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EDULIA

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Executive summary

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Children aged 9-11 participated in the study (n=114). Their implicit bias towards pictures of snacks was measured via AAT. The test instruction was based on pushing or pulling the joystick according to picture category, food vs. non-food: food (18 snack pictures varying in sweetness and calorie) vs. non-food (18 pictures visually similar to the respective food stimuli). Further, children rated their expected liking of the snack pictures, answered an attitude questionnaire related to health and sugar consumption, and completed two paired preference tests tasting real samples under blind condition and choosing between a sugar and no-sugar added chocolate milk take-home pack. The percentage of non valid AAT responses was relatively high, leading to low testing power. There was a significant difference in approach bias between food pictures and non-food pictures; approach bias was positive for food and slightly negative for non-food. Within food pictures, no significant effect of sweetness nor calorie was found. Nevertheless, children's approach biases were linked to their expected liking ratings, which revealed a clear preference towards high sweetness and high calorie snacks. Individual differences in children's approach bias to pictures differing in sweetness and calorie content were related to their hunger state but not to their attitudes or preference of chocolate milk, indicating a relevance for situational food choices. In the present study, questionnaire-based measurements (affective and cognitive attitude towards sugar, sugar craving and using food as reward) were most predictive for preadolescents' preference for a sugar and no-sugar added chocolate milk. Methodological considerations and recommendations with regards to the use of approach avoidance testing with children are critically discussed.

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Children's sweet tooth: explicit ratings vs implicit bias measured by the Approach avoidance task (AAT)

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Dear Editor

Please find attached the manuscript entitled “Children’s sweet tooth: explicit ratings vs implicit bias measured by the Approach avoidance task (AAT).” for your consideration. Authors are Martina Galler, Emma Mikkelsen, Tormod Næs, Kristian Hovde Liland, Gastón Ares and Paula Varela.

This research assessed the application of the Approach avoidance task (AAT) with children (9 to 11 y.o.) to measure implicit motivational tendencies towards food. To our knowledge the AAT has not come into application with children in a food related context although it represents a particularly easy and simple implicit procedure. In this study implicit results we compared to explicit questionnaire-based results. Further, implicit and explicit mesurements were compared to results of a blind and informed paired-preference task.

I hope you find it worth considering for publication.

With kind regards,

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https://edulia.eu/

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Highlights

- The application of the Approach avoidance task (AAT) with children 9- 11was assessed
- Children's approach biases towards snacks differing in *sweetness* and *calorie* were evaluated
- Implicit approach biases were compared to explicit questionnaire-based results
- Implicit and explicit results were compared to preference for a sugar vs. no-sugar chocolate milk

Children's sweet tooth: explicit ratings vs implicit bias measured by the Approach avoidance task (AAT)

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Keywords: Approach avoidance, Implicit, Children, Preferences, Sweetness, Calorie

Abstract

The aim of the study was to assess the application of the Approach avoidance task with children to measure implicit motivational tendencies towards foods differing in *sweetness* and *calorie* content and to explore the relationship between approach bias and explicit measurements of expected liking, attitudes, and hunger state and their relation to paired-preference tasks. The simplicity and game-like procedure of the AAT, where participants use a joystick to pull or push pictures, seems particularly suitable to measure implicit motivational biases in children. However, to our knowledge this approach has not been used with children in a food related context.

Children aged 9-11 participated in the study (n=114). Their implicit bias towards pictures of snacks was measured via AAT. The test instruction was based on pushing or pulling the joystick according to picture category, food vs. non-food: food (18 snack pictures varying in *sweetness* and *calorie*) vs. non-food (18 pictures visually similar to the respective food stimuli). Further, children rated their expected liking of the snack pictures, answered an attitude questionnaire related to health and sugar consumption, and completed two paired preference tests tasting real samples under blind condition and choosing between a sugar and no-sugar added chocolate milk take-home pack.

The percentage of non valid AAT responses was relatively high, leading to low testing power. There was a significant difference in approach bias between food pictures and non-food pictures; approach bias was positive for food and slightly negative for non-food. Within food pictures, no significant effect of *sweetness* nor *calorie* was found. Nevertheless, children's approach biases were linked to their expected liking ratings, which revealed a clear preference towards high *sweetness* and high *calorie* snacks. Individual differences in children's approach bias to pictures differing in sweetness and calorie content were related to their hunger state but not to their attitudes or preference of chocolate milk, indicating a relevance for situational food choices. In the present study, questionnaire-based measurements (affective and cognitive attitude towards sugar, sugar craving and using food as reward) were most predictive for preadolescents' preference for a sugar and no-sugar added chocolate milk. Methodological considerations and recommendations with regards to the use of approach avoidance testing with children are critically discussed.

Introduction

The rising prevalence of childhood overweight and obesity requires a better understanding of the mechanisms underlying children's self-directed food choices, as they often do not meet nutritional recommendations. As described in a wide body of literature, children tend to prefer sweet food

(Cooke & Wardle, 2005; Mennella & Bobowski, 2015; Mennella et al., 2016; Mennella et al., 2012; Venditti et al., 2020) and energy-dense food (Cooke & Wardle, 2005; Gibson & Wardle, 2003). In this sense, previous studies have also indicated a relatively high focus on hedonic over health aspects during childhood (Marty et al., 2018; Marty, Miguet, et al., 2017; Nguyen et al., 2015).

According to dual processing theory, decision making criterion can be grouped into goal-directed and automatic processes of which the latter are thought to be important drivers of food choices (Jacquier et al., 2012; Rangel, 2013). Automatic decision making processes are expected to be influenced by implicit attitudes towards foods, i.e. favourable or unfavourable feelings, thoughts, or actions towards different foods that occur without conscious awareness (Greenwald & Banaji, 1995). Implicit attitudes have been shown to have a direct impact on eating behaviour in adults (Dubé & Cantin, 2000; Raghunathan et al., 2006) and have been postulated to be a barrier for healthy food choices (Mai et al., 2011). Köster (2009) highlighted that food habit formation occurs mostly unconsciously in childhood while conscious cognitive learning becomes more important when growing up. While adults might be able to wilfully steer their food choices to a certain degree, linking them to cognitive goals (such as health considerations), children don't reflect too deeply on their food choices. Methods that can capture children's automatic tendencies might therefore offer an advantage over questionnaire-based measurements that according to Köster (2009) assume reasoned action and planned behaviour.

Test protocols to measure automatic processes are called implicit tests and are increasingly used to study eating behaviour (Monnery-Patris & Chambaron, 2020). There are different implicit testing paradigms which address different implicit aspects (Kraus & Piqueras-Fiszman, 2018; Monnery-Patris & Chambaron, 2020). Children's implicit thinking has been investigated via categorization tasks, assessing the usage of hedonic vs. nutrition-based categorization criteria. Results showed that children more frequently used hedonic categorization, especially in their implicit thinking (Marty, Chambaron, et al., 2017) and that their implicit and explicit attitudes had an additive effect on their food choice (Marty, Miguet, et al., 2017; Perugini, 2005). Further, the implicit association task (IAT) has been used to measure children's implicit bias towards healthy vs. unhealthy foods measuring the relative association of two target concepts such as healthy and unhealthy food with a positive and negative valence category. Surprisingly, studies have repeatedly found that children had an implicit bias towards healthy food while they explicitly liked unhealthy food more (Craeynest et al., 2007; DeJesus et al., 2020; van der Heijden et al., 2020). DeJesus et al. (2020) results indicated that more nutritional knowledge correlated to larger implicit biases for healthy food. None of these studies linked implicit and explicit results to actual food choices.

The application of implicit reaction time tasks with children is not free from limitations; van der Heijden et al. (2020) reported a lower testing power for the IAT performed by children over adults, which indicates that the performance of the task might be challenging for children. Therefore, it is of interest to have other implicit testing procedures to measure implicit food preference patterns in children. The simplicity of the Approach Avoidance Task (AAT) as well as its game-like procedure, where participants use a joystick to pull or push pictures appearing on a computer screen, may be suitable to study implicit tendencies in children. However, to our knowledge it has only been applied with children to measure implicit spider phobia, thus avoidance behaviour (Klein et al., 2011).

Approach and avoidance behaviour is thought to be more closely linked to wanting than liking, thus to actual behaviour (Kraus & Piqueras-Fiszman, 2016; Tibboel et al., 2015). While Tibboel et al. (2015) doubted that the AAT is able to measure wanting, there are AAT studies that would support this theory: people high in the trait food craving displayed larger approach biases to food (Brockmeyer et al., 2015). Booth et al. (2018) used a closely related but cognitively more challenging protocol (the

Manikin task) to measure approach tendencies to sweet snacks in adolescents placing approach bias as moderator between impulsivity trait and uncontrolled eating behaviour. Further, the AAT has been successfully applied as intervention for overweight children to learn to resist visual food cues (Warschburger et al., 2018) indicating a tight link to actual behaviour.

In this context, the aim of the study was threefold: i) to assess the application of the Approach avoidance task with children to measure implicit motivational tendencies towards food, ii) to evaluate approach bias towards foods differing in *sweetness* and *calorie* content, and iii) to explore the relationship between approach bias and explicit measurements of expected liking, attitudes, and hunger state and relate results to paired-preference tasks. It was hypothesized that children would display more positive approach biases towards high *sweetness* and high *calorie* foods. Further, it was assumed that implicit approach bias would be related to children's preferences of a sugar and no-sugar added chocolate milk (blind and informed choice).

