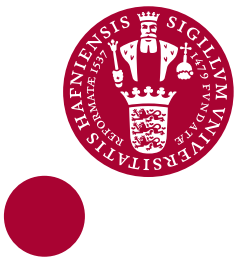

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Damsbo-Svendsen, Marie; Frøst, Michael Bom; Olsen, Annemarie

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A review of instruments developed to measure food neophobia

Marie Damsbo-Svendsen [a], Michael Bom Frøst [a, b], Annemarie Olsen [a, *]

[a] University of Copenhagen, Department of Design and Consumer Science, Rolighedsvej 26, 1958 Frederiksberg, Copenhagen, Denmark
[b] Nordic Food Lab, Rolighedsvej 26, 1958, Denmark

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ABSTRACT

Background: Food choices are influenced by an individual's attitude towards foods. Food neophobia may be associated with less variety of diets, inadequate nutrient intake and high product failure rate for new food products entering the market. To quantify the extent of these challenges, instruments to measure the food neophobia in different target groups are needed. Several such instruments with significantly different measurement outcomes and procedures have been developed. This review provides an overview and discusses strengths and weaknesses of these instruments.
Objective: We evaluate strengths and weaknesses of previously developed instruments to measure neophobia and willingness to try unfamiliar foods.
Design: Literature was searched through the databases Web of Science and Google Scholar. We identified 255 studies concerning neophobia and willingness to try unfamiliar foods. Of these, 13 studies encompassing 13 instruments to measure neophobia and willingness to try unfamiliar foods were included in the review. Results are summarized and evaluated with a narrative approach.
Results: In the 13 instruments to assess neophobia and willingness to try unfamiliar foods, 113 to 16.644 subjects aged 2–65 years were involved, scales with 3–7 response categories were used and behavioral validation tests were included in 6 studies.
Conclusions: Several instruments to measure neophobia and willingness to try unfamiliar foods exist. We recommend selecting one or more among the 13 instruments reviewed in this paper to assess relevant aspects of neophobia.

Contents

* Corresponding author.
E-mail address: ano@food.ku.dk (A. Olsen).

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1. Introduction

Food neophobia is defined as a *reluctance to eat unfamiliar foods* (Dovey, Staples, Gibson, & Halford, 2008). The phenomenon has been hypothesized to occur due to the omnivore's dilemma: In the search for food, a human may need to approach novel foods. However, he has to protect himself from potentially poisonous foods, thus restricting his diet (Armelagos, 2014; Rozin, 1976). Although food neophobia has been investigated extensively, a recent research review proposed that the mechanisms behind food rejections have not yet been clearly identified (Lafraire, Rioux, Giboreau, & Picard, 2016).

Neophobia is an important determinant of food choices, which have great impact on the quality of a diet (Lafraire et al., 2016). It has been associated with less variety of diets and inadequate nutrient intake (Falciglia, Couch, Gribble, Pabst, & Frank, 2000). Several studies have revealed that intake of vegetables, salad, fruit, meat and fish is diminished in individuals with higher levels of food neophobia (Cooke, Wardle, & Gibson, 2003; Galloway, Lee, & Birch, 2003; Siegrist, Hartmann, & Keller, 2013). Moreover, it has been demonstrated that food neophobic individuals may experience deficits in intake of protein, monounsaturated fats, magnesium and vitamin E (Capiola & Raudenbush, 2012; Falciglia et al., 2000). High product failure rate for new food products entering the market is an additional result deriving from negative attitudes towards food and food neophobia (Barrena & Sánchez, 2013; Henriques, King, & Meiselman, 2009; Winger & Wall, 2006).

Modification of eating patterns through development of health strategies and sensory testing of new products would be favorable initiatives to help overcome these challenges. To do this, it is imperative to select and use appropriate instruments to determine neophobia and willingness to try unfamiliar foods. Several instruments to measure different aspects of neophobia and willingness to try unfamiliar foods exist, see Table 1. These instruments vary in measurement outcomes, samples, scales, items and behavioral tests included. One of the instruments currently most used to assess neophobia and willingness to try unfamiliar foods is the Food Neophobia Scale (FNS) developed by Pliner and Hobden (1992). The FNS has been widely used and provided reliable results (Galloway et al., 2003; Knaapila et al., 2007; Mustonen, Oerlemans, & Tuorila, 2012; Olabi, Najm, Baghdadi, & Morton, 2009; Ritchey, Frank, Hursti, & Tuorila, 2003; Rubio, Rigal, Boireau-Ducept, Mallet, & Meyer, 2008). However, it consists of ten items, which were developed over 20 years ago.

To our knowledge no review of existing instruments to measure neophobia and willingness to try unfamiliar foods is available at present. It is necessary to evaluate the relevance of varying instruments and measurement outcomes in the different studies to enable critical selection of the most relevant instrument according to the purpose of a given investigation. Moreover, such evaluation would provide information about important considerations for future development of instruments.

The aim of our work is to review instruments to measure neophobia and willingness to try unfamiliar foods. We do this by providing an overview and evaluate strengths and weaknesses of these instruments. We assess measurement outcomes, samples, items, scales and procedures, and evaluate the quality of evidence. Finally, we discuss relevance and establish recommendations for selection of instruments to measure neophobia and willingness to try unfamiliar foods.

