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REVIEW

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Methodological approaches to assess tactile sensitivity in the food context—A scoping review

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Abstract

In contrast to taste sensitivity, the assessment of texture or tactile sensitivity has received relatively little attention in the food context. Texture plays an important role in food preferences and food intake, and individual differences make it important to understand physiological drivers of perception as tactile sensitivity. The multi-dimensional and dynamic aspects of texture perception suggest there is not one single method that can explain individual differences. This scoping review aims to systematically map methods assessing tactile sensitivity, in the context of food, highlighting differences in approach and implementation. Eligibility criteria included papers describing methods to assess individual differences in tactile sensitivity, that involved human participants and the context was relevant to food behavior. Sources are peer-reviewed publications of original research in English. In mapping the methods, we assessed how they relate to food texture parameters (mechanical, geometrical, and surface) and the dynamics of breaking down (touch with hand, first bite/sip, oral processing, residual or after-swallowing sensations). We also review other parameters associated (oral processing, preference, diet and food intake behavior). The literature in this relatively young area is still very fragmented and it is difficult to have a clear picture regarding best practices or recommendations for the measurement of tactile sensitivity in the food context. Future studies should aim to methodological harmonization for application in the food behavior area, with a design of experiment combining different aspects of tactile sensitivity to food, focusing on the thresholds and perceived intensity of textural parameters as well as affective and behavioral responses, and covering the whole spectrum of tactile texture perception (mechanical, geometrics, and surface), including the dynamics of perception.

KEYWORDS
food intake, geometrical properties, mechanical properties, preferences, sensory perception, surface properties

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1 | INTRODUCTION

1.1 | Background

Food texture plays an important role in food preferences and rejection, texture liking is in fact considered as important as flavor as driver of food choices (Pellegrino & Luckett, 2020). How the food is manipulated and perceived in the mouth is determined by the interaction with the food structure; and textural properties are not only linked to preferences, but also to food intake amounts, by influencing satiety perception and meal size estimation (McCrickerd & Forde, 2016). Different groups of consumers may have distinct textural preferences and satiety perception (Varela et al., 2021) which may in turn be reflected in different food consumption patterns (Laureati et al., 2020). The influence of texture perception in food choices can be more pronounced in sensitive periods of life, that is, childhood and old age. Neophobia and picky eating in childhood are often manifested in the rejection of, for instance, heterogeneous or clumpy textures, while in older consumers, harder and sticky textures can be an issue for chewing, together with an enhanced dryness and astringency perception (Chow et al., 2022; Schwartz et al., 2018).

Segments of consumers who like foods with different textural characteristics, have been linked by some authors to preferred ways of manipulating food in the mouth (Jeltema et al., 2016); however, the concept of mouth behavior has been disputed by some (Kim & Vickers, 2020). At the light of those group and individual differences, the concept of tactile sensitivity may be key to better understand differences in textural preferences and eating behavior. Liu et al. (2022) suggest some factors influencing tactile sensitivity may include age, sex, ethnicity as well as various physiological factors, but still, how those affect perception, preferences, and other expectations, have not been consistently studied in literature; while some works show relationships between oral tactile sensitivity and sensory perception or preference of food texture, other studies fail to do so. In a review on texture perception and preference of children the authors even went so far as to state that the two concepts, tactile sensitivity and texture preferences, appear to be unrelated (Chow et al., 2022). However, compared to basic taste sensitivity, the assessment of tactile sensitivity has received relatively little attention so far (Zhou et al., 2021) and is therefore still in a formative stage.

Texture perception is multifaceted and therefore more complex than the measurement of basic tastes. Texture perception is multidimensional: it is not perceived by a single receptor (in contrast to basic tastes and color) (Szczesniak, 2002), but composed of tactile sensation of the skin/cutaneous system (mechanoreceptors, thermoreceptors, and nociceptors embedded in the skin) as well as proprioceptive sensation through kinesthesis (mechanoreceptors embedded in muscles, tendons, and joints) needed for sensing active touch (Lederman & Klatzky, 2009; Pramudya & Seo, 2019).

To represent the highly multidimensional construct of food texture, characteristics have been classified into three primary categories: mechanical, geometrical and surface properties (Szczesniak, 1963, 2002) with further subcategories, see for example, ISO norms on texture vocabulary (ISO 5492:2008 Sensory vocabulary, ISO 11036:2020 Texture profile) and a recently developed texture sensory wheel (Bondu et al., 2022). Further, there is a dynamic component in the perception of food texture. While some texture parameters are perceived when the food is first placed in the mouth (and even previously if one includes skin touch with the hand or manipulation with utensils (Pramudya & Seo, 2019)), most texture characteristics change during consumption, and are perceived when the food is deformed, broken, manipulated and moved around with the tongue in the oral cavity and mixed with saliva, as well as leaving residual sensations after swallowing (Szczesniak, 2002).

The multidimensional as well as dynamic aspects of food texture perception and the complexity of the receptors sensing texture, indicate that there is not one single physiological method that can explain individual differences in food texture sensitivity. Instead, a wide range of methods has come into application, and they should be combined to get a more wholistic picture into texture or tactile sensitivity. Apart from physiological methods, tactile sensitivity has also been assessed through validated questionnaires, many building on the concept of sensory processing (Chow et al., 2022). Sensory processing connects neurological thresholds (high vs. low) and behavioral response (active vs. passive) leading to different sensory processing patterns.