2. Materials & Methods

The study consisted of several tasks including the implicit Approach avoidance task (AAT), explicit questionnaires of attitudes, hunger state and expected liking as well as blind and informed paired preference task of chocolate milk as displayed in Figure 1. Two workstations were set up. Children (9-11 years old) in groups of maximum 12 performed the tests and switched workstations once both groups were finished. Approximately half of the children performed the test before and half after lunch. All results were collected electronically. In each workstation children logged in with a three-digit code distributed as stickers at the beginning of the study. This allowed us to connect the results of the two workstations while ensuring that participants were not identifiable in the data.

2.1. Participants

The study was conducted at Vitenparken Campus Ås within a science outreach program which is offered to school classes in the Akershus region. A total of 114 children between 9 and 11 years old participated (52% girls; 9 years old n=68, 10 years old n=36, 11 years old n=10). Children visited the science centre with their school classes and teachers. They had different science lectures, activities and exhibitions throughout the day, among those the current study.

A protocol of the presented study was presented to The Norwegian Centre for Research Data (NSD), reference 476380. Prior to the test, parents were informed about the experiment via the school communication app, along with an electronical consent form. Some parents forgot to sign the form. In discussion with the teachers who accompanied the school classes and following EU (Regulation (EU) 2016/679) and Norwegian GDPR regulations, children with a missing consent form were allowed to participate through passive consent. All children were orally asked for their assent and food allergies or intolerances that would not allow the tasting of the chocolate milk samples. They were also informed that they could leave the test at any time without consequences.

2.2. Implicit measurement - Approach Avoidance task (AAT)

The approach avoidance task (AAT) was implemented with the software Inquisit Millisecond 5.0 using joysticks (Logitech G Extreme 3D Pro). Seats were adjusted according to children's height and joysticks were placed on the side of children's writing hand. Prior to the task, a researcher gave a detailed introduction and encouraged children to test the movement of the joystick.

Children were required to react to a single picture (stimuli) displayed in the centre of the screen of a laptop computer, by pulling or pushing the joystick, depending on the picture category and instruction of the test part. The task consisted of two test parts with opposite test instructions that required pulling or pushing according to the picture category (food vs. non-food). This setup corresponds to a feature-relevant task instruction where the reaction criterion is based on picture content which had been found to have a larger testing power regarding discrimination between picture groups (Lender et al., 2018). Other AAT studies (e.g. Brockmeyer et al., 2015; Piqueras-Fiszman et al., 2014) have used a feature-irrelevant setup where reaction criterion were, e.g. based on picture orientation (portrait vs. landscape). In such settings image processing might be less conscious which can result in lower testing power.

Pictures were enlarged when pulled and shrunk when pushed creating the illusion of coming closer / going farther away. Further, error messages were included for wrong answers so participants could correct the classification criterion in case they forgot it. The order of test instruction ("pull food and push non-food" or "push food and pull non-food") in test part was balanced across participants.

All picture stimuli were retrieved from the image database "Food-pics" (Blechert et al., 2014). The stimuli set consisted of 18 snacks (food category), commonly eaten by Norwegian children, representing approximately one portion. The snacks were selected based on their sweetness level (low, medium, high) and their calorie content (low, high, as per "Food-pics"' database). Sweetness categories were assumed a priori by the experimenters and checked a posteriori by collecting sweetness ratings from participants. Each food picture was matched to a non-food picture (non-food stimuli) regarding shape and colour (examples in Appendix, Figure 1). In total there were 36 test stimuli, 18 food and 18 non-food pictures. Snacks are listed in Table 1 according to sweetness and calorie category including snack picture number and matching non-food picture number in the "Food-pics" database (Blechert et al., 2019).

Each test instruction block consisted of 16 practice trials to train the response criterion with different pictures than the ones used in the test (#0372, #0865 for food; #1265, #1113 non-food) and 72 measurement trials consisting of two repetitions of the 36 stimuli pictures. In each repetition pictures were presented in a randomized order. For the measurement, reaction time, at a 30-degree tilt of the joystick, as well as correctness of the responses were registered. The whole test lasted approximately 15 minutes, varying according to children's reaction speed.

2.3 Explicit measurements

Electronic questionnaires were implemented in the software EyeQuestion.

Hunger level:
Children rated their hunger level (7-point scale with three anchors "I am hungry", "I am neither hungry nor full" and "I am full") prior to the AAT.

Sweetness intensity and expected liking of food pictures used in AAT:
After the implicit test, children rated their expected liking on a 7-point hedonic scale and their expected sweetness intensity (category scale: "Not sweet", "A bit sweet", "Pretty sweet", "Very sweet") of each of the food pictures (Table 1), to check the sweetness levels defined by researchers. The food pictures were presented in sequential monadic balanced order.

Attitudes to healthy eating and sweet food:

Children answered an attitude questionnaire with three subscales extracted from the Health and Taste questionnaire by Roininen et al. (1999) (General health interest, Craving for sweet food and Using food as reward) with slight adjustments to fit the age group based on a pilot study (see Appendix, Table 1). Further, two scales, affective and cognitive attitudes towards sweet food, from a study with children of the same age-group (Takemi & Woo, 2017) were included. Questionnaires were translated from English to Norwegian and pilot tested with a small group of children. For all attitude-based measurements, 7-point agreement-to-statement scales were used.

2.4. Chocolate milk preferences

To link children's implicit and explicit attitudes to their actual preferences, a chocolate milk case study was used, where children chose between two chocolate milks with added and no-added sugar in two instances, a blind tasting, and a take-home paired preference test.

Take-home paired preference test:

Children chose between two commercial chocolate milk packs (Work station 2, Figure 1). Children made their choice upon entering the room without knowing about the test scope. They were informed that they could choose one of the chocolate milks as a token for their participation. The main difference between the packs was the presence / absence of the claim "No added sugar", and the "No added sugar" version had the claim "New" in a yellow flash. There were slight variations in the pack design but they were generally similar, with a comic figure of a cow. The products were available in the Norwegian market and were well known by Norwegian children. Children recorded their take-home preference at the start of the test, clicking on their choice on a screen that displayed the photos of both packs next to each other.

Blind paired preference test:

After the attitude and demographics questions, children tasted the two chocolate milks and chose the one they preferred. Samples were served in black plastic cups that masked slight colour differences and were coded with two symbols similar in shape, a cloud and a flower. Chocolate milk recipes differed more than regarding sugar content, as they are optimized products in the market. The "No added sugar" version had been sweetened by lactose hydrolysis. A pre-tasting by the researchers confirmed a perceivable difference in sweetness intensity.

2.5. Data analysis

All analyses were performed in R, version 4.0.4. Significance was determined based on an alpha of 5%. The R package "mixlm" (Hovde Liland, 2019) was used for linear mixed ANOVAs, "lmerTest" (Kuznetsova et al., 2017) for mixed linear regression and logistic regression models and "FactoMineR" (Lê et al., 2008) to perform a multiple factor analysis (MFA).

2.5.1. Data pre-processing

Children with insufficient data quality in the AAT (n=15) or missing data due to software problems in the expected liking (n=1) were deleted from all analysis resulting in in 98 children included in the analyses reported in this study. For chocolate milk paired-preference tests three additional answers were missing (due to lactose intolerance or milk disliking) resulting in 95 answers for paired-preference tests.

2.5.2. Assessment of AAT data structure

AAT data was pre-processed according to Klein et al. (2011), excluding datapoints with errors or reaction times that exceeded test cut off values (< 200 ms and > 5000 ms) and individual cut off values (+/- 2*standard deviation), (= outliers) and excluding children with a very high amount (> 25%) of missing data.

Error and outlier structures were assessed by a mixed logistic regression including *test part, movement* with the joystick*, picture category, gender*, *age* and the interaction *gender* x *age* as fixed and *child* nested in *age* x *gender* as random variables. In the same way reaction time was tested by a mixed regression model.

2.5.3. Approach bias according to picture category (food vs. non-food)

The approach bias (AB) was calculated by subtracting the reaction time for pulling from the reaction time for pushing, per picture. The mean of the two repetitions was used. Approach bias according to picture category (food and non-food) was tested with a mixed ANOVA with *picture category* as fixed, *child* as well as the interaction *picture category* x *child* as random factors.

2.5.4. Approach bias and expected liking of food pictures

Pre-assumed sweetness levels of the snack pictures and expected sweetness ratings by children were compared via Spearman correlation also separately for low and high *calorie*. The results were displayed by a mosaic plot based on a frequency table.

The same mixed ANOVA models were calculated with approach bias and expected liking ratings as dependent variables. Using the a priori DoE (sweetness: low, medium, high and calorie content: low, high), pictures were tested for *sweetness*, *calorie*, the interaction *sweetness* x *calorie* as fixed factors and child and the two- and three-fold interactions as random factors.

Further, *individual sweetness ratings* as well as *calorie per 100 g* were used as numeric fixed variables and child as well as the interaction *child* x *calorie per 100 g* as random variables in a mixed regression model.

Children's approach bias and expected liking were compared by regression analysis and visually by a multiple factor analysis (MFA). Expected liking was included as an independent variable in the regression model based on *individual sweetness ratings* and *calorie per 100 g* to test the relationship between approach bias and expected liking. The MFA overlayed the two measurements, each matrix had snack pictures as rows and children's responses as columns. Columns were centred and standardized for the MFA.

To measure the influence of visual aspects of snack pictures on approach bias, the visual variables available in the "Food-pics" data base (e.g. redness, complexity, contrast) were included into a Mixed regression model with approach bias as dependent and DoE factors and expected liking as independent variables.

2.5.5. Linking approach bias and expected liking to other measurements

To compare children's approach bias and expected liking to other measurements, differences between the DoE levels were calculated. The associations with continuous variables (*attitude* subscales and *hunger state*) were tested by Pearson correlations, categorical variables by unpaired (two-sample) two-sided t-tests in the case of binary variable (*gender*) and ANOVA (*age*).

