FD program was implemented as designed, with tangible rewards

![Figure 2-4. Relationship between fruit consumption and Food Dudes Reward Fidelity at Phase II by Food Dudes Group. For each teacher’s consequence fidelity score (along the x-axis), their students’ mean fruit consumption is plotted (along the y-axis). Best-fit regression lines (one smoothed, one straight) are plotted for each group.](image)
delivered for FV consumption, children consumed a mean of 92% more FV during the intervention-intensive first three weeks (Phase I) than did children attending Control schools; this amounted to a mean difference of 0.35 cups more FV consumed per child per day, an outcome comparable to other published FD studies.\textsuperscript{5-8} The intervention was significantly less effective in Phase I when teacher praise was substituted for these tangible rewards. Nonetheless, children in the Praise schools consumed a mean of 50% more FV than children attending Control schools (0.19 cups more FV). When FV consumption was reassessed approximately 4 months later, at the end of Phase II when both types of rewards were no longer delivered, the intervention schools consumed a mean of 0.12 cups more FV than Control schools (a 46% difference) and this difference was not differentiated across the Praise and Prize schools. At 6-month follow-up, only those schools that implemented FD with tangible rewards consumed more FV than the

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2-5.png}
\caption{The effect of the Food Dudes Program on predicted fruit, vegetable, and combined FV consumption at follow-up. These values are from the mixed-effects model controlling for Baseline I consumption, grade, and gender.}
\end{figure}
Control schools (mean of 42.9% more; 0.12 cups). Thus, when considering long-term effects, teacher praise proved not to be an adequate substitute for tangible rewards within the FD program.

It is important to note that FV consumption decreased in the Control schools by a mean of 0.1 cups (26%) over the course of the study; a similar decrease was observed in the Praise schools at the 6-month follow-up (a mean decrease of 0.18 cups, a 38% decline). The schools that implemented FD with tangible rewards avoided these decreases (a mean 0.05 cups more FV consumed at follow-up relative to baseline, a 14% increase); this counteractive effect is of clinical significance.

The factors influencing the decreases in FV consumption in the Praise and Control groups are unclear. Given the span of time over which data were collected (just under 11 months), it is unlikely that seasonal-related quality of FV accounts for the decreases. Another possibility is that reactivity to the cafeteria data-collection procedures elevated FV consumption at baseline but not at follow-up. Because adults were taking pictures of students’ lunch trays, and because student ID numbers were on these lunch trays, students may have anticipated that consequences (beneficial or detrimental) would be delivered based on their lunchtime consumption. Because students in U.S. schools are provided with information about the health benefits of FV and are encouraged to consume these foods every day, they may have deduced that FV consumption was important to these adults taking pictures of their lunch trays. When no consequences for account is correct, then children attending the Prize schools increased their FV consumption at follow-up much more than reported above (because the baseline level of consumption was inflated by reactivity). Future researchers might avoid the possibility of
these putative reactivity effects either by developing less-intrusive procedures for quantifying FV consumption, or by conducting baseline observations for a longer duration (reactivity effects tend to decrease with continued observations\textsuperscript{13}).

An examination of the effects of consequence (reward) fidelity showed that it was important that teachers deliver tangible rewards as programmed to increase fruit consumption. Teachers who either gave a prize to students who had not earned one, or did not give a prize to students who had earned one, tended to have students who consumed less fruit than teachers who rewarded consumption in accord with the FD program. This finding supports Lowe’s\textsuperscript{10} hypothesis that implementing the FD program with inadequate fidelity may be responsible for poor short- and long-term outcomes in studies of this program (specifically, those reported by Upton and colleagues\textsuperscript{9}).

Interestingly, there was a weak tendency for fruit consumption to decline with consequence fidelity in the Praise group; i.e., teachers who reported that they praised deserving children for their fruit consumption tended to see lower levels of consumption.

Prize-school teachers’ opinion of the FD program significantly decreased from Phase I to Phase II, with opinion being neither positive nor negative in the latter phase. Anecdotally, teachers raised concerns about the time needed to manage the tangible reward system, time that was taken away from academic instruction, and some teachers objected philosophically to giving prizes in school. This finding may be unique to the way FD was implemented in these U.S. schools. When FD has been implemented in Europe, teachers observe their children eating FV at snack-time and deliver the prizes at this non-instructional time. In our schools, teachers did not see their children engaged in
healthy eating and were asked to allocate academic time to checking children’s hands for hand-stamps and delivering prizes. Teachers who observe the effects of the FD program on daily consumption may be more likely to maintain a high opinion of it because they see *in vivo* effects of their implementation efforts. Unfortunately, in-class snack time is not a common feature of U.S. classrooms.

**Limitations**

We note four limitations of the present study. First, the present implementation of FD introduced a delay between the consumption of FV and the acquisition of the reward (praise or prize). As just mentioned, when the FD program is implemented in European schools, FV are most often consumed in the classroom and teachers provide tangible rewards to children soon after they have eaten their FV.\(^5-7\) In U.S. schools, FV are eaten in the cafeteria instead of the classroom. Delivering prizes or teacher praise in the cafeteria was impractical in the present study, so they were delivered in the classroom at a time of teacher convenience. This procedural change from how FD is typically implemented introduced a delay between eating FV and obtaining the prize or praise. Because delayed rewards are discounted in value relative to immediate rewards,\(^14\) this modification of FD may have decreased its efficacy relative to past evaluations of FD. Future research should explore the effects of this delay to reinforcement on children’s FV consumption and feasible ways to decrease these delays in a school-cafeteria setting.

Second, in Phase II students self-reported their FV consumption and these were used when delivering rewarding consequences. Self-report may be prone to over-reporting inaccuracies due to the social desirability bias,\(^15\) the Hawthorne effect,\(^16\) or
children’s motivation to receive rewards. As a result, children may have received Phase II rewards that they did not entirely deserve, an outcome that would be expected to reduce the efficacy of the FD program.

Third, the methods used to collect teachers’ consequence treatment fidelity data were different across groups (i.e., permanent product measure for Prize group and self-report measure for Praise group). These different methods could have contributed to the different fidelity effects seen across groups, so these results should be interpreted with caution.

Fourth, the FD protocol aims to increase total FV consumption, not just FV consumption during the school day. We did not evaluate total FV consumption so cannot draw conclusions about the effects of the intervention on consumption outside of the school. Also, we did not measure physical health effects of the intervention (e.g., lower BMI) so cannot extrapolate direct physical benefits from the program.

**Detrimental Effects of Rewards**

Some researchers have outlined negative effects associated with the use of tangible incentives, indicating that these extrinsic motivators decrease individuals’ drive, or intrinsic motivation, to engage in certain behaviors.\(^\text{17}\) This phenomenon, sometimes referred to as the overjustification effect, is observed when a behavior that is reinforced with tangible incentives decreases below unreinforced levels when incentives are no longer provided. This effect is only observed in individuals who demonstrate some initial intrinsic motivation to engage in the target behavior prior to rewards being delivered.\(^\text{18}\) In the Prize group, when tangible incentives were no longer delivered, the overjustification
effect was not observed – FV consumption did not decrease below baseline levels either at the end of Phase II or at Follow-up. Thus, when combined with the other active components of the FD program (repeated tasting and role modeling\textsuperscript{19}) tangible incentives did not produce either momentary or lasting negative effects.

**Dissemination of Incentive-Based Interventions**

Although arranging tangible incentives within the FD program produced significant increases in FV consumption, two practical issues should be discussed. First, there are significant material costs of prizes; in the present study, we spent $12.50 per child on these tangible incentives, although these costs could be reduced if prizes were purchased in larger quantities. In addition, if a school were to implement the FD program there would presumably be additional costs to obtain the videos and other supporting materials. Second, as implemented in these U.S. schools, there are significant labor costs associated with the FD program. Teachers are asked to show videos, read letters, monitor the wall chart, and deliver prizes. Outside the classroom, there are labor costs associated with ordering, storing, and delivering prizes to teachers; arranging special servings of FV in the cafeteria; and monitoring FV consumption so that hand-stamps may be provided at lunchtime. These material and labor costs are likely a barrier to adoption of the FD program in U.S. schools.

Because children attending the FD Prize schools tended to gradually decrease their consumption of FV, it would appear that longer-lasting interventions are needed to maintain early improvements in healthy eating.\textsuperscript{10} Providing an acute incentive-based intervention would, from a behavioral principles perspective, be expected to produce
temporary improvements in healthy eating; that is, when incentives are removed the behavior should return to baseline levels. Components of FD that target mediators of behavior change (e.g., acquisition of self-control and consumption skills, motivation to consume FV) would be expected to support continued healthy eating after the incentives are removed, but influencing mediators may require a longer-lasting intervention. Providing such an intervention may be difficult given the cost-related issues noted above.

Some researchers have attempted to lower the costs of incentive-based interventions. For example, Hoffman and colleagues rewarded kindergarten and 1st-grade students’ FV consumption in the cafeteria with inexpensive stickers. The stickers were a part of a multi-component intervention that also included instructional role-model videos and take-home activity books. Although the program sustained increased FV consumption for two years, it required several teachers to pass out stickers in the cafeteria each day. Perhaps as a result of these labor costs, implementation fidelity declined in the third year, as did the efficacy of the program on FV consumption. No lasting effects on consumption were detected one year later, after the program had concluded.

The Hoffman and colleagues data suggest that sustain improvements in healthy eating can be maintained by long-lasting, multi-component, incentive-based interventions, but that implementation fidelity is important, as it was in the present study. To maintain implementation fidelity will require a low-cost, low-labor intervention. One approach that has begun to be explored uses virtual rewards in a game-based intervention designed to increase FV consumption. In these studies, schools played a game in which FV consumption was tied to rewarding outcomes in a fictional narrative read by
classroom teachers. That is, when the school met its daily FV consumption goal, the fictional characters in the game narrative made progress toward their goal of capturing a band of villains. Because the rewards were virtual, they were delivered with almost no material costs. Because the game was fun, children were engaged by the goal-setting component of the game, and acquired healthy decision-making skills when they significantly increased their FV consumption in both studies. Although these findings are encouraging, the game-based intervention required 3 min of teacher time and nontrivial cafeteria-staff labor allocated to measuring FV consumption each day; these costs, while lower than prior incentive-based interventions, may be a barrier to school adoption and sustained implementation for long periods of time.

The potential for incentives to positively influence childhood dietary decision-making both in the short- and long-term has been amply demonstrated. However, declines in healthy eating over time as children exit the intervention and live in a world in which eating unhealthy foods is promoted daily by the producers for these foods, the challenge for future interventions should be to develop creative ways to deliver effective, low-cost, long-lasting, incentive-based interventions that have a small footprint in the classroom.

CONCLUSIONS

The Food Dudes program, when implemented with tangible prizes, increased FV consumption during its implementation and at a 6-month follow-up. Substituting teacher praise for prizes tended to produce smaller increases during the program and produced no lasting benefits at follow-up. Implementation fidelity proved to be important when
delivering prizes, and these prizes produced no negative effects on long-term outcomes. Although there are material- and labor-cost issues that need to be addressed, our findings support the use of incentives as an effective approach to improving children’s healthy eating at school.

REFERENCES


CHAPTER 3

GAMIFICATION OF DIETARY DECISION-MAKING IN AN ELEMENTARY-SCHOOL CAFETERIA

Most children in the U.S. do not consume the recommended amounts of fruits and vegetables (FV) on a daily basis [1,2]. These dietary decisions are a public health concern because FV are rich in vitamins and minerals and have been associated with long-term health benefits such as a reduced risk of hypertension, coronary heart disease, some types of cancer, and stroke [3]. In addition, consuming the recommended amounts of FV may play a role in helping children and adults to maintain an appropriate body weight [4,5]. FV have low energy density and are often high in fiber and consuming them can produce satiety that may decrease the consumption of calorie-dense, nutrient-poor foods [6].