1.2 | Objective

This scoping review aims to systematically map methodological approaches to measure tactile sensitivity in the food context.

Primary research question: What tactile sensitivity methods are available to study individual differences in food related consumer behavior? Are the test protocols used consistently across studies? What are the main differences of the methods that have been proposed to measure sensitivity?

Secondary research question: Is tactile sensitivity related to food preferences and food behavior (oral processing, preference, diet and food intake behavior)?

No previous reviews on the described topic have been found in a preliminary search in database (December 9, 2021). However, two narrative literature reviews on oral tactile sensitivity (Liu et al., 2022) and texture perception (including tactile sensitivity methods) and preference of children (Chow et al., 2022) have been published recently and were considered in the writing of this paper. Liu et al. (2022) included selected psychophysical measurements (experimental methods that connect physical parameters to human perception). In this scoping review we aim to provide an extensive overview of tactile or texture sensitivity methods that have been applied in the food context also including questionnaire formats that assessed hypersensitive sensory processing.

2 | METHODS

2.1 | Protocol and registration

A protocol was registered prospectively with the Open Science Framework on November 9, 2021 (https://osf.io/u5req/?view_only=c57bee6a3f4f4cd3b6d5dceeb1a45a18).

2.2 | Eligibility criteria

Papers included in this review needed to describe a methodological approach used to assess individual differences in tactile sensitivity. Included studies involved human (not animal) participants and the context was limited to studies that described the sensitivity method as relevant to food-related consumer behavior. Experimental methods that did not control for perception via other senses, for example, chemoreceptors in the case of fat sensitivity, were not included. However, with questionnaires this distinction could not be implemented to the same degree. The source of information included was limited to peer-reviewed publications of original research in English without restriction on publication year.

2.3 | Sources of evidence

The search was conducted in two databases, Web of Science and Scopus, according to the following procedure: Initial limited search in one online database (Scopus) followed by an analysis of the text words contained in the title, abstract, and of index terms. Second search using all identified keywords and index terms across included databases on March 1, 2022 (search queries in Supplementary material 1). The reference list of identified articles was searched for additional sources to be included in the review. An excel file was used for the management of the results of the search. Source selection (both at title/abstract screening and full-text screening) was performed by one reviewer. The fulfillment of the decision criteria were then discussed with the second author.

2.4 | Charting methods

The initial data charting procedure described in the registered protocol was adapted iteratively and discussed between the two authors of this review. The following information was extracted from the included studies and summarized in a table: reference, sample (sample size and subsamples if applicable), test protocol indicators (including a reference to a previous test protocol if applicable), results related to method (if applicable), associations between methods used within a study (if applicable) as well as associations to food preferences and behavior (if applicable). The extracted methods were classified according to methodological approach (instrumental measurements, food models, questionnaires), response measured, texture category, and dynamic stage of food ingestion (if applicable).

3 | RESULTS

3.1 | Selection of articles

Figure 1 presents the flow chart of the article selection process. Fifty one studies met the inclusion criteria for this review.

3.2 | Methodological approaches used to assess food texture sensitivity

An overview of the individual studies included in this review is presented in Table 1 including an overview of methods used, results related to method assessment as well as tested associations to food preferences and behavior.

The identified studies group into three measurement approaches: instrumental measurements (Section 3.2.1), food models (Section 3.2.2) and questionnaires (Section 3.2.3). Instrumental measurements mostly used standardized, reproducible measurement devices such as clinical tools or 3D printed devices. Food models consisted of ingested samples that were manipulated in a way to measure the sensitivity toward a specified texture aspect. Questionnaires consisted mostly of scales or subscales related to tactile or food texture sensitivity but included an experimental setup where stimuli were rated in a questionnaire, either by respondents or through observation in the case of young children.

In the following sections, the methods identified will be described highlighting differences in implementation between the included studies, results related to method assessment, associations between methods if assessed, as well as tested associations to food preferences and behavior. References to the study setups can be found in Table 1 if not indicated in the text.

3.2.1 | Instrumental measurements

The instrumental methods identified included clinical measurement tools as well as more tailor-made devices. In all cases, the tactile properties could be quantified by physical measurements.

One-point pressure (15 method descriptions)

One-point pressure to measure sensitivity to light touch was the most widely applied instrumental measurement. In 14 method descriptions, commercially available clinical tools called Von Frey or Semmes-Weinstein monofilaments of different thicknesses (corresponding to different weights and forces) were applied while one study used air pressure instead of monofilaments (Chamberlain et al., 2007). For measurements with monofilaments, a fiber was pressed vertically against a skin surface until a bend was reached which translated to a specific force depending on the thickness/weight of the filament fiber. The studies differed regarding response measured and measurement location. Seven studies measured detection threshold with staircase procedures. Some staircase protocols controlled for response bias using a (temporal) 2-Alternative forced choice (2-AFC) test. Five studies measured detection of one or several filament weights via R-Index where response bias is controlled via signal detection theory a low value indicating guessing and a high value detection (see O'Mahony (1992) for a detailed explanation of R-Index), one including protocol recommendations for the measurement with children (Appiani et al., 2020). Two studies assessed discrimination threshold between filament weights with a staircase procedure using weights above