2.5.6. Implicit and explicit measurements and chocolate milk preference

Implcit and explicit (continuous) measurements were compared to chocolate milk paired-preference test results by unpaired (two-sample) two-sided t-tests.

3. Results

3.1. Assessment of AAT data structure

The AAT results of 15 children containing more than 25% errors or outliers were excluded from further analysis. The remaining dataset contained 11% errors, 5% outliers exceeding individual cut-offs and 1% outliers exceeding test cut-offs, resulting in 15% responses that were deleted for the reaction time and approach bias analyses.

In order to assess the generated AAT data by children, errors and outliers as well as reaction time structures were analysed (Table 2). It was of interest to investigate the existence of systematic differences between the first and the second *test part*, between *movement* of the joystick (pull or push) or between the two *picture categories* (food and non-food). Further *age* and *gender* differences were explored.

Error and outlier rates were lower in the first test part than in the second part where test instruction changed, indicating difficulty to switch the test response criterion in the second test part. Further, the joy stick *movement* “pull” resulted in less errors and outliers than the movement “push”. Error and outlier rates were particularly high for the first response of each test part despite the preceding practice trials (Figure 2a).

Reaction time decreased in the second test part which could indicate a training effect over the test. There were no significant differences between the two *movements* (pull and push) and also not between the two *picture categories* (food and non-food). As seen for the error and outlier rates, the first responses of each test part had a high reaction time (Figure 2b).

Gender and *age* and their interaction were not significant regarding errors and outlier rates. Reaction time decreased according to *age*, older children reacted faster (Table 2 and Figure 2c). *Gender* and the interaction *gender x age* were not significant.

3.2. Approach bias according to picture category (food vs. non-food)

For comparison of picture categories children’s approach biases were used. Positive values indicate that the pulling was faster than the pushing, thus approach tendencies, negative values indicate the opposite: avoidance tendencies.

As seen in the last section, children’s reaction times decreased over the course of the test. As the approach bias represents the difference between the first and second test part, the order of test instruction children followed had an influence on their approach bias towards food and non-food. Children that started with the instruction “pull food and push non-food” in the first test part and “push food and pull non-food” in the second test part ended up with less positive approach biases for food and less negative approach biases for non-food than children who followed the opposite order (Table 3). The difference between food and non-food was only significant for the latter group (Table 4). Therefore, children’s approach biases were adjusted by the estimate for reaction time difference between the two test parts extracted from Table 2 (= 10.6 ms) which is particularly important for the investigation in individual differences within the food category.

Children’s approach bias differed significantly between food and non-food pictures (Table 4). The approach bias was positive for food (M = 40.0 SD = 346.4) and slightly negative for non-food (M = -17.8, SD = 361.0).

3.3. Approach bias and expected liking of food pictures

3.3.1. Sweetness levels

Pre-assumed *sweetness* categories (low, medium, high) of the snack pictures used in the AAT were significantly correlated to children’s expected sweetness intensity ratings (rs = .41). However, ratings varied (Figure 3). The correlation differed somewhat between the two *calorie* groups (low calorie: rs = 0.34 and high calorie rs = 0.52). The high caloric snacks were rated as sweeter than the low caloric snacks in the high *sweetness* category. Therefore, *individual sweetness ratings* and *calorie content per 100 g* derived from the “Food-pics” database were explored additionally in the following sections (results displayed in Appendix) to confirm findings of pre-assumed DoE factors.

3.3.2. Implicit: Approach bias to food pictures

According to our hypothesis, children would display a larger approach bias for the high *sweetness* and high *calorie* levels. The effects of *sweetness*, *calorie* and their interaction were, however, not significant (Table 5). There were no significant individual differences regarding *sweetness* (*sweetness* x *child*) indicating that children did not systematically differ in how this factor influenced their reaction times. The interaction *calorie* x *child* was significant, indicating that children differed systematically in their approach towards high and low calorie snacks, some having larger biases towards high calorie snacks faster, some towards low calorie snacks.

The model with children’s *individual sweetness ratings* and *calorie content per 100 g* did not yield significant effects (Appendix, Table 2).

3.3.3. Explicit: Expected liking of food pictures

There were significant differences in children's expected liking according to *sweetness*, *calorie* content, and their interaction (Table 5). Children expected to like the foods in the high *sweetness* group more than those in the low and medium *sweetness* level. Also, foods in the high *calorie* group were expected to be more liked, but only in the low and high *sweetness* group (Figure 4). There were no significant individual differences regarding the effect of *sweetness* (*sweetness* x *child*) on explicit liking, indicating that most of the participants liked a high *sweetness* level most. The interaction between calorie and child was significant, indicating individual differences on the effect of *calorie* on expected liking. Some children liked high caloric and others low caloric snacks more.

The model with children’s *individual sweetness ratings* and *calorie content per 100 g* yielded also significant effects (Appendix, Table 2).

3.3.4. Comparison of Approach bias and Expected liking of food pictures

Figure 5 displays children’s approach bias and expected liking configurations of the food pictures overlayed by an MFA. The explained variance was only 21%. Nevertheless, it is of interest to look at common patterns between implicit and explicit responses as revealed by the first two factors of the MFA. A regression analysis confirmed that children’s expected liking were significantly associated with children’s approach bias (Appendix, Table 2). The configuration of the DoE factors that were projected on the MFA plot based on the location of the respective snack pictures is shown in Figure

5b. High *sweetness* was separated from low and medium *sweetness* in the first dimension. Further, a separation according to *calorie* in a diagonal was apparent, high towards the lower right corner and low towards the upper left corner. In the score plot based on implicit and explicit responses "Chips" was placed in the high *sweetness* cluster and "Banana" was not in the high *sweetness* cluster (Figure 5a). Almost all (91%) children's expected liking vectors displayed in the loading plot (Figure 5c) were directed towards the right hand side of the first dimension (high *sweetness*) while children's approach bias did not show a defined pattern, but vectors pointed in all directions (for 54% of children the implicit and explicit responses were directed towards high *sweetness*).

3.4. Individual differences in children's implicit and explicit assessments

In order to compare approach bias and expected liking tendencies to different snack groups, differences between factor levels were built. As the MFA (Figure 5b) separated the high *sweetness* level from medium and low, the difference high – low & medium *sweetness* was further related to other measurements (demographics, attitude, hunger state and chocolate milk preference). The difference high – low *calorie* was included, as the mixed ANOVAs for approach bias as well as expected liking (Table 5), indicated a systematic difference between children for the factor *calorie* (significant interaction *child* x *calorie*).

Children's age and gender did not influence implicit bias or explicit liking: high – low & medium *sweetness*, high – low *calorie* (Table 6). Attitude subscales, *craving for sweet food*, *using food as reward*, *affective attitude towards sweet food* and *cognitive attitude towards sweet food* were positively associated with children's expected liking for high caloric snacks.

As children participated either before or after lunch, their hunger level differed systematically. There were similar proportions of hungry, neither hungry nor full and full participants (N=39, N=31, N=28). Children who were hungry showed larger approach biases and expected liking ratings for high caloric snacks and a lower approach bias towards the high sweetness level (Figure 6).

3.5. Implicit and explicit measurements and chocolate milk preference

Neither children's approach bias nor expected liking ratings were associated with chocolate milk preferences (Table 7). All attitude subscales except for *general health interest* were associated with chocolate milk preference (blind and / or informed), indicating that they were better predictors for children's chocolate milk choice. Higher scores in the measured attitude subscales were associated with higher odds to choose the sugar added chocolate milk. Also, for *cognitive attitudes*, being more aware of the negative consequences of sugar consumption was associated with higher odds of choosing the sugar added chocolate milk.

4. Discussion

The present research work aimed to apply the Approach avoidance task (AAT) to investigate children's automatic approach tendencies for the first time in a food related context. The objective was to study if implicit testing would offer additional insights to explicit measurements of attitudes and liking towards foods of different sweetness and caloric content, and if implicit biases could explain children's actual food choice.

4.1. Implicit approach bias and explicit measurements

Children displayed a positive approach bias towards snack (food) pictures in general and a slightly negative approach bias to non-food pictures. Similar results have been reported in previous AATs based on feature-relevant task instructions in adults (Kahveci et al., 2020; Lender et al., 2018). The fact that non-food pictures had slightly negative approach biases confirmed that approach biases to food were not just the result of different movement speeds in general (pushing the joystick faster away than pulling towards) but linked to picture content. Thus, it can be concluded that snack pictures caused an approach behaviour in children.

However, the present study did not find significant differences in approach bias according to the different levels of *sweetness* and *calorie* in the DoE of the selected snack pictures. This was also the case in a study with adults where calorie content, individual food preferences and food deprivation were investigated in relation to approach bias through a touchscreen-based AAT, with a wide range of food items (Kahveci et al., 2020). The lack of discrimination among food pictures in the present study could be linked to the low-test power due to high error and outlier rates which did not allow to measure relative small differences between appealing snack pictures. This opens the door for future studies (further discussed in 4.5).

Explicit measurements of expected liking were useful to discriminate among the presented stimuli according to *sweetness*, *calorie* content, and their interaction. As in previous studies (Cooke & Wardle, 2005; DeJesus et al., 2020; Ervina et al., 2020; van der Heijden et al., 2020) children expected to like snacks high in *sweetness* and high in *calorie* more.

