


# Developing and validating a new scale to measure the acceptability of health apps among adolescents

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## Abstract

**Background:** The acceptability of health interventions is centrally important to achieving their desired health outcomes. The construct of acceptability of mobile health interventions among adolescents is neither well-defined nor consistently operationalized.

**Objectives:** Building on the theoretical framework of acceptability, these two studies developed and assessed the reliability and validity of a new scale to measure the acceptability of mobile health applications (“apps”) among adolescents.

**Methods:** We followed a structured scale development process including exploratory factor analyses (EFAs), confirmatory factor analyses (CFAs), and employed structural equation modeling (SEM) to assess the relationship between the scale and app usage. Adolescent participants used the *Fooducate* healthy eating app and completed the acceptability scale at baseline and one-week follow-up.

**Results:** EFA ( $n = 182$ ) determined that the acceptability of health apps was a multidimensional construct with six latent factors: affective attitude, burden, ethicality, intervention coherence, perceived effectiveness, and self-efficacy. CFA ( $n = 161$ ) from the second sample affirmed the six-factor structure and the unidimensional structures for each of the six subscales. However, CFA did not confirm the higher-order latent factor model suggesting that the six subscales reflect unique aspects of acceptability. SEM indicated that two of the subscales—ethicality and self-efficacy—were predictive of health app usage at one-week follow-up.

**Conclusions:** These results highlight the importance of ethicality and self-efficacy for health app acceptability. Future research testing and adapting this new acceptability scale will enhance measurement tools in the fields of mobile health and adolescent health.

## Keywords

Public health, digital health, behavior change, adolescents, apps

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## Background

Mobile technologies (e.g. smartphones and tablets) can deliver mobile health (mHealth) interventions that are affordable, easy to use, and that can be widely adopted across socioeconomic and age groups.<sup>1</sup> Advantages to mHealth interventions as compared to in-person interventions include cost-effective dissemination, real-time data

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collection and feedback, lower participant burden, and flexibility for tailoring.<sup>2</sup> Increasing evidence demonstrates that mHealth interventions are effective in changing an array of health behaviors and improving health outcomes.<sup>1–4</sup>

In 2018, ~95% of U.S. adolescents aged 13 to 17 years had consistent access to smartphones and that percentage continues to increase.<sup>5</sup> Adolescents with smartphones report being online via computer or cellphone—almost constantly (45%), or several times a day (45%).<sup>5</sup> Thus, reaching adolescents on their smartphones to target health behaviors may be an effective health promotion strategy. mHealth interventions delivered as applications on smartphones (i.e. health apps) are effective among adolescents in changing behaviors related to obesity prevention, type 2 diabetes management, and medication adherence.<sup>2,3,6</sup>

There is substantial competition in the health apps marketplace; in 2015, there were already 165,000 health and fitness apps available for download,<sup>7</sup> though limited information about app effectiveness.<sup>8</sup> To build engaging health apps, mHealth researchers and app developers must understand how and what adolescents value in these apps. Only 21% of U.S. adolescents have ever downloaded a health app on their smartphone as compared to 36% of adults.<sup>9,10</sup> Among adolescents who have downloaded a health app, 47% hardly ever or never use them, 45% sometimes use them, and only 8% use them often.<sup>9</sup> Public health interventions that are more acceptable are more likely to be adopted or used, and usage is necessary to bring about the intended outcomes of the intervention.<sup>11</sup> To deliver mHealth intervention apps that adolescents will use, the field needs tools to assess the acceptability of these apps throughout the development process. No validated measures of acceptability of health apps among adolescents (AHAA) currently exist

### Justification for scale development

Currently, many researchers rely on qualitative methods to assess the acceptability of mHealth interventions.<sup>12–17</sup> For example, researchers describe the use of semi-structured interviews and focus groups to collect qualitative data about acceptability, but often do not collect complementary quantitative data on acceptability.<sup>12–17</sup> The development of an acceptability scale that can be readily integrated into formative studies, pilot studies, and larger efficacy and effectiveness studies would strengthen researchers' ability to collect rigorous, quantitative data that can complement qualitative data to guide mHealth intervention development, save time and resources, and increase the likelihood of adoption and use in the real world.

Existing acceptability measures of mHealth and eHealth for adults have differently operationalized this construct, assessing a range of observed characteristics such as

aesthetics<sup>18,19</sup> (e.g. the way the app looks) and latent characteristics such as participants' interest in the app, credibility of the app, and the app's personal relevance.<sup>20</sup> Rigorous, standardized processes for evaluating the acceptability of mHealth interventions would increase the ability to compare across interventions, an essential component of evaluation research as the number of mHealth interventions continues to grow.<sup>21–23</sup>

### Theoretical framework of acceptability

We define the acceptability of health apps as whether intended users (in this case, adolescents) would use the health app in their everyday lives.<sup>24</sup> This definition conceptualizes acceptability as a multi-dimensional construct because many factors are likely to influence whether individuals use health apps in their everyday lives.<sup>25–27</sup> Following work by Sekhon et al.,<sup>11</sup> we consider acceptability as a necessary but not sufficient condition for the effectiveness of an intervention. Using Sekhon et al.'s<sup>11</sup> theoretical framework of acceptability (TFA) we aimed to consider seven domains of acceptability pertaining to health-related interventions: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy.<sup>11</sup> The definitions provided by the authors are described in Table 1.

**Table 1.** Theoretical framework of acceptability (TFA) domains.

Domain	Definitions
Affective attitude	How an individual feels about the intervention
Burden	The perceived amount of effort that is required to participate in the intervention
Ethicality	The extent to which the intervention has a good fit with an individual's value system
Intervention coherence	The extent to which the participant understands the intervention and how it works
Opportunity costs	The extent to which benefits, profits, or values must be given up to engage in the intervention
Perceived effectiveness	The extent to which the intervention is perceived as likely to achieve its purpose
Self-efficacy	The participant's confidence that they can perform the behavior(s) required to participate in the intervention

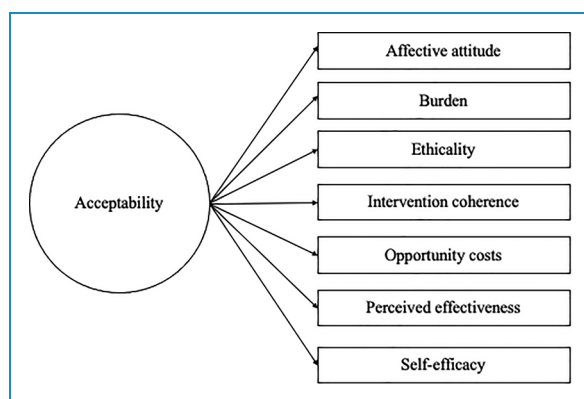
Sekhon et al.<sup>11</sup> emphasized that the acceptability of health-related interventions should be assessed at multiple time points during intervention implementation because participants' perceptions of acceptability may change over time. Sekhon et al.<sup>11</sup> also proposed that the TFA should be applied to collect quantitative data via surveys or visual analog rating scales based on the TFA domains throughout all stages of a health-related intervention's development, implementation, and evaluation cycle.

Sekhon et al.<sup>11</sup> published their TFA framework in 2017 and few researchers have applied it to mHealth research in the published literature to date.<sup>28,29</sup> A subset of the authors of this manuscript used the TFA as their foundation to qualitatively assess how adolescents define and conceptualize the acceptability of health apps (Chen et al.<sup>30</sup>). Results indicated that two additional domains (i.e. dimensions) of acceptability were important to adolescents beyond the seven from the TFA: intervention expectations and peer norms. See Figure 1 below for an updated conceptual model for acceptability. Adolescents described what they expected out of the health apps based on prior experiences with health apps and other non-health apps (intervention expectations) and whether they perceived that their peers were experiencing the same health problem covered in the health app they were using (peer norms).

## Purpose

The goal of this research was to develop a new scale to assess the AHAA. We designed two studies to build on the qualitative research from our earlier study to address the following two research questions:

1. *Research Question 1 (Studies 1 & 2):* What are the psychometric properties of a newly developed scale to measure the AHAA?
2. *Research Question 2 (Study 2):* What is the relationship between acceptability (as measured by the newly



**Figure 1.** Updated theoretical framework of acceptability (TFA) for mHealth interventions among adolescents (Chen et al.<sup>30</sup>).

developed acceptability scale) and actual health app usage (as measured by the number of minutes spent on a health app one week after downloading the app)?

We hypothesized a positive association between health app acceptability and health app usage such that the greater the acceptability score, the greater the number of minutes participants will use the health app.

Below, we present the methods and findings for Study 1 and Study 2, respectively.

## Study 1

### Overview

Using the TFA<sup>11</sup> and the findings from the previous qualitative study (Chen et al.<sup>30</sup>), we set out to create and test a new acceptability scale with adolescents in North Carolina by asking participants to try the nutrition tracker app Fooducate.<sup>31</sup> Fooducate's motto is "Eat healthy. Lose weight." and has five features: Food Finder (scans food items and shares nutritional information), Community (for posting your own updates to share with other Fooducate users), Tracker (for daily calories), Recipes, and Diet Tips. All protocols associated with this study were approved by the Institutional Review Board at The University of North Carolina at Chapel Hill (IRB Number 17-295).

### Methods

We used DeVellis' scale development process<sup>31</sup> to guide study activities in combination with Múthen and Múthen's five-step research strategy for exploratory factor analyses (EFAs) and confirmatory factor analyses (CFAs).<sup>33</sup> We also included cognitive interviews and field tests to strengthen the scale development process, as recommended by<sup>34</sup> and Willis.<sup>35</sup> We synthesized these into a 7-step scale development process (shown in Table 2) with three distinct phases: item generation, theoretical analysis, and psychometric analysis.<sup>35</sup>

Determine what latent variable we aim to measure<sup>37,38</sup>

Parts of Step 1 including "collect and analyze formative qualitative data," and "propose revised measurement model," were conducted prior to this study, and were described elsewhere (Chen et al.<sup>30</sup>). This manuscript covers Steps 2 through 7. A more detailed description of our scale development approach is contained in Table 2 which includes the scale development steps as well as the specific activities we completed for each of those steps.

