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Memorizing fruit: The effect of a fruit memory-game on children's fruit intake

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ABSTRACT

Food cues of palatable food are omnipresent, thereby simulating the intake of unhealthy snack food among children. As a consequence, this might lead to a higher intake of energy-dense snacks and less fruit and vegetables, a habit that increases the risk of developing chronic diseases. The aim of this experimental study is to examine whether playing a memory game with fruit affects fruit intake among young children. We used a randomized between-subject design with 127 children (age: 7–12 y) who played a memory-game, containing either fruit ($n = 64$) or non-food products ($n = 63$). While playing the memory-game in a separate room in school during school hours, free intake of fruit (mandarins, apples, bananas, and grapes) was measured. Afterwards, the children completed self-report measures, and length and weight were assessed. The main finding is that playing a memory-game containing fruit increases overall fruit intake ($P = 0.016$). Children who played the fruit version of the memory-game ate more bananas ($P = 0.015$) and mandarins ($P = 0.036$) than children who played the non-food memory-game; no effects were found for apples ($P > 0.05$) and grapes ($P > 0.05$). The findings suggest that playing a memory-game with fruit stimulates fruit intake among young children. This is an important finding because children eat insufficient fruit, according to international standards, and more traditional health interventions have limited success. Healthy eating habits of children maintain when they become adults, making it important to stimulate fruit intake among children in an enjoyable way.
Trial registration: Nederlands Trial Register TC = 5687

1. Introduction

Nutrition during childhood and adolescence is essential for growth and development, health and well-being (Story et al., 2002). In addition, eating behaviors established during childhood track into adulthood and contribute to long-term health and chronic disease risks (Kaikkonen et al., 2013; Patton et al., 2011). Numerous studies have consistently shown that dietary intake patterns of children and adolescents are poor and do not meet national dietary standards (Cavadini et al., 2000; Neumark-Sztainer et al., 2002; Nicklas et al., 2001; Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2012). As a consequence, childhood overweight and obesity is one of the most serious public health concerns, considering its alarming increase over the last decades (Karnik and Kanekar, 2015). The obesogenic food environment (e.g., food advertising, availability of energy-dense snacks, and omnipresence of food-related cues), is considered to be a key driver of this obesity epidemic (Vandevijvere et al., 2015).

While multiple factors influence eating behaviors and food choices among youth, one potent force that affects eating behavior is food cue exposure (Boswell and Kober, 2016; Boyland et al., 2016; Folkvord et al., 2016a). Multiple studies have shown that food cue exposure leads to actual eating by activating a series of physiologic responses (Stice et al., 2009a, 2009b; Nederkoorn and Jansen, 2002; Castellanos et al., 2009) and psychological (Folkvord et al., 2016a; Castellanos et al., 2009; Gearhardt et al., 2014; Yokum et al., 2014; Saunders and Robinson, 2013) responses. This automatic reactivity makes it more difficult to inhibit responses to palatable food cues (Folkvord et al., 2016a, 2016b; Gearhardt et al., 2014; Yokum et al., 2014; Saunders and Robinson, 2013). Food cues of palatable food are omnipresent and mostly designed to be attention-grabbing, thereby stimulating the intake of highly available energy-dense snacks that are high in salt, sugar and fat, and have low nutritional value (Harris et al., 2012).

Previous research on food-cue exposure has investigated the effects of food cues on intake of high-caloric foods, while studies that examine the effect of fruit cues on fruit intake are relatively scarce (Boyland et al., 2016; Folkvord et al., 2016a; Coelho et al., 2012). Folkvord et al. (2013) tested the effect of food-cue exposure (energy-densed snacks or fruit) in a memory-game on fruit intake, but also offered energy-dense snacks next to fruit. Results showed that children consumed more energy-dense snacks after exposure to food cues of either energy-dense snacks or fruit, and not more fruit, compared to intake after exposure to non-food cues. Hence, it is still unclear whether fruit-cue exposure can

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influence the intake of nutritious, low-caloric foods among children in the absence of high-caloric food. More specific, health-oriented games are emerging as a promising intervention approach as a preventive medicine, because they target implicit associative cognitive processes (Baranowski et al., 2008; Thompson et al., 2015). Health games are able to attract and maintain attention because children enjoy playing them, thereby enhancing exposure to fruits, transferring positive associations with fruit, possibly leading to conditioned responses (i.e., intake) among children (Baranowski et al., 2008).