1.1. Identification of relevant literature

We review direct instruments to measure neophobia and willingness to try unfamiliar foods. Literature was searched in English through the databases Web of Science by using the keywords “food neophobia”, “neophobia”, “willingness to taste new food”, “food attitude”, “pickiness”, “expectation” and “taste” in August to September 2015. Literature was searched by the first author and selection criteria were set by the first and last author. When full articles were not available in this database, Science Direct and Google Scholar were used. Pertinent literature was further identified through citations and bibliographies from articles. In total 255 studies were identified. Successive evaluation of relevance was based on 1) title, 2) abstract and 3) article content. Criteria for inclusion in this review were; that studies concerned development of instruments to measure food neophobia and willingness to taste unfamiliar food. Moreover, studies did not concern pickiness or food preferences unless other measures connected with neophobia and willingness to try unfamiliar foods were also included, items included in instruments were presented, more than one item related to food neophobia (to ensure the instrument incorporated a minimum of information) and human subjects were involved. Studies concerning instruments to measure food-related disorders and cognitive restraints were excluded. Moreover, studies, in which previously developed instruments were applied to new samples, were excluded. Initially, a total of 22 studies concerning 23 different instruments to measure neophobia and willingness to try unfamiliar foods were identified. Further evaluation based on the inclusion criteria, resulted in exclusion of ten instruments (Arnett, 1994; Bell & Marshall, 2012; Haidt, McCauley, & Rozin, 1994; Musher-Eizenman & Holub, 2007; Pearson, 1970; Pliner & Hobden, 1992; Schnettler et al., 2013; Steptoe, Pollard, & Wardle, 1995; Ullrich, Touger-Decker, O'sullivan-Maillet, & Tepper, 2004; Zuckerman, 1979). Finally, 13 instruments were included in this review (see Table 1). Data was extracted and included: population from which subjects were recruited, sample size, sex and age. Moreover, procedure, items, scales, behavioral validation tests and measures of reliability were extracted. In this review, results are summarized and evaluated with a narrative approach.

2. Review of instruments

2.1. Overview of instruments

Reviewing the 13 instruments leads to the immediate conclusion that different aspects of neophobia and willingness to try unfamiliar foods can be measured by several means. This implies that in a planned study a clear aim must be defined to enable selecting of an appropriate instrument to measure food neophobia, and/or willingness to try unfamiliar foods.

2.1.1. Subjects

Within the studies reviewed, sample size including all subjects involved in tests of the instrument ranged from 113 to 16.644 with most studies including from around 280 to 600 subjects. It has been proposed that 100 to 200 subjects are required to construct a scale (Spector, 1992). Accordingly, all studies included the minimum number of respondents required to construct a scale. However, the number of respondents involved in relation to the questionnaire and behavioral tests varied. Yet, more than 100 respondents completed the questionnaire in all studies.

Children, adolescents, adults and elderly alike were involved in development of the different instruments with subjects' ages ranging from 2 to 65 years. However, one study did not report age (van Trijp & Steenkamp, 1992). This implies, instruments are developed for varying age groups in accordance with their cognitive abilities. Seven instruments were developed for children (Kaiser et al., 2012; Loewen & Pliner, 2000; Pliner, 1994; Raudenbush et al., 1995; Rubio et al., 2008; Thomson et al., 2010;

Table 1
Instruments used to measure neophobia and willingness to try unfamiliar foods in subjects (note that an "item" is considered a question or statement).

Appendix	Name of Instrument & author(s)	Measurement outcome	Instru-ment	Subjects	Scale (Cronbach's α)[a] [measures of validity][b]	Comments/conclusions
A-1	Children's Eating Behavior Questionnaire (CEBQ) (Wardle, Guthrie, Sanderson, & Rapoport, 2001)	Children's eating behavior rated by their parents	+	Items were developed based on interviews with 15 parents and discussion of items by 20 parents (to children 2-6y). 131 and 187 parents rated their child's eating behavior. Final items were rated by 208 parents of children 2–9 years.	**CEBQ**: 35-item test with 8 subscales (α = 0.74–0.91) [Construct (convergent) validation - factor analysis, Criterion (concurrent) validity - correlation between subscales].	Several factors are covered by the CEBQ; responsiveness to and enjoyment of food, satiety responsiveness, slowness in eating, fussiness, emotional overeating, emotional undereating, and desire for drinks. CEBQ was developed to assess early precursors of obesity in children, hence questions were directed towards measures of obesity. However, questions relating to fussiness and enjoyment of food appear relevant in relation to measuring food neophobia.
A-2	Fruit and Vegetable Neophobia Instrument (FVNI) (Hollar, Paxton-Aiken, & Fleming, 2013)	Children's willingness to try vegetables and fruits	+	1485 subjects, 8–10 years.	**FVNI:** 18-item test with 2 subscales (α = 0.83–0.92) [Construct (convergent) validation -factor analysis, Content validity demonstrated through paired item residual correlations].	Items were similar for vegetables and fruits on the 2 subscales. Transmission of answers from one scale to the other may occur and lead to bias in responses on the second scale. The tool was developed specifically for vegetables and fruits. The tool is easy to apply.
A-3	Food and Eating Questionnaire (FEQ) (Raudenbush, van der Klaauw, & Frank, 1995)	Preference, attitude and willingness to try foods measured by a combination of instruments: neophobia, pickiness, eating apathy and sensation seeking tests, and Food Attitude Scale (FAS) - see Frank and van der Klaauw (1994)	+	146 subjects completed the FAS, mean age 20.5 years. 158 subjects participated in test of FAS and sensation seeking, mean age 20.2 years. 101 subjects completed FEQ, mean age 19.3 years.	**Neophobia, pickiness and eating apathy tests:** 20 item-test (α = 0.39–0.86) **Food preference test**: Liking of 217 foods/beverages were rated **Sensation seeking:** 40-item test **Odor evaluation:** Pleasantness of 10 odors were rated (α = 0.55) **FAS:** See Frank and van der Klaauw (1994) [Construct (convergent) validation - factor analysis, Criterion (predictive) validity between pickiness-FAS and FNS-FAS].	Like and won't try responses in the food attitude survey (measured by FAS) were predicted by neophobia scores. However, FNS was not correlated with FAS. Odor pleasantness was correlated significantly with liking and willingness to try new foods; hence odor tests could have potential in behavioral investigation of neophobia. Odor pleasantness and sensation seeking were correlated with FAS. Certain aspects of FAS may consequently be relevant when measuring neophobia.
A-4	FNS + Domain Specific Innovativeness (DSI) Scale (Goldsmith & Hofacker, 1991; de Barcellos, Aguiar, Ferreira, & Vieira, 2009)	Willingness to try and use innovative products within specific product categories	+	279 Brazilian and 101 British subjects, 18–29 years.	**DSI**: 6 items about respondents' attitude to innovation (α = 0.78–0.80) **FNS**: See Pliner and Hobden (1992) (α = 0.77–0.80) [–].	Reformulation of original FNS items has led to poor quality of English. The complete questionnaire is relatively long (28 items). The instrument is developed for the food industry and may not be appropriate for simply measuring FNS. Willingness to purchase innovative foods may indicate neophobic traits, hence a combination of DSI and FNS may capture more aspects of reasons for being neophobic.
A-5	Food Attitude Scale (FAS) (Frank & van der Klaauw, 1994)	Attitudes towards food and eating, and willingness to try new food	+	719 subjects completed the questionnaire. 100 subjects rated familiarity with foods. 215 subjects completed a questionnaire for a health survey. 30 subjects participated in a chemosensory test, 19–53 years.	**FAS:** Willingness to try 455 foods/beverages were rated along with a 20-items test (–) **Neophobia test:** subjects evaluated how often they had seen 455 foods on a menu (<350 foods from the previous test), seen others eat it or had it served [Construct (convergent) validation – correlation between FAS and FNS, Content (face) validity doubted: Tendency towards females being more neophobic than males].	In the preference test both liking and attitude was included in the same questionnaire which may be confusing and could benefit from being presented in different questionnaires. Common, unusual and fictitious foods were included in the food preference rating. A FAS score therefore reveals a general attitude towards novel foods, which may reflect neophobia. Many foods were included in the preference test to overcome issues related to allergies, food practices and idiosyncratic food aversions. Preference patterns (divided into "likers", "dislikers" and "won't tryers") were correlated with the 20-item questionnaire to provide information about attitude that accounts for liking. However, preference may not relate to neophobia and willingness to try unfamiliar foods. Several tests were carried out to obtain information about reasons for attitude