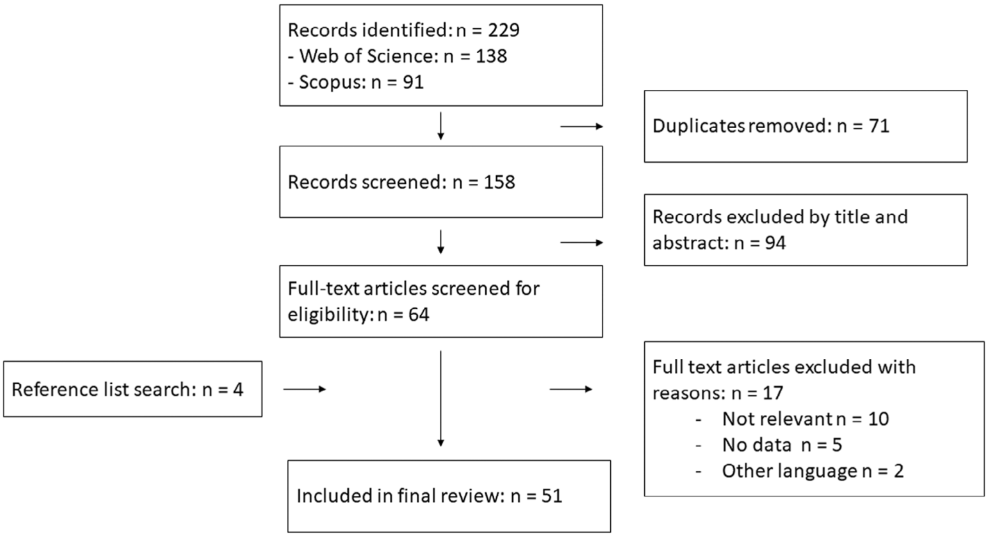

FIGURE 1 Flow chart of article selection process.

individuals' detection threshold. Further, two studies measured the perceived intensity of filament weight/air pressure on a visual analogue scale (VAS). One-point pressure sensitivity was measured at different locations on the tongue, other places in oral cavity, on the outer lips and fingers.

A methodological study estimated the time to measure thresholds (detection or discrimination) to 20 min per respondent, also providing test protocol recommendation such as rewetting the tongue continuously in order to maintain sensitivity (Etter et al., 2020). Further, the authors of the study concluded a floor effect for measuring detection thresholds where the majority of respondents could detect the lowest filament weight that is commercially available (0.008 g) as limitation, a result found in several other studies as well (Breen et al., 2019; Lv et al., 2020; Santagiuliana et al., 2019). Correspondingly, the detection measurement via R Index with lowest filament weight showed a better discrimination between respondents than the next heavier filament (Appiani et al., 2020; Zhou et al., 2021); distributions being; however, still skewed toward a high fraction of detecting respondents (Appiani et al., 2020). Two studies measured discrimination thresholds additionally to detection thresholds and concluded a better discrimination between individuals with this procedure (Breen et al., 2019; Etter et al., 2020). Some studies further found that measurement place had an effect on sensitivity; Aktar et al. (2015b) (but not Aktar et al. (2015a)) found a lower detection thresholds on the tongue than fingertip, Yackinous and Guinard (2001) found a higher detection rate (R-Index) on the front tongue than mid tongue and Chamberlain et al. (2007) a higher perceived intensity on the anterior tongue than the posterior tongue and velum.

One study compared one-point pressure detection via R-Index to a second instrumental measurement, the grating orientation task, finding a significant but weak correlation between low filament weights and finer gratings[1] (Appiani et al., 2020). Further, several studies compared one-point pressure detection (threshold or R-Index) to texture sensitivity in food models without finding associations to viscosity (Aktar et al., 2015b; Lv et al., 2020), hardness (Aktar et al., 2015b), elasticity (Aktar et al., 2015b) and particle texture (Breen et al., 2019; Santagiuliana et al., 2019). However, Breen et al. (2019) did find a significant association with particle texture measuring discrimination thresholds (instead of detection thresholds).

Four studies measuring one-point pressure detection (threshold or R-Index) and one study measuring perceived intensity (Ludy & Mattes, 2012) investigated in the association with food preferences and behavior. In two studies, researchers concluded an association with oral processing: mastication performance (Schimmel et al., 2017) and preferred oral processing behavior (firm vs. soft) (Cattaneo et al., 2020). However, no associations to preferences: liking of yoghurt samples (Liu et al., 2021), food texture (Appiani et al., 2020) or diet and food intake behavior: food consumption frequency (Appiani et al., 2020), food neophobia (Appiani et al., 2020), spicy food usage (Ludy & Mattes, 2012) were found in total samples. Appiani et al. (2020) found a weak but significant effect of one-point detection on food neophobia in the youngest age group (6–7 y.o.) of children suggesting a potential relevance for young children.