A wide variety of school-based programs have been implemented with the goal of increasing FV consumption among elementary school-aged children. According to a recent meta-analysis, interventions that provide access to or education about FV tend to not produce the large and lasting increases in FV consumption that are required to impact public health [7]. By contrast, what Evans et al. referred to as “multicomponent

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interventions” tended to produce larger increases in FV consumption than education- or access-based interventions; however, many of the studies reporting these outcomes rely exclusively on children’s self-reported FV consumption [8-10]. Because of the children’s experience with the intervention (clearly designed to increase their FV consumption), concerns about the Hawthorne effect (sometimes referred to as the “good subject effect”) [11, 12] influencing self-reports in a direction desired by the experimenter diminishes confidence in the outcomes of these studies. Of those studies that objectively measured FV consumption, the most effective approaches have used a combination of role-modeling and tangible rewards for the repeated tasting of FV [13-20]. For example, children participating in the Horne et al. [16,17] studies watched videos of heroic role models as these characters derived benefits from consuming FV. Concurrently, participating children who consumed FV earned tangible prizes as rewards. This combination of role models and rewards for repeated tasting produced 45-73% increases in FV consumption in these studies.

As noted by Hoffman et al. (2010) [14], two shortcomings of this latter, multicomponent approach are its labor and material costs and lower probability of being implemented properly. Specifically, teachers and cafeteria staff may not have time to carry out tasks such as showing videos, managing a token reinforcement program, or monitoring children’s consumption of FV. Hoffman et al. [14] decreased the material costs of their multicomponent approach by using free videos produced by a fruit company and inexpensive stickers as rewards for consuming FV. Objectively measured FV consumption increased in the first year (Cohen’s d = 0.86 for fruit and 0.34 for
vegetables) but by the second year of the intervention vegetable consumption had returned to baseline levels despite the continued implementation of the multicomponent intervention. By the end of the third year when the intervention was no longer in place, both fruit and vegetable consumption returned to baseline levels [15]. Although material costs of the intervention were low, significant labor costs remained (e.g., each day in the cafeteria, 1 staff member per 30 children was required to observe and reward FV consumption). Nonetheless, implementation fidelity was generally high and school staff rated the program as highly acceptable.

The present study was conducted to further reduce the material and labor costs of a multicomponent intervention designed to increase FV consumption in an elementary school. Like past multicomponent interventions, we used role models [21] and operant reinforcement contingencies [22] to encourage FV consumption. To address concerns about the material costs of tangible rewards (in addition to concerns about the possible negative side-effects of such rewards) [23], a gamification approach was taken in which rewards were virtual – existing only in the game. Gamification describes efforts to use effective video-game design principles to influence workplace and/or socially significant human behavior [24]. A well-designed video game will provide, for example, a compelling narrative in which a character(s) under the player’s control completes quests, earns in-game currency, and purchases in-game equipment to aid in these quests. Compelling video games adjust to the skill level of the player so that the game plays as neither too easy nor too difficult. In the gamification intervention employed here, the school played a cooperative game in which, by consuming FV, they helped hero
characters to complete quests to find and capture a band of evil villains, to earn virtual currency, and to purchase virtual equipment that aided in their quests. The difficulty level of the game was designed to be neither too easy nor too difficult. To achieve this, virtual rewards were obtained when the school met a daily fruit or vegetable consumption goal, and that goal was set at the 60th percentile of the range of consumption during the preceding 10 days. Thus, the students at the school had consumed the amount of the goal or greater on 4 of the last 10 days.

In addition to reducing material costs by using virtual rewards, our gamification intervention was designed to reduce labor costs relative to other multicomponent interventions. Classroom time spent watching role-model videos was replaced by placing the role models in the brief science-fiction episodes that were read by teachers to their students. Because reading to students is an important part of elementary education, the labor requested of teachers was time spent engaged in a curricular-consistent activity. In the cafeteria, labor costs were reduced by using a school-wide waste-based measure of FV consumption. By having children sort their FV waste into color-coded bins, we quantified daily consumption by comparing FV-supply weights to FV-waste weights. Because we had access to only one school, we employed an alternating-treatments time-series experimental design to evaluate the effects of the game on FV consumption [25].

Methods

Ethics Statement

All procedures involving human subjects were approved by the Utah State University Institutional Review Board (USU IRB). An opt-out consent procedure was
used in which all students participated unless a parent or legal guardian returned the consent form indicating that (s)he did not want the student to participate. Students who were opted out \((n = 3)\) were not included in data collection procedures such that informed consent was obtained from all participating subjects. Written informed consent was not required; our opt-out, passive consent was approved by the USU IRB because of the group curricular aspect of the intervention and the extremely low risks to participants within data collection procedures (see *General Procedures*).

Participants and Setting

All kindergarten through 8\textsuperscript{th}-grade students \((n = 180, \text{ minus students who were absent on any given day})\) enrolled at a charter school in Northern Utah were invited to participate in the program. Kindergarteners were 5-6 years old during the study, and each subsequent grade was one calendar year older than this. The charter school did not participate in the US Department of Agriculture’s National School Lunch Program (NSLP), though a portion of fruit and vegetables was included with all purchased school lunches each day. The student body was comprised of 54\% boys and 46\% girls; 87\% of students were Caucasian, 6\% Hispanic, and 5\% Asian.

Materials

A 317-kg capacity scale with a resolution of 100 gm was used to measure food weights (LW Measurements, LLC; Santa Rosa, California). A smaller scale with a resolution of 1 gm was used to measure portion weights (Ozeri; San Diego, California). Different-colored 62.5-liter storage bins were used as fruit- and vegetable-waste
receptacles. A game display measuring 2.1 x 1.1 m, made from colored poster boards, was mounted approximately 1.5 m above the floor on a wall in the cafeteria; icons for the game display were created using commonly available materials (e.g., construction paper, pipe cleaners). Poster boards (55.9 x 71 cm) were used on days when participating children voted on the direction of the game narrative.

Procedure

**General procedures.** Throughout the study, one variety of fruit and one variety of vegetable (see Table 3-1 for varieties) were served daily to all students according to the pre-planned school lunch menu. A total of five varieties of fruit (three fresh and two canned) and five varieties of vegetables (three fresh and two canned) were served throughout the study. Students who brought lunch from home were allowed to take servings of the FV at no cost; parents and students were informed of this prior to the onset of the study. Fruits and vegetables were provided in volumetric servings (just under ¼ cup for K-2 grade, approx. ¼ cup for 3-5 grades, and approx. 1/3 cup for 6-8 grades). Students were allowed to return to the serving area to take additional servings of fruits, vegetables, or both. Upon finishing lunch, students placed their FV waste into the differently colored fruit- and vegetable-waste receptacles; one cafeteria staff member supervised students in this activity throughout the experiment.

Daily school-wide consumption of fruit and vegetables were calculated separately using a weight-based measure:

\[
\text{Consumption} = \frac{(P - U - W)}{S} \div N
\]

(Equation 1)
Table 3-1

*Daily Consumption Goals and the Fruit and Vegetable Served each Day in the Gamification Phase*

<table>
<thead>
<tr>
<th>Day</th>
<th>Consumption Goal (cups)</th>
<th>Consumption Goal (gm)</th>
<th>Target Food(s)</th>
<th>Non-target Food</th>
<th>Goal Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.15</td>
<td>27</td>
<td>Mandarin Oranges</td>
<td>Salad</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>0.15</td>
<td>24</td>
<td>Oranges</td>
<td>Veggie Sticks</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>0.11</td>
<td>12</td>
<td>Veggie Sticks</td>
<td>Bananas</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>0.15</td>
<td>39</td>
<td>Applesauce</td>
<td>Carrots</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>0.15</td>
<td>23</td>
<td>Bananas</td>
<td>Carrots</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>0.11</td>
<td>12</td>
<td>Veggie Sticks</td>
<td>Oranges</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>0.11</td>
<td>13</td>
<td>Carrots</td>
<td>Apples</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>0.15</td>
<td>25</td>
<td>Oranges</td>
<td>Corn</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>0.15</td>
<td>33</td>
<td>Peaches</td>
<td>Salad</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>0.15</td>
<td>29</td>
<td>Mandarin Oranges</td>
<td>Salad</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>0.12</td>
<td>13</td>
<td>Veggie Sticks</td>
<td>Oranges</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>0.15</td>
<td>39</td>
<td>Applesauce</td>
<td>Carrots</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>0.12</td>
<td>18</td>
<td>Green Beans</td>
<td>Oranges</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Note:* Veggie sticks were raw carrots and celery.

where $P$ is the total weight of the supply of fruit or vegetable prepared for serving that day, $U$ is the weight of the unserved supply of fruit or vegetables, $W$ is the weight of the fruit or vegetable waste collected in the lunchroom waste receptacles, $S$ is the weight of a single serving of fruit or vegetable, and $N$ is the number of children in attendance on the school day. The numerator of Equation 1 yields school-wide consumption, the denominator converts this to the number of single servings consumed, and dividing by the number of students in attendance provides a between-student average proportion of a serving consumed. On days when salad or vegetable sticks were served, the weight of the salad dressing used was subtracted from the numerator of the vegetable consumption equation (a subtraction that erred on the side of underestimating the amount of vegetables consumed because all numerator subtractions translate to less consumption). Inedible
portions of fruit (orange peel and banana peel) were removed prior to weighing the single servings (i.e., S).

**Baseline.** Baseline fruit and vegetable consumption were measured across a ten-day baseline using the procedures outlined above. Consumption of fruit and vegetables decreased over the baseline revealing either a reactivity to measurement effect [26,27] or a reduction in novelty to the availability of unlimited free fruits and vegetables to all students. Because consumption of vegetables was stable over the final five days of baseline (runs test indicated the slope of the regression line did not significantly deviate from zero, $p = .84$), vegetable consumption during the Gamification phase was compared to these final five days of baseline. Fruit consumption continued to decline over the final five days of baseline. Because the intervention was anticipated to reverse this trend, the Gamification phase was initiated despite this continued decline in fruit consumption. The final five days of baseline fruit consumption was used for comparison purposes with data from the Gamification phase.

**Gamification phase.** An alternating-treatments experimental design was employed throughout the Gamification phase. Each day, the intervention sought to increase either fruit consumption or vegetable consumption by giving the school a goal to consume more of the food targeted for an increase on that day. The targeted food (fruit or vegetable) was randomly selected with the constraint that no food category could be selected on more than three consecutive days.

Goals were set daily using a percentile schedule of reinforcement [28] with the goal being the 60$^{th}$ percentile of the preceding 10 days’ consumption. For example, if the
targeted food was fruit, the prior 10 days of fruit consumption on fruit-target days were rank-ordered and the 60th percentile of this array of values served as the goal. On each new day in which fruit, for example, served as the target food, a new fruit goal was calculated using the same procedure except that the oldest fruit-consumption data point in the array was discarded and replaced with the amount of fruit consumed on the last day that fruit was the targeted food. This was designed to gradually increase the consumption goals over the course of the phase. Table 3-1 shows the targeted foods and quantitative consumption goals on the 13 days of the Gamification Phase.

Daily consumption goals were communicated to students by instructing them to eat more fruit or vegetable than they would normally consume during lunch (no specific amounts [e.g., half a serving] were mentioned because this goal might be too difficult for some [e.g., vegetable refusers] and might lower consumption in others [those who already consume full portions of FV]). The first of these goals was communicated during a school-wide assembly held just before lunch on the first day of the Gamification phase. During the assembly, the heroic and villainous characters were introduced and students were told that over the next few weeks they would play a game in which they could help the heroic characters to capture each of the villains. This help would come in the form of energy that the students could harness for the heroes by eating fruits or vegetables in the cafeteria. On subsequent days, just before lunchtime, teachers identified the target food (fruit or vegetable) and encouraged them to eat more of it than normal.

At the conclusion of the assembly that opened the Gamification phase, students had the opportunity to visit seven tasting stations where small portions of three fruits and
four vegetables were served. Five of the seven fruits and vegetables were those that regularly appeared on the school lunch menu. Students who consumed six of seven tasting portions earned a small prize (e.g., temporary tattoo), and students who consumed all seven foods earned a small prize plus a large prize (e.g., mechanical pencil, flying disc, etc.). Tangible rewards were arranged at the beginning of the intervention because we anticipated that virtual rewards might be insufficient to encourage some children to try foods that they normally avoided. No other tangible rewards were used for the remainder of the study.