Table 1 (*continued*)

Appendix	Name of Instrument & author(s)	Measurement outcome	Instru-ment	Subjects	Scale (Cronbach's α)[a] [measures of validity][b]	Comments/conclusions
						(health condition survey, neophobia test and chemosensory tests).
A-6	FNS + General Neophobia Scale (GNS) + Food Technology Neophobia Scale (FTNS) (Cox & Evans, 2008; Evans, Kermarrec, Sable, & Cox, 2010; Pliner & Hobden, 1992)	Consumer segments which accepts or rejects novel foods (GNS: Preference for familiar/ willingness to experience unfamiliar situations and people)	+	480 subjects rated 81 items, which were reduced to 31 items. These were rated by 459 subjects and reduced to 13 items, which were tested by 294 subjects, 18–65 years.	**FTNS:** 13 item-test (α = 0.84) **GNS:** 8-item test (α = 0.78) **FNS:** See Pliner and Hobden (1992) [Construct (convergent) validation - factor analysis, Content (face) validity of items, Criterion (predictive) validity between FNTS - willingness to try novel technologies and FNTS - FNS].	FTNS measures neophobia in relation to technology, which is highly specific and may therefore not embrace all aspects having an impact on neophobia. GNS may not reflect food-related neophobia. However, statements as "I am afraid of the unknown" and "I am very uncomfortable in new situations" may capture personality traits related to food neophobic behavior. Investigation of correlations between FNS and GNS, and FTNS respectively, provides information about whether neophobic trait in individuals is generic or specific to foods. FTNS was significantly correlated with FNS and GNS, but correlation was not as strong as for FTNS. FTNS may predict food neophobia, but developing a FNS including questions regarding FTN may be more useful
A-7	Variety Seeking Tendency Scale (VARSEEK) (van Trijp & Steenkamp, 1992)	Variety seeking tendency in relation to food	+	Subjects were engaged in focus-group discussions and 30 in-depth interviews. A preliminary protocol was tested with 72 subjects. 159 subjects were interviewed in relation to further developed the protocol. The final protocol was administered to 151 subjects, and twice to 59 subjects, age not reported.	**VARSEEK:** 8-item test (α = 0.90) [Construct validation - factor analysis (convergent validation) and discriminant validation between VARSEEK & Optimal Stimulus Level-scale, Criterion (predictive) validation on new sample of subjects].	Only one item was reversed, which may be confusing for subjects. The terminology "exotic foods" and "foods … from other countries" may not be relevant currently, as exotic foods may be familiar foods simply imported from foreign countries (for example a banana).The test is easy to apply and not very time-consuming (8 items). "Variety" is represented in the VARSEEK in terms of unusual foods, new recipes and foods one is not familiar with, which may reflect food neophobia. Items refers to feelings *and* actions related to unfamiliar foods, hence investigates different aspects of variety seeking.
A-8	Teacher-administered Taste-Test Tool (TTT) (Kaiser et al., 2012)	Children's and adolescents' willingness to try novel foods and ask for the foods at home	+ ++	9 teachers were interviewed and a draft version of TTT was applied to 168 children to determine feasibility of instrument. Pilot study included 114 students and a validation study of the final TTT was conducted with 514 classrooms (16,644 children), ≥8 years (school-aged).	**TTT and behavioral test:** One food was evaluated in 6-item test (in one session) (α = 0.86) [Construct (convergent) validation − correlation between liking and willingness to try food (behavioral validation)].	The instrument does not assess neophobia directly, but provides information about willingness to try specific foods. However, these foods may not be novel to children, and consequently the instrument does not capture neophobia. Administration order may lead to bias: Taste session followed by questions about willingness to try foods may lead to different responses than if administration order was reversed. A taste session along with questions asked by teacher may give more valid results than a questionnaire with imaginary food items alone. The instrument seems appropriate for measuring willingness to try specific food categories such as vegetables and fruits.It is a relatively easy and fast instrument, as it provides class-room level responses.
A-9	Food Situation Questionnaire (FSQ) (Loewen & Pliner, 2000)	Children's willingness to eat novel foods in different situations	+ ++	24 items were administered to 125 children. 32 items concerning unfamiliar and 12 items concerning familiar foods were administered to 335 children. 44 and 90 children participated in the behavioral validation test, 5–12 years.	**FSQ**: 10 item-test with 2 subscales (α = 0.71–0.80) **Behavioral validation test:** Willingness to try presented foods was assessed [Construct (convergent) validation - factor analysis and correlation between FSQ-behavior (behavioral validation) and FSQ-FNS].	Food situations *and* specific foods are included in the same items. Children may therefore not focus on the food situations presented in the FSQ. The instrument might measure children's approach of foods *or* feeling of safety in presented situations. This may lead to bias in responses to items. Situations are culturally dictated; Halloween party is not celebrated all over the world, and is therefore not relevant to include in the FSQ if applied to children where this event is not celebrated. Items relate to stimulating situations (low and high), and therefore provide information about the impact of the food