Regarding the explicit measurements of attitudes via questionnaires, the internal consistency (measured by Cronbach's alpha) of the attitude subscales that were filled autonomously (with assistance from researchers only on request) were lower than 0.7, which is generally considered as good (Cortina, 1993), and also lower than in Takemi and Woo (2017) where questionnaire completion was assisted by researchers. Nevertheless, even if the low consistency may call for care in the interpretation of results, children's attitude measurements made sense from an interpretation point of view (further discussed in 4.3. and 4.4.)

4.2. Comparison of approach bias and expected liking of food pictures

We were able to see some common and some distinct patterns between the implicit and explicit responses. On one side, the regression analysis confirmed that children's expected liking ratings were significantly correlated to children's approach bias, in line to that described by Kahveci et al. (2020) in adults. However, it is interesting to note, that expected liking and implicit bias were not representing similar tendencies for all children, as suggested by the MFA loading plot. While half of the children showed expected liking responses in line with their implicit bias responses (associated to high sweetness), many other children had opposite patterns for both responses. These results link back to what was suggested by Piqueras-Fiszman et al. (2014): implicit test results may be more sensitive for studying individual differences amongst certain groups of consumers and are not necessarily linked to (positive) affective ratings measured via visual analogue scales (VAS) (e.g. wanting).

4.3. Individual differences in children's implicit and explicit assessments

There were no significant individual differences regarding the effect of *sweetness* on explicit liking, indicating that most of the participants liked most the foods with a high *sweetness* level. However, we observed individual differences on expected liking as related to *calorie* level which were related to attitude subscales (craving for sweet food, using food as reward, affective and cognitive attitude towards sweet food) and children's hunger level.

With regards to approach bias tendencies, there were no significant individual differences regarding the effects of *sweetness* or *calorie* and explicit attitudes. Interestingly enough, there was a significant link to children's hunger state. The children in this study seemed to implicitly regulate their approach bias response to snack pictures according to their appetite level. Children who were hungry (who performed the AAT just before their lunch) had a stronger approach bias to high caloric snacks and snacks with medium and low sweetness level, so they were significantly more attracted to calorie dense non-dessert food in the case of being hungry which was very similarly to the results described by Finlayson et al. (2007). Kahveci et al. (2020) did not find food deprivation to produce a larger approach bias towards high calorie food in adults. In our study hunger state also influenced children's explicit expected liking rating of snack pictures, children who were hungry showed larger expected liking ratings for high caloric snacks. However, the effect was only seen for calorie content and not for sweetness level. This indicates that the approach tendency patterns may have been more predictive of situational food choices while expected liking was somewhat more static. Kraus and Piqueras-Fiszman (2016) highlighted that approach or avoidance tendencies may be more linked to dynamic, motivational states, associated to the specific state (e.g. hungry vs full) or a momentaneous desire to eat, while liking represents an evaluative concept, linked to habitual preferences. So, our results add to the literature suggesting that implicit bias measured via AAT and affective responses to food items (expected liking in our case) may be representing different driving forces behind food behaviour. Also Finlayson et al. (2007) found similar dissociated liking (measured by ratings) and wanting (forced-choice-tasks) tendencies between high vs. low fat and sweet vs. savoury foods depending on participant's hunger state.

4.4. Implicit approach bias and explicit measurements to predict children's food choices

In the present study implicit approach bias was not linked to children's food choices based on a blind or informed paired-preference tasks with sugar and no-sugar added chocolate milk. In line with previous studies (Craeynest et al., 2007; DeJesus et al., 2020; van der Heijden et al., 2020), children expected to like unhealthy snacks (=high *calorie* and high *sweetness*) more than healthy snacks, which also manifested itself in an general preference for the unhealthier option (chocolate milk with sugar added over no-sugar added). These results suggest that children explicit affective ratings (expected liking of snack images and preferences for chocolate milk) were not affected by social desirability effects, as e.g. found by Raghunathan et al. (2006) in adults, who may claim to like healthy foods but ultimately chose unhealthy food. Furthermore, results obtained in the blind preference test (where children were aware of being tested) were consistent with the "take-home" preference test, in which children were "choosing a token for his effort". Thus, results suggest that social desirability may not bias explicit liking measurements in self-administered test settings, with children in this age group, which should be further studied in other products and settings.

Children's attitude measurements (craving for sweet food, using food as reward, affective and cognitive attitude towards sweet food) were significant predictors for children's preferences in chocolate milk. Cognitive attitudes towards eating sugar were proposed to be negatively associated to children's behavioural intention to eat sweets in Takemi and Woo (2017). However, in the present study children's cognitive attitudes towards sweet food (the awareness of negative health consequences of eating sweets) were associated with higher odds of choosing the unhealthier chocolate milk version. This is in line with what Marty, Miguet, et al. (2017) suggested, that an increased focus on nutritional aspects might lead children to make less healthy food choices, rather than having the desired effect.

Implicit testing to predict food choice might be more relevant in populations where implicit motivation and liking, representing goal-directed intention, stand in opposition, e.g. overweight children who are trying to lose weight but do not manage. The approach avoidance task has come into application with overweight adults (Kakoschke et al., 2017; Maas et al., 2016; Paslakis et al., 2016) and as intervention to "retrain" overweight children (Warschburger et al., 2018).

4.5. Methodological considerations and recommendations

When planning and evaluating the study we were confronted with the question, if the AAT is most suitable to compare individuals regarding their approach biases as done in most previous food related AAT studies (Booth et al., 2018; Brockmeyer et al., 2015; Kahveci et al., 2020; Kakoschke et al., 2017; Lender et al., 2018; Maas et al., 2016; May et al., 2016; Paslakis et al., 2016; Piqueras-Fiszman et al., 2014; Rohr et al., 2015) or if differences between food categories could be investigated as well. We decided to focus on both, as done in a few studies (Kahveci et al., 2020; Maas et al., 2016; Paslakis et al., 2016; Rohr et al., 2015). First, investigating children's general approach bias tendencies and then investigating individual differences in the assessments. However, we did not find significant effects of the DoE parameters (*sweetness* and *calorie*) within snack pictures, as discussed above. This question remains open and future studies should include varying levels or relevant product features, based in controlled DOE, to better understand the applicability of AAT and other implicit methods to product differentiation.

Measuring reaction time is likely to contain a high amount of noise (due to distraction), which might be more pronounced in children, as noted by (van der Heijden et al., 2020), who compared test power of children and adults in the implicit association task. Although the pulling and pushing of a joystick as reaction tool in the AAT is particularly easy, the task still required children to stay focused over an extended period of time (appr. 15 minutes in the presented study). In the present study, 15 children had to be excluded from the data analysis due to large error and outlier rates and the resulting AAT dataset contained 15% missing values which reduces test power which was higher than in previous studies with adults (e.g. Lender et al., 2018).

The multidimensional characteristics of pictures as test stimuli, makes the setup of a suitable test design challenging, as there are many potential confounders. In our test, visual aspects (shape and colour) of food were controlled for by the inclusion of visually similar non-food items. However, within food items no standardization was easily attainable if the objective was to vary levels of sweetness and calories. Foroni et al. (2016) found that human's arousal is linked to colour (however only in food not visually similar non-food pictures). Therefore, colour imbalances between factor levels of snacks could have biased findings. We explore this aspect when checking data quality (Appendix, Table 2) but no visual picture features (such as redness or contrast) had a significant effect on Approach bias. Further, picture meaning can be confounded as well. Coricelli et al. (2019) proposed natural vs. processed food as an additional dimension which was almost 1:1 represented by the factor *calorie* in our study (the high calorie foods were processed to a certain degree, low calorie were not). However, our results may indicate that calorie content rather than processing level were decisive for children's response as implicit and explicit tendencies towards high calorie content correlated to children's hunger level. Further, our results suggest a main separation between the frequently consumed and the more special snacks (more seasonal or usually restricted by parents), as shown by the MFA, an aspect that could be worth investigating further. It could also be of interest to compare two extreme food groups as done by Piqueras-Fiszman et al. (2014). They compared individuals regarding approach and avoidance towards appealing and disgusting foods and also assessed the role of their hunger state. With children, food neophobia topics could potentially be explored this way.

In the feature-relevant task instruction chosen in the presented study, the response criteria is based on the stimulus picture content; in the feature-irrelevant used by other authors the task focuses on a different aspect (e.g. landscape and portrait format of stimulus picture). Lender et al. (2018) found larger effects comparing food and non-food pictures in a feature-relevant setting. It could be that in feature-irrelevant task instructions, participants are so much focused on the task goal that they do not perceive the picture content. Selective attention has been well demonstrated, e.g. in the Nobel price winning "Gorilla experiment" (Simons & Chabris, 1999). It can be assumed that the discrimination between stimuli could be even weaker in feature-irrelevant AAT tasks where stimulus processing mostly occurs subliminal. However, more than just assuring the processing of picture content, similar as in the Implicit association task, the feature-relevant AAT task instruction brings the classification concepts into participants' consciousness. This could extend participants' response towards the concept of the two groups (food vs. non-food in our study) rather than the presented stimuli in the pictures. Lavender and Hommel (2007) argued that the intention to act upon affect will lead to approach behaviour. In our setup participants were aware of the food vs. non-food group and were instructed to act upon this criterion. But they were not aware and therefore had also no intention to act upon the factor levels within food which could explain a weaker discrimination within food pictures. Perhaps, a feature-relevant AAT where the task instruction was based on a food category (e.g. sweet vs. not sweet) would lead to higher discriminability. Although it seems to be standard procedure in the AAT, visually similar object pictures might not be essential and some studies (Paslakis et al., 2016; Rohr et al., 2015) did not include them. Similar as in the IAT, two clearly separatable food groups could potentially be compared this way.