### Item generation

*Generate an item pool.* After identifying the nine sub-constructs of acceptability in the previous qualitative study (Chen et al.<sup>30</sup>) (attitudes, burden, ethicality,

**Table 2.** Seven-step scale development process for studies 1 and 2.

Phase	Scale development step	Activities
Item generation	1. Determine what latent variable we aim to measure <sup>37</sup>	<ul style="list-style-type: none"> <li>• Review theoretical foundation</li> <li>• Review empirical evidence</li> <li>• Provide a justification of new instrument</li> <li>• Collect and analyze formative qualitative data (<math>n=19</math>)</li> <li>• Propose revised measurement model</li> </ul>
Item generation	2. Generate an item pool <sup>37</sup>	<ul style="list-style-type: none"> <li>• Draft items using language from formative qualitative data from the previous study</li> </ul>
Item generation	3. Determine the format for measurement <sup>37</sup>	<ul style="list-style-type: none"> <li>• Choose a tentative format for measurement</li> </ul>
Theoretical analysis	4. Have the initial item pool reviewed by experts <sup>37</sup>	<ul style="list-style-type: none"> <li>• Seek feedback from experts in adolescent health and mHealth (<math>n=12</math>)</li> <li>• Assess content validity</li> <li>• Revise, delete, add items and update formatting</li> </ul>
Theoretical analysis	5. Identify and include validation items <sup>37</sup>	<ul style="list-style-type: none"> <li>• Add items to assess construct validity (convergent validity and discriminant validity)</li> <li>• Seek feedback from target population judges (i.e. conduct cognitive testing, <math>n=6</math>, and field testing with adolescents, <math>n=10</math>)</li> </ul>
Psychometric analysis	6. Conduct EFA <sup>37,38</sup>	<ul style="list-style-type: none"> <li>• Recruit the first sample of adolescents (<math>n=182</math>) in grades 7 through 9</li> <li>• Collect data</li> <li>• Assess reliability (internal consistency and inter-item reliability)</li> <li>• Assess construct validity (analyze convergent validity and discriminant validity items and conduct EFA)</li> <li>• Revise, delete, add items</li> <li>• Formulate tentative measurement model for CFA (i.e. assign items to factors)</li> </ul>
Psychometric analysis	7. Conduct CFA <sup>38</sup>	<ul style="list-style-type: none"> <li>• Recruit the second sample of adolescents (<math>n=161</math>) in grades 7 through 9</li> <li>• Collect data</li> <li>• Assess construct validity (conduct CFA)</li> <li>• Revise CFA model</li> </ul>

CFA: confirmatory factor analysis; EFA: exploratory factor analysis;

intervention coherence, opportunity costs, perceived effectiveness, self-efficacy, intervention expectations, and peer norms), we generated a pool of 56 possible items (28 item pairs) intended to measure each sub-construct. Each item pair included a positively framed item (e.g. I like the app) and a negatively framed item (e.g. I don't like the app) for a total of 56 items and each of the nine sub-constructs had between 4 and 12 items. The initial item pool is included in Appendix 1.

*Determine the format for measurement.* We chose to measure each of these items on a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) because survey methodologists have found that offering four response options is optimal with children and adolescents as respondents.<sup>39</sup> Negative items were reverse coded after data collection and before analysis so that higher scores indicated higher levels of acceptability for all items.

### Theoretical analysis

*Have the initial item pool reviewed by experts.* To assess content validity 12 experts at the University of Chapel Hill at North Carolina reviewed the initial item pool via email in September 2018. These experts had expertise in the following areas: eHealth, mHealth, adolescent health, social work, media and journalism, survey research, scale development, program development, and program evaluation. In addition, their research interests covered a variety of health topics, including nutrition, human immunodeficiency virus prevention, smoking, cancer, and sexual health.

Based on the feedback from these experts, we revised our items and included 52 items in the updated pool. This list of items is included in a survey in Appendix 2.

*Include validation items.* We wanted to include additional items in the survey to assess the convergent and

discriminant validity of the acceptability scale.<sup>31</sup> To assess convergent validity,<sup>31</sup> we included adapted items from the system usability scale (SUS)<sup>40,41</sup> because the usability of health apps is expected to be directly correlated with the acceptability of health apps.<sup>37,38</sup> Developed in the 1990s for desktop computer systems,<sup>42</sup> the SUS has been used by mHealth researchers to collect data for health apps and other mHealth interventions.<sup>43,44</sup> The SUS consists of 10 items and includes items such as “I thought the system was easy to use” and “I found the system very cumbersome to use.”<sup>40,41</sup> Response options include 5-point Likert scale items (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). We adapted the original SUS items for use with health apps similar to other mHealth studies<sup>45,46</sup> and replaced “system” with the name of the health app adolescents were testing. For example, the adapted items included “I thought Fooducate was easy to use” and “I found Fooducate very cumbersome to use.” The adapted SUS items are included in the survey in Appendix 2.

Conversely, the proposed acceptability scale items should not correlate with items on the money attitudes scale<sup>47</sup> as there is no theoretical or empirical evidence to suggest that they would, so we included 6 items from the money attitudes scale in the survey to assess discriminant validity.<sup>31</sup> Some of the items included “I feel it is my parents’ job to pay for my everyday needs” and “I deserve to get most of the things I want.”<sup>47</sup> Response options included 4-point Likert scale items (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) and a mean money attitudes score was calculated taking the mean of all of the items.<sup>47</sup> The money attitudes items are also included in the survey in Appendix 2.

*Conduct cognitive interviews and field tests.* We conducted cognitive interviews with a sample of six adolescents at partner schools in North Carolina in October 2018 to assess their opinions and reactions to each item on the proposed acceptability scale prior to finalizing items for a pilot study to collect data for EFA. Participants seemed to understand the survey items on acceptability and money attitudes and no changes were made to these items. However, participants repeatedly asked the principal investigator to define several words and phrases in items from the SUS, including “cumbersome,” “well integrated,” “technical person,” and “unnecessarily complex.” Since these words were included in the original SUS,<sup>40</sup> we chose to keep these items for comparison purposes but noted that these items are not necessarily teen-friendly.

We also conducted field tests with 10 adolescents across three partner school sites in rural North Carolina to test the updated survey, as well as to ensure that there was acceptable Wi-Fi connectivity at each school site since these

schools would be participating in future waves of data collection.

*Psychometric analysis.* In December 2018, we recruited 182 participants across two school districts—one rural and one non-rural—in grades 7 through 9 to download and test the Fooducate app and complete the survey that included acceptability items, adapted SUS items, items from the entitlement subscale of the money attitudes scale, and basic demographic and smartphone usage items. We sent parent letters home with student grades at partner schools. The parent letters included basic information on the Fooducate food tracker app and the activity students would complete as part of the research study. Students were eligible if they returned parent consent and participant assent forms within a two-week window. We entered participants who completed the Fooducate activity and survey into a drawing for one of five \$20 VISA gift cards.

*Conduct EFA.* We conducted a round of EFAs<sup>36</sup> to help us: (1) identify how many latent constructs underlie the set of items in the instrument; (2) better understand the nature of the latent constructs that account for the variation and covariation among the items; and (3) determine which items are performing well and which are not.<sup>33</sup> We adhered to the fundamental steps and procedural recommendations for EFA put forth by Brown<sup>48</sup> and the resulting measurement model from the EFAs in Study 1 served as the hypothesized measurement model for Study 2. We conducted analyses in Mplus version 7.1<sup>48</sup> and used weighted least squares estimation (wlsmv estimator) given the categorical nature of item responses.<sup>49</sup> We used oblique rotation to allow for potential correlation among factors.<sup>50</sup> We ran a series of exploratory factor models ranging from one to 10 factors and compared model findings to determine the appropriate factor structure.

### Results for study 1

*Sample characteristics.* In January and February 2019, 182 students completed the Fooducate activity and survey (Appendix 3). Participant characteristics ( $n = 182$ ) are included in Table 3. More than half (54%,  $n = 104$ ) of the participants identified as female, almost half of the participants (47%,  $n = 86$ ) were in the ninth grade, and all participants were between the ages of 12 and 16 years. The majority of the participants identified as Black/African American (69%,  $n = 126$ ) and 17% ( $n = 31$ ) of participants identified as Hispanic or Latino. The characteristics of this sample were similar to those of the schools. The participants were recruited from two schools—one rural and one non-rural—and about half (57%,  $n = 103$ ) of the participants attended the rural school and about half (43%,  $n = 79$ ) attended the non-rural school. See Table 3 for sample characteristics.

**Table 3.** Sample characteristics for exploratory factor analysis (EFA) sample ( $n = 182$ ).

Characteristic	Category	<i>n</i>	%
Gender	Male	76	41.8
	Female	104	57.1
	Non-binary	1	0.6
	Other	1	0.6
Grade	7th grade	50	27.5
	8th grade	46	25.3
	9th grade	86	47.3
Age	12	22	12.1
	13	62	34.1
	14	58	31.9
	15	28	15.4
	16	12	6.6
Race	American Indian/Alaska Native	10	5.5
	Asian	2	1.1
	Black/African American	126	69.2
	Native Hawaiian/Other Pacific Islander	0	0.0
	White	31	17.0
	Other	33	18.1
Ethnicity	Hispanic/Latino	31	17.0
Rurality/urbanicity	Rural	103	56.6
	Non-rural	79	43.4

**Descriptive statistics.** We inspected the means, standard deviations (SDs), and observed response ranges for all scale items (Table 4). Negative items were reverse coded and these variable names had the word “reverse” added to them. For all 52 items, the range was from 1.00 to 4.00. The scale item means ranged from 1.88 to 3.54 with SDs ranging from 0.63 to 0.93.

**Internal consistency reliability.** Cronbach’s alpha for the 52-item instrument was 0.94, which is considered to be high, with magnitudes of inter-item correlations ranging from

<0.01 to 0.63. For each of the nine subscales (i.e. attitude, burden, ethicality, intervention coherence, opportunity costs, effectiveness, self-efficacy, intervention expectations, and peer norms) Cronbach’s alpha ranged from 0.40 to 0.88 (Appendix 4). Magnitudes of inter-item correlations within these subscales ranged from 0.03 to 0.66. This range of inter-item correlations indicates that some items showed effectively no inter-item correlation up to moderately high inter-item correlation, underscoring the need to drop items.

**Exploratory factor analysis (EFA).** We conducted several EFAs before and after instrument revisions. Based on our EFA results, there was evidence that our instrument likely had a nine-factor structure in alignment with the nine acceptability domains (attitude, burden, ethicality, intervention coherence, opportunity costs, effectiveness, self-efficacy, intervention expectations, and peer norms). The nine-factor model had the fewest items cross-loading on three or more factors and the majority of the significant factor loadings were over 0.40. Factor loadings and communalities for each of the 52 items are shown in Appendix 5.

**Scale revisions.** We then updated scale items to maximize reliability, to eliminate items that were not loading on the same factors as others in the same subscale, and to delete items with low communalities (<0.5).<sup>32,50</sup> We wanted to keep at least three items for each of the subscales include and in the end we retained 22-items from the original 52-item scale. Six subscales remained of the original nine with the subscales for opportunity costs, intervention expectations, and peer norms being deleted. We used an iterative modeling technique to optimize fit and interpretation and it became evident that a six-factor model would best suit the data. We named the new scale the AHAA scale and Cronbach’s alpha for the new scale was 0.91. Cronbach’s alphas for the subscales ranged from 0.74 to 0.88. See Table 5 for the 22 items along with Cronbach’s alphas and inter-item correlation ranges for each of the six included subscales.

**Scoring the acceptability scale items.** Each of the 22 items in the AHAA scale had four response options that were coded from 1.00 to 4.00. Acceptability scores were calculated by taking the mean of items responses within each of the six subscales and then totaling the six means. This approach was better than summing item responses because a summed score would artificially deflate scores with missing data and the subscales had different numbers of items. Additionally, we did not have evidence that one subscale should be weighted more than another. Therefore, possible acceptability scores ranged from 6.00 to 24.00. The mean acceptability score was 18.32 with an SD of 2.75. The minimum was 7.75 and the maximum was 24.00.