(*continued on next page*)

Table 1 (*continued*)

Appendix	Name of Instrument & author(s)	Measurement outcome	Instru-ment	Subjects	Scale (Cronbach's α)[a] [measures of validity][b]	Comments/conclusions
						presentation situation on willingness to eat foods. The behavioral validation test is comprehensive; it includes both tasting of foods and rating of willingness to taste novel and familiar foods.
A-10	Food Neophobia Scale (FNS) (Pliner & Hobden, 1992)	Rated willingness to eat novel foods	+ ++	27 subjects choose relevant items. 55 subjects rated items. 18 items were chosen and administered to 135 subjects, 18–74 years. In the behavioral validation tests 3 samples of 41, 35 and 80 subjects participated, 18–49 years.	**FNS:** 10-item test (α = 0.88) **Behavioral validation test**: Foods were evaluated a priori for degree of novelty/familiarity and rank ordered according to willingness to try the food [Construct (convergent) validation –FNS scores was correlated with anxiety, general neophobia, familiarity with foreign cuisine, finickiness, sensation seeking and behavioral responses (behavioral validation)].	FNS was developed in 1992 and may not be valid at present as specific foods and situations in questionnaire ("ethnic" food, "food from different cultures", "dinner parties" & "ethnic restaurants") may not reflect food neophobia currently. Thorough statistical approach: Item means & standard deviations, corrected item-whole correlations & highest correlation with the other items were calculated. FNS scores were highly predictive of behavioral response. The instrument correlated with general neophobia, general familiarity & experience with unusual foods and the Experience Seeking Subscale of the Sensation Seeking Scale.
A-11	Food Neophobia Questionnaire (FNQ) + Changing Neophobic Behavior + Food Presentation Situations (Rubio et al., 2008)	Choice of and rated willingness to try novel foods	+ ++ +++	166 subjects selected relevant items. 603 subjects completed the FNQ. 503 subjects were included in a validation test of FNQ through a food task, 5–8 years.	**FNQ:** 13-item test: 2 items tested for general neophobia, 6 items evaluated children's willingness to taste novel foods & 5 items evaluated typology of food neophobia (α = 0.84) [Construct (convergent) validation - factor analysis, Criterion (predictive) validation – FNQ scores predict food choice and willingness to try foods (behavioral validation)].	The tool was developed for French children and may therefore not be valid for other nationalities. Scale with considerably few points may be more easy to use for children. Using various types of novel food presentation contexts may help capture some of the factors influencing food neophobia. Presentation of novel food items through pictures rather than real foods is cheaper and easier, and using pictures have in other studies been shown to be reliable, but for novel foods this may not be the case.
A-12	Food Neophobia Scale for Children (FNSC) (Pliner, 1994)	Choice of and willingness to eat foods among 10 novel- and 10 familiar foods	+ ++ +++	117 children (113 were included in the statistical analysis), 5, 8, 11 years.	**FNS**: See Pliner and Hobden (1992). **Behavioral validation test**: Parents and children indicated familiarity with and willingness to eat each of 34 foods. Children were presented with 5 foods they had rejected and asked why they had rejected it (open-ended). Finally, they tasted samples they had agreed to taste. Ten novel foods were selected for the final measure and internal consistency was calculated based on these (α = 0.84) [Construct (convergent) validation –FNS scores was correlated with parents' and child's prediction of a child's willingness to try foods (behavioral validation), item-total correlations: 0.48–0.60, FNS – see Pliner and Hobden (1992)].	Food items used to assess behavioral food neophobia may not be novel to children nowadays. The instrument was developed in 1994 and availability of foods from other countries has increased since then. Familiarity with food items was measured by number of times eaten, which may not reflect novelty, as eating a food just once leads to considerably decreased novelty of the food. Children's behavioral food neophobia was significantly correlated with trait neophobia and parents' prediction of the child's willingness to eat foods, hence both tools may be useful to measure food neophobia in a child. Children's and parents' behavioral and trait neophobia scores correlated. Investigating neophobia in parents, and parents' prediction of their child's level of neophobia along with administration of a behavioral test to the child is likely to be an appropriate instrument to measure food neophobia in children.
A-13	WillTry Instrument (Thomson et al., 2010)	Children's willingness to try vegetables and fruits	+ ++ +++	The instrument was developed through telephone interviews with parents and 3 pilot studies. Interventions consisted of 3 groups of subjects: Group 1 was served a snack of fruits/ vegetables as nutrition intervention, group 2 was pseudo-controls (involved in physical	**WillTry:** 31-item test with 3 subscales (α = 0.46–0.77) [Construct (convergent) validation - factor analysis and rated willingness to try foods correlated with percentage consumed foods (behavioral validation)].	The instrument is comprehensive tool - it measures both familiar and novel vegetables and fruit, but also parameters which are irrelevant in relation to neophobia. It is a time-consuming instrument, as it is interviewer-administered in a one-to-one setting. Items regarding locations where children would be willing to try new foods provide insight into cultural aspects that influence acceptability of novel foods. Observation of direct food intake along with

Table 1 (*continued*)

Appendix	Name of Instrument & author(s)	Measurement outcome	Instru-ment	Subjects	Scale (Cronbach's α)[a] [measures of validity][b]	Comments/conclusions
				activity intervention), group 3 was a control (no intervention). In total 284 subjects, 5–14 years.		the questionnaire is used as a validation method, which may be appropriate to avoid bias in self-reported data.