Throughout the remainder of the Gamification phase, when goals were met, on the next school day and just before lunch, classroom teachers read to their students the next episode (approximately 3 min in duration) of a science-fiction adventure story that was written for the purpose of this study by the second author of this paper (available upon request; greg.madden@usu.edu). Each episode described the exploits of the heroic characters as they attempted to find and capture the villains. Each episode concluded by encouraging students to eat more of the targeted food than normal so that the heroes would have enough energy to continue their struggles against evil. If the school failed to meet a goal, no new episode was read; instead, teachers read a message from the fictional heroes that encouraged them to eat more of that food than normal. When the first consumption goal was met, the first villain was captured on a planet chosen by the school. The second villain was captured after the 8th goal was met and the game concluded after meeting the 11th goal, and with the capture of the third and most fearsome of the villains (i.e., the boss battle).
A game display made of construction paper and commonly available art materials was posted on the wall of the cafeteria. The display showed hand-drawn depictions of the planets to which the heroes travelled within the narrative, the villains captured during the course of the game, and the cumulative amount of a game currency that the school had earned. Game currency was earned by exceeding the daily quantitative consumption goal; one currency unit was awarded for every 1% of a portion by which the goal was exceeded. A research assistant updated the game display daily before lunch.

On Days 2-4, 6, and 11-13 of this phase, students voted in the cafeteria to influence events happening in the narrative episodes. For example, students sometimes voted on the planet on which to search for the villains. The planet that received the most votes was inserted into a blank placeholder space in the pre-written episode to be read the next day (e.g., “Wow, you met your goal to eat more vegetables than normal so the heroes flew their ship to the ______ planet.”) This allowed use of the same episode regardless of the outcome of the vote. As a second example, on the final day of the Gamification phase, students voted on which tool to purchase with their accumulated game currency (e.g., a tornado gun, a dirty-sock cannon). During voting, each student made a check mark on a poster board near hand-drawn or clip-art depictions of the alternatives (e.g., the three nearby planets). A research assistant supervised voting.

Satisfaction Surveys. At the end of the Gamification phase, teachers, parents, and students were encouraged via e-mail notification to complete an online satisfaction survey. The student response rate (< 5%) was too low to interpret. The other surveys of teachers and parents are shown in Table 3-2. Both surveys used a five-point Likert scale
Table 3-2

*Teacher (n = 7) and Parent (n = 35) Satisfaction Surveys*

<table>
<thead>
<tr>
<th>Teacher Survey</th>
<th>Median</th>
<th>Low Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I read the episodes to my class every day</td>
<td>5.0*</td>
<td>2</td>
</tr>
<tr>
<td>Students enjoyed the episodes</td>
<td>5.0*</td>
<td>2</td>
</tr>
<tr>
<td>Student behavior/concentration has improved</td>
<td>3.0</td>
<td>3</td>
</tr>
<tr>
<td>My FV consumption has increased</td>
<td>4.0</td>
<td>2</td>
</tr>
<tr>
<td>The program would be beneficial to other schools</td>
<td>4.0*</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parent Survey</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>My child enjoyed the episodes</td>
<td>4.0**</td>
<td>2</td>
</tr>
<tr>
<td>My child enjoyed the change in school culture toward eating FV</td>
<td>4.0**</td>
<td>3</td>
</tr>
<tr>
<td>My child consumed more FV at school</td>
<td>4.0**</td>
<td>3</td>
</tr>
<tr>
<td>My child consumed more FV at home</td>
<td>4.0**</td>
<td>2</td>
</tr>
<tr>
<td>My child was more willing to try new FVs</td>
<td>4.0**</td>
<td>3</td>
</tr>
<tr>
<td>My child asked me to buy more of a specific FV</td>
<td>3.0</td>
<td>1</td>
</tr>
<tr>
<td>My child's behavior/concentration has improved</td>
<td>3.0</td>
<td>1</td>
</tr>
<tr>
<td>My child's general health has improved</td>
<td>3.0</td>
<td>1</td>
</tr>
<tr>
<td>My FV consumption has increased</td>
<td>3.0</td>
<td>1</td>
</tr>
<tr>
<td>I am happy with results and believe other schools would benefit</td>
<td>5.0**</td>
<td>3</td>
</tr>
</tbody>
</table>

*Lower 95% CI of median $>3$ (neither agree nor disagree)*

**Significantly different from 3; $p < .0001$, Wilcoxon Signed-Rank Test

where 1 = Strongly Disagree, 3 = Neither Agree nor Disagree, and 5 = Strongly Agree.

The exception was the final two questions of the parent survey, which asked parents to categorize their child’s daily FV consumption before and after the intervention (1 = less than one cup, 2 = 1-1.5 cups, 3 = 2-2.5 cups, 4 = 3-3.5 cups, 5 = 4 or more cups).

Data Analysis. All statistical analyses were performed using the proportion of portions metric yielded by Equation 1. These values were also converted to grams (weight-based measure) and cups (volume-based measure) after the study was completed.
for reporting purposes. Some varieties of fruits and vegetables weighed different amounts despite similar volumes; for example, a ¼-cup serving of fresh salad weighs 14.25 grams, and a ¼-cup serving of canned green beans weighs 38.25 grams. Examining changes in consumption as measured by weight (grams) may be misleading because of these weight differences. For example, large increases in salad consumption volume would translate to small increases in vegetable consumption weight compared to small increases in green bean consumption volume.

To evaluate the effects of the game-based intervention, we first used a Simulation Modeling Analysis (SMA) to determine if post-baseline fruit and vegetable consumption (analyzed separately) increased above baseline levels in the Gamification phase. The two time-series of fruit and vegetable consumption included all post-baseline days (i.e., vegetable consumption on days in which fruit was targeted by the game were included in the vegetable time series). This analysis evaluated if FV consumption increased significantly despite only one food being targeted for change on most days of the Gamification phase.

The SMA is appropriate for brief time-series data because it takes into consideration autocorrelation within the data stream [29]. An ANOVA is inappropriate for time-series data. Likewise a generalized estimating equation could not be used because (i) the baseline was too brief and (ii) only one school participated in the study. Briefly, the SMA estimates autocorrelation in the obtained baseline and intervention phases and corrects for small-n bias [30]. It then obtains a Pearson correlation coefficient ($R$) between the obtained time-series data and the dummy-coded (0 and 1) baseline and
intervention phases. Spearman rank-order correlation coefficients may also be used within the SMA. We report Pearson’s coefficient values because the statistical significance of the outcome was unaffected by the correlation coefficient selected. The SMA then randomly generates 5000 random-normal time-series data streams with the same autocorrelation and the same number of observations in each phase as the observed data. The proportion of randomly generated data streams with a correlation coefficient (against the phase vector) greater than or equal to the obtained correlation coefficient serves as the p-value.

The second analysis was designed to evaluate if the Gamification intervention was responsible for increased consumption of FV. If it was, then on days when fruit (vegetable) consumption was targeted by the game, fruit (vegetable) consumption should be significantly higher than during baseline and vegetable (fruit) consumption should not be significantly elevated relative to baseline. To evaluate the role of the intervention on consumption we used the Conservative Dual Criteria (CDC) method developed by Fisher, Kelly, and Lomas [31]: a method developed using Monte Carlo simulations to yield acceptable power and low rates of Type I error with time-series data sets as small as five observations in baseline and treatment. The two criteria in the CDC are binomial tests that determine if the treatment data are significantly elevated above (i) the baseline mean plus 0.5 standard deviations (i.e., a moderate effect size), and (ii) the baseline trend-predicted level (assessed via linear regression) elevated by 0.5 standard deviations. Applied to our data, if binomial tests indicated that consumption of the target food was significantly higher than the baseline level (+0.5 SD) and the projected trend (+0.5 SD),
then both criteria in the CDC were satisfied and the difference was considered significant. We predicted that the consumption of FV would meet the dual criteria only on days when that particular food (fruit or vegetable) was the target food.

For parent post-intervention satisfaction surveys, a Wilcoxon’s Signed-Ranks test was used to determine if item ratings deviated significantly from 3 (the response indicating neither a positive nor negative opinion). Although the proportion of teachers that completed their satisfaction survey was high (87.5%) the number of teachers in the sample was small (N = 8). Therefore, if a single teacher provided a rating at or below 3, the Wilcoxon’s test was rendered nonsignificant. To avoid this overly conservative criterion, item ratings were considered significantly higher than 3 if the lower 95% confidence interval (CI) was greater than 3.

**Results**

Figure 3-1 shows the average (+SEM) cups of fruit and vegetable consumed per day in the Baseline and Gamification phases (all data may be obtained from the second author upon request). The right side of each panel separates consumption on those days when the target food was the food indicated in each panel. Baseline levels of fruit and vegetable consumption were 0.11 cups (17.71 gm) and 0.09 cups (11.41 gm), respectively. The SMA indicated that fruit (R = .57, p < .01) and vegetable (R = .48, p < .05) consumption increased significantly following the Baseline phase. The R values are Pearson’s correlation coefficients obtained when consumption data are plotted as a function of the dummy coded baseline (0) and intervention (1) phases. Recall that this analysis ignored what food (fruit or vegetable) was targeted by the intervention,
evaluating instead the overall level change following the Baseline phase (i.e., the left sides of the graphs in Figure 3-1). During the Gamification phase, fruit consumption increased by 66% to an average of 0.18 cups (32.56 gm, an 84% increase) per day. Similarly, vegetable consumption increased by 44% to an average of 0.13 cups (14.65 gm, a 28% increase) per day.

The CDC analysis revealed that consumption of fruit (p < .01) and vegetables (p < .05) were significantly higher than baseline on days when these were the target foods.

![Figure 3-1. Fruit and vegetable consumption across baseline and gamification phases. The left sides of the panels show fruit (top panel A) and vegetable (bottom panel B) consumption (in cups) from the last 5 baseline days and all 13 days of the Gamification Phase. The right side of each panel separates consumption on days when the food indicated in the panel was targeted by the intervention for increased consumption (hatched bar) and on days when that food was not targeted (grey fill bar). *p < .05 **p < .01](image.png)
during the Gamification phase. Consistent with the hypothesis that the contingent relation between target-food consumption and game-based rewards was responsible for elevated consumption, there was no significant increase in fruit or vegetable consumption when these foods were the non-target foods (i.e., the foods unassociated with goals and game-based rewards; both $p’s > .5$).

The results of the post-intervention teacher and parent satisfaction surveys are presented in Table 3-2. Response rate was high for teachers (87.5%) and moderate among parents (23%, a response rate that falls well within the range of rates empirically demonstrated to produce valid outcomes when compared with higher response rates) [32]. Noting only the significant findings, most teachers indicated that they were able to read the episodes in their class, the students enjoyed the episodes, and they believed the program would be beneficial if implemented at other schools. The principal of the school invited our research team to return to the school next year to play the FV game again. Among parents, several survey items obtained scores significantly greater than 3 (e.g., my child enjoyed the change in school culture toward eating FV). Of greatest interest was that parents reported that after the intervention their children were consuming more FV at home and that they were more likely to try a new FV. Parents were highly satisfied with the intervention and indicated it would be beneficial if implemented at other schools. On those survey questions that asked parents to estimate their child’s FV consumption before and after the gamification intervention (not shown in Table 3-2), parents indicated that consumption had increased by an average of 0.41 cups per day and a Wilcoxon Signed Rank test applied to pre-post difference scores indicated that this increase was
significantly different from zero ($p < .01$).

**Discussion**

Cafeteria-based FV consumption among K-8th grade students increased significantly above baseline levels when a low-cost, behaviorally based gamification intervention was introduced. Across all days of the intervention, fruit and vegetable consumption increased above baseline levels by 66% and 44%, respectively when measured in cups, and 84% and 28%, respectively when measured in grams. Importantly, because consumption of the targeted food (fruit or vegetable) increased significantly above baseline levels but consumption of the non-targeted food did not, the overall increases in FV consumption may be attributed to the efficacy of the intervention. After the intervention had ended, teachers indicated that other schools would benefit by playing the game. Likewise, parent responses were significantly positive on survey items inquiring about FV consumption and satisfaction with the school-based intervention. Therefore, the goal of positively impacting children’s dietary choices at school, and to do so in a fun, low-cost, low-labor fashion, was achieved.