Letter recognition (eight method descriptions)

The stereognosis assessment via letter recognition task required respondents to recognize capital letters of the Latin alphabet by active touch of the letter on their tongue involving kinesthetic perception. Most studies used commercial Teflon strips with embossed letters, while one study used custom-made 3D printed letters and three studies used confectionary letters. Only a subset of letters was used of which respondents were however not aware resulting in a low guessing probability. The studies differed regarding response measured. The most common test protocol (with engraved or 3D printed letters) aimed to measure the letter size recognition threshold, all studies referring to a test protocol proposed by Essick et al. (1999) resulting in aligned implementations via a staircase procedure while the studies with confectionary letters measured recognition of one font size via forced-choice tests.

Steele et al. (2014) found fewer reversals than recommended by Essick et al. (1999) to be sufficient: three for young adults and five for elderly participants. Further, one study administered the letter

TABLE 1 Overview of the individual studies included in this review: methods used, results related to method and (when relevant) assessment, and tested associations to food preferences and behavior. Methods were ordered according to measurement approach and number of method descriptions in studies within each measurement approach.

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
24	Aktar et al. (2015a)	Instrument	One-point pressure with monofilaments *Detection threshold* (*weight: 0.008–1 g*)*: descending staircase* *Tongue, index fingertip* (*passive touch*)	$N = 30$ adults	Measurement location: fingertip versus tongue (ns)	ns (1&2)	
		Food model	Viscosity in syrup solution *Discrimination threshold of attribute "viscosity"* (*dynamic viscosity: 1.05–495 mPa s*)*: ascending staircase w/Same/Different test, constant reference at lowest viscosity* *Tongue and index fingertip* (*active touch*)		Measurement location: lower thresholds on tongue than fingertip (tongue measurement confounded by difference in sweetness taste corresponding to syrup concentration)		
61	Aktar et al. (2015b)	Instrument	One-point pressure with monofilaments *Detection threshold* (*weight: 0.008–300 g*)*: ascending staircase* *Tongue, index fingertip* (*passive touch*)	$N = 32$ adults	Measurement location: tongue more sensitive than fingertip	ns (1&3,1&4,2&3,2&4)	
		Instrument	Two-point discrimination *Distance threshold* (*distance: 0.25–15 mm*)*: descending staircase, static pressure* *Index fingertip, tongue* (*passive touch*)		Discrimination between respondents: limitation through floor effect, lowest distance detected by majority Measurement location: tongue more sensitive than fingertip		
		Food model	Hardness in jelly *Discrimination threshold of attribute "firmness"* (*firmness: 2.6–4.6 N*)*: ascending staircase w/same/*		Measurement location: tongue versus fingertip (ns)		

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			different test, constant reference at lowest hardness *Tongue and index fingertip (active touch)*				
		Food model	Elasticity in jelly *Discrimination threshold for attribute "elasticity" (Young's modulus: 2.7–3.4 × 10^4 Pa): ascending staircase w/same/different test, constant reference at lowest elasticity* *Tongue and index fingertip (active touch)*		Measurement location: tongue more sensitive than fingertip		
2	Appiani et al. (2020)	Instrument	One-point pressure with monofilaments *Detection (weight: 0.008, 0.02 g): R-Index* *Tongue (passive touch)*	*N* = 217 adults and children *n* = 147 children (6–13 y.o.), *n* = 70 adults	Discrimination between respondents: wider distribution for 0.008 than 0.02 g in children and adults Test protocol recommendations with children (e.g., warm-up with monofilament on arm first)	s (1&2)	**Preference:** Food texture preference (ns) **Diet and food intake behavior:** Food consumption frequency (ns), Food neophobia (ns*) 2* In youngest age group of children weak but significant positive effect of lingual tactile sensitivity to the finest Von Frey filament
		Instrument	Grating orientation with custom-made 1 cm^2 stamps *Recognition (groove width:0 .2, 0.25, 0.5, 0.75, 1, 1.25 mm): R-Index* *Tongue (passive touch)*		Groove widths (0.2–0.5 mm) was determined as not suitable for testing with children in a pilot; sensitivity of children for higher groove widths were comparable to adults. Test protocol recommendations for children: for example, indication of orientation (horizontal/vertical) with hand		**Preference:** Food texture preference (ns) **Diet and food intake behavior:** Food consumption frequency (ns), Food neophobia (ns)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
39	Bangcuyo and Simons (2017)	Instrument	Letter recognition with 3D printed letters *Size threshold (size: 1.5–8 mm): adaptive staircase w/visual answer key (alphabet)* *Tongue (active touch)* *Ref*: Essick et al. (1999)	$N = 48$ adults	Threshold, average: 4.2 mm	-	
45	Breen et al. (2019)	Instrument	One-point pressure with monofilaments *Detection threshold (weight: 0.008–15 g): adaptive staircase w/2-AFC* *Tongue: left and right anterior lateral edge and midline tip (passive touch)*	$N = 51$ adults	Discrimination between respondents: limitation through floor effect, lowest filament weight detected by majority Measurement location: left versus right anterior lateral edge versus midline (“center”) of the tongue tip (ns)	s (1&2) ns (1&3)	
		Instrument	One-point pressure with monofilaments *Discrimination threshold (weight: above individual's threshold): adaptive staircase w/2-AFC* *Tongue: left and right anterior lateral edge and midline tip (passive touch)*	$n = 47$	Discrimination between respondents: larger variance measured than for one-point detection threshold Measurement location: left versus right anterior lateral edge versus midline (“center”) of the tongue tip (ns)		
		Food model	Particle texture in chocolate *Discrimination for attribute “grittiness” (D_{90}: 19.7 & 25.2 µm): 2-AFC* *Oral cavity (active touch)*	$n = 44$	Association with one-point pressure discrimination: significant association between grittiness discrimination and one-point pressure discrimination group (high versus low) on midline tongue but not lateral edges of tongue.		