**Convergent and discriminant validity.** We predicted that the acceptability of a health app as measured by the AHAA scale would be associated with the usability of the health app as measured by an adapted version of the

**Table 4.** Means, standard deviations, and the range of responses from an exploratory factor analysis (EFA) sample.

Variable	Item	N	Mean	Standard deviation (SD)
ATT_1	I like this app	181	3.07	0.63
ATT_2reverse	I dislike this app	180	3.34	0.77
ATT_3	I enjoy using the app.	182	2.89	0.70
ATT_4reverse	I hate using the app.	182	3.42	0.69
ATT_5	This app makes me feel good.	182	2.81	0.79
ATT_6reverse	This app makes me feel bad,	181	3.36	0.67
BUR_1	This app is easy to use.	182	3.24	0.69
BUR_2reverse	This app is hard to use.	182	3.28	0.68
BUR_3	This app is confusing.	182	1.88	0.84
BUR_4	This app is simple.	182	2.97	0.80
BUR_5reverse	It takes a lot of effort for me to use this app.	182	2.85	0.88
BUR_6	It takes little effort for me to use this app.	182	2.80	0.78
ETH_1	I approve of this app.	182	3.28	0.72
ETH_2reverse	I disapprove of this app.	181	3.31	0.67
ETH_3	This app helps me do something that I agree with.	182	2.94	0.70
ETH_4reverse	This app helps me do something that I'm against	182	3.00	0.93
ETH_5	I care about healthy eating.	182	3.35	0.71
ETH_6	Eating healthy is important to me.	182	3.40	0.67
ETH_7reverse	Eating healthy is unimportant to me.	182	3.43	0.74
ETH_8	It's good to care about eating healthy.	182	3.51	0.73
ETH_9reverse	It's bad to care about eating healthy.	182	3.54	0.71
ETH_10	This app helps me do something that I care about.	182	3.09	0.72
COH_1	I understand how to use this app to track my food calories.	181	2.98	0.81
COH_1	I can show a friend how to use this app to track their food calories.	182	3.16	0.78
COH_3reverse	I need to use this app more to figure out how the app works to track my food calories.	182	2.01	0.85
COH_4	I understand how to use all of the features in this app.	182	2.63	0.84

(continued)

Table 4. Continued.

Variable	Item	N	Mean	Standard deviation (SD)
COH_5	I can show a friend how to use all of the features in this app.	182	2.88	0.89
OPP_1reverse	If I use this app, I will miss out on doing other activities.	180	3.04	0.78
OPP_2reverse	Using this app will take time away from using other apps on my phone.	182	3.04	0.82
OPP_3	This app is a good use of my time.	182	2.93	0.74
OPP_4reverse	This app is a waste of my time.	181	3.27	0.75
EFF_1	This app will help me eat healthier in the next week.	181	3.01	0.77
EFF_2	I think I will eat healthier because of this app in the next week.	181	2.79	0.85
EFF_3	This app will lead me to eat healthier.	182	3.08	0.82
EFF_4	I will eat healthier because of this app.	181	2.78	0.83
SELF_1	I'm confident that I can use this app.	182	3.08	0.75
SELF_2	I'm confident that I can use this app even if I'm not reminded about it.	182	2.70	0.83
SELF_3	I'm confident that I can use this app even if I'm really busy.	182	2.71	0.80
SELF_4	I'm confident that I can use this app to track my food calories.	182	3.10	0.69
SELF_5	I'm confident that I can use this app to track my food calories even if I'm not reminded to do it.	182	2.79	0.82
SELF_6	I'm confident that I can use this app to track my food calories even if I'm really busy.	182	2.81	0.82
SELF_7	I can fit this app into my daily routine.	182	2.89	0.77
EXP_1	This nutrition tracker app does what I think a nutrition tracker app should do.	182	3.24	0.71
EXP_2	This app does everything a nutrition tracker app should do.	181	3.17	0.70
EXP_3	This app does everything I want a nutrition tracker app to do.	182	3.04	0.72
EXP_4reverse	The app does more than a nutrition tracker app should do.	181	2.24	0.83
EXP_5reverse	This app does less than a nutrition tracker app should do.	182	3.16	0.65
EXP_6	When talking to a friend, I would describe this app as a nutrition tracker app.	182	3.13	0.73
PEER_1reverse	I'd be embarrassed if my friends saw me using this app.	181	3.38	0.75
PEER_2	I have friends who would use this app.	182	2.68	0.91
PEER_3reverse	Nobody I know would use this app.	182	3.08	0.83
PEER_4	My friends would think that it's cool I'm using this app.	181	2.51	0.82



**Table 5.** Cronbach's alphas and inter-item correlations for subscales of 22-item acceptability of health apps among adolescents (AHAA) scale.

Subscale	# items	Cronbach's alpha	Inter-item correlation min	Inter-item correlation max
Attitude	4	0.81	0.48	0.63
Burden	4	0.75	0.30	0.52
Ethicality	4	0.81	0.42	0.72
Intervention coherence	3	0.81	0.50	0.63
Effectiveness	4	0.88	0.60	0.72
Self-efficacy	3	0.79	0.51	0.60

SUS. The adapted SUS items were scored using the guidelines put forth by Sauro<sup>51</sup> and the converted scores had a possible range of 0 to 100.00. In our sample of 182, the mean SUS score for our sample was 60.96 with an SD of 10.12. The minimum was 32.50 and the maximum was 87.50. Given Sauro's guidelines,<sup>51</sup> the average SUS score among our participants was lower than the benchmark average score (68). Cronbach's alpha for the SUS items was 0.45. We ran correlations and found that acceptability, as measured by the new 22-item AHAA scale, was associated with usability ( $\rho = 0.62$ ,  $p < 0.001$ ) as predicted by theoretical and empirical literature.

We also predicted that the acceptability, as measured by the AHAA scale, would not be associated with money attitudes as measured by the money attitudes subscale to measure entitlement.<sup>47</sup> There were six items to measure money attitudes and we took the mean of the items to calculate a money attitudes score that had a possible range of 1.00 to 4.00. In our sample of 182, the mean of the money attitudes score was 2.47 with an SD of 0.62. Cronbach's alpha for the money attitudes items was 0.79. The minimum was 1.00 and the maximum was 4.00. We ran correlations and found that acceptability was not associated with money attitudes ( $\rho = -0.02$ ,  $p = 0.80$ ) as predicted.

## Study 2

### Overview

To further assess the psychometric properties of the new 22-item AHAA scale developed in Study 1 and to measure the relationship between acceptability and actual health app usage, we recruited a new sample of adolescents in grades 7 through 9 in Study 2. We asked these participants to download and test the same Fooducate app. This time, we also asked participants to use it as much or as little as they desired in the one week that followed the initial data collection so that we could also collect

Fooducate usage data from their phones to assess the relationship between acceptability and actual health app usage.

### Methods

**Recruitment.** We recruited a separate sample of adolescents in grades 7 through 9 from a rural school in Eastern North Carolina with demographic characteristics similar to the sample for EFA. All students with iPhones at the participating school were eligible. iPhones were required for this sample because we used the Screen Time feature available on all iPhones to track the number of minutes participants spent on the app after completing the Fooducate activity for the following week (7 days).

**Data collection.** These participants were asked to download the Fooducate app during their lunch or elective period, play with the app for a few minutes, and complete a survey (Appendix 6) with the AHAA scale items, the SUS items, the money attitudes scale items, and the same demographic items and iPhone usage items (e.g. How many minutes have you spent on messages today? How many minutes have you spent on messages in the past 7 days?). There was an additional question asked to collect the number of minutes participants spent on the Fooducate app prior to completing the survey. After the in-class activity, participants were asked to use the Fooducate as much or as little as they wanted in the next week. Then, we returned to the school site exactly one week later to collect data from participants' Screen Time feature to see how many minutes they spent on the Fooducate app in the previous week so that we could assess predictive validity<sup>32</sup> since we expect an association between acceptability and usage. We took pictures of each participant's Screen Time that showed their Fooducate app usage along with their assigned participant identification number. We transcribed the number of minutes participants spent on the Fooducate app in the past week then subtracted the total number of minutes they recorded in their surveys (the number of minutes

they spent on the app during the in-class activity) to obtain the number of minutes participants spent on the Fooducate app after the initial encounter.

**Conduct CFA.** CFA is a type of structural equation modeling (SEM) that assesses the relationship between observed measures or indicators (i.e. scale items) and latent variables (i.e. factors).<sup>48</sup> CFA is commonly used during the scale development process for construct validation to verify the number of underlying dimensions of the instrument (factors) and the pattern of item–factor relationships (factor loadings). CFA results also help determine how scales should be scored. CFA should also be conducted prior to the specification of a larger structural equation model that incorporates antecedents and distal outcomes of factors.

Based on the EFA results in Study 1, we had three hypotheses for Study 2 to test with CFA.

**Hypothesis 1.** Responses from the 22-item acceptability scale should fit the predicted six-factor model indicated by results from EFAs in Study 2. Each of the six factors represented a latent variable and each item was an indicator variable. See Figure 2 for this predicted measurement model.

**Hypothesis 2.** Each of the six subscales (attitude, burden, ethicality, intervention coherence, effectiveness, and self-efficacy) was unidimensional.

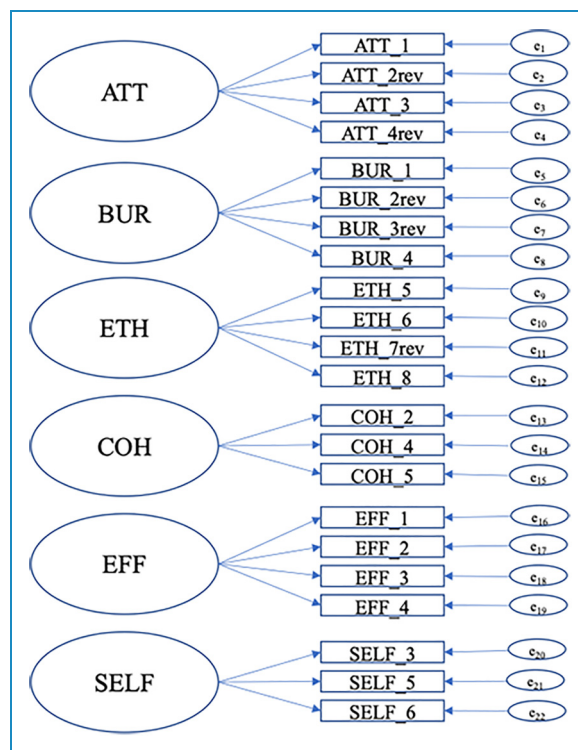
**Hypothesis 3.** Data from the 22-item acceptability scale should fit a higher-order latent factor model where the six factors (attitude, burden, ethicality, intervention coherence, effectiveness, and self-efficacy) were latent factors of the higher-order latent factor acceptability. See Figure 3 for this predicted measurement model.

We conducted CFAs in Mplus version 7.1<sup>49</sup> and used weighted least squares estimation (wlsmv estimator) given the categorical nature of item responses.<sup>48</sup>

**Assess the relationship between acceptability and actual app usage.** To assess predictive validity and the relationship between acceptability and actual app usage (Research Question 2), we then ran structural equation models in Mplus to assess whether the acceptability scale or any acceptability subscales were predictive of actual app usage one week after downloading the Fooducate app. Results from CFA informed which SEM models we ran. We chose to run these models with SEM instead of with logistic or linear regression models because the SEM analytics framework assumes that there is measurement error whereas the more traditional analytics approaches do not.

## Results

**Sample characteristics.** In March 2019, 161 students completed the Fooducate activity and survey (Appendix 6). Participant characteristics ( $n = 161$ ) are included in Table 6.