Although FV consumption was increased by the gamification intervention, the amounts of FV consumed still fell below the per-meal amounts recommended by the USDA. Where the USDA recommends children grades K-8 consume 0.5 and 0.75 cups of fruit and vegetables, respectively at lunch, our participants consumed an average of 0.18 and 0.13 cups, respectively during the gamification phase. Even when nontarget days are excluded (because the game targeted the other food for increased consumption), fruit ($0.2 \text{ cups} \pm 0.05$) and vegetable ($0.17 \text{ cups} \pm 0.02$) consumption were still below the
USDA guidelines.

The gap between baseline levels of FV consumption and the USDA guidelines might be further decreased if the game were played for a longer duration. Daily consumption goals were set modestly above recent consumption (always the 60th percentile of the last 10 days’ consumption) and were updated daily. Assuming that the school would continue to meet its consumption goals during a longer version of the game, this dynamic goal-setting algorithm would continue to gradually increase the consumption goal until consumption approximates the USDA standards. An empirical research base supports the use of these percentile schedules of reinforcement [28] for producing gradual changes in socially significant behavior [33-35]; the technique is used in basic behavioral pharmacology and toxicology research with nonhuman animals [36-38]. Investigating the efficacy of a longer version of the gamification intervention should be a direction for future research, while maintaining the goal of minimizing its material and labor costs.

Minimizing Material and Labor Costs

As noted earlier, multicomponent school-based interventions are effective in improving healthy eating in schools [8]. However, these multicomponent interventions may require the purchase of materials (e.g., stickers, videos, tangible rewards) and always require some amount of teacher labor (e.g., passing out stickers during lunch [14,15]; managing a point system for delivering intermittent tangible rewards [16,17,19]). In our gamification intervention material costs were minimized. The game display that hung in the cafeteria (and perhaps served to remind children of the game and their goal to
consume more FV) was made of construction paper and other readily available art supplies. Although our research team made the game display and updated it daily, children in an art class and/or in a before/after-school club could undertake these activities. Because all of the rewards were delivered within the narrative (e.g., learning if a villain was captured by searching on a planet) or on the game display (e.g., game currency) the material costs of the game-based rewards were nominal.

Teacher labor in the current study was confined to reading the science-fiction episodes before lunch (approximately 3 min for 13 days) and, as noted above, teachers reported that they were able to complete this task daily. Nonetheless, future game-based interventions should seek to lower this labor cost, as it may be a barrier to school adoption. One solution is to play audio-recorded versions of the episodes over a school-wide public-address system. This would allow teachers to pursue other academic-preparatory tasks while potentially increasing the production quality of the episodes. Perhaps the largest labor-cost of the present intervention was placed on the kitchen staff, who was asked to weigh FV before and after lunch. In addition, if a school were to implement this intervention without outside assistance, they must allocate one cafeteria employee to monitor children’s sorting of FV waste. Although weighing tasks were typically completed in less than 10 minutes, and monitoring the sorting of FV waste is not onerous, some schools may not agree to these reallocations of labor. A low-labor alternative would be to install automated tray-photo stations where pictures of pre- and post-lunch trays are taken and advanced software estimates FV consumption [39]. Of course, this low-labor approach increases the materials cost of the intervention.
Other Limitations

Four other limitations of this pilot project are noteworthy. First, the intervention was conducted in a single charter school in Utah that did not explicitly follow the USDA’s NSLP guidelines and were thus serving smaller amounts of FV than typical schools. Whether the intervention would work as well in other larger, culturally more diverse, or rural schools is unknown. Likewise, the acceptability of the program to other teachers and parents cannot be evaluated from this single-school study. Answering these questions of generality and between-school replicability will have to await future studies.

Second, the intervention began with a school-wide tasting session in which children earned tangible rewards for consuming small portions of FV. Some children may have anticipated that additional tangible rewards would be obtained for consuming FV during the gamification phase, and this may have played a role in the significant increases in FV consumption. Three pieces of evidence argue against this. First, the narrative episodes made it clear that game-based rewards (e.g., new episodes, game currency) were the only rewards for increased FV consumption. Second, if tangible rewards were anticipated but never delivered, one would expect a decreasing trend on FV consumption during the intervention phase. No such decrease was detected by runs tests applied to the slope of regression lines fit to the time-series fruit ($p = .36$) or vegetable ($p = .93$) data from the gamification phase. Third, in a recently completed systematic replication of our game-based intervention (unpublished data), we obtained significant increases in FV consumption when no tangible rewards were used at any time during the gamification phase.
A third limitation is that the school-wide consumption measure developed for this study did not allow us to evaluate the effects of the intervention on the FV consumption of individuals. Thus, the source of the increased consumption is impossible to identify: did all students consume more than normal or did a smaller group of students drastically increasing their consumption? When rewards are given to the group based on the collective performance of the group, there may be a tendency for some within the group to exert less effort; i.e., social loafing [40]. At present, we know only that FV consumption increased significantly following the intervention and that the intervention was responsible for this increase; we do not know how this increased consumption was distributed across individual children. As above, automated analysis of lunch tray photos offer one avenue for addressing this limitation.

Fourth, the duration of the intervention was brief, so we do not know if the increased levels of FV consumption could be maintained if the duration of the Gamification phase were extended by, for example, playing a game that required more accomplishments be made before the ultimate goal was met. For example, a number of industry-based gamification interventions involve earning virtual trophies and/or leaderboards. One way in which the present game could be extended would be to place the school on a leaderboard with fictional schools from, for example, other planets, and with whom the school competes for trophies and to qualify to play the science fiction game played in the present study.
Learning Theory and Gamification

The gamification intervention employed here is theoretically grounded in social learning theory [21] and operant learning theory [22]. Role-model heroes encouraged students to consume more FV and when students met these goals, a variety of game-based reinforcers were delivered. The game context adds to the incentive-based approach by providing a platform for delivering low-cost virtual reinforcers for FV consumption. That platform was the science-fiction adventure game and the reinforcers were the episodes that teachers read to their students, the capturing of villains, the acquisition of virtual currency, and the goods purchased with that currency, etc.

Gamification proponents [24] have argued that the game-design techniques used by video-game programmers can improve the efficacy of behavior-change interventions. A potentially important one of these techniques is to create a compelling narrative in which the game is played. In our game, the narrative pitted the heroes against the villains and enlisted the school in this battle. The narrative clearly established the object of the game (find and capture the villains) and clearly connected player behavior to game outcomes (if the school meets its FV consumption goal, then episodes in the narrative will be read, currency will be earned, villains will be captured, etc.). Within behavior analysis, these functions of the narrative are identified as establishing operations [41]; that is, stimulus changes that enhance the value of a consequence as a reinforcer. The science fiction adventure episodes were often written with cliff-hanger endings designed to enhance the value of a virtual reward. For example, one episode ended with a giant eating the hero’s spaceship, leaving them stranded on a planet with no communication
abilities except for that with the school. However, if the school met their consumption goal on that day, the heroes could purchase a new ship with the virtual currency earned.

An empirical challenge for future research is to quantify the value-enhancing effects (if any) of contextualizing reinforcers within a game narrative. A trinket reward, like a rubber ball, may have reinforcing value, but can the value of that reward be enhanced if the student must earn the rubber ball before a hero in the game-narrative may acquire the same ball and use it in a battle with a high-level villain? The widespread sale of toys that appear in cartoons and video games and the purchasing with real money of virtual items earned within video games [42] suggests that virtual rewards have quantifiable value that may enhance or replace more costly incentive-based interventions.

As previously mentioned, another question for future research is if using game-based virtual rewards can enhance student interest in the game and, as a result, can sustain increases in FV consumption in longer duration interventions. Video game programmers use the acquisition of virtual rewards to increase the probability of sustained game play. For example, when a player earns a magic scroll or unlocks a new area of the game, the player may be less likely to quit because they want to use the scroll or to explore the new area of the game. Translated to a gamified intervention, virtual rewards may enhance engagement with the game, with the characters in the game, and with the goal of consuming more FV. How long increased FV consumption can be maintained is an empirical question. Designing an effective game will employ principles of social learning theory (e.g., role models), behavior analysis (e.g., schedules of incentives, establishing operations, token economies, etc.), and newly emerging
principles of gamification [24].

Conclusions

Because (a) the majority of children in the US do not consume recommended amounts of FV [1], (b) the health benefits of doing so are well established [3], (c) some evidence suggests eating FV plays a role in maintaining an appropriate body weight [4], and (d) schools offer a venue in which more than 30 million US children consume at least one important meal each day; developing and empirically evaluating practical, low-cost, low-effort, school-based interventions should be a national priority. The present study demonstrates the initial feasibility and efficacy of a gamification-based intervention for increasing school-wide FV consumption.

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Because children and adolescents do not consume recommended daily amounts of fruits and vegetables (FV; Guenther & Dodd, 2006; Striegel-Moore et al., 2006), they are at an increased risk of developing hypertension, coronary heart disease, some types of cancer, and stroke (Boeing et al., 2012). In addition, these children may be at increased risk of overweight and obesity as increased FV consumption may displace consumption of energy-dense, high-fat foods (Epstein et al., 2001). Simply providing FV in school cafeterias does not appear to increase FV consumption (Cooke et al., 2011; Evans, Christian, Cleghorn, Greenwood, & Cade, 2012; Just & Price, 2013a; Smith & Cunningham-Sabo, 2013). Thus, there is a need for school-based interventions that target FV consumption.

Placing healthier choices in convenient cafeteria locations or presenting them in appealing ways (Wansink, 2013) generally increases the taking of healthier foods (e.g., Hanks, Just, Smith, & Wansink, 2012; Hanks, Just, & Wansink, 2013b; Wansink, Just,
Payne, & Klinger, 2012 [Study 1]) but the effects of these interventions on consumption are less clear. When consumption increases are reported, they tend to be small (Hanks et al., 2012; Musher-Eizenman et al., 2011) and are assessed for just a few days (Hanks, Just, & Wansink, 2013a; Wansink, Just, Hanks, & Smith, 2013; Wansink et al., 2012 [Study 2]). Nonetheless, the goal of implementing these or similar low-cost, low-effort interventions should be embraced because schools with tight budgets are most likely to adopt them.

In studies in which FV consumption is objectively measured (e.g., plate waste, digital imaging), incentives are a common component of effective interventions. Incentives, in combination with role modeling and repeated tasting (e.g., Hoffman, Franko, Thompson, Power, & Stallings, 2010; Hoffman et al., 2011; Horne et al., 2004, 2009; Lowe, Horne, Tapper, Bowdery, & Egerton; 2004; Wengreen, Madden, Aguilar, Smits, & Jones, 2013), in combination with default provision of FV (Just & Price, 2013a), and in isolation (Hendy, Williams, & Camise, 2005; Just & Price, 2013b) significantly increased FV consumption.

Although incentives positively influence FV consumption, their lasting effects are either unknown or negligible. To our knowledge, only four studies have assessed the effects of incentive-based interventions at least three months after the intervention concludes. In three of these studies (Hoffman et al., 2011; Upton, Upton, & Taylor, 2013) incentives produced no lasting effects on consumption, while in the fourth study (Jones, Madden, Wengreen, Fargo, & Aguilar, 2014), FV consumption remained modestly elevated (0.07 cup and 0.05 cup difference in F and V consumption,
respectively, between full experimental and control groups). Given these outcomes, one approach to producing sustained increases would be to incentivize FV consumption for an extended duration. For example, Hoffman et al. (2010) rewarded FV consumption in the cafeteria with inexpensive stickers ($0.04 each), which (when combined with educational videos [free], books [$3.38 per child], and posters [$100]) increased consumption for at least one year (Hoffman et al., 2011). While this is a model low-cost intervention, it required the daily involvement of six lunchroom aids per cafeteria, and the entire academic staff; these labor reallocations may be a barrier to school adoption.