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
A6	Calhoun et al. (1992)	Instrument	Two-point discrimination *Distance threshold (distance not indicated): ascending and descending staircase, static pressure* *Cheek: left and right, lip: upper and lower, tongue: anterior, midpalate (passive touch)*	$N = 60$ adults 5 age categories:20–< 80 y.o.		-	
		Instrument	Shape recognition with plastic shapes *Recognition (size not indicated): forced choice w/visual answer key* *Tongue (active touch)*		Discrimination between respondents: 41.7% to 100% in age groups, differences in accuracy between shapes		
		Instrument	Vibratory sensation with tuning fork (256 Hz) *Discrimination (vibration* vs. *non-vibration pressure): forced-choice* *Lower lip (passive touch)*		Discrimination between respondents: majority of young age group could discriminate, decline with age		
		Instrument	Sharp versus soft discrimination with compass needle and cotton tip *Discrimination (sharp/soft): forced-choice* *Tongue: anterior, midpalate (passive touch)*		Discrimination between respondents: majority could discriminate (99% on tongue and 95% on palate)		
13	Cattaneo et al. (2020)	Instrument	One-point pressure with monofilaments *Detection (weight: 0.008, 0.02, 0.04 g): R-Index* *Tongue (passive touch)*	$N = 152$ adults $n = 75$ Chinese, $n = 77$ Danish			**Oral processing:** Firm processing likers more sensitive than soft processing likers.
37	Chamberlain et al. (2007)	Instrument	One-point pressure with air *Perceived intensity (weight: 0.000–0.140 g): gLMS* *Tongue & velum: anterior and posterior thirds (passive touch)*	$N = 372$ adults $n = 195$ Mexican American, $n = 177$ European American	Measurement location: perceived intensity stronger on anterior tongue than other locations		

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
64	Coulthard, Abdullahi, et al. (2022)	Questionnaire	Adolescent/Adult Sensory Profile (AASP), low neurological threshold tactile items *Frequency rating (items describe hypersensitive affective and behavioral responses, for example, "I dislike having my back massaged"): 5-point Likert scale* *Body (active and passive touch)* Ref: Brown & Dunn (2002) (commercial questionnaire)	$N = 232$ $n = 127$ picky eaters, $n = 105$ non-picky eaters			**Preference:** Mediation of willingness to taste food with edible changes compared to "normal" food: tactile sensitivity was mediator; Mediation of willingness to taste food with non-edible changes compared to "normal" food (ns) **Diet and food intake behavior:** Picky eating: Higher tactile sensitivity in picky eaters
28	Coulthard, Aldridge, and Fox (2022)	Questionnaire	Adolescent/Adult Sensory Profile (AASP), low neurological threshold tactile items *Frequency rating (items describe hypersensitive affective and behavioral responses, for example, "I dislike having my back massaged"): 5-point Likert scale* *Body (active and passive touch)* Ref: Brown & Dunn (2002) (commercial questionnaire)	$N = 534$	Internal consistency: $\alpha > .6$		**Diet and food intake behavior:** Food neophobia: significant correlation and prediction in multivariate model
48	Coulthard and Sealy (2017)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver (items describe hypersensitive affective and behavioral responses): 5-point Likert scale* *Whole body (active and passive touch)* *Ref*: McIntosh et al. (1999) *(commercial questionnaire)*	$N = 62$ children (3–4 y.o.)	Internal consistency: $\alpha = .69$		

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
27	Coulthard and Sahota (2016)	Questionnaire	Tactile play with visible, edible stimuli *Enjoyment rating by parent and researcher for children/parent themselves (stimuli expected to evoke negative affective and behavioral responses in hypersensitive individuals): 5-point Likert scale* *Hands (active touch)*	$N = 126$ $n = 63$ children (2–5 y.o.) $n = 63$ parents		s (1&2, 1&3)	**Diet and food intake behavior:** Food neophobia: negative correlation and strongest predictor in linear regression including (tactile sensitivity of child and parent, enjoyment of tactile play of child and parent, and food neophobia of parent)
		Questionnaire	Sensory profile (SP), low neurological threshold tactile items *Frequency rating by caregiver (items describe hypersensitive affective and behavioral responses*, for example, *“Avoids going barefoot, especially in sand or grass”): 5-point Likert scale* *Whole body (active and passive touch)* *Ref*: Dunn (1999) (*commercial questionnaire*), Coulthard and Thakker (2015b)	$n = 63$ children (2–5 y.o.)	Internal consistency $\alpha = .84$		**Diet and food intake behavior:** Food neophobia: negative correlation
		Questionnaire	Adolescent/Adult Sensory Profile (AASP), low neurological threshold tactile items *Frequency rating (items describe hypersensitive affective and behavioral responses, for example, “I dislike having my back massaged”): 5-point Likert scale* *Body (active and passive touch)* Ref: Brown & Dunn (2002) (commercial questionnaire)	$n = 63$ parents	Internal consistency $\alpha = .69$		**Diet and food intake behavior:** Food neophobia: negative correlation