**Figure 2.** Measurement model of six factors of acceptability.

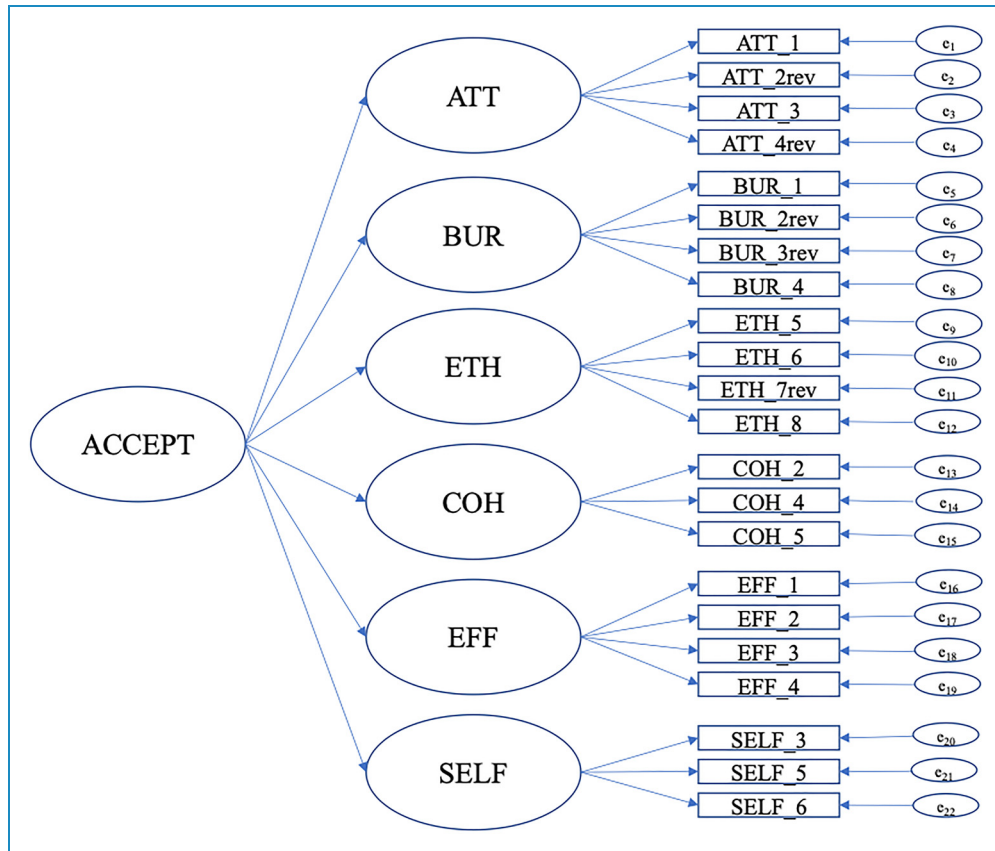
About half (52%,  $n = 84$ ) of the participants identified as male, about half of the participants (55%,  $n = 89$ ) were in the ninth grade, and all participants were between the ages of 12 and 16 years. The majority of the participants identified as Black/African American (78%,  $n = 125$ ) and only 5% ( $n = 8$ ) of participants identified as Hispanic or Latino. We recruited participants from one rural school and sample characteristics were similar to the demographics of the school population. See Table 6 for additional sample characteristics.

**Descriptive statistics.** We inspected the means, SDs, and observed response ranges for all scale items (Table 7). For the 22-item scale, the observations ranged from 1.00 to 4.00 for the majority of items. The response options ranged from 2.00 to 4.00 for ATT\_4reverse, BUR\_1, BUR\_2reverse, and ETH\_8. The scale item means ranged from 2.69 and 3.63 with SDs ranging from 0.49 to 0.83.

**Confirmatory factor analysis (CFA).** First, we ran the six-factor model (Hypothesis 1).

This model had a good fit and therefore confirmed Hypothesis 1 that there were six distinct factors present among the 22 items included in the acceptability scale.

Next, we ran each subscale as single-factor models (Hypothesis 2). We examined the fit statistics for each of the six models and the single-factor model for perceived effectiveness had an excellent fit since fit statistics met all recommended thresholds. On the other hand, the remaining



**Figure 3.** Measurement model of higher-order latent variable acceptability and first-order latent variables.

single-factor models had a good fit. Therefore, this led us to confirm Hypothesis 2 that each of the six subscales was therefore unidimensional.

We also examined the factor loadings,  $R^2$  values, and Cronbach's alphas for each of the subscales. The factor loadings for each of the items in all six subscales were statistically significant and ranged from 0.77 to 1.28.  $R^2$  for items in subscales ranged from 0.40 to 0.93. Cronbach's alpha ranged from 0.77 to 0.90 among subscales. These subscale reliabilities were comparable to those for the EFA sample above. See Table 8 for more information on factor loadings,  $R^2$  values, and Cronbach's alphas for each of the six subscales.

Third, we examined the fit statistics for the higher-order six-factor model of acceptability (Hypothesis 3) and our findings indicated poor model fit. We could not confirm Hypothesis 3 based on these findings.

Even though CFA results indicated poor model fit for the second-order model, we examined the factor loadings,  $R^2$  values, and Cronbach's alphas for the higher-order six-factor acceptability model. With all 22 items grouped in their subscale factors, the factor loadings ranged from 0.80 to 1.234.  $R^2$  values ranged from 0.30 to 0.72. Cronbach's alpha for the 22-item acceptability scale is 0.90. For more information on factor loadings,  $R^2$  values,

and Cronbach's alpha for the six-factor model of acceptability, see Appendix 7.

*Structural equation modeling (SEM).* Since the six-factor model for the second-order latent variable acceptability was not a good fit according to CFA results, we moved forward with the six subscales representing distinct variables for our analyses on actual app usage. For SEM, we hypothesized that each of the six latent variables (attitude, burden, ethicality, intervention coherence, effectiveness, and self-efficacy) as measured by their individual subscale items were predictive of the observed variable usage (see Figure 4) measured by the number of minutes reported by Screen Time on participants' iPhones.

Participants spent between 0 and 95 min on the Fooducate app in the one week after they first downloaded the app and completed the in-class survey. The mean number of minutes was 12.29, the median number of minutes was 9.00, and 17 participants did not use the app after they completed the in-class survey.

The results of our SEM indicated that two latent variables—ethicality and self-efficacy—were significant predictors of actual app usage. See Table 9 for unstandardized and standardized regression coefficients.

**Table 6.** Sample characteristics for confirmatory factor analysis (CFA) sample ( $n=161$ ).

Characteristic	Category	<i>n</i>	%
Gender	Male	84	52.17
	Female	74	45.96
	Non-binary	1	0.62
	Other	2	1.24
Grade	7th grade	30	18.63
	8th grade	42	26.09
	9th grade	89	55.28
Age	12	5	3.11
	13	22	13.66
	14	76	47.20
	15	52	32.30
	16	6	3.73
Race	American Indian/Alaska Native	14	8.70
	Asian	1	0.62
	Black/African American	125	77.64
	Native Hawaiian/Other Pacific Islander	2	1.24
	White	21	13.04
	Other	15	9.32
Ethnicity	Hispanic/Latino	8	4.97

**Discussion.** We developed and tested a 22-item scale to measure the acceptability of the Fooducate app among adolescents in grades 7 through 9 in North Carolina. This final acceptability scale had six domains, including attitude, burden, ethicality, intervention coherence, perceived effectiveness, and self-efficacy in alignment with previous acceptability research<sup>11</sup> and formative research completed by our research team with this specific adolescent population. Items that assessed three additional domains—opportunity costs, intervention expectations, and peer norms—did not appear in the final scale even though evidence from our formative research (Chen et al.<sup>31</sup>) and other studies<sup>11</sup> suggested that these would be important domains. Our 22-item scale had strong reliability among our EFA and CFA samples

with Cronbach's alphas of 0.91 and 0.90 respectively. Although the CFA results did not confirm the hypothesized higher-order factor model for the latent construct acceptability as indicated by EFA results, CFA results did confirm the six-factor model predicted from EFA results and confirmed that each of our six individual subscales (attitude, burden, ethicality, intervention coherence, perceived effectiveness, and self-efficacy) were single-factor models with good to great model fit. Of these six factors, SEM analyses showed that self-efficacy ( $\beta = 5.17$ ,  $p < 0.05$ ) and ethicality ( $\beta = 2.58$ ,  $p < 0.05$ ) were significant predictors of actual app usage in a one-week follow-up period.

Self-efficacy, operationalized as an individual's confidence in their ability to perform a specific behavior, is an important theoretical construct that is predictive of various health behaviors. Self-efficacy is included in several popular health behavior theories including the health belief model,<sup>52</sup> social cognitive theory (as human agency),<sup>53</sup> and the theory of planned behavior (as perceived behavioral control).<sup>54</sup> However, it is important to note that our scale items on self-efficacy were intended to assess participants' confidence to use the health app (e.g. to track food calories) instead of their confidence to perform the health behavior (e.g. eat healthy). We found eHealth and mHealth studies among adolescents that measured self-efficacy for health behaviors<sup>55</sup> but not self-efficacy for intervention usage or adoption. Vandelanotte et al.<sup>56</sup> emphasized the need for eHealth and mHealth researchers to explicitly measure intervention self-efficacy (e.g. confidence to use a health app) or internet self-efficacy (e.g. confidence to use the internet) in addition to self-efficacy for health behaviors. In addition, Baker et al.<sup>57</sup> suggested that since technology is quickly and constantly evolving, eHealth and mHealth researchers should consider self-efficacy as an important outcome in and of itself because it can be quickly assessed and is a precursor for intervention adoption and future behavior change. Among eHealth studies that did assess self-efficacy to use interventions among adults, though, self-efficacy did not predict usage.<sup>58,59</sup> Given our results, the self-efficacy to use the health app latent construct may be particularly salient among adolescents and should be explicitly measured in future mHealth studies.

Popular health behavior theories (e.g. health belief model and theory of planned behavior)<sup>52,54</sup> have not explicitly included the construct of ethicality (the extent to which the intervention has a good fit with an individual's value system). However, it is possible that constructs from these theories impact ethicality and how much participants value a health app. For example, perceived susceptibility and perceived severity from the health belief model<sup>52</sup> and normative beliefs and subjective norms from the theory of planned behavior<sup>54</sup> are constructs from these theories that may relate to ethicality. Similarly, there is evidence that

**Table 7.** Descriptive statistics for confirmatory factory analysis (CFA) sample.

Latent variable	Items variable	Item	n	Mean	Standard deviation	Min	Max
ATT	ATT_1	I like this app	161	3.16	0.49	1.00	4.00
	ATT_2reverse	I dislike this app	160	3.52	0.59	1.00	4.00
	ATT_3	I enjoy using the app.	161	3.04	0.62	1.00	4.00
	ATT_4reverse	I hate using the app.	161	3.56	0.55	2.00	4.00
BUR	BUR_1	This app is easy to use.	161	3.35	0.64	2.00	4.00
	BUR_2reverse	This app is hard to use.	161	3.40	0.64	2.00	4.00
	BUR_3reverse	This app is confusing.	161	3.24	0.78	1.00	4.00
	BUR_4	This app is simple.	161	3.09	0.78	1.00	4.00
ETH	ETH_5	I care about healthy eating.	161	3.21	0.72	1.00	4.00
	ETH_6	Eating healthy is important to me.	161	3.25	0.73	1.00	4.00
	ETH_7reverse	Eating healthy is unimportant to me.	161	3.46	0.77	1.00	4.00
	ETH_8	It's good to care about eating healthy.	161	3.63	0.51	2.00	4.00
COH	COH_2	I can show a friend how to use this app to track their food calories.	161	3.14	0.78	1.00	4.00
	COH_4	I understand how to use all of the features in this app.	161	2.73	0.83	1.00	4.00
	COH_5	I can show a friend how to use all of the features in this app.	161	2.82	0.82	1.00	4.00
EFF	EFF_1	This app will help me eat healthier in the next week.	159	2.84	0.75	1.00	4.00
	EFF_2	I think I will eat healthier because of this app in the next week.	160	2.74	0.76	1.00	4.00
	EFF_3	This app will lead me to eat healthier.	161	2.93	0.83	1.00	4.00
	EFF_4	I will eat healthier because of this app.	161	2.73	0.74	1.00	4.00
SELF	SELF_3	I'm confident that I can use this app even if I'm really busy.	161	2.69	0.79	1.00	4.00
	SELF_5	I'm confident that I can use this app to track my food calories even if I'm not reminded to do it.	161	2.73	0.83	1.00	4.00
	SELF_6	I'm confident that I can use this app to track my food calories even if I'm really busy.	161	2.78	0.82	1.00	4.00

motivation to achieve a health outcome (e.g. to quit smoking) is predictive of mHealth intervention usage among adults.<sup>60,61</sup> In exploring the relationship between ethicality and acceptability in the context of health apps it may also be useful to consider frames of reference that have intrinsic values-focused components, such as