A major disadvantage of a feature-relevant task instruction lies in the need of participants to switch task instruction after the first test part which is not necessary in feature-irrelevant task instructions. Our results suggest that it was not easy for children to switch task instruction resulting in more errors and outliers in the second test part with a lower testing power as consequence. Furthermore, children's reaction time decreased over the course of the task probably due to training effects. Because approach bias represents the difference between the first and second test part in the feature-relevant task setup, a systematic difference between children that started with one and children that started with the opposite task instruction occurred. In order to allow an accurate estimation larger training blocks might be necessary, or otherwise the decrease in reaction time per test part needs to be corrected as done in the presented study. To our knowledge this effect has not been investigated before. It could be particularly relevant in the application with children.

5. Conclusions

The present work aimed to apply the Approach avoidance task (AAT) to investigate children's automatic approach tendencies for the first time in a food related context. We explored children's implicit approach bias to snacks differing in *sweetness* and *calorie* content and the link to explicit questionnaire-based results and preferences for a sugar vs. no-sugar added chocolate milk.

Children displayed a significant positive approach bias towards snack (food) pictures in general and a slightly negative approach bias to non-food pictures; we did not find significant differences in approach bias towards snack pictures with different levels of *sweetness* and *calorie* content.

Explicit expected liking discriminated among snacks varying in *sweetness* and *calorie* content, with most children liking *high sweetness* most, but individual differences regarding *calorie* content, some liked high caloric and others low caloric snacks more.

Individual differences in hunger state influenced children's implicit and explicit assessments; children who were hungry showed larger approach biases and expected liking ratings for high caloric snacks and a lower approach bias towards the high sweetness level, being more attracted to calorie dense non-dessert food.

There were some common and some distinct patterns between the implicit and explicit results, around half of the children showed expected linking responses in line with their implicit bias responses (associated to high sweetness), while other children had distinct or even opposite patterns for both responses, suggesting that implicit bias measured via AAT and liking ratings may be representing different driving forces behind food behaviour.

Attitude subscales *craving for sweet food, using food as reward, affective attitude towards sweet food* and *cognitive attitude towards sweet food* were positively associated with children's explicit liking for high caloric snacks and were significant predictors for children's preferences in chocolate milk. Implicit approach bias was not linked to children's blind or informed paired-preference for sugar and no-sugar added chocolate milk. Overall, the explicit measurements were more predictive of chocolate milk preference in the present study.

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Author statement

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Figure Captions

Figure 1 Test setup

Figure 2 a: Ratio of errors and outliers along the AAT test progression. b: Median reaction time according to test progression (data points with errors and outliers were excluded). In Test part 2 the test instruction was switched (order of test instruction was balanced among children). Each Test part started with a practice trial of 16 pictures, followed by the measurement of 36 different pictures in two repetitions. c: Significant age effect on reaction time: 11-year-olds were faster then 9-year-olds.

Figure 3: Mosaic plot of sweetness categories by researchers and children's ratings. Sweetness ratings by participants (1=Not sweet, 2=A bit sweet, 3=Pretty sweet, 4=Very sweet). Ratings were significantly correlated to a priori classification.

Figure 4: The DoE factors *sweetness*, *calorie* as well as their interaction had a significant effect on children's expected liking ratings

Figure 5 Multi factor analysis of implicit (Approach bias) and explicit (Expected iking) responses to snack pictures differing in sweetness level and calorie content. Both matrices were centred and standaridzed with snack picture as row and child as column. a: score plot showing snack pictures (exact location in centre of text unless marked with red dot), b: projection of DoE factor levels with lines showing implicit and explicit location, c: loading plot representing children regarding their explicit and implicit response.

Figure 6 Approach bias (mesured by AAT) and expected liking ratings (7-point hedonic scale) according to hunger level (7-point scale). Regression lines were drawn per sweetness level and calorie content. There were similar ratios of hungry, neither hungry nor full and full participants (N=39, N=31, N=28).

Tables

Table 1

Design of Experiment of pictures used for the AAT (picture numbers in the "Food-pics" database (Blechert et al., 2019))

	Food pictures (food picture / matching non-food picture)	
	High calorie (160-621 Kcal / 100 g)	Low calorie (16-93 Kcal / 100 g)
High sweetness	Gummi candy (#153, #1139) Ice cream (#25, #1314) Chocolate bar (#287, #1004)	Banana (#789, #1256) Grapes (#284, #1072) Watermelon (#829, #1276)
Medium sweetness	Muesli bowl (#181,#1136) Waffle (#9, #1060) Jam toast (#347,#1080)	Pear (#402,#1308) Blueberries (#202,#1137) Orange juice (#358,#1094)
Low sweetness	Cheese toast (#593,#1147) Chips (#26,#1208) Cashew nuts (#110,#1129)	Milk (#573,#1017) Carrot and cucumber (#215,#1311) Cherry tomatoes (#275,1132)

Table 2

The effect of test design factors as well as children's *age* and *gender* on the binary error and outlier variable was analysed with a mixed logistic regression with *child* as random nested in *age* x *gender*. The effect of test design factors as well as children's *age* and *gender* on the continuous reaction time variable was tested with a linear regression model with *child* as random nested in *age* x *gender*.

	Errors and/or outlier (binary yes/no) Mixed logistic regression				**Reaction time (ms)** Mixed linear regression				
	Estimate	Std. Error	z value	Pr(>|z|)	Estimate	Std. Error	df	t value	Pr(>|t|)
(Intercept)	-1.81	0.06	-30.68	**<0.001**	855.9	24.2	91.9	35.3	**<0.001**
Test part, 1 - 2	-0.31	0.02	-12.79	**<0.001**	10.6	2.9	11880	3.7	**<0.001**
Movement, pull - push	-0.06	0.02	-2.54	**0.011**	-4.6	2.9	11879	-1.6	0.110
Picture, food - non-food	-0.01	0.02	-0.60	0.546	-5.6	2.9	11879	-2.0	0.050
Age, 9 y. - 11 y.	0.05	0.06	0.82	0.415	82.1	26.9	92	3.1	**0.003**
Age, 10 y. - 11y.	-0.04	0.07	-0.55	0.582	8.4	29.4	92	0.3	0.777
Gender, boys - girls	0.09	0.06	1.52	0.129	13.4	24.2	92	0.6	0.582
Age, 9 y. - 11 y. x Gender, boys - girls	-0.03	0.06	-0.47	0.642	-10.7	26.9	92	-0.4	0.691
Age, 10 y. - 11y. x Gender, boys - girls	0.07	0.07	0.97	0.335	-37.1	29.4	912	-1.3	0.211

Table 3

Approach bias as influenced by the order of test instruction. The order of test instruction influenced approach bias of picture category (food, non-food). Children who followed the test instruction “push food and pull non-food” in the first test part, where reaction time was generally slower, ended up with larger approach biases for food and particularly a larger difference to non-food pictures than the other group.

Order of test instruction	**Measurement during test**				**Approach bias calculation**	
	Test part 1: slower RT		Test part 2: faster RT		AB Food	AB Non-food
	Food	Non-food	Food	Non-food	RT push – RT pull	RT push – RT pull
Started with “Push food and pull non-food”, N=52	RT push	RT pull	RT pull	RT push	Mean = 54.1 SD = 366.8	Mean = -39.8 SD = 395.3
Started with “Pull food and push non-food”, N=47	RT pull	RT push	RT push	RT pull	Mean = 26.5 SD = 319.5	Mean = 4.8 SD = 315.7

Table 4

The effect of picture category on the continuous Approach bias variable was analysed with a mixed regression with *child* as random factor and the interaction between *picture category* and *child*.

Group of children	**Picture category compared**	**Independent factors**	**DF**	**SS**	**MS**	**F-value**	**P-value**
Started with “Push food and pull non-food”, N=52	18 food, 18 matching non-food	Picture category	1	3775625	3775625	13.05	**<0.0001**
		Child	51	9225640	180895	0.63	0.952
		Picture category x child	51	14757510	289363	2.07	**<0.0001**
		Error	1660	232203790	139882		
Started with “Pull food and push non-food”, N=46	18 food, 18 matching non-food	Picture category	1	145606	145606	0.40	0.520
		Child	45	3758416	83520	0.24	1.000
		Picture category x child	45	15543294	345407	3.59	**<0.0001**
		Error	1470	140696645	95712		
Entire group, AB based on RT where test parts were adjusted, N=98	18 food, 18 matching non-food	Picture category	1	2567194	2567194	8.21	**0.005**
		Child	97	13028124	134311	0.43	1.000
		Picture category x child	97	30343188	312816	2.63	**<0.0001**
		Error	3130	372900436	119138		-

Table 5

The effect of DoE factors *sweetness*, *calorie* and their interaction of the food pictures was analysed with a mixed ANOVA with child as random factor and the interaction between DoE factors and child. Approach bias was the continuous response for implicit responses and expected liking for explicit responses.

Dependent variable	**Factors**	**DF**	**SS**	**MS**	**F-value**	**P-value**
Implicit: approach bias to food pictures	Sweetness	2	245238	122619	1.2	0.308
	Calorie	1	120190	120190	1.0	0.323
	Child	97	25632992	264258	2.0	**0.002**
	Sweetness x calorie	2	67771	33886	0.4	0.687
	Sweetness x child	194	20099648	103606	1.2	0.167
	Calorie x child	97	11821755	121874	1.4	**0.040**
	Sweetness x calorie x child	194	17495298	90182	0.8	0.980
	Error	1078	245238	122619		
Explicit: expected liking of food pictures	Sweetness	2	251	125	49.29	**<0.001**
	Calorie	1	111	111	22.33	**<0.001**
	Child	97	872	9	2.07	**0.002**
	Sweetness x calorie	2	85	43	13.47	**<0.001**
	Sweetness x child	194	494	3	0.8	0.937
	Calorie x child	97	481	5	1.57	**0.004**

	Sweetness x calorie x child	194	615	3	1.09	0.199
	Error	1176	3410	3	-	-

Table 6

Individual differences in explicit and implicit responses to snack pictures linked to other measurements: Demographics, health and taste questionnaire subscales, behavioural intention subscales, hunger state and chocolate milk preference. Continuous variables (health and taste subscales, behavioural intention subscales, hunger state) were tested by Pearson correlation (correlation coefficient and p-value reported), categorical variables by unpaired T-tests (chocolate milk preference, gender) and ANOVAS (age).