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
23	Coulthard and Thakker (2015b)	Questionnaire	Sensory profile (SP), low neurological threshold tactile items *Frequency rating by caregiver (items describe hypersensitive affective and behavioral responses, for example, "Avoids going barefoot, especially in sand or grass"): 5-point Likert scale* *Whole body (active and passive touch)* *Ref*: Dunn (1999) (*commercial questionnaire*)	*N* = 70 children (2–5 y.o.)	Internal consistency: $\alpha = .75$ (with 11/12 items kept for analysis)	s (1&2)	**Diet and food intake behavior:** Fruit and vegetable consumption: lower FV consumption in children with high tactile sensitivity (SSP) Food neophobia (ns)
		Questionnaire	Tactile play with visible food stimuli *Enjoyment rating by caregiver and researcher (stimuli expected to evoke negative affective and behavioral responses in hypersensitive individuals): 5-point Likert scale* *Hands (active touch)*				**Diet and food intake behavior:** Fruit and vegetable consumption (ns) Food neophobia: lower food neophobia in children who enjoyed tactile play
29	Coulthard and Blissett (2009)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver (items describe hypersensitive affective and behavioral responses): 5-point Likert scale* *Whole body (active and passive touch)* *Ref*: McIntosh et al., 1999 (*commercial questionnaire*)	*N* = 73 children (2–5 y.o.)			**Diet and food intake behavior:** Fruit and vegetable (FV) consumption: negative correlation Food neophobia: positive correlation Moderation of mother's and child's FV consumption
A8	Engelen et al. (2005)	Food model	Particle texture in custard dessert *Perceived intensity of attribute "particle size" (D_{50}: 2–*	*N* = 11 trained assessors		s (1&2)	

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			180 μm): VAS, no particles and 250 μm particles as anchors *Oral cavity* (*active touch*)				
		Food model	Particle texture in custard dessert *Perceived intensity of attribute "roughness after-feel"* (D_{50}: *2–180 μm*): *VAS* *Oral cavity* (*active touch*)				
54	Engelen et al. (2004)	Instrument	Two-point discrimination *Distance threshold* (*distance*: *0–8 mm*): *staircase, static pressure* *Tongue*: *anterior* (*passive touch*)	*N* = 22 adults		ns (1&2)	**Oral processing:** Mastication indicators (ns)
		Instrument	Size estimation with steel spheres *Perceived intensity* (*size*: *4–9 mm*): *VAS with visual reference set* *Oral cavity* (*active touch*)				**Oral processing:** positive correlation for particles of 6.4 mm and larger with chewing efficiency after 15 strokes
A2	Essick et al. (2003)	Instrument	Letter recognition with *Teflon strips* *Size threshold* (*size*: *2.5–8 mm*): *adaptive staircase* *Tongue* (*active touch*) *Ref*: Essick et al. (1999)	*N* = 83 female adults *n* = 52 Asians, *n* = 31 Caucasians	Threshold: 2.5–6.8 mm		
3	Etter et al. (2020)	Instrument	One-point pressure with monofilaments *Detection threshold* (*weight*: *0.008–15 g*): *adaptive staircase w/2-AFC* *Tongue*: *midline* (*passive touch*)	*N* = 51 adults	Discrimination between respondents: limitation through floor effect, lowest filament weight detected by majority Measurement time per participant: appr. 20 min Test protocol recommendations (e.g., rewetting tongue in-between measurements)		

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
		Instrument	One-point pressure with monofilaments *Discrimination threshold (weight: above individual's threshold): adaptive staircase w/2-AFC* *Tongue: midline (passive touch)*	*N* = 107 adults	Discrimination between respondents: higher variance measured than for one-point detection threshold Measurement time per participant: appr. 20 min		
15	Heinze et al. (2018)	Food model	Fatty texture in milk-based samples with paraffin oil *Discrimination threshold of attribute "fattiness" (conc.: 5.4–894 mM): ascending staircase w/3-AFC, constant reference at lowest concentration* *Oral cavity (active touch)*	*N* = 30			**Diet and food intake behavior:** Food consumption (food diaries): higher processed meat and lower carotene (found in fruits and vegetables) consumption in lower tertile versus upper tertile
19	Kremer et al. (2007)	Instrument	Letter recognition with confectionary letters *Recognition (size not indicated): forced-choice w/visual answer key (10 alternatives)* *Tongue (active touch)*	*N* = 50 adults *n* = 22 elderly (60–85), *n* = 16 young (18–35)			
		Food model	Particle texture in powdered sugar *Discrimination for attribute "finer particles" (size not indicate): 2-AFC* *Oral cavity (active touch)*				
30	Lee et al. (2022)	Instrument	Grating orientation with 3D printed 1 cm^2 and 2 cm^2 stamps *Recognition (groove width: 0,5, 0.75, 1,25 mm): R-Index* *Tongue (passive touch)*	*N* = 2194 children (5–12 y.o.)	Method recommendations with children (e.g., familiarization run, indication of direction verbally/with hand or on visual answer key) Method assessment with children: 4% of children excluded due to difficulties with task. No significant difference in sensitivity		