Jones, Madden, Wengreen, Aguilar, and Desjardins (2014) implemented a brief game-based intervention designed to decrease the material- and labor-costs below those of Hoffman et al. (2010). In their pilot project, school-wide FV consumption was rewarded daily with virtual rewards embedded within a game that was designed using seven principles of gamification (i.e., game-design techniques used in video games; e.g., Adams, 2010; Reeves & Read, 2009). Their non-video-based game included (i) a clear object of the game, (ii) a compelling narrative in which, (iii) characters under the player’s control, (iv) completed quests, (v) earned in-game currency, (vi) purchased in-game equipment to aid in these quests, and (vii) success in the game was tied to meeting daily fruit or vegetable consumption goals that were neither too easy nor too difficult. Much like the narrative developed for the original Food Dudes program (e.g., Lowe et al., 2004) the heroes were children who sought to foil the plans of a handful of villains. Waste-based measures of FV consumption collected by one lunchroom aid revealed that the game maintained significantly higher FV consumption than baseline across the 13-day
intervention. As the non-tangible, game-based rewards were free, the intervention had lower material and labor costs than Hoffman et al.

The purpose of the current study was to further evaluate the effects of a low-cost, game-based intervention on elementary-school children’s FV consumption. The game (henceforth the FIT Game) was expanded in duration (from 13 days to 29 days) and technique beyond Jones et al. (2014) and was played in a new school. Introducing a competition in which the school competed against virtual opponents expanded the gamification technique. As in Jones et al., we used an alternating-treatments design to evaluate the role of the intervention on objectively measured increases in school-wide FV consumption.

Method

Participants & Setting

All first- through fifth-grade students (n = 252) attending an elementary school in Logan, UT were invited to participate. An opt-out consent procedure was used; only one student opted out. Students participated on days when they purchased school lunch.

Materials

A floor scale (180-kg capacity, 0.1-kg resolution; EatSmart; Mahwah, NJ) was used to measure FV weights. Waste bins (37.9-liter capacities) were used as separate fruit- and vegetable-waste receptacles. A 91.4 x 121.9 cm printed poster was hung on a bulletin board near the cafeteria and served as the FIT Game Display (i.e., where information about the game was posted). A 152-cm flat screen monitor mounted on the
cafeteria wall was used to display game rules and character biographies. Poster boards
(56 x 71 cm) were used on days on which students voted to determine the actions of the
fictional characters.

**Procedures**

One fruit variety and one vegetable variety were served daily in ½-cup servings as
part of the usual school lunch menu. Students purchasing lunch could also take items
from a salad bar stocked with two varieties of fruit and several salad components. After
lunch, students placed their FV waste in the respective waste receptacles. This task was
supervised by a research assistant.

Daily FV consumption was calculated using a weight-based measure (see
Wansink et al., 2012 for a similar procedure):

\[
Consumption = \frac{P - U - W}{N}
\]  

(Eq 1)
in which \( P \) is the weight of all fruit (vegetable) prepared, \( U \) is the weight of the unserved
fruit (vegetable), \( W \) is the weight of the fruit (vegetable) waste, and \( N \) is the number of
students who purchased school lunch that day. Thus, the numerator is the weight
consumed by the school and dividing by \( N \) yields average per-student consumption.

**Baseline**

During baseline, FV consumption was calculated daily as just described. There
were no programmed consequences for FV consumption. Baseline data collection
continued for at least 15 days and until the time-series consumption data either stabilized
or demonstrated a downward trend (fruit, 16 days; vegetables, 19 days).
FIT Game Phase

An alternating-treatments design (see Perone & Hursh, 2013) was used to evaluate the effects of the FIT Game on FV consumption. Accordingly, either fruit or vegetable consumption (randomly selected) was targeted for improvement each day. Students were notified of the target food (fruit or vegetable) daily before lunch and were instructed that their goal was to eat “a little more” than normal. Goals were met when students consumed at or above a criterion of the 60th percentile of consumption over the last 10 target days (see Galbicka, 1994). On occasions when consumption fell below this criterion level, the target food was repeated until the goal was met. According to the logic of an alternating-treatments design, if consumption increases on days on which the food is targeted by the intervention but not on days on which that food is not targeted, then the increase is attributed to the intervention.

To start the FIT Game, a school-wide assembly was held to orient the students to the hero and villain characters and to establish the object of the game – to help the FITs (the heroes) capture members of the villainous Vegetation Annihilation Team (VAT). At the assembly, students were told that (i) several schools in the galaxy want to help the FITs, (ii) the FITs will hold a competition to select the most qualified school, (iii) the competition will involve three elimination rounds, and (iv) the school that wins the final elimination round will be selected to help battle the VAT.

The competition was held over the first seven days of the FIT Game and on each day teachers informed their students of their progress by reading a brief (< 1 min)
The school putatively competed against one, two, and then three fictional schools, respectively, in the three elimination rounds of the competition. Each round was won by eating more of the target food (fruit or vegetable) than the other school(s) and for the number of days equal to the numbered elimination round (i.e., 1, 2, and then 3 days, not necessarily sequential). In reality, if the school met or exceeded the criterion level of consumption (as described above) they were said to have consumed more than the fictional school(s). After winning an elimination round, a whimsical medal (e.g., a silly-string medal) was awarded to the school by placing a printed depiction of the medal on the FIT Game Display. After the third elimination round, the school qualified to help the FITs capture the villains.

In the second (post-competition) portion of the FIT Game (22 days), teachers were asked to read stories to their students before lunch. The 3-min stories described the efforts of the FITs to capture the VAT and outlined the students’ role in completing this objective – to eat fruit or vegetables (depending on the target food) in the cafeteria. When students met or exceeded the criterion level of consumption, teachers read an episode of the story the next day. Each episode began by congratulating the school on their success and progressed through the narrative, which usually had a cliffhanger ending. When consumption did not meet the criterion, teachers read a script that prompted students to eat more than normal because the heroes need their help.

For every gram by which the average student exceeded the consumption criterion, one unit of game currency was added to an account displayed on the FIT Game Display.

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\(^d\) The scripts read by teachers, and all materials used in the FIT Game, are available upon request: greg.madden@usu.edu.
On four days during the second portion of the FIT Game, students were given the opportunity to vote on how to spend the currency or on the direction of the game narrative. The unmonitored voting board was placed near the cafeteria entrance, displayed the options (e.g., which equipment to buy), and had attached markers available. On days when the consumption criterion was met, the option that garnered the most votes appeared in the next day’s story.

**Statistical Analysis.** To evaluate the effects of the FIT Game on FV consumption, we used the Conservative Dual Criterion (CDC) developed for brief time-series data sets using Monte Carlo simulations to yield acceptable power and low Type I error rates (Fisher, Kelly, & Lomas, 2003). Each intervention data point is scored as above baseline if it is 0.5 SD above the baseline mean and the baseline trend (i.e., baseline regression line shifted up by 0.5 SD and extended into the intervention time series). A binomial test is then applied to the scored (0 or 1) data points. In accord with the alternating-treatments design, we predicted that consumption would be significantly above baseline only on days when that particular food (fruit or vegetable) was the target food.

**Results**

Figure 4-1 shows average daily FV consumption (in gm per student) in the baseline and FIT Game phases. Linear best-fit functions plotted through baseline fruit and vegetable consumption data (not shown) revealed that both baselines were stable over time (slopes = 0.0003 and 0.0002 respectively). Within the FIT Game phase, data are separated by days on which the food was targeted for increased consumption by the
FIT Game (filled bars) or days on which the other food was targeted (gray bars). During baseline, students consumed an average of 62 gm of fruit (equivalent to ½ cup of chopped apples; USDA National Nutrient Database for Standard Reference, version 1.3.1.) and 42 gm of vegetables (equivalent to approximately 1/3 cup of raw carrot strips). Thus, at baseline, students were already consuming a serving of fruit but less than a serving of vegetables.

When the FIT Game targeted fruit, students consumed an average of 86 gm of

![Figure 4-1](image)

*Figure 4-1.* FIT Game fruit and vegetable consumption. Fruit consumption (top panel) and vegetable consumption (bottom panel) presented by phase (baseline vs. FIT Game) and contingency (target vs. nontarget). Error bars represent SEM. This study was conducted in Fall 2013 in Logan, UT. * p < .05 **p < .01
fruit (a statistically significant 38.7% increase; p < .01, Cohen’s d = 0.75).
By contrast, on vegetable-target days (Nontarget Days in the upper panel of Figure 4-1) students consumed an average of 60 gm of fruit (not statistically greater than baseline fruit consumption).

When the FIT Game targeted vegetables, students consumed an average of 56 gm of vegetables (a statistically significant 33.3% increase; \( p < .05, \) Cohen’s \( d = 0.48 \)). On vegetable Nontarget Days (i.e., when the target food was fruit), students consumed an average of 46 gm of vegetables (not statistically greater than that consumed during baseline).

Nine of ten teachers completed a four-item, post-intervention Likert-scaled survey (1 = strongly disagree, 3 = neutral, 5 = strongly agree). On the first item, eight teachers indicated that their students enjoyed the FIT Game episodes (i.e., they provided scores of 4 or 5 on this item), with teachers in grades 4 and 5 rating the stories lower (range 2-4) than teachers in grades 1-3 (range 4-5). Although seven teachers reported that they could incorporate the Game into their classroom routine (item 2), only four teachers said that they read the story every day (item 3), with four teachers disagreeing with this statement. In an open comment section of the survey, the latter teachers said that the stories were too long and, therefore, they often summarized them. Consistent with the item asking about student enjoyment, six of seven teachers in grades 1-3 said they would recommend the FIT Game to other schools (item 4), whereas neither of the teachers in grades 4 and 5 recommended it (scores = 2 and 3).

**Discussion**

When elementary-school children played a cafeteria-based game in which virtual
outcomes were tied to real-world FV consumption, significant increases in objectively measured FV consumption were observed. These increases replicate and extend the increases reported by Jones et al. (2014) using a similar game-based approach. Because the present study’s increases were confined to the days on which the intervention targeted either fruit or vegetable for increased consumption, we may conclude that the intervention was responsible for the improvement.

The two primary strengths of this game-based intervention are its low material- and labor-costs. The material costs were nominal as they were confined to printing the posters used as the FIT Game display. By comparison, the low-cost sticker-based intervention of Hoffman et al. (2010) had higher materials expenses, as they used posters, stickers, and educational books. The labor required to implement the FIT Game included (i) weighing FVs, (ii) monitoring the FV waste receptacles to ensure appropriate waste sorting, (iii) teachers reading a 3-min episode to their students, and (iv) updating the FIT Game Display. These labor reallocations were probably lower that those of Hoffman et al. who used six lunchroom aids per cafeteria and involved the entire academic staff. A secondary strength of the Game is that, because it uses no tangible rewards, teachers and parents do not object based on research suggesting that extrinsic rewards undermine intrinsic motivation to, in this case, make healthy choices (e.g., Ryan & Deci, 2000).

Notably, students in our study were consuming full portions of fruit and two-thirds of a portion of vegetables at baseline, an average intake higher than observed in most school-based studies. This may have been because the school served a variety of FV everyday (Just, Lund, & Price, 2012). Nonetheless, the FIT Game produced
significant increases above these baselines levels.

We note five limitations to be addressed in future studies. First, although the narrative episodes required 3 min or less to read, many of the teachers surveyed felt that they were too long. A second, related limitation is that teachers in grades 4 and 5 reported that their students did not enjoy the stories as much as children in grades 1-3 (this may be why the former teachers would not recommend the FIT Game to other schools). An obvious approach to addressing these limitations is to shorten the episodes and develop versions for older children. Another approach would be to remove most of the episodes, replacing them with additional information posted on the FIT Game Display (e.g., in comic-book format). If the latter could maintain increased FV consumption, it would do so in a way that makes playing the Game more acceptable to school administrators who are, in our experience, reluctant to direct time away from academics.

A third limitation is that no information is available about the effects of the FIT Game on individual children’s FV consumption. To meet consumption goals, the whole school had to consume more than they had on half of the prior 10 days. This could be accomplished if all children ate a little more than they normally did (which was encouraged in the episodes) but it also could have been accomplished if children who normally ate FV consumed much more than normal. Future studies should evaluate the effects of the Game on individual consumption, particularly for those children who consume no FV.