The current study was designed to elucidate the effects of in-game fruit-cue exposure, and to investigate whether fruit-cue exposure could augment intake of fruit. If fruit-cue exposure can promote intake of nutritious foods, this could provide insights for programs aimed at improving children's diet. The study main research question is whether a memory-game that contains fruit cues can stimulate fruit intake among young children. Research has shown that priming children with healthy food choices can induce children to select healthier food choices (Chandon and Wansink, 2007; Hollands et al., 2011), so we expect that children who play a memory-game with fruit will eat more fruit than children who play a memory-game with nonfood products.

2. Methods

2.1. Experimental design and stimulus materials

We used a randomized between-subjects design with two conditions (type of memory-game: fruit [see Fig. 1] vs. nonfood products [see Fig. 2]). The two games were identical, except for the items on the backside. Children were told that they could eat freely from the bowls with fruit during the experiment; the dependent variable in this study was fruit intake. During playtime, children were presented four bowls of fruit, containing (1) mandarins, (2) apples, (3) bananas, and (4) grapes. The types of fruit that were selected for the memory-game and for the test food were based on popularity levels assessed in studies examining fruit intake among children in the Netherlands (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2012; Voedingscentrum (Dutch Nutrition Centre), 2016). A pilot test was conducted ($N = 6$) to test whether children understood and liked the memory-game.

2.2. Procedures

The committee for ethical concerns in the Faculty of Social Sciences at the Radboud University approved the current study. The data collection occurred in January 2016. We individually tested the children at one primary school in the Netherlands for two weeks during regular school hours, every consecutive day until all children had participated. We randomized the conditions and the conditions were counterbalanced to start with a different condition every day, so that none of the conditions were tested more in the morning or just before or after the break. After obtaining consent from the principal to participate, we sent the parents of the children a letter with detailed information regarding the study, and we asked them to inform us if they did not want their child to participate in the experiment. Children who attend this school are from families with middle to high social economic status. >95% of the children whose parents we approached were allowed to participate in the current study. We emphasized that all of the data that we collected would remain confidential and that children could cease participation at any moment.

The procedure of the experiment was as follows. First, the experimenter collected one child at a time from the classroom, that was appointed in alphabetical order to the experimenter. Second, the experimenter brought each child to another quiet classroom or office containing a table on which the cut and peeled fruit was presented. When the experimenter and the child entered the room, the experimenter told the child the following: "Thank you for participating in this research. You can sit here. There is also some food on the table. If you want to eat something, you can take as much as you like". Third, children started with a short questionnaire assessing gender, age, class, and hunger levels (masked with filler questions about energy-levels, thirst, and level of excitement). Fourth, the experimenter explained shortly what the goal of the memory-game was, namely: "You are going to play a memory-game with twelve cards. You should try to finish the game as fast as possible. What you have to do is the following. You turn one card, and then another card. If they match, you can take these two cards and put them on a pile over here. If they do not match, I will turn them on their flipside and you can start again with a new turn. If you have collected all pairs, you are finished. You can use as much turns as you need to finish the game. You are allowed to eat while playing the game. Do you understand the game? Do you have any questions?". After the instruction children started playing the game. The children played the memory-game for an average of 2–3 min. Comparable studies (Folkvord et al., 2013; Folkvord et al., 2014) have used approximately the same amount of playtime. The experimenter assessed how many turns each child used to play the game and no differences were found between conditions. Fifth, after playing, children were told that they had a short break for 5 min and could read a magazine for children. The experimenter left the room and returned after 5 min. Sixth, the experimenter asked some additional questions (i.e., attitude towards the game, experimenter's research intentions) and measured weight and length of the children. None of the children guessed the experimenter's correct research intentions. When the
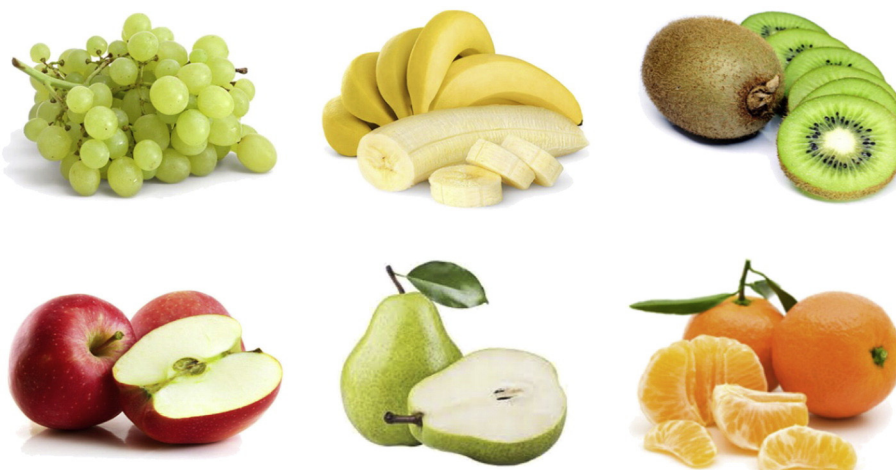