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
					between age groups of children Discrimination between respondents: R-Index closest to normal distribution with a maximum at 0.5 at 1 cm^2 and 0.5 mm groove width* *as R-Index = 0.5 indicates the guessing probability a skewed distribution might be expected for groove width in the threshold region while a normal distribution at 0.5 would indicate no detection		
52	Linne and Simons (2017)	Instrument	Roughness sensitivity with stainless steel coupons *Detection threshold* (*Ra: 0.177–0.465 μm*)*: adaptive staircase w/2-AFC, constant reference at lowest roughness* *Tongue* (*active touch*)	N = 30			**Preference:** Liking of astringent versus less astringent version of food (unripe banana and dark chocolate): Higher liking of astringent food in low roughness threshold group
		Instrument	Roughness sensitivity with stainless steel coupons *Perceived intensity* (*Ra: 0.51 to 22.8 μm*)*: gLMS* *Tongue* (*active touch*)				
47	Liu et al. (2021)	Instrument	One-point pressure with monofilaments *Detection* (*weight: 0.008, 0.02, 0.04 g*)*: R-Index* *Tongue* (*passive touch*)	*N* = 152 adults *n* = 75 Chinese, *n* = 77 Danish			**Preference:** Liking of yoghurt samples (ns)
12	Ludy and Mattes (2012)	Instrument	One-point pressure with monofilaments *Perceived intensity* (*force: 2.83–5.46 mN**)*: VAS* *Tongue tip* (*passive touch*)	*N* = 25 *n* = 13 spicy food users, *n* = 12 non users			**Diet and food intake behavior:** Spicy food usage (ns)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			*although filament strength in mN was reported values identical to filament numbers corresponding to the following weights: 0.07–26 g				
38	Lukasewycz and Mennella (2012)	Instrument	Letter recognition with *Teflon strips* *Size threshold* (*size*: *2.5–8 mm*): *adaptive staircase w/visual answer key* (*alphabet*) *Tongue* (*active touch*) *Ref*: Essick et al. (1999)	*N* = 93 *n* = 49 children (7–10 y.o.), *n* = 44 mothers	Task duration, average: 7.5 min Threshold: 2.5–7.5 mm in children and adults Method recommendations with children (e.g., no blind-folding, visual answer key) Method assessment with children: two children (4%) excluded due to difficulties with task.		**Preference:** Hardness and particles preference (ns) **Diet and food intake behavior:** Food neophobia of children (ns) Negative reaction to food of children (ns)
		Instrument	Size estimation with 3D printed letter O *Perceived intensity* (*size: 1.5–8 mm*): *VAS with intermediate size as reference for mid-scale* *Tongue* (*active touch*)		Slope (actual size versus estimate) analyzed as psychophysiological curve		
21	Lv et al. (2020)	Instrument	One-point pressure with monofilaments *detection threshold* (*weight*: *0.008–0.4 g*): *ascending staircase* *Tongue tip* (*passive touch*)	*N* = 20 adults	Discrimination between respondents: limitation through floor effect, lowest filament weight detected by majority	s (3&4) ns (1&4, 2&4)	
		Instrument	Two-point discrimination *Distance threshold* (*distance:0.25-8 mm*): *ascending and descending staircase, static pressure* *Tongue tip* (*passive touch*)		Discrimination between respondents: limitation through floor effect, lowest filament weight detected by majority		
		Instrument	Vibration sensitivity with Bio-Thesiometer (100 Hz)				

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			Detection threshold (amplitude: 0–15 V): ascending and descending staircase *Tongue: anterior (passive touch)*				
		Food model	Viscosity in maltodextrin solution *Discrimination threshold of attribute "viscosity" (dynamic viscosity: 50–100 mPa s): ascending staircase w/Same/Different test, constant reference at lowest viscosity* *Oral cavity (active touch)*				
10	Lyu et al. (2021)	Food model	Viscosity in soup *Discrimination threshold of attribute "thickness" (dynamic viscosity: 11–48 mPa s): ascending staircase w/2-AFC, constant reference at lowest viscosity* *Oral cavity (active touch)*	$N = 47$ adults $n = 24$ infrequent chili consumers, $n = 23$ frequent chili consumers			**Diet and food intake behavior:** Chili consumption frequency (ns)
58	Malhi et al. (2021)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver (items describe hypersensitive affective and behavioral responses): 5-point Likert scale* *Whole body (active and passive touch)* *Ref*: McIntosh et al. (1999) *(commercial questionnaire)*	$N = 78$ children (4–10 y.o) $n = 50$ with diagnosis for Autism, $n = 28$ control			
6	Navarrete-Muñoz et al. (2020)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver (items describe hypersensitive affective and*	$N = 445$ children (3–7 y.o.)	Internal consistency: $\alpha \geq .72$		