A fourth limitation is that the influence of the various game elements on increased FV consumption cannot be articulated from the present data. At worst, the increases in
consumption are due to daily teacher encouragement to consume fruit or vegetables (and not due to the game elements). This is unlikely given that informational approaches to increasing FV consumption (e.g., encouraging children to consume “5 a day”) do not increase FV consumption for the approximately 6-week duration of the present study (Evans et al., 2012). Informal observations made in the cafeteria and near the FIT Game display indicated that the children were engaged by the Game (e.g., children so frequently poked the depictions of the villains on the FIT Game display, that when it was removed upon game completion, it had a hole in it). Nonetheless, future studies should evaluate the unique contributions of each of the game elements.

A final limitation is that the FIT Game was played for only about six weeks and follow-up data have yet to be collected. Increasing FV consumption over 29 days provides evidence that the Game can maintain healthy eating for this interval, and perhaps longer if the Game were further developed. However, if past studies are a predictor, the Game will produce no lasting effects on FV consumption after it ends (e.g., Hoffman et al., 2011; Upton et al., 2013). If so, then producing long-term effects on FV consumption in schools will require a long-term intervention. Such interventions will need to have low material- and labor-costs while capturing children’s attention and enthusiasm. Principles of gamification (Adams, 2010; Reeves & Read, 2009) were used when developing the FIT Game and should be drawn upon as its duration is extended and its footprint in the classroom is reduced. Such an intervention may prove useful in improving habitual dietary decision-making in children with the long-term goal of decreasing chronic disease and obesity.
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CHAPTER 5
GENERAL DISCUSSION

This document presents a cohesive review and evaluation of school-based fruit and vegetable (FV) consumption interventions that have objectively measured this outcome (Chapter 1). In the three experiments conducted here, children’s in-school FV consumption was targeted for increase using either tangible or praise rewards (Chapter 2) or virtual, game-based incentives (Chapters 3 and 4). Significant increases in fruit, vegetable, and combined FV consumption were obtained when comparing experimental groups to a control group at different time points (Chapter 2) or when comparing intervention time points with baseline or control data points using within-subject comparisons (Chapters 3 and 4).

In the review provided in Chapter 1, we found that multicomponent interventions that feature incentives were more consistently effective than either multicomponent interventions featuring education or single-component interventions. The post-intervention effects of these single- and multi-component interventions are mixed. Follow-up assessments were not conducted in the single-component interventions reviewed (Adams, Pelletier, Zive, & Sallis, 2005; Just & Price, 2013; McCool, Myung, & Chien, 2005; Upton, Upton, & Taylor, 2012; Wansink, Just, Payne, & Klinger, 2012), so their long-term effects on behavior are unknown. Given their modest or nonsignificant effects, there is reason to be skeptical that a single-component intervention can influence dietary decision making enough to impact public health. In multi-component interventions featuring education, no studies produced significant effects at follow-up.
Finally, multicomponent interventions featuring incentives (specifically, the Food Dudes [FD] program) have shown either positive (e.g., Horne et al., 2009) or negative (Upton, Upton, & Taylor, 2013) follow-up effects, with the latter effect hypothesized to be due to poor implementation fidelity.

When a school-based intervention uses tangible incentives there are increased material costs associated with purchasing, shipping, and storing the prizes. In addition, the school must distribute the prizes to teachers and instruct teachers in their proper use. Teachers must use what might otherwise be academic-instruction time to determine which students are deserving of and subsequently distribute the prizes. These materials and labor costs may impact the acceptability of the intervention to the school and the correct implementation and sustainability of the intervention.

With these costs in mind, the experiment summarized in Chapter 2 evaluated if teacher praise could function as an effective substitute for tangible prizes in the FD program. Following the most intervention-intensive portion of the FD program, children attending schools at which tangible prizes were awarded for FV consumption ate more FV than children attending no-treatment control schools (16 days). The FD program with praise rewards also increased FV consumption above control levels, but this effect was significantly less than was observed in the FD Prize schools. At the conclusion of the 4-month FD program, the Prize and Praise schools were consuming more FV than the Control schools. However, at 6-month follow-up, only the Prize schools were consuming more FV than the Control and Praise schools, the latter two groups being undifferentiated. Analyses of treatment fidelity data indicated that when teachers
delivered prizes contingent upon FV consumption, their students ate more fruit than those of teachers who implemented the program with less fidelity. The latter outcome supports the earlier hypothesis that poor follow-up outcomes in the Upton et al. (2013) study were due to poor implementation fidelity of the FD program.

**FD Effects in Middle School**

A follow-up question to the analyses summarized in Chapter 2 is whether there were differences in FV consumption for students who matriculated to middle school between Phase II and the follow-up assessment. An examination of FV consumption among the older students who moved to a new school could yield interesting results regarding the robustness of the effect of the FD program in a new environment. If similar results to the main analyses are not obtained, this would suggest the necessity of programming more intently for generalization of FV consumption across school settings and other environments. If similar results are obtained, these similarities would suggest that the FD program prepares students to continue their healthy eating habits when they move on to another school, and perhaps non-school environments, as well.

To address this question, mixed-effects models similar to those described in Chapter 2 were constructed but included only the data from sixth-grade students \( n = 239 \). The effects of group (Prize, Praise, or Control) on fruit, vegetable, and combined FV consumption were evaluated at follow-up while controlling for Naturalistic Baseline consumption and including gender as a covariate. As before, classroom was used as a random (slope) effect. Table 5-1 depicts results of this analysis for each outcome. There
Table 5-1

Results of the Linear Mixed-effects Models Evaluating Sixth-grade Students’ Fruit, Vegetable, and Combined FV Consumption by Group

<table>
<thead>
<tr>
<th></th>
<th>Fruit Consumption</th>
<th>Vegetable Consumption</th>
<th>FV Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>SE</td>
<td>t value</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.114</td>
<td>0.026</td>
<td>4.473*</td>
</tr>
<tr>
<td>Nat BL Consump.</td>
<td>0.173</td>
<td>0.041</td>
<td>4.209*</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.051</td>
<td>0.017</td>
<td>-3.063*</td>
</tr>
<tr>
<td>Praise</td>
<td>-0.047</td>
<td>0.026</td>
<td>-1.808</td>
</tr>
<tr>
<td>Prize</td>
<td>0.01</td>
<td>0.038</td>
<td>0.258</td>
</tr>
</tbody>
</table>

Note. Values in the Estimate columns are slope estimates of consumption from the regression model that controlled for consumption in the Naturalistic Baseline phase and for gender. Negative estimates in the Gender row reveal less consumption among males. Negative values in the Praise and Prize rows indicate that these groups consumed less FV than children who had previously attended Control schools. *t-values <-1.96 and >1.96 are statistically significant.

was a significant gender effect for all three outcomes: girls consumed more fruit, vegetables, and FV than did boys. Of greater interest, students who had previously attended one of the Praise schools consumed significantly less vegetables and less FV than students who had previously attended Control schools. There were no significant differences between the 6th-grade students who had previously attended Prize or Control schools.

This pattern of results suggests that the therapeutic follow-up outcome of the FD program, when implemented with tangible prizes (an outcome summarized in Chapter 2),
was due to the FV consumption of the younger students who remained in the school in which they completed the FD program. However, there were large disparities in the number of students per group in this sub-analysis as compared to the main analysis ($n = 118, 93, \text{ and } 28$ in Control, Praise, and Prize groups, respectively). Because of these group-size differences, these results should be interpreted with caution. Despite the preliminary nature of this sub-analysis, the question of intervention effects across different school environments is both an interesting and important one.

One reason that the effects of the FD Prize program may not influence FV consumption in the middle-school setting is that in their new school, students are surrounded by new peers, most of whom did not complete the FD program. If one’s peers do not eat, or eat limited amounts of FVs, the student may conform to this new social norm (Brug, Tak, te Velde, Bere, & Bourdeaudhuij, 2008). Because children tend to consume foods that are similar to those consumed by their same-age or slightly older peers (Brody & Stoneman, 1981), and because this effect is larger when the child is surrounded by multiple peers consuming the same types of foods (Fehrenbach, Miller, & Thelen, 1979), eating habits acquired in elementary school may be under considerable peer pressure to change. Future researchers should examine methods to generate behavior change that generalizes to new environments and is robust to negative peer influences.

Taken together, the results summarized here and in Chapter 2 show that tangible incentives are effective for increasing children’s FV consumption, but these incentives (a) must be delivered with high levels of treatment fidelity and (b) have limited effects over time and possibly when children move to new schools in which same age and older peers
may have less healthy eating habits. These results are consistent with those reported by Hoffman et al. (2011): even when an incentive-based intervention is implemented for an extended period of time, therapeutic effects dissipate when the intervention is removed. One strategy for addressing this shortcoming of incentive-based interventions is to develop a program that could be implemented for an extended duration, if not indefinitely, within extant school time and financial resources.

Gamification

The study conducted in Chapter 3 was designed to explore the possibility of replacing tangible incentives with virtual game-based rewards. If the intervention increased FV consumption, it would reduce the materials costs of other incentive-based programs. In addition, the gamification intervention was designed to reduce labor costs below those of the FD program (see Chapter 1, Table 1-3). Over the course of the 13 school-day intervention, objectively measured school-wide FV consumption increased significantly above baseline levels. In post-experiment surveys, parents and teachers rated the program favorably.

The study conducted in Chapter 4 was designed to address three shortcomings of the first gamification intervention. First, the school participating in the first gamification study did not follow the USDA’s NSLP guidelines; thus, the efficacy of the intervention in a school that adheres to these widely followed guidelines was unknown. Therefore the second gamification experiment was conducted in a school that adhered to these guidelines. Second, the first gamification intervention initially used tangible prizes to
incentivize the tasting of FV. As the use of even these incentives increases the materials costs of the intervention, the second gamification intervention used no tangible incentives. Finally, the first gamification experiment was brief. We did not know if children would (a) tire of the game if played longer, or (b) achieve elevated levels of consumption over a longer period, which is thought to be important in habit formation (Lally, van Jaarsveld, Potts, & Wardle, 2010). Thus, the second gamification intervention was extended in duration to 29 days.

As outlined in Chapter 4, the second gamification intervention, the FIT Game, significantly increased school-wide FV consumption from baseline levels over the 29-day intervention period. However, teacher surveys were less positive than those in Chapter 3, and some teachers indicated that they failed to read the narrative episodes every day.

**FV Consumption of Individuals in the FIT Game**

An unaddressed issue from the FIT Game studies summarized in Chapters 3 and 4 involves the effects of the game on individual students’ FV consumption. As discussed in Chapters 3 and 4, group contingencies can foster social loafing (Karau & Williams, 1995), whereby a “loafer” shares in the rewards earned by others while him/herself doing nothing to earn the reward. In our studies, this would translate to increased FV consumption among some students and no change in eating among those students who are “loafing.” We hypothesized that loafing would be most likely among children who normally consumed no FV, so we compared the effects of the FIT Game across students who consumed no FV during baseline and those students who consumed some FV during baseline. Previous investigations of the FD program have found the largest effect among
students who were consuming no FV at baseline (e.g., Lowe, Horne, Tapper, Bowdery, & Egerton, 2004; Wengreen, Madden, Aguilar, Smits, & Jones, 2013), but those studies employed individual contingencies, whereas the FIT Game used a group contingency that may foster social loafing.

Effects of the FIT Game on individual students’ FV consumption were examined by taking top-down photos of students’ pre- and post-lunch trays (as in Chapter 2). These photos were taken over the final four days of baseline and the final four days of the intervention summarized in Chapter 4. Photos collected on one baseline day were not used in the analysis because salad was served as an entrée instead of as a side-dish (all such days were excluded from the data presented in Chapter 4). Likewise, photos collected on one photo day during the intervention phase were excluded from analysis because, on that day, a pilot test was conducted in which we explored the effect of individual non-tangible reward contingencies. Thus, we analyzed three baseline and three intervention days (two vegetable-target days and one fruit-target day). Because the intervention was designed to increase consumption of only the targeted food, the baseline three-day average vegetable consumption was compared to the average of the two intervention vegetable-target days, and the baseline three-day average fruit consumption was compared to consumption on the one fruit-target day. This limited sample of behavior is a limitation of the assessment.