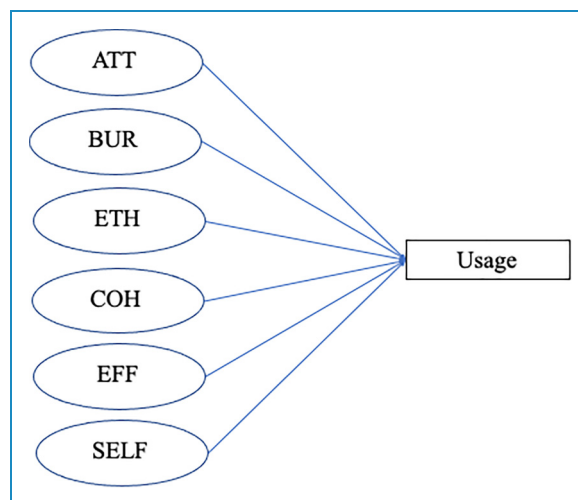
acceptance and commitment therapy-informed interventions<sup>62</sup> and intervention approaches proposed by self-determination theory.<sup>63</sup>

Lastly, it is important for us to consider when to administer this scale in future research. We recommend that the acceptability scale be administered to adolescents during

**Table 8.** Factor loadings,  $R^2$  values, and Cronbach's alphas for six subscales.

Latent variable	Items	Factor loading	$R^2$	Cronbach's alpha
ATT	ATT_1	1.00	0.71	0.77
	ATT_2reverse	0.86	0.53	
	ATT_3	0.91	0.59	
	ATT_4reverse	1.05	0.78	
BUR	BUR_1	1.00	0.62	0.82
	BUR_2reverse	1.20	0.89	
	BUR_3reverse	1.08	0.73	
	BUR_4	0.85	0.45	
ETH	ETH_5	1.00	0.91	0.84
	ETH_6	1.02	0.93	
	ETH_7reverse	0.77	0.53	
	ETH_8	0.79	0.56	
COH	COH_2	1.00	0.60	0.80
	COH_4	0.96	0.55	
	COH_5	1.21	0.88	
EFF	EFF_1	1.00	0.61	0.90
	EFF_2	1.18	0.85	
	EFF_3	1.13	0.79	
	EFF_4	1.24	0.95	
SELF	SELF_3	1.00	0.72	0.82
	SELF_5	0.83	0.49	
	SELF_6	1.11	0.88	

the app development phase so that adjustments can be made to improve acceptability. Moving forward we recommend assessing acceptability at multiple time points during the evaluation of health apps so that we can determine whether acceptability changes over time. By measuring the acceptability of health apps with the same instrument at multiple time points, we will also be able to consider acceptability as a predictor variable, a mediating variable,



**Figure 4.** Hypothesized structural equation model for latent variables attitudes, burden, ethicality, intervention coherence, effectiveness, and self-efficacy on the observed Variable App usage.

**Table 9.** Latent variable predictors and regression coefficients from structural equation modeling predicting usage.

Latent variable predictor	Unstandardized regression coefficient	Standardized regression coefficient
ATT	-1.39	-0.09
BUR	2.40	0.14
ETH	2.58*	0.18*
COH	1.07	0.06
EFF	-1.30	-0.08
SELF	5.17*	0.32*

\*Denotes regression coefficients with  $p$ -values  $<0.05$ .

or an outcome variable, depending on the research question of future studies.

**Strengths.** This research offered a conceptual definition of AHAA, operationalized the domains of acceptability, and presented initial validation results. These two studies adhered to a structured scale development process. The results also provided evidence that ethicality and self-efficacy are two predictors of actual app usage among adolescents which is helpful for researchers as they design health apps for this population.

In addition, the reliability of the items in the AHAA scale (Cronbach's alpha = 0.91) is greater than the reliability of the items from the current gold standard, the SUS:

Cronbach's alpha for SUS items was only 0.45 among the EFA sample and 0.60 among the CFA sample. Therefore this new AHAA scale may be more appropriate for adolescents than the SUS and can be used early and often and used in conjunction with other instruments such as the Mobile App Rating Scale to create apps that better meet the needs of their intended users.<sup>64</sup>

*Limitations and future research.* While these studies had many strengths, there were also limitations. First, we

were surprised that items from several acceptability domains (opportunity costs, intervention expectations, and peer norms) did not load well on factors in the EFA and were subsequently deleted from the proposed scale prior to data collection for EFA. It is possible that the items we drafted and included in earlier waves of data collection did not accurately measure the proposed latent constructs. Moving forward, we should conduct additional formative research with adolescents so the target population can write items to measure these three constructs.

**Table 10.** Acceptability of health apps among adolescents (AHAA) scale items.

Variable	Item
ATT_1	I like this app.
ATT_2reverse	I dislike this app.
ATT_3	I enjoy using the app.
ATT_4reverse	I hate using the app.
BUR_1	This app is easy to use.
BUR_2reverse	This app is hard to use.
BUR_3reverse	This app is confusing.
BUR_4	This app is simple.
ETH_5	I care about [health topic].
ETH_6	[Health topic] is important to me.
ETH_7reverse	[Health topic] is unimportant to me.
ETH_8	It's good to care about [health topic].
COH_2	I can show a friend how to use this app to [health behavior].
COH_4	I understand how to use all of the features in this app.
COH_5	I can show a friend how to use all of the features in this app.
EFF_1	This app will help me [health behavior] in the next week.
EFF_2	I think I will [health behavior] because of this app in the next week.
EFF_3	This app will lead me to [health behavior/health outcome].
EFF_4	I will [health behavior/health outcome] because of this app.
SELF_3	I'm confident that I can use this app even if I'm really busy.
SELF_5	I'm confident that I can use this app to [health behavior] even if I'm not reminded to do it.
SELF_6	I'm confident that I can use this app to [health behavior] even if I'm really busy.

We also noted differences between our EFA sample and our CFA sample. The largest difference was in rurality: 57% of participants in the EFA sample were recruited from rural schools whereas all (100%) participants in the CFA sample went to one rural school. There were differences with regard to race/ethnicity as well. Ideally, we would have recruited a sample for CFA with participant characteristics that were more similar to our EFA sample than our CFA sample. It is possible that the higher-order six-factor model would have been confirmed for a CFA sample more similar to the EFA sample. It is also possible that our sample size was not large enough to run CFA and SEM to test the higher-order model hypothesis given the number of parameters included in our final measurement models.<sup>65</sup>

Moving forward, we also need additional testing of our 22-item AHAA scale (Table 10) that can be applied to other health apps for different health topics.

These studies were the first of their kind to develop an acceptability scale specific to mHealth apps and were also unique because of their focus on adolescents. We encourage other researchers to use the full AHAA scale so that we can continue testing the scale to see if ethicality and self-efficacy continue to be consistent predictors of actual usage as we vary the health topics and the adolescent populations.

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**Ethical approval:** The ethics committee of The University of North Carolina at Chapel Hill approved this study (IRB Number 17-295).

**Guarantor:** EC

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## Appendix 1: Initial item pool

### Overview

After conducting 19 pairs of semi-structured interviews with seventh-, eighth-, and ninth-grade students in the spring and summer of 2018 and reviewing the peer-reviewed literature on acceptability, I have put together this draft scale to measure the acceptability of mHealth apps among teens. I propose that there are eight sub-constructs of acceptability. Seven of these sub-constructs (i.e. affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy) and their listed definitions are from the Sekhon et al.<sup>11</sup> paper on health interventions. I have adapted the definitions so that they refer to an app instead of an intervention. The eighth sub-construct, app expectations, was added as a result of the qualitative interviews with teen participants. The items were drafted using participants' language from the interviews. The table below includes component constructs, their definitions, and the draft items for each sub-construct in both the affirmative and the negative (e.g. "I like the app" is the affirmative version and "I don't like the app" is the negative version). The scale is intended to be administered after teens have spent 2 to 3 min with a new mHealth app. This could be during the app development phase or part of a feasibility or outcome evaluation study.

The person administering the scale would substitute the relevant health topic, health behavior(s), and intended app behavior(s) for that specific mHealth app into the scale items. For example, for the Fooducate app, the health topic is healthy eating, the health behavior could be eating healthier, and the desired app behavior could be tracking food calories. Examples are included in the chart below.

Subconstructs	Definitions	Draft items
Affective attitude	How an individual feels about the app	<ul style="list-style-type: none"> <li>I like the app/I don't like the app</li> <li>I enjoy using the app/I don't enjoy using the app</li> <li>The app makes me feel good/The app makes me feel bad</li> </ul>
Burden	The perceived amount of effort that is required to participate in the app	<ul style="list-style-type: none"> <li>The app is easy to use/The app is hard to use</li> <li>The app is confusing/The app is simple</li> <li>It takes a lot of effort for me to use the app/It takes little effort for me to use the app</li> </ul>
Ethicality	The extent to which the app has a good fit with an individual's value system (i.e. what they should and should not do)	<ul style="list-style-type: none"> <li>I should care about [insert health topic] right now/I shouldn't care about [insert health topic] right now <ul style="list-style-type: none"> <li>For example, I should care about healthy eating right now/I shouldn't care about healthy eating right now</li> </ul> </li> <li>I should use the app/I shouldn't use the app.</li> <li>It's good to care about [insert health topic]/It's bad to care about [insert health topic] <ul style="list-style-type: none"> <li>For example, it's good to care about healthy eating/it's bad to care about healthy eating.</li> </ul> </li> <li>I should [insert health behavior]/I should not [insert health behavior] <ul style="list-style-type: none"> <li>For example, I should eat healthier/I should not eat healthier</li> </ul> </li> <li>I care about [insert health topic]/I don't care about [insert health topic] <ul style="list-style-type: none"> <li>For example, I care about healthy eating/I don't care about healthy eating</li> </ul> </li> <li>The app helps me do something that I care about/The app does not help me do something that I care about.</li> </ul>
Intervention coherence	The extent to which the participant understands the app and how it works	<ul style="list-style-type: none"> <li>I know how to use the app to [insert desired app behavior]/I don't know how to use the app to [insert desired app behavior] <ul style="list-style-type: none"> <li>For example, I know how to use the app to track food calories/I don't know how to use the app to track food calories</li> </ul> </li> <li>I can explain to a friend how the whole app works/I can't explain to a friend how the whole app works</li> <li>I need more time to figure out how the app works to [insert desired app behavior]/I don't need more time to figure out how the app works to [insert desired app behavior] <ul style="list-style-type: none"> <li>For example, I need more time to figure out how the app works to track food calories/I don't need more time to figure out how the app works to track food calories.</li> </ul> </li> <li>I figured out how to use all the app's features/I haven't figured out how to use all the app's features</li> </ul>
Opportunity costs	The extent to which benefits or profits must be given up to engage in the app	<ul style="list-style-type: none"> <li>If I use the app, I will miss out on doing something else/If I use the app, I will not miss out on doing something else</li> <li>Using the app will take time away from using other apps on my phone/using the app will not take time away from using other apps on my phone</li> <li>If I use the app, I won't be able to spend time doing other things/If I use the app, I will be able to spend time doing other things</li> </ul>
Perceived effectiveness	The extent to which the app is perceived as likely to achieve its purpose	<ul style="list-style-type: none"> <li>The app will help me [insert health behavior] in the next week/The app won't help me [insert health behavior] in the next week <ul style="list-style-type: none"> <li>For example, the app will help me eat healthier in the next week/the app won't help me eat healthier in the next week</li> </ul> </li> </ul>

(continued)

Continued.