Fig. 1. Pictures of the fruit displayed on the memory cards.

Fig. 2. Pictures of the nonfood products displayed on the memory cards.

children finished the experiment they could select 1 sticker as a reward for participation. After children started to play the memory-game, children could eat ad libitum from the four bowls of fruit. After each session, the experimenter weighed the bowls to calculate caloric intake. The experimenter refilled and weighed the bowls before the next child entered the room to make sure that the children did not notice how much the previous child had eaten.

2.3. Measures

2.3.1. Fruit intake

To measure intake, we weighed the individual amount of fruit snacks that a child ate before each child entered the room and weighed again after eating, so we were able to calculate intake in grams. We used a professional balance scale to estimate to the nearest 0.1 g. The amount of fruit that a child ate is the sum of the intake of the individual fruits.

2.3.2. BMI

We calculated Body Mass Index (BMI), measured as weight (kg)/height^2 (m), and classified children as underweight, normal weight, overweight, or obese using international cut-off scores (Cole et al., 2000). We measured weight to the nearest 0.1 kg while the children were wearing clothing, with no jacket and shoes on. We also measured height according to standard procedures (no shoes) to the nearest 0.5 cm.

2.3.3. Hunger

We controlled for individual differences in hunger by presenting the children with a visual analogue scale (VAS; 14 cm) to measure the extent to which they felt hungry before the experiment began. We assessed hunger before the children played the game and ate. VASs are widely used and are reliable and valid rating scales for measuring subjective experiences

related to food intake (King and Hill, 2008; Laerhoven et al., 2004). The anchors were "not hungry at all" and "very hungry."

2.3.4. Attitude towards the memory game

Furthermore, at the end of the experiment, we examined whether there were differences in attitude to the memory-game. The attitude to memory-game was assessed with four different items (nice, stupid, cool, boring) on a VAS (14 cm).

2.4. Statistical analysis

Before testing our hypotheses, we conducted randomization checks with a 1-factor ANOVA for sex, hunger, BMI, age, and attitude to the memory-game. Table 1 presents the means and standard deviations for all variables separately for each condition. We estimated outlying scores on caloric intake that could affect the results by computing residual scores and testing them for Mahal's distance, Cook's distance, and leverage scores, but we found no indications to assume outlying scores. To examine which factors should be used as covariates, we conducted correlational analyses. Table 2 shows Pearson's correlations between the variables in the model. Because hunger and age were significantly related to fruit intake, we included these variables as covariates in the analyses.