Of the 252 students who participated in the study reported in Chapter 4, 239 participated in individual data collection. Students who did not have at least two (of the possible three) photo pairs were excluded from analysis (see Wengreen et al., 2013).
Thus, 23 were excluded based on missing baseline photos, and 60 were excluded from vegetable-target day analysis. Because there was only one fruit-target day available, students who did not have a photo pair for that single fruit-target day were excluded from the fruit-consumption analysis ($n = 31$).

Individual consumption data were analyzed within a 2x2 mixed-design ANOVA. The within-subject factor was time (baseline vs. intervention), and the between-subjects factor was baseline level of FV consumed (consumed zero at baseline vs. consumed some at baseline). Assumptions of normality (e.g., normality, homoscedasticity, sphericity) were evaluated and the data were found to be suitable for analysis. Separate ANOVAs were conducted for fruit and vegetable consumption. Combined FV consumption was not evaluated as an outcome variable because of the alternating-treatments design used to demonstrate experimental control in Chapter 4.

Table 5-2 shows that for both fruit and vegetable consumption there was a significant main effect of time – consistent with the waste-based measure of FV consumption reported in Chapter 4, students’ fruit and vegetable consumption increased above baseline levels during the FIT Game. There was also a signification time x baseline consumption interaction for vegetable consumption. Students who ate some vegetables at baseline showed slightly decreased levels of vegetable consumption during the FIT Game, but students who consumed no vegetables at baseline significantly increased their vegetable consumption during the FIT game.

ANOVA-estimated marginal mean fruit and vegetable consumption, separated by time point and baseline-consumption group are depicted in Figure 5-1. For vegetable
Table 5-2

Results of the Mixed-design ANOVA Evaluating Fruit and Vegetable Consumption on the Individual Level Within the FIT Game

<table>
<thead>
<tr>
<th></th>
<th>Fruit Consumption</th>
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<th>Vegetable Consumption</th>
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<tr>
<td></td>
<td>$F$</td>
<td>df</td>
<td>MS</td>
<td>$p$</td>
</tr>
<tr>
<td>time</td>
<td>6.737</td>
<td>1</td>
<td>0.27</td>
<td>0.01</td>
</tr>
<tr>
<td>BL Cons</td>
<td>76.77</td>
<td>1</td>
<td>2.532</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>time*BL Cons</td>
<td>2.213</td>
<td>1</td>
<td>0.089</td>
<td>0.139</td>
</tr>
</tbody>
</table>

consumption, there was a significant interaction between time and group. Specifically, the FIT Game had a greater impact on vegetable consumption among those students who consumed no vegetables at baseline as compare to those students who consumed some vegetables at baseline. There was no significant time by group interaction when fruit-consumption outcomes were considered. Thus, both groups increased their fruit consumption by about the same amount during the FIT Game. When considered from the hypothesis that zero-consumers would be more likely to social loaf during the FIT game, there does not appear to be a social-loafing effect.

The same conclusion is supported when we examine the percentage of students who consumed no fruit or vegetables across the baseline and FIT Game phases. The average number of students who either consumed no fruit or no vegetables during baseline was calculated and compared to the average number of students who consumed no fruit on the single fruit-target photo day or the two vegetable-target photo days during the intervention. During baseline, 44.7% of students (mean $n = 87$) consumed no fruit and 55.4% consumed no vegetables (mean $n = 107$). These percentages decreased during the
intervention: 28.1% of the students consumed no fruit on the one day for which photo data were available during the FIT Game phase, and 38.5% of students consumed no vegetables on the two vegetable-target days on which photos were taken. This decrease in zero-consumers combined with increases in mean FV consumption reported in Chapter 4 and the individual-data analysis above indicates that the FIT Game increases whole-school consumption of FV and does not encourage social loafing. This finding suggests that group contingencies are a viable approach to impacting public health, especially given the relative ease of a group-contingency approach to an individual contingency approach (e.g., Chapter 2). It is additionally notable given that vegetable consumption tends to be more difficult to increase than fruit consumption (Evans, Christian, Cleghorn, Greenwood, & Cade, 2012). The FIT game was particularly successful for increasing the percentage of students who were willing to consume more vegetables (some) than they

![Figure 5-1.](image_url)

*Figure 5-1.* Individual consumption during the FIT game categorized by phase and Baseline consumption. This figure depicts individual fruit (circles) and vegetable (squares) consumption categorized by phase (Baseline vs. Gamification) and baseline consumption characteristic (consumed zero at baseline vs. consumed some at baseline).
usually did (none).

In addition to the limited number of photo days, an additional limitation of this analysis is that the fruits and vegetables served on the main lunch line across baseline photo days and intervention photo days were not matched. Offsetting this concern is that apples, oranges, lettuce, and baby carrots were served every day on the salad bar and the FVs served on the main cafeteria line were split equivalently between canned and fresh items across phases. Future researchers should investigate these preliminary results further by extending the number of photo days on which data are collected and ensuring FV are matched across phases to avoid potential effects of preference for and variety of FV served (Just, Lund, & Price, 2012).

**Follow-up for the FIT Game**

A second unaddressed issue from Chapter 4 involves a follow-up assessment. As discussed in Chapter 1, determining the lasting effects of an intervention after it concludes is important if the intervention is to impact public health. Effects of the FIT game on long-term FV consumption were examined 4 months following the completion of the study reported in Chapter 4. Food-waste data were collected over four consecutive days under baseline conditions. As shown in Figure 5-2, fruit and vegetable consumption returned to baseline levels at follow-up. These data are similar to (Hoffman et al., 2011) who showed significant effects while their incentive-based intervention was being implemented, but nonsignificant effects when it was removed. Future researchers should investigate the extent to which the FIT game can be fortified to enhance its lasting impact. One method by which to achieve this goal may be to increase the duration of the
game or, perhaps, play the game indefinitely. Another method may be to provide
“booster” sessions or cafeteria-based mini-games at prespecified intervals to encourage
continued FV consumption.

**Overall Impact on Human Health**

Though definitive increases in FV consumption were demonstrated in Chapters 2-
4, the impact of these statistically significant changes on human health may be less clear.

An analysis to examine the effects of these interventions on changes in individual

![Figure 5-2. FIT Game fruit and vegetable consumption with follow-up. Fruit consumption (top panel) and vegetable consumption (bottom panel) presented by phase (baseline vs. FIT Game vs. Follow-up) and contingency (target vs. nontarget). Error bars represent SEM. *p < .05 **p < .01](image-url)
children’s consumption of different foods (fruit vs. vegetables) was conducted to aid in describing these effects. The purpose of this analysis was to determine the extent to which children who consumed only one food variety in baseline (either fruit or vegetables) subsequently consumed both varieties following the intervention, which is the most meaningful outcome for long-term health benefit. By increasing willingness to taste and consume different varieties of healthy foods, the students may be more likely to form a habit of consuming these healthy foods regularly. Children who had the criterion number of photo pairs for both the naturalistic baseline and Phase III (for Chapter 2) or baseline and gamification phases (for Chapter 4) participated in this analysis \( n = 671, 555, \) and 668 in the Prize, Praise, and Control groups, respectively, for Chapter 2 and \( n = 141 \) for Chapter 4. Table 5-3 shows post-intervention consumption profiles for children who consumed either fruit or vegetables in baseline. A higher percentage of children in the Prize group consumed both varieties during Phase III than the Praise group and the Control group. In addition, a smaller percentage of the Prize group consumed neither variety at Phase III than the Praise group and the Control group. The FD program with prizes showed the most therapeutic effects for increasing children’s willingness to increase their consumption of different varieties of healthy foods.

For Chapter 4, when examining the percentage of students who consumed one variety at baseline, 35.5% consumed both fruit and vegetables, 48.4% continued to consume one variety, and 16.1% decreased their consumption of FV during the gamification phase. As above, this pattern of results suggests that students increased their willingness to consume different foods after the gamification intervention. Future studies
Table 5-3

*Among Children Who Consumed Either Fruit or Vegetables (F or V) in Baseline in Chapters II and IV, the Percentage that Consumed Both Fruit and Vegetables (F&V), Continued to Consume F or V, or Consumed Neither*

<table>
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<tr>
<td>Prize</td>
<td>43.8%</td>
<td>31.3%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Praise</td>
<td>26.9%</td>
<td>22.1%</td>
<td>51.0%</td>
</tr>
<tr>
<td>Control</td>
<td>26.3%</td>
<td>32.2%</td>
<td>41.4%</td>
</tr>
<tr>
<td>Chap. 4</td>
<td>n = 31</td>
<td>35.5%</td>
<td>48.4%</td>
</tr>
</tbody>
</table>

should aim to increase these therapeutic effects seen across these studies, possibly by using procedures targeted at specific baseline-consumption profiles to increase the proportions of students who consume more varieties of healthful foods post-intervention. Additionally, the relative effects of the interventions evaluated in Chapters 2, 3, and 4 on both fruit and vegetable consumption would be useful to compare their health impact.

Effect sizes (Cohen’s $d$) provide a measure of comparison across studies and are depicted in Table 5-4 for all significant intervention effects. For Chapter 2, effect sizes were calculated for each group (Prize vs. Praise, Prize vs. Control, Praise vs. Control) at each time point (Baseline to Phase I, Baseline to Phase II, Baseline to Phase III) for significant effects. Effect sizes ranged from 0.15 to 0.61 (mean = 0.3) for fruit consumption and 0.3-1.1 (mean = 0.66) for vegetable consumption. For Chapters 3 and 4, the effect size for the gamification interventions were calculated for group-level data between Baseline and the Gamification phase. Effect sizes for fruit were 1.44 (Chapter 3)


Table 5-4

Effect Sizes (Cohen’s d) for Fruit and Vegetable Consumption for Chapters 2, 3, and 4

<table>
<thead>
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<th>Phase II</th>
<th>Follow-up</th>
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<td>V</td>
<td>F</td>
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<tr>
<td>Chapter 2</td>
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<tr>
<td>Praise vs Prize</td>
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<td>0.15</td>
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<td>Prize vs Control</td>
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<td>1.02</td>
<td>0.23</td>
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<td>0.58</td>
<td>NS</td>
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<tr>
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<tr>
<td>Chapter 4</td>
<td>2.3</td>
<td>1.1</td>
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and 2.3 (Chapter 4), and effect sizes for vegetables were 1.27 (Chapter 3) and 1.1 (Chapter 4). The gamification interventions had larger effect sizes when increasing FV consumption than did the FD program. These results provide further evidence for the effectiveness of both interventions as well as comparative evidence that the gamification interventions had a greater impact on children’s in-school FV consumption than did the FD program.

Future Directions

An overarching theme across Chapters 2, 3, and 4 involves the fidelity with which teachers implemented the intervention. While we discovered that fidelity affects child outcomes in Chapter 2, consistent with previous research (Durlak & DuPre, 2008), we did not examine objectively the effects of individual teachers’ treatment fidelity in Chapters 3 and 4. Some of these teachers volunteered data regarding their fidelity in
the post-experiment survey and it suggested between-teacher variation in how they implemented the program. This variability in fidelity could be addressed in two ways in future research. First, more effort could be focused on teacher training and support during the FIT game. However, the labor and materials costs for this training and support would add to the intervention cost structure. Alternatively, as suggested in Chapters 3 and 4, more effort could be focused on reducing teachers’ roles in incentive-based programs. This effort would not preclude a focus on treatment fidelity: intervention components, no matter how small, would still need to be implemented as designed. However, intervention components that take less time away from classroom activities than previous iterations of incentive-based interventions may be easier to train and sustain by schools.

All three of the empirical studies reported here focused exclusively on in-school FV consumption. A higher level of public-health impact may be achieved if interventions expanded their focus to FV consumption outside of school. For these types of studies, researchers often rely on self-report measures (e.g., Bennett, de Silva-Sanigorski, Nichols, Bell, & Swinburn, 2009). However, due to the probability of biases in these subjective measures as discussed in Chapter 1, they are not ideal for examining FV consumption outside of school. Future researchers should work to develop objective ways to evaluate total FV consumption and subsequently use these methods to evaluate effects of incentive-based interventions on FV consumption outside of school.