Subconstructs	Definitions	Draft items
		<ul style="list-style-type: none"> <li>• I will [insert health behavior] because of this app in the next week/I won't [insert health behavior] because of this app in the next week</li> <li>• For example, I will eat healthier because of this app in the next week/I won't eat healthier because of this app in the next week</li> </ul>
Self-efficacy	The participant's confidence that they can perform the behavior(s) required to participate in the app	<ul style="list-style-type: none"> <li>• I'm confident that I can use the app to [insert desired app behavior]/ I'm not confident that I can use the app to [insert desired app behavior].</li> <li>• For example, I'm confident that I can use the app to track food calories in the next week/ I'm not confident that I can use the app to track food calories in the next week</li> <li>• I'm confident I can use the app in the next week/I'm not confident that I can use the app in the next week.</li> <li>• I can fit this app into my daily routine/I can't fit this app into my daily routine.</li> </ul>
Intervention expectations	The extent to which the intervention aligns with the participant's archetype of the app	<ul style="list-style-type: none"> <li>• This [insert health topic] app does what I think a [insert health topic] app should do/ This [insert health topic] app doesn't do what I think a [insert health topic] app should do</li> <li>• For example, this healthy eating app does what I think a healthy eating app should do/This healthy eating app doesn't do what I think a healthy eating app should do</li> <li>• This app does everything a [insert health topic] app should do/This app doesn't do everything a [insert health topic] app should do</li> <li>• For example, this app does everything a healthy eating app should do/This all doesn't do everything a healthy eating app should do</li> <li>• This app does everything I want a [insert health topic] app to do/This app doesn't do everything I want a [insert health topic] app to do</li> <li>• For example, this app does everything I want a healthy eating app to do/This app doesn't do everything I want a healthy eating app to do</li> <li>• When talking to a friend, I would describe this app as a [insert health topic] app/When talking to a friend, I wouldn't describe this app as a [insert health topic] app</li> <li>• For example, when talking to a friend, I would describe this app as a healthy eating app/When talking to a friend, I wouldn't describe this app as a healthy eating app</li> </ul>

## Appendix 2: Survey for cognitive interviews and pilot testing

*Directions:* Download the Fooducate app and use it for a few minutes before completing the questionnaire. How much do you agree or disagree with the following statements? Circle one response per row.

### Money attitudes scale

*Directions:* How much do you agree or disagree with the following statements? Circle one response per row.

### System usability scale

*Directions:* Reach each statement and circle the number that represents how much you agree or disagree with that statement.

## Appendix 3: Study 1 survey

### Fooducate survey

*Directions:* How much do you agree or disagree with the following statements? Circle one response per row.

## Usability

*Directions:* Reach each statement and circle the number that represents how much you agree or disagree with that statement.

		Strongly disagree	Disagree	Agree	Strongly agree
1	I like this app.	1	2	3	4
2	This app is easy to use.	1	2	3	4
3	I approve of this app.	1	2	3	4
4	I understand how to use this app to track my food calories.	1	2	3	4
5	If I use this app, I will miss out on doing other activities.	1	2	3	4
6	This app will help me <u>eat healthier</u> in the next week.	1	2	3	4
7	I'm confident that I can use this app.	1	2	3	4
8	This <i>nutrition tracker</i> app does what I think a <i>nutrition tracker</i> app <b>should</b> do.	1	2	3	4
9	I'd be embarrassed if my friends saw me using this app.	1	2	3	4
10	I dislike this app.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
11	This app is hard to use.	1	2	3	4
12	I disapprove of this app.	1	2	3	4
13	I can show a friend how to use this app to <i>track their food calories</i> .	1	2	3	4
14	Using this app will take time away from using other apps on my phone.	1	2	3	4
15	I think I will <i>eat healthier</i> because of this app in the next week.	1	2	3	4
16	I'm confident that I can use this app even if I'm not reminded about it.	1	2	3	4
17	This app does everything a <i>nutrition tracker</i> app <b>should</b> do.	1	2	3	4
18	I have friends who would use this app.	1	2	3	4
19	I enjoy using this app.	1	2	3	4
20	This app is confusing.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
21	This app helps me do something that I agree with.	1	2	3	4
22	I need to use this app more to figure out how the app works to <i>track my food calories</i> .	1	2	3	4
23	This app is a good use of my time.	1	2	3	4
24	This app will lead me to <i>eat healthier</i> .	1	2	3	4
25	I'm confident that I can use this app even if I'm really busy.	1	2	3	4
26	This app does everything I <b>want</b> a <i>nutrition tracker</i> app to do.	1	2	3	4
27	Nobody I know would use this app.	1	2	3	4
28	I hate using this app.	1	2	3	4
29	This app is simple.	1	2	3	4
30	This app helps me do something that I'm against	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
31	I understand how to use all of the features in this app.	1	2	3	4
32	This app is a waste of my time.	1	2	3	4
33	I will <i>eat healthier</i> because of this app.	1	2	3	4
34	I'm confident that I can use this app to <i>track my food calories</i> .	1	2	3	4
35	This app does <b>more than</b> a <i>nutrition tracker</i> app should do.	1	2	3	4
36	My friends would think that it's cool I'm using this app.	1	2	3	4
37	This app makes me feel good.	1	2	3	4
38	It takes a lot of effort for me to use this app.	1	2	3	4
39	I care about <i>eating healthy</i> .	1	2	3	4
40	I can show a friend how to use all of the features in this app.	1	2	3	4

### Money attitudes

Directions: How much do you agree or disagree with the following statements? Circle one response per row.

### Demographic information

Directions: Answer the questions below.

69. What is your name? \_\_\_\_\_

70. What is your email address? \_\_\_\_\_

71. What school do you attend? \_\_\_\_\_

\_\_\_\_\_

		Strongly disagree	Disagree	Agree	Strongly agree
41	I'm confident that I can use this app to <i>track my food calories</i> even if I'm not reminded to do it.	1	2	3	4
42	This app does <b>less than</b> a <i>nutrition tracker</i> app should do.	1	2	3	4
43	This app makes me feel bad.	1	2	3	4
44	It takes little effort for me to use this app.	1	2	3	4
45	<i>Eating healthy</i> is important to me.	1	2	3	4
46	I'm confident that I can use this app to <i>track my food calories</i> even if I'm really busy.	1	2	3	4
47	When talking to a friend, I would describe this app as a <i>nutrition tracker</i> app.	1	2	3	4
48	<i>Eating healthy</i> is unimportant to me.	1	2	3	4
49	I can fit this app into my daily routine.	1	2	3	4
50	It's good to care about <i>eating healthy</i> .	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
51	It's bad to care about <i>eating healthy</i> .	1	2	3	4
52	This app helps me do something that I care about.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
53	I feel it is my parents' job to pay for my everyday needs.	1	2	3	4
54	My parents should provide me with spending money.	1	2	3	4
55	I feel my parents should pay for the "extras."	1	2	3	4
56	I feel my parents should pay for my college education.	1	2	3	4
57	I deserve to get most of the things I want.	1	2	3	4
58	I feel my parents should help me get the things I want.	1	2	3	4

*Directions:* For each of the questions below, circle your answer(s).

72. How old are you?

- a) 11
- b) 12
- c) 13
- d) 14
- e) 15
- f) 16
- g) 17
- h) 18 or older

73. What grade are you in?

- a) 7th
- b) 8th
- c) 9th

74. What gender do you identify with?

- a) Male

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
59 I think that I would like to use Fooducate frequently.	1	2	3	4	5
60 I found Fooducate unnecessarily complex.	1	2	3	4	5
61 I thought Fooducate was easy to use.	1	2	3	4	5
62 I think that I would need the support of a technical person to be able to use Fooducate.	1	2	3	4	5
63 I found the various functions in Fooducate were well integrated.	1	2	3	4	5
64 I thought there was too much inconsistency in Fooducate.	1	2	3	4	5
65 I would imagine that most people would learn to use Fooducate very quickly.	1	2	3	4	5
66 I found Fooducate very cumbersome to use.	1	2	3	4	5
67 I felt very confident using Fooducate.	1	2	3	4	5
68 I needed to learn a lot of things before I could get going with Fooducate.	1	2	3	4	5

Step 1 Take out your iPhone or Android phone and connect to the *Guest* network (no password required).

Step 2 Download the app *Fooducate* to your phone.

Step 3 Create a Fooducate account.

Step 4 Log into the app so that you can get to this colorful menu screen.

~~Step 5 Play with the app for 2 to 3 min. Try out as many features as you can before moving on to the questionnaire on the next page.~~



- b) Female  
 c) Non-binary/non-conforming  
 d) Other (fill-in-the-blank): \_\_\_\_\_
75. What is your race? Circle all that apply.
- a) American Indian or Alaska Native  
 b) Asian  
 c) Black or African American

		Strongly disagree	Disagree	Agree	Strongly agree
1	I like this app.	1	2	3	4
2	This app is easy to use.	1	2	3	4
3	I approve of this app.	1	2	3	4
4	I understand how to use this app to <i>track my food calories</i> .	1	2	3	4
5	If I use this app, I will miss out on doing other activities.	1	2	3	4
6	This app will help me <i>eat healthier</i> in the next week.	1	2	3	4
7	I'm confident that I can use this app.	1	2	3	4
8	This <i>nutrition tracker</i> app does what I think a <i>nutrition tracker</i> app should do.	1	2	3	4
9	I'd be embarrassed if my friends saw me using this app.	1	2	3	4
10	I dislike this app.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
11	This app is hard to use.	1	2	3	4
12	I disapprove of this app.	1	2	3	4
13	I can show a friend how to use this app to <i>track their food calories</i> .	1	2	3	4
14	Using this app will take time away from using other apps on my phone.	1	2	3	4
15	I think I will <i>eat healthier</i> because of this app in the next week.	1	2	3	4
16	I'm confident that I can use this app even if I'm not reminded about it.	1	2	3	4
17	This app does everything a <i>nutrition tracker</i> app should do.	1	2	3	4
18	I have friends who would use this app.	1	2	3	4
19	I enjoy using this app.	1	2	3	4
20	This app is confusing.	1	2	3	4

- d) Native Hawaiian or Other Pacific Islander  
 e) White  
 f) Other (fill-in-the-blank): \_\_\_\_\_  
 76. Do you consider yourself Hispanic or Latino?  
 a) Yes

- b) No  
 77. What kind of phone do you have?  
 a) iPhone – if you have an iPhone, continue with question 78 on the next page (page 10).