Furthermore, we tested our hypothesis with a univariate analysis of covariance (ANCOVA) with total fruit intake as the dependent variable and conducted an additional multivariate analysis of covariance (MANCOVA) to test the effect of the memory-game on intake of the different types of fruit. In addition, we examined the interaction effects for sex, hunger, BMI, and age because, according to earlier research, these factors can have a combined effect with food cues on intake (Anschutz et al., 2009; Berridge, 2009). The adjusted one-sided P value that was considered significant was 0.05. We calculated effect sizes for Cohen's

Table 1
Variables measured by the condition[a,b].

	Nonfood memory-game (n = 63)	Fruit memory-game (n = 64)	
Sex (boy)	51%	56%	P > 0.05
Hunger (cm on VAS)	4.1 ± 4.0	3.7 ± 3.8	P > 0.05
BMI	17.1 ± 2.5	17.1 ± 2.7	P > 0.05
Age (y)	9.3 ± 1.6	9.2 ± 1.5	P > 0.05
Attitude to the game	5.3 ± 1.3	5.5 ± 1.2	P > 0.05
Mandarin intake (g)	3.7 ± 12.1	8.2 ± 16.9	P = 0.045
Apples intake (g)	7.9 ± 16.7	9.1 ± 15.0	P > 0.05
Banana intake (g)	2.6 ± 6.5	9.5 ± 22.1	P = 0.009
Grapes intake (g)	6.3 ± 20.5	4.3 ± 11.7	P > 0.05
Fruit intake (g)	20.4 ± 35.8	31.2 ± 38.4	P = 0.030

[a] (N = 127).
[b] Mean ± SD (all such values). VAS, visual analogue scale.

Table 2
Pearson's correlations between the mode variables[a].

	Sex	Hunger	BMI	Age	Attitude to the game
Sex (boy = 1, girl = 0)					
Hunger (cm on VAS)	0.05				
BMI, corrected	−0.01	−0.10			
Age (y)	−0.02	−0.23[b]	0.05		
Attitude to the game	0.17	0.07	0.02	−0.17[c]	
Fruit intake (g)	0.03	0.51[b]	−0.08	−0.26[b]	−0.08

[a] (N = 127).
[b] $P < 0.01$.
[c] $P < 0.05$.

f. Cohen's *f* effect sizes of 0.02, 0.15, and 0.35 indicate small, medium, and large effect sizes, respectively.

3. Results

The total sample consisted of 127 children (grades 3–6) from one primary school in the Netherlands. The sample size that was used in this study was appropriate according to an a-priori G*power analyses (Faul et al., 2007). With a large-size effect of Cohen's $f = 0.40$ (based on the study from Folkvord et al. (2013), who used comparable stimulus materials and procedure as in this study), alpha level set at 0.05 and a power of 0.80, the total number of participants should be set at a minimum of 45. The mean ($\pm$SD) age of the children was 9.3 ± 1.5 y, and 53% were girls. In the current sample, 6.3% of the children were underweight, 80.3% were normal weight, 11.0% were overweight, and 2.4% were obese. The percentage of children in this study that were overweight and obese (13.4%) was comparable with the current percentage of overweight and obese children in the Netherlands (13.3%). No significant differences were found between the experimental conditions for sex, game attitude, hunger, BMI, and age ($P > 0.05$). The Cronbach's alpha for attitude to the memory-game was 0.72. Analyses were done with SPSS statistical software, version 24. Table 3 shows the results of the ANCOVA.

A significant main effect of type of memory game on fruit intake ($P = 0.016$) was found, with children who played a memory-game that contained fruit ate more fruit than children who played a memory game that contained nonfood products ($M = 31.9$ g, $SD = 38.4$ g versus $M = 20.4$ g, $SD = 35.8$ g). No main effect was found for age on fruit intake ($P > 0.05$), but a significant main effect for hunger was found ($P = 0.000$).