Instruments included a questionnaire (+), a behavioral test (++) and/or use of pictures of food instead of actual food, which forms part of either the questionnaire or behavioral test (+++).

[a] (−) indicates Cronbach's alpha (α) was not available in the study.

[b] [-] indicates measures of validity was not included in the study.

Wardle et al., 2001). Children were 2–14 years of age. They completed questionnaires and behavioral tests themselves or an adult did it on behalf of the child. In the CEBQ, parents of 2–6 years old children completed the questionnaire (Wardle et al., 2001) and in the TTT, a teacher completed the questionnaire and behavioral test for a class of children who were over the age of 8 years (Kaiser et al., 2012). It appears, that relevance of the different instruments depends on age and setting for the administration, which is therefore highly important to consider when selecting an instrument.

2.1.2. Items (questions or statements)

The 13 instruments reviewed in this study included 6 to 35 items. It may be time consuming and complicated to complete many items. Short and simple instruments capturing the most important information are therefore desirable. Within the instruments reviewed, 6 encompassed ≤10 items (Frank & van der Klaauw, 1994; Kaiser et al., 2012; Loewen & Pliner, 2000; Pliner & Hobden, 1992; Pliner, 1994; de Barcellos et al., 2009) and 5 instruments encompassed 13 to 20 items (Frank & van der Klaauw, 1994; Hollar et al., 2013; Raudenbush et al., 1995; Rubio et al., 2008). These instruments appear relatively short, which may prevent exhaustion in subjects. The Cronbach's α obtained with the complete indices varied from 0.80 to 0.92, indicating they are highly reliable although they do not contain a large number of items. However, in studies where a more comprehensive or detailed measure of the construct under investigation is needed, researchers may renounce short instruments, but continue to want a high Cronbach's α. The CEBQ and Willtry Instrument, which contain 31 and 35 items divided into 3 and 8 subscales, respectively, may be more time-consuming, but encompass more information the remaining instruments included in this review. However, only a few subscales are relevant to the topic at hand.

2.1.3. Reversed items

In 4 out of 13 instruments, reversed items were included (Cox & Evans, 2008; van Trijp & Steenkamp, 1992; Pliner & Hobden, 1992; Rubio et al., 2008). The purpose of recoding items is, that generally respondents have a tendency to express agreement to a larger extent than disagreement on Likert scales (Spector, 1992). Within the instruments with recoded items, the number of reversed items was balanced in relation to the total number of items in only one instrument (Pliner & Hobden, 1992).

2.1.4. Scales

The scoring system in items was based on quantitative measurements and summated rating scales, which is commonly used to assess individuals' attitude. By including several response categories and items, summated rating scales lead to improved reliability, precision and assessed scope compared to single yes-or-no questions (Spector, 1992). Most studies included Likert-type rating scales with 3–7 response categories to evaluate subjects' responses. Other scales encompassed a 5-point smiley scale (Loewen & Pliner, 2000), frequency scales with 4–5 response categories (Wardle et al., 2001; Frank & van der Klaauw, 1994; Hollar et al., 2013), scales about willingness to try foods with 3–7 response categories (Loewen & Pliner, 2000; Pliner, 1994; Rubio et al., 2008; Thomson et al., 2010) and varying preference rating or liking scales with 3–5 response categories (Frank & van der Klaauw, 1994; Kaiser et al., 2012; Raudenbush et al., 1995).

It has been discussed what the optimal number of items in a scale is (Preston & Colman, 2000), and suggested that test content is developed in relation to what the intended measure outcome is (Nunnally, 1978). The scales in studies included in this review were selected according to the instrument and target group. It could be relevant to select or develop distinctive scales from the ones included in the instruments, however. In cases where an instrument is applied to a different target group than the one the instrument was developed for it would be valuable to evaluate which scale and number of response categories would be the most appropriate.

Likert scales permit graduation of a response, but less graduation of a response is possible with 3- and 5-point scales than 7- and 9-point scales. Nevertheless, it has been found that 3- to 5-point scales are relatively easy and quick to use, whereas scales with 7–10 response categories result in more reliable results (Preston & Colman, 2000). Starting at the age of 7, the cognitive abilities of children are more developed than in younger children. At the age of 7, children are better at systematic and logic thinking, and they acquire language and reading skills (Piaget, Tomlinson, & Tomlinson, 1929; de Leeuw, Borgers, & Smits, 2004). It could therefore be advantageous to include scales with more points (5–7) for children from the age of 7 years and less points for younger children (3–5). In relation to adults the optimal number of points on a scale has been discussed (Preston & Colman, 2000). To enable increased graduation of responses, we suggest including 7 to 10 response categories in scales for adults. However, it has been suggested that more points should be included in a scale when an instrument contains less items, whereas less points are needed when more items are included in an instrument (Lee & Paek, 2016). The number of points on a scale therefore highly depends on the instrument and target group. Furthermore, most studies reviewed included an uneven number of response category, which typically offers the respondent the option of choosing a neutral statement.

2.2. Evaluation of instruments

Instruments in reviewed studies examined food neophobia and willingness to try unfamiliar food. However, differences in the target group and measurement outcome varied, and the instruments are consequently relevant in different contexts. In the following section, quality of instruments is assessed through

reliability of scales in terms of Cronbach's α coefficients. These vary between 0 and 1, and generally α-values of 0.70 or above are considered acceptable (Andersen, Hansen, & Klemmensen, 2012; Cortina, 1992; Iacobucci, 2001; Spector, 1992). Validity is evaluated in terms of construct, content, criterion (predictive) validity and subcategories of these (Cronbach, 1955; Nunnally, 1978). We consider validity to be *very good*, when three types of validity have been assessed, *good*, when two types of validity have been demonstrated, *quite good*, when one validity measure has been established and *weak* when no validity measures are presented or validation could not be established.