		Strongly disagree	Disagree	Agree	Strongly agree
21	This app helps me do something that I agree with.	1	2	3	4
22	I need to use this app more to figure out how the app works to <i>track my food calories</i> .	1	2	3	4
23	This app is a good use of my time.	1	2	3	4
24	This app will lead me to <i>eat healthier</i> .	1	2	3	4
25	I'm confident that I can use this app even if I'm really busy.	1	2	3	4
26	This app does everything I want a <i>nutrition tracker</i> app to do.	1	2	3	4
27	Nobody I know would use this app.	1	2	3	4
28	I hate using this app.	1	2	3	4
29	This app is simple.	1	2	3	4
30	This app helps me do something that I'm against	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
31	I understand how to use all of the features in this app.	1	2	3	4
32	This app is a waste of my time.	1	2	3	4
33	I will <i>eat healthier</i> because of this app.	1	2	3	4
34	I'm confident that I can use this app to <i>track my food calories</i> .	1	2	3	4
35	This app does <b>more than</b> a <i>nutrition tracker</i> app should do.	1	2	3	4
36	My friends would think that it's cool I'm using this app.	1	2	3	4
37	This app makes me feel good.	1	2	3	4
38	It takes a lot of effort for me to use this app.	1	2	3	4
39	I care about <i>eating healthy</i> .	1	2	3	4
40	I can show a friend how to use all of the features in this app.	1	2	3	4

b) Android – if you have an Android, you are done with this questionnaire. Please turn it in!

*Directions:* For iPhone users, click on *Settings > Screen Time*. Once there, select your iPhone. Answer the following questions below.

	Strongly disagree	Disagree	Agree	Strongly agree
41 I'm confident that I can use this app to <i>track my food calories</i> even if I'm not reminded to do it.	1	2	3	4
42 This app does <b>less than</b> a <i>nutrition tracker</i> app should do.	1	2	3	4
43 This app makes me feel bad.	1	2	3	4
44 It takes little effort for me to use this app.	1	2	3	4
45 <i>Eating healthy</i> is important to me.	1	2	3	4
46 I'm confident that I can use this app to <i>track my food calories</i> even if I'm really busy.	1	2	3	4
47 When talking to a friend, I would describe this app as a <i>nutrition tracker</i> app.	1	2	3	4
48 <i>Eating healthy</i> is not important to me.	1	2	3	4
49 I can fit this app into my daily routine.	1	2	3	4
50 It's good to care about <i>eating healthy</i> .	1	2	3	4
51 It's bad to care about <i>eating healthy</i> .	1	2	3	4
52 This app helps me do something that I care about.	1	2	3	4

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
53 I think that I would like to use Fooducate.	1	2	3	4	5
54 I found Fooducate unnecessarily complex.	1	2	3	4	5
55 I thought Fooducate was easy to use.	1	2	3	4	5
56 I think that I would need the support of a technical person to be able to use Fooducate.	1	2	3	4	5
57 I found the various functions in Fooducate were well integrated.	1	2	3	4	5
58 I thought there was too much inconsistency in Fooducate.	1	2	3	4	5
59 I would imagine that most people would learn to use Fooducate very quickly.	1	2	3	4	5
60 I found Fooducate very cumbersome to use.	1	2	3	4	5
61 I felt very confident using Fooducate.	1	2	3	4	5
62 I needed to learn a lot of things before I could get going with Fooducate.	1	2	3	4	5

		Strongly disagree	Disagree	Agree	Strongly agree
63	I feel it is my parents' job to pay for my everyday needs.	1	2	3	4
64	My parents should provide me with spending money.	1	2	3	4
65	I feel my parents should pay for the 'extras.'	1	2	3	4
66	I feel my parents should pay for my college education.	1	2	3	4
67	I deserve to get most of the things I want.	1	2	3	4
68	I feel my parents should help me get the things I want.	1	2	3	4

78. Do you have Screen Time on your iPhone?

- a) Yes—if yes, continue to questions 79 and 80 on the next page (page 11).  
 b) No—if no, continue to questions 81 and 82 on page 12.

*Directions:* For those of you with Screen Time, tap on *Today* and *Last 7 days* to see how much time you spend on different apps.

79. How long have you spent on iMessages *today*?  
 \_\_\_hours (h) \_\_\_ minutes (m)

*The example above would be* 0 hours (h) 22 minutes (m).

80. How long have you spent on iMessages in the *Last 7 Days*? \_\_\_hours (h) \_\_\_ minutes (m)

*The example above would be* 3 hours (h) 56 minutes (m)

*Directions:* For those of you who have iPhones but do not have the Screen Time feature, click on *Settings* and then *Battery*.

Tap on *Last 24 Hours* and *Last 7 Days* to see how much time you spend on different apps.

81. How long have you spent on iMessages (on-screen) *today*? \_\_\_hours (h) \_\_\_ minutes (m)

*The example above would be* 0 hours (h) 3 minutes (m).

82. How long have you spent on iMessages in the *Last 7 Days*? \_\_\_hours (h) \_\_\_ minutes (m)

## Appendix 4: Cronbach's alpha and inter-item correlations for each acceptability subscale

## Appendix 5: Factor loadings and communalities for a nine-factor model of 52 items included in the original acceptability scale

### Appendix 6: Study 2 survey

#### Fooducate questionnaire

*Directions:* How much do you agree or disagree with the following statements? Circle one response per row.

#### Usability

*Directions:* Reach each statement and circle the number that represents how much you agree or disagree with that statement.

#### Money attitudes

*Directions:* How much do you agree or disagree with the following statements? Circle one response per row.

#### Demographic information

*Directions:* Answer the questions below.

40. What is your name? \_\_\_\_\_

41. What is your email address? \_\_\_\_\_

42. What school do you attend? \_\_\_\_\_

*Directions:* For each of the questions below, circle your answer(s).

43. How old are you?

- i) 11
- j) 12
- k) 13
- l) 14
- m) 15
- n) 16
- o) 17
- p) 18 or older

44. What grade are you in?

- d) 7th
- e) 8th
- f) 9th

g) 10th

h) 11th

i) 12th

45. What gender do you identify with?

e) Male

f) Female

g) Non-binary/non-conforming

h) Other (fill-in-the-blank): \_\_\_\_\_

46. What is your race? Circle all that apply.

g) American Indian or Alaska Native

h) Asian

i) Black or African American

j) Native Hawaiian or Other Pacific Islander

k) White

l) Other (fill-in-the-blank): \_\_\_\_\_

47. Do you consider yourself Hispanic or Latino?

Subscale	# items	Cronbach's alpha	Inter-item correlation min	Inter-item correlation max
Attitude	6	0.83	0.30	0.63
Burden	6	0.67	0.06	0.46
Ethicality	10	0.81	0.03	0.59
Intervention coherence	5	0.65	-0.03	0.63
Opportunity costs	4	0.66	0.14	0.45
Effectiveness	4	0.88	0.59	0.66
Self-efficacy	7	0.86	0.29	0.60
Intervention expectations	6	0.40	0.09	0.51
Peer norms	4	0.56	0.06	0.40

Variable	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Communality
ATT_1	I like this app	<b>0.68*</b>	0.03	0.39*	-0.04	0.17*	0.01	0.00	-0.08	-0.07	0.85
ATT_2reverse	I dislike this app	<b>0.65*</b>	0.02	-0.03	0.28*	-0.08	-0.02	-0.03	0.15	0.11	0.74
ATT_3	I enjoy using the app.	<b>0.43*</b>	0.17*	0.41*	0.13	0.04	0.11	0.02	-0.07	0.09	0.82
ATT_4reverse	I hate using the app.	0.35*	0.13	0.16	<b>0.42*</b>	0.07	-0.10	-0.07	0.00	0.08	0.60
ATT_5	This app makes me feel good.	-0.07	0.09	<b>0.52*</b>	0.06	0.08	-0.02	0.10	0.15*	0.22*	0.67
ATT_6reverse	This app makes me feel bad.	-0.02	0.11	0.28*	<b>0.65*</b>	0.16*	0.08	0.06	-0.05	-0.01	0.76
BUR_1	This app is easy to use.	0.15	<b>0.56*</b>	0.03	0.09	-0.02	-0.16*	0.10	-0.01	0.04	0.49

(continued)

Continued.

Variable	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Communality
BUR_2reverse	This app is hard to use.	0.03	<b>0.79*</b>	-0.01	0.11	0.02	0.03	-0.00	-0.01	-0.10	0.66
BUR_3	This app is confusing.	0.12	<b>0.67*</b>	0.05	0.29*	-0.15	-0.02	-0.21	-0.04	-0.04	0.64
BUR_4	This app is simple.	-0.26	<b>0.65*</b>	-0.04	-0.01	-0.09	0.02	0.52*	0.05	0.06	0.74
BUR_5reverse	It takes a lot of effort for me to use this app.	0.14	0.09	0.01	<b>0.43*</b>	0.00	0.15	0.04	0.03	-0.27*	0.34
BUR_6	It takes little effort for me to use this app.	-0.21	0.04	0.04	0.08	-0.03	<b>0.48*</b>	0.40*	-0.01	-0.02	0.42
ETH_1	I approve of this app.	<b>0.68*</b>	-0.01	-0.04	0.11	0.01	-0.09	0.30*	0.03	0.03	0.73
ETH_2reverse	I disapprove of this app.	<b>0.59*</b>	-0.02	0.04	0.36*	-0.01	0.03	0.02	0.11	-0.01	0.73
ETH_3	This app helps me do something that I agree with.	0.08	0.09	<b>0.55*</b>	0.07	0.13	0.18*	0.20	0.03	-0.15	0.65
ETH_4reverse	This app helps me do something that I'm against	-0.03	-0.07	-0.10	<b>0.54*</b>	0.05	0.30*	-0.12	0.08	-0.11	0.39
ETH_5	I care about healthy eating.	-0.05	0.01	0.36*	0.09	<b>0.68*</b>	-0.01	0.02	0.07	0.04	0.83
ETH_6	Eating healthy is important to me.	0.04	-0.05	0.43*	0.07	<b>0.64*</b>	-0.06	0.05	0.01	0.03	0.84
ETH_7reverse	Eating healthy is unimportant to me.	-0.01	-0.09	0.00	<b>0.58*</b>	0.55*	-0.26*	-0.01	0.04	0.06	0.81
ETH_8	It's good to care about eating healthy.	0.11	-0.06	0.12	0.30*	<b>0.43*</b>	0.02	0.31*	-0.01	-0.06	0.63
ETH_9reverse	It's bad to care about eating healthy.	-0.04	0.06	-0.07	<b>0.60*</b>	0.44*	0.04	0.10	-0.05	-0.11	0.66
ETH_10	This app helps me do something that I care about.	0.01	0.11	<b>0.58*</b>	-0.08	0.31*	0.25*	-0.06	-0.03	0.11	0.70
COH_1	I understand how to use this app to track my food calories.	0.32*	<b>0.36*</b>	-0.00	-0.03	-0.02	0.22*	-0.05	0.10	0.02	0.40
COH_2	I can show a friend how to use this app to track their food calories.	-0.03	<b>0.46*</b>	0.02	0.03	0.09	0.31*	0.02	0.45*	0.09	0.75
COH_3reverse	I need to use this app more to figure out how the app works to track my food calories.	-0.10	0.06	-0.16	0.1	-0.20*	-0.02	<b>-0.29*</b>	0.24*	-0.11	0.24
COH_4	I understand how to use all of the features in this app.	0.09	0.46*	0.01	-0.08	-0.05	-0.06	0.06	<b>0.55*</b>	-0.02	0.69
COH_5	I can show a friend how to use	-0.03	0.39*	0.12	-0.01	0.14	0.10	0.02	<b>0.55*</b>	0.02	0.74

(continued)

Continued.