To target FV consumption in environments other than school and populations other than children, researchers have suggested strategies for use in grocery stores (e.g., Glanz & Yaroch, 2004), restaurants (e.g., Glanz & Hoelscher, 2004), workplaces (e.g.,
Sorensen, Linnan, & Hunt, 2004), and communities (Ciliska et al., 2000). Though systematic review of each of these types of interventions is beyond the scope of this paper, an overarching conclusion is that targeting dietary decisions in a single environment has not been sufficient to reverse public health crises and more comprehensive approaches are needed. Options may include specifically targeting dietary decisions in all environments or developing interventions that are so robust as to change behavior in multiple environments. Though our ultimate goal throughout this series of studies was to do exactly the latter, future researchers need to refine methods by which to fortify current interventions such that their reach extends across all dietary decision-making opportunities. For example, the gamification intervention developed in Chapters 3 and 4 could be developed into an interactive computer app in which students earn their school-wide virtual rewards for meeting in-school goals (the outlined procedure) but also can earn virtual rewards for completing at-home dietary and/or exercise goals. For example, a commercially available pedometer could be linked to the app and provide individual rewards for meeting an individualized step goal, perhaps based on a percentile schedule as those outlined in Chapters 3 and 4. Though there are methodological issues to consider with respect to dietary decisions, this direction fits seamlessly into extant health and fitness apps (e.g., MyFitnessPal) as well as child-oriented interactive apps and games that are solely for entertainment purposes (e.g., Club Penguin). This comprehensive extension is no small task, but basing developments largely on objective measures and a sustainability model should ultimately lead toward an implementable and therefore impactful solution for thwarting a lifetime of poor dietary decisions.
Conclusion

In Chapter 1, we found that multi-component incentive-based interventions are the most effective way to increase elementary-school children’s in-school FV consumption. In Chapter 2, we attempted to lower the labor and material costs of incentive-based interventions by replacing tangible prizes with praise, but praise proved to be an inadequate substitute for prizes as it yielded poor outcomes at a 6-month follow-up. In Chapters 3 and 4, we replaced tangible prizes with in-game, virtual rewards and found significant short-term effects on FV consumption, but no lasting effects (Figure 5-2). These results support the use of a gamification framework for improving FV consumption in schools, as well as the use of a group contingency as the percentage of children consuming no FV decreased in the FIT game phase, indicating no maladaptive “social loafing” effects. Future researchers should further refine this gamification approach to improve long-term outcomes.

References


McCool, A. C., Myung, E., & Chien, T.-C. (2005). Modification of the form in which fresh fruit is served as a possible means of increasing the consumption of fruit offered to elementary and middle school students. *Journal of Foodservice Business Research, 8*, 73-85. doi: 10.1300/J369v08n02_06


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CURRICULUM VITAE

Brooke Ashley Jones

CERTIFICATION

Board-Certified Behavior Analyst (#1-12-12134)   Cert. Date: 9/30/2012

EDUCATION


HONORS AND AWARDS

2013 – 2014  Utah State University, Alvord Scholarship ($1000, 1 awarded per year)

2012  Kansas Association for Behavior Analysis Service Award

2005  Honorable Mention, Chair’s Award for Outstanding Co-Authored Writing in Psychology Research Paper

2003 – 2007  Florida Bright Futures Scholarship Award

2003 – 2005  University of Florida Honors Program

GRANTS SUBMITTED

Society for the Advancement of Behavior Analysis (SABA), 2012. Increasing fruit and
vegetable consumption by playing the Food Dudes game. $20,000. Scored in the top 10th percentile. Not funded.

PEER-REVIEWED PUBLICATIONS


BOOK CHAPTER


MEDIA COVERAGE OF RESEARCH


**MANUSCRIPTS IN PREPARATION**

Jones, B. A., Wengreen, H. J., Madden, G. J., Aguilar, S. A., & Fargo, J. A randomized-controlled trial of the Food Dudes program: Tangible rewards are more effective than social rewards for increasing short- and long-term fruit and vegetable consumption. *Journal of the Academy of Nutrition and Dietetics.*

Jones, B. A., & Dozier, C. L. An evaluation of the effects of social interaction on preference and task allocation.


**PRESENTATIONS**


**COURSEWORK**

**USU Graduate:**
- Behavioral Economics
- Research Design and Analysis
- Advanced Psychometrics
- Research Design/Analysis II
- Multivariate Statistical Analysis I: Observed Variables
- Seminar: Acceptance and Commitment Therapy (ACT)
Literature Reviews
Multivariate Statistical Analysis II: Latent Variables

KU Graduate: Within-Subjects Research Methodology
Laboratory in Behavioral Development and Modification
Behavior Analysis in Developmental Disabilities
Legal, Ethical, and Professional Issues in Applied Behavioral Science
Conceptual Foundations of Applied Behavioral Science
Designing Early Intervention Environments (Autism)
Applied Behavior Analysis 1
Readings in Applied Behavioral Science
Verbal Behavior
Behavioral Consultation

UF Graduate: Applied Behavior Analysis 1
Behavior Analysis in Developmental Disabilities

UF Undergraduate: Applied Behavior Analysis
Lab in Applied Behavior Analysis
The Natural Science and Technology of Charting Behavior
Writing In Psychology
American Sign Language I & II

TEACHING EXPERIENCE

1/2010 – 8/2010 Instructor of Record (Spring 2010 and Summer 2010): ABS 308 (Research Methods and Application)
University of Kansas, Department of Applied Behavioral Science
Duties: Presented lectures three times per week; communicated with students regarding course content and requirements; graded research protocols, quizzes, in-class activities, and homework; maintained course Blackboard site, including lecture slides, in- and out-of-class activities, homework quizzes, and course grades; modified 16-week course to be taught during 8-week summer semester

8/2009 – 12/2009 Graduate Teaching Assistant: ABS 308 (Research Methods and Application)
University of Kansas, Department of Applied Behavioral Science
Supervisor: Claudia L. Dozier, Ph.D., BCBA-D
Duties: Communicated with students regarding course content and requirements; attended lectures; graded quizzes and activities; maintained course Blackboard site, including lecture slides, in- and
out-of-class activities, homework quizzes, and grades; lecture
during several classes throughout the semester

8/2007 – 8/2009  Graduate Teaching Assistant: ABS 677/678 (Practicum in
Preschool Education and Intervention)
University of Kansas, Department of Applied Behavioral Science
Supervisor: Claudia L. Dozier, Ph.D., BCBA-D
Duties: Supervised undergraduate teacher behavior with respect to
child and parent interactions and proper implementation of
behavior management strategies, protocols, and teaching methods
within a preschool setting; trained undergraduate teachers to
implement behavioral protocols in cooperation with other
supervisors; prepared and conducted weekly instructional meetings
with undergraduate teachers; led daily meetings with
undergraduate teachers prior and following class times;
participated in weekly supervisor meetings

1/2006 – 5/2007  Undergraduate Teaching Assistant
University of Florida, Department of Psychology
Communicating Psychological Science
Supervisor: Diane Stevenson, Ph.D.

CLINICAL EXPERIENCE

Classrooms
University of Kansas, Department of Applied Behavioral Science
Duties: Oversaw daily operation of two preschool classrooms;
trained graduate students, undergraduate students, and student-
hourly employees; ensured adherence to state licensing
requirements; assisted with tuition collection, receipts, and
documentation; completed paperwork to maintain adherence to
state-funded food program; assisted with undergraduate teacher
enrollment and scheduling; collected and maintained
undergraduate enrollment paperwork; attended clinical meetings

University of Kansas, Department of Applied Behavioral Science
Supervisor: Claudia Dozier, Ph.D., BCBA-D
Duties: Oversaw management of preschool classroom (children
ages 2.5-4.5 yrs) >20 hrs/wk, including free-play activities,
structured-learning activities, transitions, and meal times;
implemented class-wide proactive functional communication
intervention designed to prevent problem behavior; taught skills
within each child’s curriculum using incidental and errorless teaching strategies; implemented behavior management strategies with individual children to decrease problem behavior (e.g., timeout) and increase appropriate behavior (e.g., differential reinforcement of alternative behavior)

5/2006 – 8/2006 1:1 Habilitation Technician
ARC of Alachua County
Supervisor: Pamela L. Neidert, Ph.D., BCBA-D (Behavior Program Manager)
Duties: Tracked target behaviors (e.g., aggression, property destruction, SIB, etc.) exhibited by a high-risk consumer, implemented contingencies specified in her behavior intervention plan during daily activities, wrote progress notes

INDUSTRY EXPERIENCE

6/2014 – 8/2014 Lab Associate
Disney Research Pittsburgh
Behavioral Economics Research Group
Supervisor: Maarten Bos, Ph.D., Research Scientist

SERVICE

PROFESSIONAL SERVICE

2012 Guest Reviewer, The Journal of Pediatrics

2010 – 2011 Guest Reviewer, Journal of Applied Behavior Analysis

10/2010 – 5/2011 Kansas Association for Behavior Analysis (KansABA) Executive Council Secretary
Duties: Met monthly to discuss fulfilling KansABA’s mission; organized and facilitated events during annual conference (From Research to Practice in Kansas: Evidence-based Strategies in Education, April 2011); organized meeting records

Duties: Met monthly to discuss fulfilling KansABA’s mission; organized and facilitated events during annual conference (From Research to Practice: Autism and Other Developmental Disabilities, April 2010); recruited ABS graduate students for volunteer service opportunities
DEPARTMENTAL SERVICE

8/2013 – present  Utah State University (USU) Experimental and Applied Psychological Science (EAPS) Student Representative
Duties: Attend faculty meetings; gather input on programmatic changes from graduate students; communicate changes to graduate students

5/2010 – 5/2011  University of Kansas (KU) Department of Applied Behavioral Science (ABS) Graduate Student Organization (GSO), President
Duties: Represented graduate students at faculty meetings; led initiative for book/journal fundraiser; compiled and designed departmental newsletter; planned and organized departmental activities for graduate students; raised funds to support departmental events; encouraged graduate-student participation in departmental meetings and events

5/2009 – 5/2010  KU ABS Graduate Student Organization, Vice President
Duties: Represented graduate students at faculty meetings if GSO president was unavailable; compiled and designed departmental newsletter; raised funds for, planned, and organized departmental activities; encouraged activity participation by all relevant students and faculty

5/2009 – 5/2011  KU ABS Faculty Search Committee, Student member
5/2008 – 5/2011  KU ABS Honors Program Committee, Student member
5/2008 – 5/2011  KU ABS Graduate Curriculum Committee, Student member
5/2008 – 5/2011  KU ABS Course Evaluations Committee, Student member
5/2008 – 5/2009  KU ABS Undergraduate Advising and Curriculum Committee, Student member
5/2008 – 5/2009  KU ABS Awards Committee, Student member
5/2008 – 5/2009  KU ABS Graduate Student Organization, Secretary
Duties: Planned and organized departmental activities; compiled and designed departmental newsletter; encouraged activity participation by all relevant students and faculty; updated GSO website; recorded meeting minutes
COMMUNITY AND PUBLIC SERVICE

2009 Consultant, private client enrolled in Baldwin City Public Schools. Duties: Conducted observations and prepared treatment evaluation for a child diagnosed with Asperger’s syndrome who engaged in severe problem behavior; met with school personnel; conducted parent training.


2008 – 5/2011 Clinical Training, KCART, Lawrence, KS. Duties: Conducted hands-on clinic to train groups of staff members to conduct functional analyses as part of the KCART Functional Analysis and Function-Based Treatment training module under the Medicaid waiver.

2004 – 2005 Collegiates Helping As Mentors in Public Schools (CHAMPS) Supervisor: Kelley Kostamo Duties: Mentored an at-risk elementary-aged child once per week during school hours; focused on academic work and achievement

MEMBERSHIPS

2006 – present Association for Behavior Analysis International, member
2009 – 2011 Kansas Association for Behavior Analysis, member
2006 – 2007 Florida Association for Behavior Analysis, member

REFERENCES

Dr. Gregory J. Madden Dr. Heidi J. Wengreen
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