2.2.1. Instruments without behavioral tests for children

To investigate early signs of food neophobia, the **CEBQ** (Wardle et al., 2001) appears the most appropriate instrument to use, because it was developed for 2–9 years old children. An association between a decrease in reliability of responses with less cognitive functioning has been established (Borgers & Hox, 2000). To increase reliability of the responses, and because the children may not be able to respond themselves, it seems appropriate that parents to very young children complete the questionnaire instead of the children. Cronbach's α of the CEBQ was relatively high (α = 0.74–0.91) and validity was good implying the CEBQ constitute a reliable and valid instrument for measuring eating behavior in children rated by parents. The CEBQ and **FVNI** (Hollar et al., 2013) were the only two instruments intended for children, which included solely questionnaires and no behavioral tests. The FVNI, contrary to the CEBQ, was designed to be completed by the child. The FVNI was designed to target 8–10 years old children. Consequently, the cognitive abilities of this target group would be expected to be more developed than in the children of the **CEBQ** who were younger. Reliability of this instrument was slightly higher than that of the CEBQ (α = 0.83–0.92 compared to α = 0.74–0.91), and measures of validity were good. The FVNI measures fruit and vegetable intake, which makes it more food specific in regards to measuring eating behavior and willingness to eat food.

2.2.2. Instruments with behavioral tests for children

A questionnaire-based measurement of neophobia and willingness to try unfamiliar foods may not reflect actual behavior manifested as hedonically negative responses towards novel foods. Moreover, it has been discussed whether beliefs, attitudes and intentions predict behavior (Fishbein & Ajzen, 1975; Madden, Ellen, & Ajzen, 1992; Sheeran, 2002). Including a behavioral test serve to reveal construct validity and provide information about actual behavior. It may be more time-consuming and expensive to administer than a questionnaire alone. Yet, it provides evidence of behavioral validation of a questionnaire, which implies the questionnaire can be administered alone to assess behavior. Five instruments developed for children included behavioral tests with or without use of pictures of food: The FNSC, FNQ, FSQ, TTT and WillTry Instrument (Kaiser et al., 2012; Loewen & Pliner, 2000; Pliner, 1994; Rubio et al., 2008; Thomson et al., 2010). In case a behavioral test is administered along with a questionnaire, it is important to consider which foods are included. To assess validation between responses in a questionnaire and actual behavioral, it is important that foods are unfamiliar to subjects and represent foods from categories, which may be rejected and reveal neophobic behavior. It has been suggested that foods most often rejected are the ones considered most dangerous. Eggs and meat may be sources of the potentially most noxious bacteria causing food poisoning, hence including foods from these categories might be useful to reveal neophobic behavior (Cooke et al., 2003).

The **FNSC** (Pliner, 1994) was developed for children aged 5–11 years and encompasses a behavioral test along with the FNS (adjusted with items phrased as “my child”, ”he” or ”she” instead of “I” in the adult version). It is therefore a more time consuming and expensive instrument than the FNS alone, but it may produce more reliable results in cases where the child is not able to complete the FNS. Reliability of the behavioral test was relatively high (α = 0.84) and measures of validity were quite good. The instrument can be administered as a combination of the FNS and the behavioral test or simply the behavioral test, since a correlation between results from the FNS and behavioral test have been demonstrated ($r = 0.38$, $p < 0.001$) (Pliner, 1994). Correlation coefficients $r \geq 0.3$ are generally accepted according to guidelines from Andersen et al. (2012). However, novelty of foods used in the behavioral test should be revised, because novelty depends on culture and previous. The instrument can also be used on its own (without the behavioral test) (Damsbo-Svendsen, Frøst, & Olsen, 2017) . In this way it has also been applied in shortened versions, for instance including only 4 (Cooke & Wardle, 2007) or 6 items (Cooke, Carnell, & Wardle, 2006).

The **FNQ** (Rubio et al., 2008) applies partly to the same target group as the FNSC. It was developed for 5–8 years old children and includes a behavioral test and pictures of food. Reliability of the scale is equal to that of the behavioral task in FNS (α = 0.84) and assessment of validity was good. It was developed and tested in French and then translated into English. Testing comprehensibility of the items would be valuable to confirm reliability of the English version. The instrument may be less expensive and time-consuming than instruments including actual foods, as the behavioral task includes pictures of food. Pictures have previously been shown suitable for obtaining information about food preferences and food choice in children across different ages (Olsen, Kildegaard, Gabrielsen, Thybo, & Møller, 2012). However, behavioral tests with actual foods may be more reliable to assess food-related behavior, because it is possible to evaluate an actual food with more senses than a picture, which may be judged only by the sight, associations and memories of other sensory attributes of the food. Accordingly, using pictures of novel foods may be particularly challenging in this context.

The **WillTry** Instrument (Thomson et al., 2010) intended for 5 to 14-year-old children constitute another way to assess willingness to try unfamiliar foods – mainly fruits and vegetables. It is therefore similar to the FVNI, but the target group is wider (FVNI: 8 to 10-year-olds). Moreover, the WillTry Instrument, in contrast to the FVNI, included a behavioral test with pictures of food accompanying the questionnaire. To make the instrument relevant to measure food neophobia, it is important to assess the familiarity of foods included. In the WillTry Instrument, construct validity was established between the questionnaire and a behavioral food task, implying the questionnaire could be administered alone and predict willingness to try food. However, reliability of the questionnaire is low, but improve and become acceptable when certain items are excluded (α = 0.46–0.77), while measures of validity appear to be quite good. Results from this instrument should therefore be interpreted with some caution.

The **FSQ** (Loewen & Pliner, 2000) was developed to target 5–12 years old children, however 5 to 6-year-old children were discarded, because they were unable to maintain attention throughout the task, and they used the scale differently than the remaining children by fixating on extreme or intermediate responses, or on one response category. This emphasizes the importance of considering the instrument in relation to the target group. Reliability of the method is relatively high for the 7 to 12-year-old children (α = 0.71–0.80) and measures of validity quite good. However, phrasing of items in the questionnaire may lead to confusion and responses may apply to different aspects of the items (food situations or specific foods). Additionally, cultural elements in

items (Halloween) make use of the instrument country-specific, which should be considered if intending to use the instrument.