Variable	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Communality
	all of the features in this app.										
OPP_1reverse	If I use this app, I will miss out on doing other activities.	0.09	0.01	-0.21	<b>0.62*</b>	0.00	-0.13	0.05	0.06	0.05	0.42
OPP_2reverse	Using this app will take time away from using other apps on my phone.	0.20	-0.01	0.05	<b>0.45*</b>	-0.27*	0.03	0.19	-0.08	0.05	0.42
OPP_3	This app is a good use of my time.	0.33*	-0.10	<b>0.46*</b>	0.11	-0.10	0.25*	0.13	-0.03	0.07	0.68
OPP_4reverse	This app is a waste of my time.	0.20*	0.15	0.30*	<b>0.57*</b>	-0.01	0.01	-0.04	-0.04	0.09	0.78
EFF_1	This app will help me eat healthier in the next week.	0.10	-0.05	<b>0.84*</b>	-0.14*	0.03	-0.05	-0.04	0.01	-0.06	0.66
EFF_2	I think I will eat healthier because of this app in the next week.	-0.02	-0.03	<b>0.82*</b>	0.01	-0.25*	0.00	0.07	0.12	0.04	0.75
EFF_3	This app will lead me to eat healthier.	0.00	-0.01	<b>0.94*</b>	0.01	-0.09	-0.21*	0.02	0.03	-0.08	0.82
EFF_4	I will eat healthier because of this app.	-0.07	-0.02	<b>0.96*</b>	-0.05	-0.03	-0.08	-0.01	0.04	-0.03	0.81
SELF_1	I'm confident that I can use this app.	<b>0.43*</b>	0.18*	0.31*	0.01	-0.07	-0.00	0.05	0.08	0.12*	0.69
SELF_2	I'm confident that I can use this app even if I'm not reminded about it.	0.15	-0.03	0.17	0.10	-0.08	0.14	0.12	0.01	<b>0.41*</b>	0.46
SELF_3	I'm confident that I can use this app even if I'm really busy.	0.29*	0.17*	0.05	-0.01	-0.02	-0.03	0.03	0.04	<b>0.57*</b>	0.68
SELF_4	I'm confident that I can use this app to track my food calories.	-0.02	0.13	0.28*	0.07	0.09	-0.14	0.30*	<b>0.31*</b>	0.22*	0.74
SELF_5	I'm confident that I can use this app to track my food calories even if I'm not reminded to do it.	0.18*	0.13	0.32*	-0.18*	0.19*	0.06	-0.03	0.14	<b>0.38*</b>	0.71
SELF_6	I'm confident that I can use this app to track my food calories even if I'm really busy.	0.11	-0.03	-0.00	0.01	0.02	0.13	0.12	0.01	<b>0.80*</b>	0.79
SELF_7	I can fit this app into my daily routine.	-0.02	0.03	0.36*	0.13	0.07	-0.17	-0.03	-0.06	<b>0.50*</b>	0.59

(continued)

Continued.

Variable	Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Communality
EXP_1	This nutrition tracker app does what I think a nutrition tracker app should do.	0.31*	0.15*	0.10	-0.01	0.02	-0.01	<b>0.40*</b>	0.21*	-0.15*	0.57
EXP_2	This app does everything a nutrition tracker app should do.	0.24*	0.12	0.10	0.15	0.02	0.05	<b>0.30*</b>	0.22*	-0.04	0.52
EXP_3	This app does everything I want a nutrition tracker app to do.	0.34*	0.00	-0.05	-0.08	0.13	-0.01	<b>0.47*</b>	0.35*	-0.02	0.65
EXP_4reverse	The app does more than a nutrition tracker app should do.	-0.07	-0.14	-0.18	0.08	-0.10	0.16	<b>-0.33*</b>	-0.01	-0.02	0.37
EXP_5reverse	This app does less than a nutrition tracker app should do.	-0.07	-0.05	0.02	<b>0.53*</b>	-0.01	-0.16	0.19*	0.02	0.01	0.36
EXP_6	When talking to a friend, I would describe this app as a nutrition tracker app.	0.07	-0.14	<b>0.33*</b>	0.14	0.16	0.17	0.19	0.18*	0.08	0.54
PEER_1reverse	I'd be embarrassed if my friends saw me using this app.	0.10	0.20	0.00	<b>0.46*</b>	0.06	0.04	-0.31*	0.11	-0.07	0.34
PEER_2	I have friends who would use this app.	0.21	-0.26*	0.21*	0.05	-0.08	0.03	0.01	<b>0.50*</b>	-0.02	0.46
PEER_3reverse	Nobody I know would use this app.	0.25	-0.07	0.03	<b>0.40*</b>	-0.03	-0.03	-0.18*	0.39*	0.04	0.46
PEER_4	My friends would think that it's cool I'm using this app.	0.03	-0.00	<b>0.53*</b>	-0.08	-0.04	0.28*	-0.14	0.21*	0.17	0.57

Note. \*Indicates statistically significant factor loadings with  $p$ -values  $<0.05$ ; bolded factor loadings indicate the item's largest factor loading.



c) Yes

Step 1	Take out your iPhone phone and connect to the Wi-Fi network.
Step 2	Download the app <i>Fooducate</i> to your phone. Be sure to download the app with this logo:
Step 3	Sign up for a Fooducate account as a new user.
Step 4	Log into the app.
Step 5	Play with the app for 2 to 3 min. Try out the Food Finder, Community, Tracker, Recipes, and Diet Tips features. Wait for further instructions.

		Strongly disagree	Disagree	Agree	Strongly agree
1	I like this app.	1	2	3	4
2	This app is easy to use.	1	2	3	4
3	I care about <i>healthy eating</i> .	1	2	3	4
4	I can show a friend how to use this app to <i>track their food calories</i> .	1	2	3	4
5	This app will help me <i>eat healthier</i> in the next week.	1	2	3	4
6	I hate using the app.	1	2	3	4
7	I'm confident that I can use this app even if I'm really busy.	1	2	3	4
8	This app is confusing.	1	2	3	4
9	<i>Eating healthy</i> is important to me.	1	2	3	4
10	I understand how to use all of the features in this app.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
11	I think I will <i>eat healthier</i> because of this app in the next week.	1	2	3	4
12	I dislike this app.	1	2	3	4
13	I'm confident that I can use this app to <i>track my food calories</i> even if I'm not reminded to do it.	1	2	3	4
14	This app is hard to use.	1	2	3	4
15	It's good to care about <i>eating healthy</i> .	1	2	3	4

(continued)

Continued.

		Strongly disagree	Disagree	Agree	Strongly agree
16	I can show a friend how to use all of the features in this app.	1	2	3	4
17	This app will lead me to <i>eat healthier</i> .	1	2	3	4
18	I'm confident that I can use this app to <i>track my food calories</i> even if I'm really busy.	1	2	3	4
19	I enjoy using the app.	1	2	3	4
20	<i>Eating healthy</i> is unimportant to me.	1	2	3	4

		Strongly disagree	Disagree	Agree	Strongly agree
21	I will <i>eat healthier</i> because of this app.	1	2	3	4
22	This app is simple.	1	2	3	4
23	I plan to use this app in the next week.	1	2	3	4

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
24	I think that I would like to use Fooducate.	1	2	3	4	5
25	I found Fooducate unnecessarily complex.	1	2	3	4	5
26	I thought Fooducate was easy to use.	1	2	3	4	5
27	I think that I would need the support of a technical person to be able to use Fooducate.	1	2	3	4	5
28	I found the various functions in Fooducate were well integrated.	1	2	3	4	5
29	I thought there was too much inconsistency in Fooducate.	1	2	3	4	5
30	I would imagine that most people would learn to use Fooducate very quickly.	1	2	3	4	5
31	I found Fooducate very cumbersome to use.	1	2	3	4	5
32	I felt very confident using Fooducate.	1	2	3	4	5
33	I needed to learn a lot of things before I could get going with Fooducate.	1	2	3	4	5

		Strongly disagree	Disagree	Agree	Strongly agree
34	I feel it is my parents' job to pay for my everyday needs.	1	2	3	4
35	My parents should provide me with spending money.	1	2	3	4
36	I feel my parents should pay for the 'extras.'	1	2	3	4
37	I feel my parents should pay for my college education.	1	2	3	4
38	I deserve to get most of the things I want.	1	2	3	4
39	I feel my parents should help me get the things I want.	1	2	3	4

d) No

*Directions:* Click on *Settings* > *Screen Time*. Once there, select your iPhone. Answer the following questions below.

48. Do you have Screen Time on your iPhone?

c) Yes—if yes, continue to questions 49 through 51 on the next page (page 9).

d) No—if no, continue to questions 52 through 54 on page 10.

*Directions:* For those of you with Screen Time, tap on *Today* and *Last 7 Days* to see how much time you spend on different apps.

49. How long have you spent on messages *today*? \_\_\_ hours (h) \_\_\_ minutes (m)

*The example above would be* 0 hours (h) 22 minutes (m).

50. How long have you spent on Messages in the *Last 7 Days*? \_\_\_ hours (h) \_\_\_ minutes (m)

*The example above would be* 3 hours (h) 56 minutes (m)

51. How long have you spent on Fooducate *today*? \_\_\_ hours (h) \_\_\_ minutes (m)

*Once you answer questions 49 through 51, you are done with the questionnaire. Please turn it in.*

*Directions:* For those of you who have iPhones but do *not* have the Screen Time feature, click on *Settings* and then *Battery*.

Tap on the *Last 24 Hours* and *Last 7 Days* to see how much time you spend on different apps.

52. How long have you spent on messages (on-screen) *today*? \_\_\_ hours (h) \_\_\_ minutes (m)

*The example above would be* 0 hours (h) 3 minutes (m).

53. How long have you spent on messages in the *Last 7 Days*? \_\_\_ hours (h) \_\_\_ minutes (m)

*The example above would be* 0 hours (h) 22 minutes (m).

54. How long have you spent on Fooducate *today*? \_\_\_ hours (h) \_\_\_ minutes (m)

*You have reached the end of the questionnaire. Please turn it in.*

## Appendix 7: Factor loadings, $R^2$ values, and Cronbach's alphas for higher-order six-factor acceptability model

Higher-order latent variable	Latent variables	Higher-order factor loadings	Higher-order $R^2$	Items	Factor loading	$R^2$	Cronbach's alpha
ACCEPT	ATT	1.00	0.63	ATT_1	1.00	0.70	0.90
				ATT_2reverse	0.82	0.47	
				ATT_3	1.10	0.85	
				ATT_4reverse	0.93	0.60	
	BUR	0.76	0.39	BUR_1	1.00	0.66	
				BUR_2reverse	1.08	0.77	
				BUR_3reverse	1.06	0.74	
				BUR_4	0.93	0.58	
	ETH	0.79	0.32	ETH_5	1.00	0.88	
				ETH_6	1.01	0.90	
				ETH_7reverse	0.83	0.60	
				ETH_8	0.87	0.66	
	COH	0.89	0.52	COH_2	1.00	0.68	
				COH_4	0.93	0.58	
				COH_5	1.07	0.78	
	EFF	0.82	0.46	EFF_1	1.00	0.64	
				EFF_2	1.14	0.83	
				EFF_3	1.15	0.85	
				EFF_4	1.18	0.89	
	SELF	0.95	0.55	SELF_3	1.00	0.73	
SELF_5				0.97	0.68		
SELF_6				1.00	0.73		