In addition, a MANCOVA was conducted to test individual fruits intake. A significant effect of type of memory game on bananas ($P = 0.015$) and mandarins intake ($P = 0.036$) was found, while no effects of type of memory game on apples ($P > 0.05$) and grapes ($P > 0.05$) were found. Children who played the memory-game containing fruit ate significantly more bananas ($M = 9.5$ g, $SD = 22.1$ g) than the children who played the memory-game containing nonfood products ($M = 2.6$ g, $SD = 6.5$ g). Children who played the memory-game containing fruit ate significantly more mandarins ($M = 8.2$ g, $SD =$ 16.9 g) than the children who played the memory-game containing nonfood products ($M = 3.7$ g, $SD = 12.1$ g).

In all analyses, interaction effects between type of memory game and sex, game attitude, hunger, or BMI were tested, but no significant interaction effects were found. Sex, game attitude, hunger, and BMI did not moderate the effect of the memory game on food intake.

4. Discussion and conclusion

The main objective of this study was to examine if playing a memory-game with fruit increases children's fruit consumption. The results showed that children who played a memory-game with fruit had a higher fruit intake compared to children who played a memory-game with nonfood products. Separate analyses showed that the results for the fruit intake were based on the intake of bananas and mandarins. We found no interaction effects for sex, game attitude, hunger, and BMI; therefore, the effects of the memory-game were the same for these groups.

These results support our expectations; playing a memory-game that contains fruit increases fruit intake among children. The presence of sensory inputs that have been associated with past consumption primes cravings and, when available, actual food intake. The cues presented in the memory-game in the current study signaled food intake (Folkvord et al., 2016a), which led to a higher fruit intake compared with the condition that did not signal food intake. A heightened responsiveness to external cues that predict palatable food intake has been identified by the incentive-sensitization model of obesity as an important mechanism that stimulates overeating (Folkvord et al., 2016a; Berridge, 2009) and weight gain in some individuals (Stice et al., 2009b; Volkow et al., 2008). The opposite process might also occur, in which a higher responsiveness to external cues that stimulate fruit intake leads to less weight gain or weight loss (Folkvord et al., 2016a).

A large body of research has shown that health interventions that focused on explicit ways of changing cognitive structures have only limited effect, and do not result in behavioral changes (Papies, 2016). In fact, warning children about the dire effects on their future health prospects of not eating healthy food, or just explaining them that a food is "healthy", may well even reduce their acceptance of such food (Wardle et al., 2003). Novel methods to facilitate behavioral changes are needed, that do not relay on conscious intentions, but focus more on automatic processes (Papies, 2016; Folkvord et al., 2016c; Hollands et al., 2016). The memory-game that was used in this study can be seen as an example of such a novel method. The fun part of playing the game might be automatically transferred towards more positive associations about fruit, thereby increasing the possibility that children will consume fruit, without making it explicit that it is important or healthy to consume more fruits.

In general, children do not consume adequate fruit. In the Netherlands, for example, only 5–10% of the children meet the recommended amount of fruit intake (Vandevijvere et al., 2015). Eating more fruit may improve energy-density and overall diet quality. Fruit and vegetables have low energy-density and are excellent

Table 3
Results from ANCOVA and MANCOVA analyses with fruit intake as dependent variable[a,b].

	Fruit intake	Mandarin intake	Apples intake	Bananas intake	Grapes intake
Hunger (cm on VAS)	F (1126) = 38.419[c]	F (1126) = 4.314[d]	F (1126) = 10.024[c]	F (1126) = 11.167[c]	F (1126) = 18.109[c]
Age (y)	F (1126) = 3.377	F (1126) = 0.956	F (1126) = 0.112	F (1126) = 0.066	F (1126) = 0.579
Memory-game	F (1126) = 4.731[d]	F (1126) = 3.263[d]	F (1126) = 0.285	F (1126) = 7.019[c]	F (1126) = 0.202
Effect size	0.04	0.03	n.a.	0.06	n.a.
Explained variance	28.6%	5%	9.4%	14.9%	11.1%

[a] VAS, visual analogue scale.
[b] N = 127.
[c] $P < 0.01$.
[d] $P < 0.05$.