The **TTT** (Kaiser et al., 2012) is developed to be administered in a class-setting for children above 8 years of age and instructed by a teacher. It is a relatively easy instrument to apply to many children at a time, as responses are given as the total number of raised hands in a class. Reliability of the instrument is high ($\alpha = 0.86$) and validity quite good suggesting measurement outcomes reflects children's actual willingness to taste foods. However, the approach may lead to bias in responses due to influence by peers. In the protocol, the authors have tried to overcome this challenge by instructing teachers administering the TTT to tell children to wait expressing their opinion until everyone have tried the food presented. The instrument encompasses tasting of a single food. Therefore, food neophobia and willingness to taste is limited to only concern the specific food included in the test. Yet, it is possible to repeat the test, allowing to test several foods in consecutive sessions. The TTT has potential to test children's willingness to try specific foods. It may be relevant to use for industries, parents and health care professionals working with children to investigate the potential of a new product, the likelihood of children liking or disliking specific foods and to identify in which settings children would be willing to eat a food. It could be advantageous to develop alternative means of collecting responses from subjects than raise of hands to minimize peer influence. Accordingly, we propose use of electronic devices and programs for collection of responses e.g. *"Clickers"* or *"Kahoot"*.

2.2.3. Instruments with and without behavioral tests for adults

Six instruments were developed to target adults (The FNS, VARSEEK, FEQ, FAS, DSI and FNTS). Of these, only one (the FNS) included a behavioral validation test. Several instruments include various elements and the measurement outcome varies greatly.

The **FNS** (Pliner & Hobden, 1992) is currently the most widely used instrument to investigate food neophobia (Galloway et al. 2003; Knaapila et al. 2007; Mustonen et al. 2012; Olabi et al. 2009; Ritchey et al. 2003; Rubio et al. 2008). It consists of a simple instrument with 10 items, which are highly reliable ($\alpha = 0.88$) and have quite good measures of validity. It has been validated with a behavioral test, which may be incorporated into the instrument. However, this would be time-consuming and it would require that foods included in the behavioral test are assessed for familiarity. Thus, we recommend not to apply the behavioral test. It is suspected that several items in the FNS are not relevant worldwide at the moment. In line with this, it has been demonstrated that excluding 2 or 4 items from the FNS improve the method when used in several countries (Ritchey et al., 2003). We therefore recommend to evaluate the content of items in the FNS and apply those that are relevant in each context. Moreover, re-testing reliability of the FNS and critical assessment of items in the FNS nowadays would be valuable.

The **VARSEEK** (van Trijp & Steenkamp, 1992), is similar to the FNS. It measures intrinsic desire for variety in food choices. It is shorter than the FNS (8 compared to 10 items), but items are longer in the VARSEEK compared to the FNS. The VARSEEK is slightly more reliable ($\alpha = 0.90$) than the FNS ($\alpha = 0.88$), and has good measures of validity compared to quite good measures in the FNS. This would not be expected, because Cronbach's α depends on the number of items. Internal consistency increases when more items are added to an index, because the impact on the index of random error in each item is reduced (Andersen et al., 2012; Cronbach, 1951). The VARSEEK therefore seems more reliable than the FNS, and items in the VARSEEK appear to measure the underlying phenomenon it investigates a little more precisely than the FNS. Both the VARSEEK and the FNS were send to review in 1991 (in April and May, respectively) and published in 1992, so it could be suspected that both instruments would be improved by revising items regarding current relevance of the content.

The **FEQ** (Raudenbush et al., 1995) approaches a combination of constructs; neophobia, pickiness and eating apathy in one questionnaire. The subscale "eating apathy" is not very reliable ($\alpha = 0.39$), whereas the subscales "neophobia" consisting of 7 items and "pickiness" consisting of 4 items, are highly reliable ($\alpha = 0.85–0.86$). However, the subscales are administered together as one questionnaire implying the overall reliability is in between $\alpha = 0.39–0.86$ (exact α is not reported). The FEQ has good measures of validity. When examining the content of items in the FEQ, it appears that only the subscale "neophobia", which consist of a modified version of the original FNS, is relevant to measure food neophobia and willingness to try unfamiliar foods. The usefulness of the FEQ to measure neophobia is therefore very limited, and we recommend to use the original FNS instead of the FEQ.

The **FAS** (Frank & van der Klaauw, 1994) constitutes a comprehensive instrument including rated willingness to try 455 foods and beverages. Moreover, it includes the same items as the FEQ, but the items are not separated into subscales. Cronbach's α is not specified, and reliability of the instrument can therefore not be evaluated. However, the researchers find that familiarity and pleasantness is correlated with rejection of foods ($p < 0.0001$). The FAS therefore has potential to assess individual differences in responses to food. However, it is highly time-consuming for the respondent and it encompasses specific foods, which may not be relevant across cultures. Nevertheless, the 20-item scale, which constitutes the questionnaire of the FAS, may have potential to assess neophobia and willing to try unfamiliar food. Based on the content of items and because the Cronbach's α was not reported, we believe the FNS is a more reliable instrument to assess food neophobia and willingness to try unfamiliar foods, however.

The **DSI** (de Barcellos et al., 2009) combined with a modified version of the FNS is a instrument intended for industry and manufacturers of food products. It is highly reliable ($\alpha = 0.78–0.80$), but measures of validity are not reported and are therefore considered weak. The potential to measure food neophobia and willingness to try unfamiliar foods may therefore be questioned. The DSI assesses respondents attitude towards purchasing new and innovative foods and the FNS has been modified, so that focus in the items is on innovative foods. Attitude towards innovative foods and intent to purchase a product may not reflect food neophobia, but rather prioritization and economic considerations. However, the content of items in the FNS is related to attitude towards unfamiliar foods, and a combination of the FNS and DSI may therefore be useful, especially to manufacturers. The **FTNS** (Cox & Evans, 2008), which is also relevant for manufacturers, assesses consumers' willingness to eat foods produced with novel technologies. The FNTS is highly reliable ($\alpha = 0.84$) and correlations between the FTNS and FNS, and FTNS and willingness to try scales ($p < 0.01$) indicate validation of the instrument is very good. The content of items relates to the necessity of new food technologies, perception of risks, healthy choices and information, which makes the FNTS highly relevant for manufacturers and researchers within consumer science. Compared to the DSI, the FNTS has a greater potential to measure phobia related to food technology, while the DSI is more relevant to measure intention to purchase innovative food products.