			High – medium & low sweetness		**High – low calorie**	
	Variables	**Frequency for categorical / mean (SD) for continuous variables**	**Implicit:** approach bias	**Explicit:** expected liking	**Implicit:** approach bias	**Explicit:** expected liking
Demographics (N=98)	Gender	Girls:47%, boys:53%	T(96) = .1 p = .922	T(96) = 1.7 p = .090	T(96) = 1.7 p = .100	T(96) = 1.0 p = .317
	Age	9: 62%, 10: 29%, 11: 9%	F(2,95) = .4 p = .642	F(2,95) = 1.8 p = .175	F(2,95)=0.1 p=0.904	F(2,95)=1.1 p=0.345
Attitude subscales (N=98)	General health interest (1-7) (α = 0.41)	4.4 (0.9)	-0.18 p = .080	0.04 p = .697	-0.05 p = .646	-0.06 p = .579
	Craving for sweet food (1-7) (α = 0.69)	4.7 (2.0)	0 .14 p = .167	0.08 p = .445	0.09 p = .390	**0.32** p = **.001**
	Using food as reward (1-7) (α = 0.64)	4.1 (1.1)	0 .01 p = .930	-0.02 p = .859	-0.06 p = .536	**0.37** p < **.001**
	Affective attitude towards sweet food (1-7) (α = 0.64)	4.4 (0.8)	0 .01 p = .911	0.02 p = .866	-0.00 p = .978	**0.41** p < **.001**
	Cognitive attitude towards sweet food (1-7) (α = 0.52)	4.3 (0.6)	0.01 p = .919	0.01 p = .919	-0.04 p = .666	**0.41** p < **.001**
State (N=98)	Hunger (1-7)	4.2 (1.7)	**-0.24** p = **.017**	0.06 p = .552	**0.25** p = **.014**	**0.26** p = **.010**

Table 7

Two sample, two-sided unpaired t-tests comparing implicit and explicit measurements with paired-preference tasks. N was reduced to 95 in this part because. Three children did not participate in the chocolate milk preference task due to disliking / lactose intolerance / milk allergy)

			Blind paired preference test (tasted samples)	**Take-home paired preference test**
			79% preferred added sugar, 21% preferred no added sugar	74% preferred added sugar, 25% preferred no added sugar
Implicit	Approach bias	High – medium & low sweetness	T(93)=1.2 p = .235	T(93) = .4 p = .671
		High – low calorie	T(93) = .6 p = .554	T(93) =- .4 p = .670
Explicit	Expected liking	High – medium & low sweetness	T(93)=1.4 p = .167	T(93) = 1.1 p = .275
		High – low calorie	T(93)=1.4 p = .161	T(93) = .5 p = .645
	Hunger state	Hunger level before AAT	T(93) = 1.2 p = .235	T(93) = -1.2 p = .224
	Health and Taste	General Health interest	T(93) = .1 p = .898	T(93) = .8 p = .433
		Craving for sweet food	T(93) = 1.8 p = .063	T(93) = 2.2 p = **.027**
		Using food as reward	T(93) = 2.2	T(93) = 2.5

		p = **.028**	p = **.015**
Attitudes towards eating sweets	Affective attitude	T(93) = 2.7 p = **.008**	T(93) = 3.5 p < **.001**
	Cognitive attitude	T(93) = 2.5 p = **.013**	T(93) = 3.0 p = **.003**

Appendix

Appendix figure 1: Food pictures and visually matching non-food pictures

Appendix, Table 1

In the health subscale three questions were simplified after a pilot test as follows (back translated from Norwegian)

Original question as in (Roininen et al., 1999)	**Simplified question**
The healthiness of food has little impact on my food choices.	It is not important for me that the food I eat is healthy.
I am very particular about the healthiness of food I eat.	It is important for me that the food I eat is good for me.
I always follow a healthy and balanced diet.	I eat healthy and varied at all times.

Appendix, Table 2

The effect of children's *individual sweetness ratings*, *calorie per 100 g* and their interaction of the food pictures was analysed with a mixed regression with *child* and the interaction *calorie per 100 g x child* as random numeric variables. Approach bias was the continuous response for implicit and expected liking for explicit ratings. In Model 3 expected liking was added to Model 1 as independent variable. In Model 4 visual picture properties were also included.

Model	**Dependent variable**	**Independent variables**	**Estimate**	**Std. Error**	**df**	**t value**	**Pr(>|t|)**
1	Approach bias to food pictures (ms)	Intercept	9.6	31.7	1157	0.3	0.764
		Sweetness (individual)	11.2	13.4	1646	0.8	0.403
		Calorie per 100 g	0.1	0.1	1637	1.1	0.290
		Sweetness (individual) * Calorie per 100 g	0.0	0.0	1647	-0.9	0.374
2	Expected liking of food pictures (1-7 scale)	Intercept	3.2	0.2	1147	20.7	**<0.001**
		Sweetness (individual)	0.8	0.1	1757	12.3	**<0.001**
		Calorie per 100 g	0.0	0.0	1723	2.9	**0.004**
		Sweetness (individual) * Calorie per 100 g	-0.0	0.0	1735	-2.1	**0.034**
3	Approach bias to food pictures (ms)	Intercept	-22.4	35.2	1308	-0.6	0.525
		Sweetness (individual)	2.8	14.0	1645	0.2	0.841

		Calorie per 100 g	0.1	0.1	1636	0.9	0.368
		Sweetness (individual) * Calorie per 100 g	0.0	0.0	1647	-0.8	0.441
		Expected liking	10.1	4.9	1643	2.1	**0.039**
4	Approach bias to food pictures (ms)	Intercept	-41.4	183.7	1532	-0.23	0.822
		Sweetness (individual)	-3.7	15.1	1627	-0.25	0.805
		Calorie per 100 g	0.0	0.1	1615	0.17	0.865
		Sweetness (individual) * Calorie per 100 g	0.0	0.0	1644	-0.25	0.803
		Expected liking	10.9	5.0	1634	2.20	**0.028**
		Red	14.1	208.4	1565	0.07	0.946
		Green	-34.5	305.4	1562	-0.11	0.910
		Size	200.9	215.3	1533	0.93	0.351
		Intensity	-1.0	1.3	1565	-0.78	0.435
		Contrast	0.7	1.1	951	0.69	0.490
		Complexity	24.7	504.5	1295	0.05	0.961
		Spatial frequency	-1.7	11.3	1180	-0.15	0.879

Figure 1

Click here to access/download;Figure;Figure 1.jpg

Workstation 1	Hunger state rating (scale)	Implicit Approach Avoidance task (AAT)	Rating of sweetness intensity and expected liking of food pictures used in AAT
Workstation 2	Paired preference test (take-home chocolate milk packs)	Demographics (age and gender), Self-reported attitudes	Paired preference test (blind tasting of chocolate milks)