sources of vitamin C, beta-carotene, potassium, and fiber (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2012; Papies, 2016; Wardle et al., 2003). Several studies have shown that higher fruit consumption is also related to decreased sodium intake, a risk factor for hypertension (Papies, 2016; Wardle et al., 2003. In contrast, consuming energy-dense snacks activates brain activity in the reward system and stimulates overeating, instead of fulfilling craving (Stice et al., 2009b; Volkow et al., 2008). Consuming fruits when craving for food can affect body weight successfully, because fruits are high in water and fiber and low in energy-density, and fulfill hunger to a larger extent than energy-dense snacks (Folkvord et al., 2016b; Brownell and Gold, 2013). Therefore, scholars advise to improve health interventions to increase the availability and accessibility of fruit and vegetables to children, and reduce access to unhealthy snacks (Eilat-Adar et al., 2011). Playing simple games that contain fruit might for example be an effective and cheap intervention technique.

Moreover, dietary behaviors track into adulthood (Mikkilä et al., 2005) and an increase in fruit consumption among young children may decrease future risks of overweight and obesity (Ledoux et al., 2011) and associated chronic diseases (Boeing et al., 2012). For example, results suggest that children who cope with craving for energy-dense snacks by eating apples after playing a memory-game with energy-dense food cues, have a lower BMI (Folkvord et al., 2016b). Although eating behavior among young children is highly correlated with eating behavior at a later age, there has been limited research demonstrating the effectiveness of interventions to increase fruit intake and lower energy-dense dietary patterns among children in this age (Knai et al., 2006). Therefore, the finding that a simple but enjoyable memory-game increases fruit intake in young children is a promising finding.

Most dietary approaches for obesity prevention attempt to limit intake of energy-dense foods, but this might be perceived as an unwanted restriction for children who find these foods rewarding (Epstein et al., 2001). Because the feeling that they are restricted can lead to increases in preference for these foods (Fisher and Birch, 1999), it might be more beneficial to teach children in an enjoyable way to consume healthy high-nutrient dense foods when they feel craving for food (Folkvord et al., 2016b). As an intervention, substituting energy-dense snacks, like candy, for fruits has been shown to be an effective weight-management strategy in short-term clinical studies (Rolls et al., 2004). Furthermore, in families where parents were encouraged to increase fruit and vegetable intake, significant decreases were shown in the percentage of overweight among both parents and children (Brown and Ogden, 2004).

The first strength of this study was that we were able to test a large number of young children. The second strength was that the game we used was popular among all the children that participated in this study, both for boys and girls, and younger and older children, making it attractive as a possible additional intervention technique for health practitioners or school teachers. One limitation of this study was that children played the memory game only once and we only examined the direct effect on intake, so long-term effects have not been examined. When children play the game more frequently, this could lead to even stronger effects of the game on fruit intake than observed in this study (Harris et al., 2012). A second limitation is that we did not assess baseline individual fruit preferences and intake habits to control for when testing causal relationships. Although previous studies have shown that attitudes towards food snacks that were presented did not differ between groups (Folkvord et al., 2013; Folkvord et al., 2014), to overcome that individual differences in fruit preferences would affect our results, we have randomization and used large groups (Field and Hole, 2010). Final, since the current sample lacked socioeconomic diversity, the results of the study may not be applicable to all socioeconomic strata due to the characteristics of the sample.

Additional studies are needed to address the barriers for success in changing children's eating habits. For example, this study showed that children who played the memory game with fruit consumed more bananas and mandarins, but not more apples and grapes, but a clear explanation why we found no differences for these two kinds of fruits is unclear. Future research should examine whether a memory game containing vegetables could also stimulate children to eat vegetables. In addition, more research is needed to examine the psychological mechanisms that can explain how memory-games are so effective in affecting eating behavior among children (Folkvord et al., 2013; Folkvord et al., 2014; Folkvord et al., 2016a, 2016b) and how these games might stimulate health-related behaviors of children. The obesogenic environment will not change quickly into a healthier one, and stimulating children to consume fruits and vegetables via entertaining games like memory-games might be an addition to existing intervention techniques.

Conflict of interest

No authors have potential conflict of interest.

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