It appears that the different instruments measure distinctive aspects of food neophobia and willingness to try unfamiliar food. Target group and measurement outcomes are generally specific, and the time and cost requirements vary. Recommendations for selection of the most appropriate instrument according to the purpose of an investigation may therefore be useful.

2.3. Recommendations and conclusion

Although neophobia and willingness to try unfamiliar foods may appear as relatively simple personality traits, which can be measured with one questionnaire, our findings revealed that it is complex and consists of many aspects. Instruments are associated with different strengths and weaknesses, and no instrument is suitable for measuring all aspects of neophobia and willingness to try unfamiliar foods.

In the instruments reviewed, aspects of neophobia, which were assessed included attitude towards innovative food products (de Barcellos et al., 2009) and foods produced with new technology (Cox & Evans, 2008), specific food categories such as fruits and vegetables (Hollar et al., 2013; Thomson et al., 2010) and food situations (Loewen & Pliner, 2000). Moreover, specific instruments are developed to measure variety seeking (van Trijp & Steenkamp, 1992), food attitude (Frank & van der Klaauw, 1994), willingness to try unfamiliar foods (Kaiser et al., 2012; Rubio et al., 2008), eating behavior (Raudenbush et al., 1995; Wardle et al., 2001) and food neophobia (Pliner & Hobden, 1992; Pliner, 1994). Many aspects of nephobia and willingness to try unfamiliar foods may consequently be assessed by means of instruments already developed. However, for some subcategories of novel foods - such as gene modified and functional foods - the relation between consumer's attitude and food neophobia may not be straightforward (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). This indicates a need for more knowledge about food neophobia in relation to food types - possibly with subcategories of "novel foods".

Seven instruments were developed to target children of varying age. For very small children from the age of 2 (to 9), the CEBQ encompasses a reliable and valid instrument to measure eating behavior, when completed by a parent. From the age of 5, the FNSC, FNQ and Willtry Instrument appears to be reliable instruments to assess neophobia and fruit and vegetable intake, respectively. However, certain subscales of the Willtry Instrument were not very reliable, and the instrument should include all subscales to be reliable. These three instruments included behavioral tests and validity measures were quite good. The FSQ measuring willingness to try unfamiliar foods in different situations may be applied to children from the age of 7. This instrument is highly reliable and includes quite good validity measures. From 8 years of age, the TTT may be administered by a teacher in a class setting to measure willingness to try unfamiliar foods. It is a highly reliable instrument with quite good validity measures. Moreover, it is easy to administer to many children at a time. Additionally, the CEBQ may be administered to children from 8 to 10 years old. It is a highly reliable instrument to measure fruit and vegetable intake in children, and it produces results with very good validity.

Within the validity measures, behavioral validation included tasting of foods and/or demonstration of pictures of foods (see the FNSC, FNQ, FSQ, TTT and WillTry Instrument). It may be relevant to include behavioral tests for small children, especially children below the age of 7, because the cognitive abilities are less developed in this age group. However, it is more time-consuming and costly to include a behavioral test.

Six instruments were developed to target adults (The FNS, VARSEEK, FEQ, FAS, DSI and FNTS). Of these, only one (the FNS) included a behavioral validation test. Additionally, the FNS was the only instrument, which included a balanced number of reversed items in the scale. The FNS is highly reliable in measuring food neophobia and have quite good measures of validity. The FNS has been combined with the DSI and FTNS to measure attitude towards purchasing new and innovative foods and foods produced with technology. These instruments are highly reliable, and measures of validity of the FTNS are very good. However, no data on validation is reported in relation to the DSI. To measure willingness to try unfamiliar foods, the FAS and FEQ, which incorporates the FAS, can be used. However, reliability of the FAS is not reported, but measures of validity are quite good. Including all subscales of the FEQ, it is highly reliable and has good measures of validity. Finally, the VARSEEK produces highly reliable measures of intrinsic desire for variety in food choices and quite good measures of validity.

In the 13 instruments reviewed, 113 to 1485 subjects aged 2–65 years were involved, 6 to 35 items were included, scales with 3–7 response categories were used and in 6 studies behavioral validation tests were included.

We recommend selecting the instrument, which most accurately measures an intended outcome in relation to the target group. Moreover, it is important to select a scale accordingly. No studies reported what the optimal number of items in relation to specific target groups is. In accordance with findings discussed previously, it seems appropriate to select 3- to 5-point scales for children, 5- to 7-point scales for parents responding on behalf of their child and 7 to 10 response categories for adults. The attention span of different age groups may differ, and we consequently suggest including fewer items in relation to children and more in relation to adults. In any case, we recommend including as few and relevant items as possible when developing a new instrument.

The optimal number of items in questionnaire has been discussed, but we suggest including a limited amount of highly relevant items to prevent exhaustion in subjects and make instruments applicable to a wide range of age groups meanwhile obtaining adequate relevant information. However, researchers may want to compromise this argument to obtain more detailed information in their investigation.

Instruments with high reliability, which have quite good, good and very good validation measures appear to be the best methods to select among the instruments presented. However, researchers may compromise measures of reliability and validity in cases where a more detailed picture of food neophobia and willingness to try unfamiliar foods is required. Food neophobia and the mechanisms behind are complex, and researchers may therefore want to combine several instruments to obtain more information about different aspects of food neophobia.

The instruments reviewed in this paper are especially relevant for health care professionals and food product developers.

We conclude that there are multiple and different instruments to measure food neophobia and willingness to try unfamiliar foods. The instruments needed depend on the purpose of an investigation, which may for example be to enable development of strategies for improvement of diets or to increase the success rate of new food products entering the market.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.appet.2017.02.032.

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