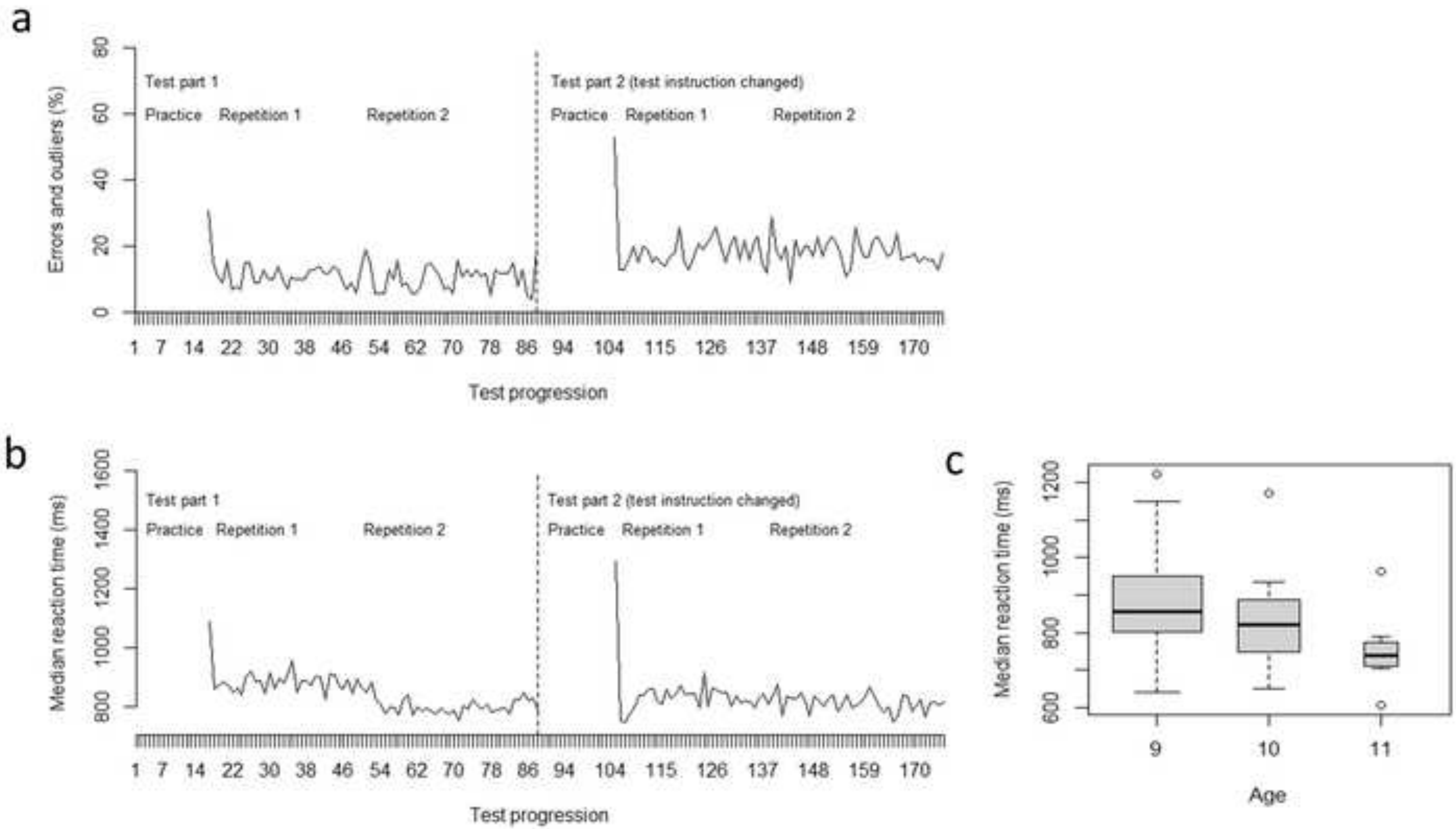
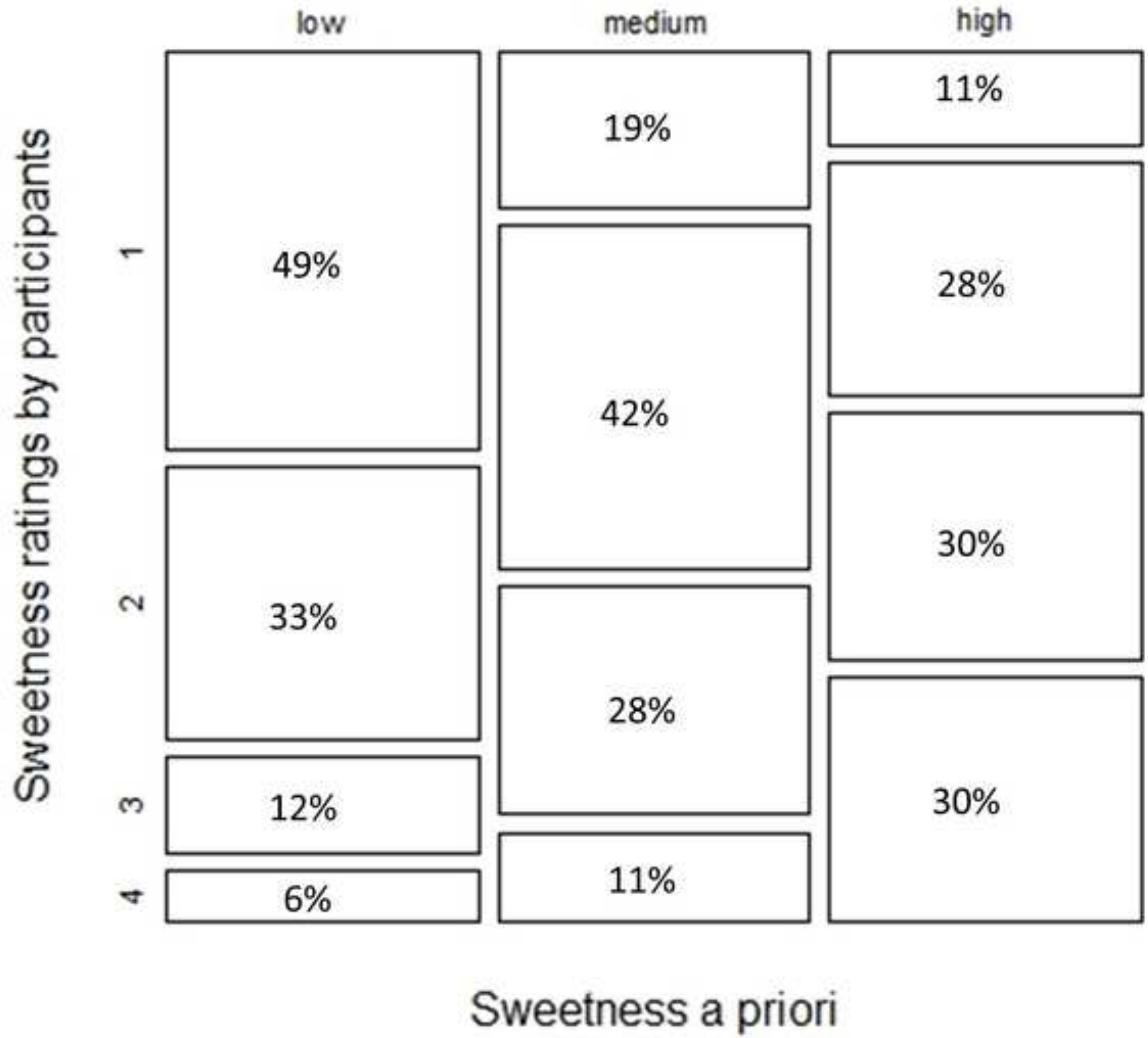

a
Errors and outliers (%)
0
20
40
60
80
Test part 1
Practice
Repetition 1
Repetition 2
Test part 2 (test instruction changed)
Practice
Repetition 1
Repetition 2
1 7 14 22 30 38 46 54 62 70 78 86 94 104 115 126 137 148 159 170
Test progression
b
Median reaction time (ms)
800
1000
1200
1400
1600
Test part 1
Practice
Repetition 1
Repetition 2
Test part 2 (test instruction changed)
Practice
Repetition 1
Repetition 2
1 7 14 22 30 38 46 54 62 70 78 86 94 104 115 126 137 148 159 170
Test progression
c
Median reaction time (ms)
600
800
1000
1200
9
10
11
Age

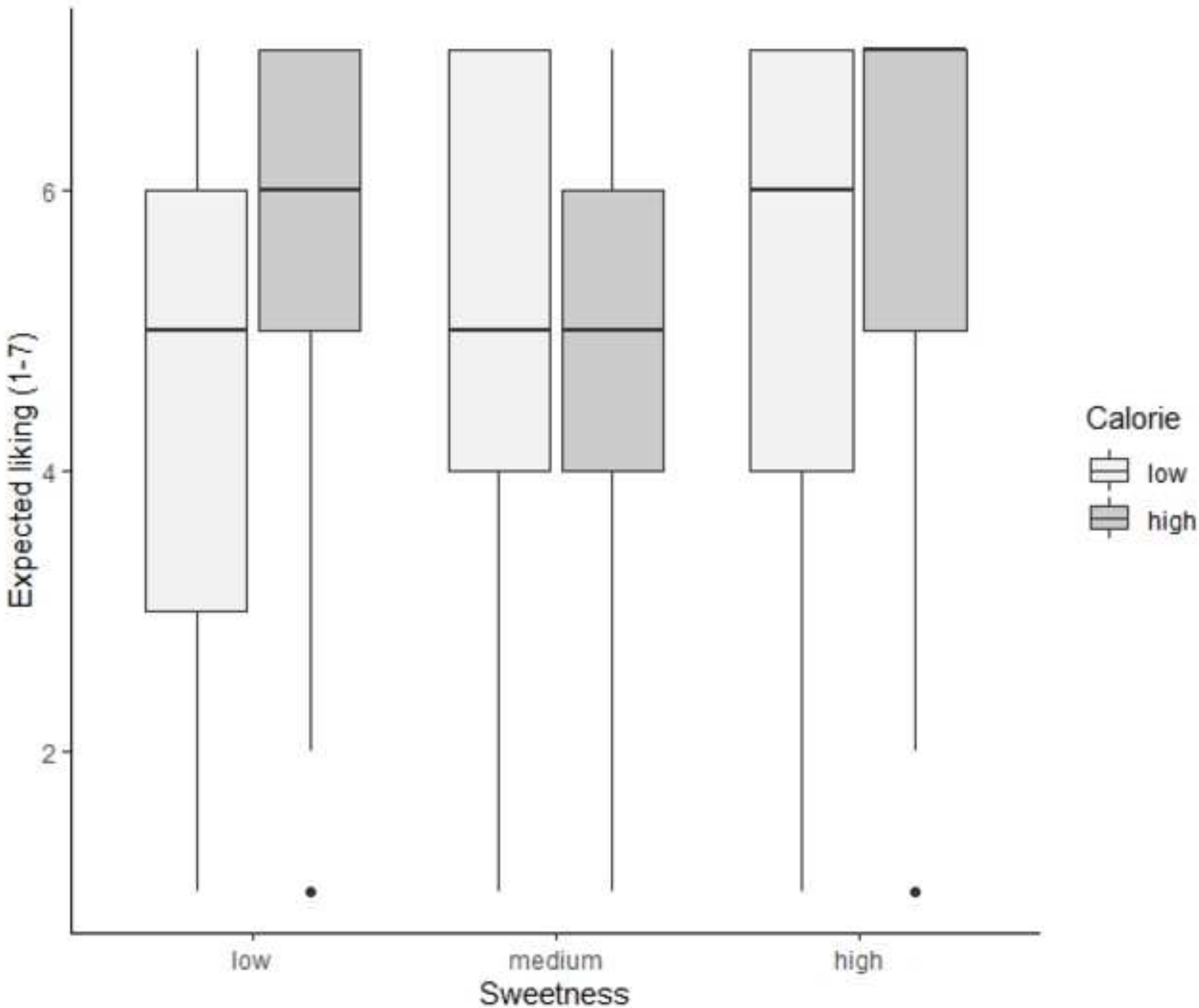
Figure 3



low
medium
high
Sweetness ratings by participants
1
2
3
4
49%
33%
12%
6%
19%
42%
28%
11%
11%
28%
30%
30%
Sweetness a priori

Figure 4

Click here to access/download;Figure;Figure 4.jpeg



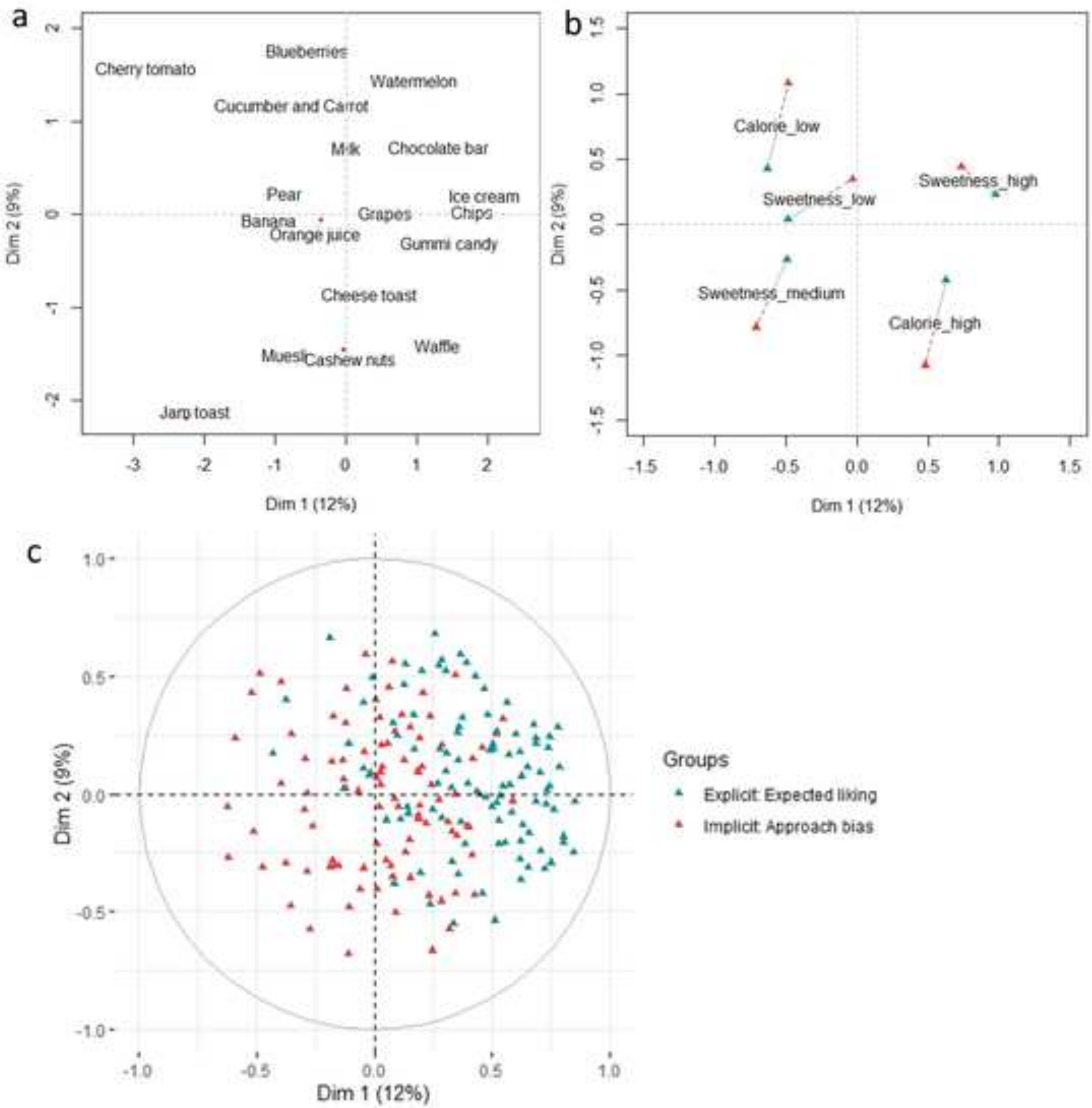
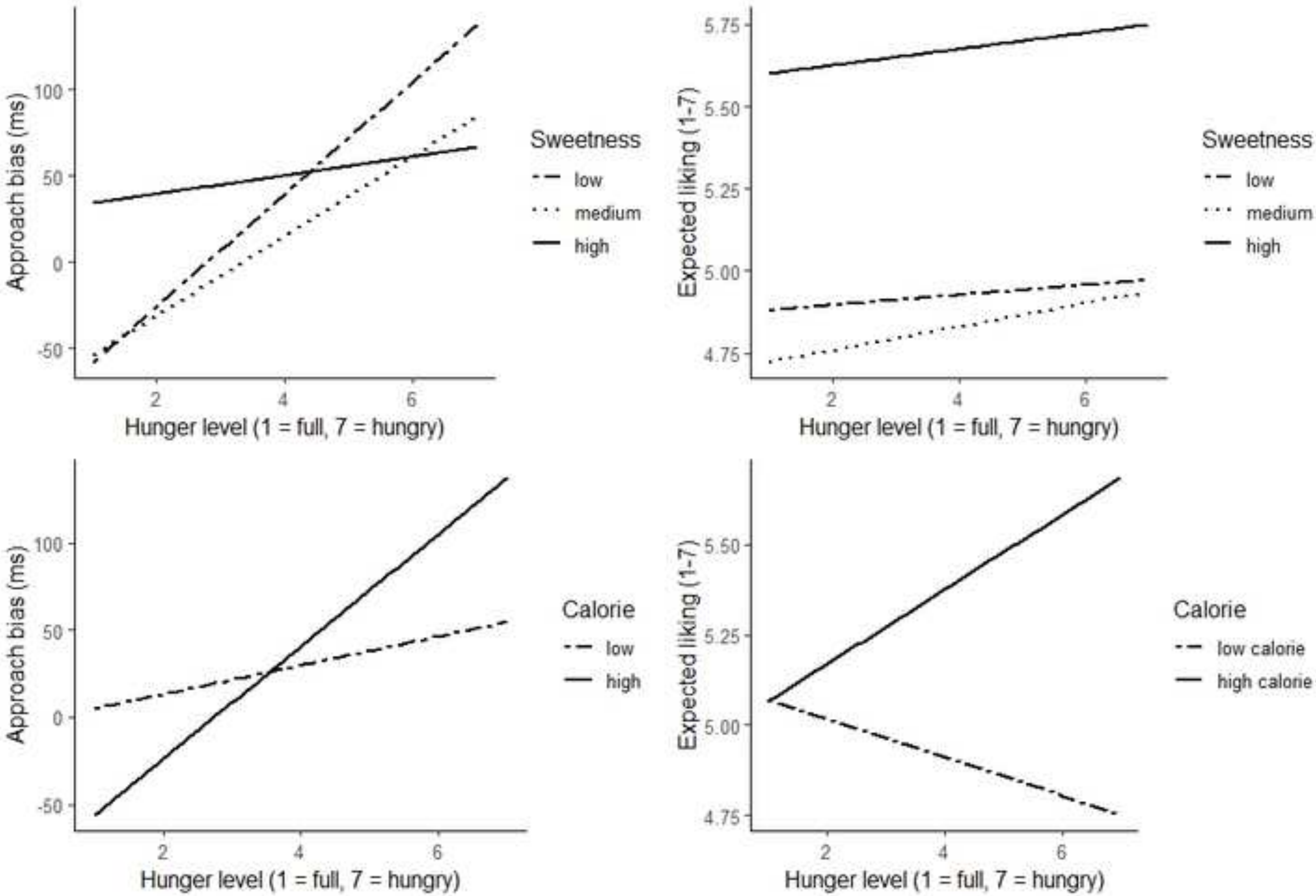

a
Cherry tomato
Blueberries
Watermelon
Cucumber and Carrot
Milk
Chocolate bar
Pear
Ice cream
Chips
Grapes
Banana
Orange juice
Gummi candy
Cheese toast
Waffle
Muesli
Cashew nuts
Jam toast
Dim 1 (12%)
Dim 2 (9%)
b
Calorie_low
Sweetness_high
Sweetness_low
Sweetness_medium
Calorie_high
Dim 1 (12%)
Dim 2 (9%)
c
Groups
Explicit: Expected liking
Implicit: Approach bias
Dim 1 (12%)
Dim 2 (9%)

Figure 6


Approach bias (ms)
100
50
0
-50
2
4
6
Hunger level (1 = full, 7 = hungry)
Sweetness
low
medium
high
Expected liking (1-7)
5.75
5.50
5.25
5.00
4.75
2
4
6
Hunger level (1 = full, 7 = hungry)
Sweetness
low
medium
high
Approach bias (ms)
100
50
0
-50
2
4
6
Hunger level (1 = full, 7 = hungry)
Calorie
low
high
Expected liking (1-7)
5.50
5.25
5.00
4.75
2
4
6
Hunger level (1 = full, 7 = hungry)
Calorie
low calorie
high calorie