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			behavioral responses): *5-point Likert scale* *Whole body* (*active and passive touch*) *Ref*: McIntosh et al., 1999 (*commercial questionnaire*), Román-Oyola and Reynolds (2010) *and* Beaudry-Bellefeuille (2015) (*validation in Spanish*)				
5	Navarrete-Muñoz et al. (2019)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver* (*items describe hypersensitive affective and behavioral responses*): *5-point Likert scale* *Whole body* (*active and passive touch*) *Ref*: McIntosh et al. (1999) (*commercial questionnaire*), Román-Oyola and Reynolds (2010) *and* Beaudry-Bellefeuille (2015) (*validation in Spanish*)	*N* = 583 children (3–7 y.o.)	Internal consistency: $\alpha \geq .72$		**Diet and food intake behavior:** Adherence to Mediterranean diet (in Spain): lower tactile sensitivity associated with having medium and high adherence
62	Nederkoorn et al. (2019)	Questionnaire	Subjective tactile sensitivity with non-visible food and non-food stimuli *Enjoyment rating* (*stimuli expected to evoke negative affective and behavioral responses in hypersensitive individuals*): *5-point Likert scale* *Hands* (*active touch*)	*N* = 87	Internal consistency: $\alpha = .50$		**Diet and food intake behavior:** Picky eating: direct effect by subjective tactile sensitivity, mediated by mouthfeel rating of food items
26	Nederkoorn et al. (2015)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver* (*items describe hypersensitive affective and*	*N* = 44 children (4–10 y.o.)	Internal consistency: $\alpha = .75$	ns (1&2)	**Diet and food intake behavior:** Picky eating behavioral test (ns)

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			behavioral responses): *5-point Likert scale* *Whole body* (*active and passive touch*) *Ref*: McIntosh et al. (1999) (*commercial questionnaire*)				Food variety questionnaire (ns)
		Questionnaire	Subjective tactile sensitivity with non-visible food and non-food stimuli *Enjoyment rating* (*stimuli expected to evoke negative affective and behavioral responses in hypersensitive individuals*): *5-point Likert scale* *Hands* (*active touch*)				**Diet and food intake behavior:** Picky eating behavioral test: enjoyment of tactile play correlated to number of food items tasted and liking of food items Food variety questionnaire (ns)
42	Olarte Mantilla et al. (2022)	Instrument	Two-point discrimination *Distance threshold* (*distance*: *0–15 mm*): *adaptive staircase, static and dynamic pressure* *Tongue*: *posterior and anterior* (*passive touch*)	$N = 117$ adults	Measurement location: sensitivity higher on anterior than posterior tongue (static and dynamic) Discrimination between respondents: better discrimination on posterior tongue (static and dynamic)	s (1&3) ns (2&3)	
		Instrument	Letter recognition with *Teflon strips* *Size threshold* (*size*: *2–8 mm*): *adaptive staircase* *Tongue* (*active touch*) *Ref*: Essick et al. (1999)				
		Food model	Particle texture in yoghurt *Detection of particles for attributes "particle" and "drying"* (D_{95}: *0 & 100 & 250 µm, hardness*: *210 & 550 kPa*): *CATA* *Oral cavity* (*active touch*)				

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
59	Panerai et al. (2020b)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver* (*items describe hypersensitive affective and behavioral responses*): *5-point Likert scale* *Whole body* (*active and passive touch*) *Ref*: McIntosh et al. (1999) (*commercial questionnaire*)	$N = 111$ children (2–12 y.o.) diagnosed for autism $n = 37$ with feeding problems, $n = 74$ without feeding problems			**Diet and food intake behavior:** Problematic feeding behavior of children living with autism: tactile sensitivity higher in children with feeding problems
60	Pellegrino et al. (2021)	Questionnaire	Sensory perception quotient (SPQ), touch sensitivity subscale *Agreement to statement* (*items describe hypo- and hypersensitive perception*, for example, *"I notice the weight and pressure of a hat on my head"*): *6-point Likert scale* *Oral and other* (*active and passive touch*) *Ref*: Tavassoli et al. (2014), Pellegrino and Luckett (2020)	$N = 143$ adults, $n = 29$ high (upper 25th quartile), $n = 28$ low touch sensitive (lower 25th quartile)		s (1&4) ns (1&2, 1&3)	
		Food model	Hardness in gummy *Discrimination* (*gelatine bloom strength 190, 200, defined in pilot*): *triangle test* *Oral cavity* (*active touch*)	$n = 29$ high, $n = 28$ low touch sensitive			
		Food model	Particle texture of icing sugar *Discrimination* (*particle content: 8, 12%, defined in pilot*): *triangle test* *Oral cavity* (*active touch*)				
		Food model	Viscosity in fruit-flavored beverage				

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			Discrimination (*xanthan gum concentration: 0 & 0.05%, defined in pilot*): *triangle test* *Oral cavity* (*active touch*)				
8	Pellegrino and Luckett (2020)	Questionnaire	Sensory perception quotient (SPQ), touch sensitivity subscale *Agreement to statement* (*items describe hypo- and hypersensitive perception, for example, "I notice the weight and pressure of a hat on my head"*): *6-point Likert scale* *Oral and other* (*active and passive touch*) Ref: Tavassoli et al. (2014)	$N = 473$	Internal consistency: $\alpha = .71$, normal distribution: $W = 0.99$		**Preference:** Reasons for food rejection: motivators (unpleasantness, anticipation of consequences, other factors) and sensory modalities (texture, flavor and aroma) increased in upper compared to lower touch sensitivity quartile.
44	Puleo et al. (2021)	Food model	Viscosity in chocolate cream *Perceive intensity of attribute "flowability"* (*differences in stress overshoot checked, exact values not reported*): *gLMS* *Oral cavity* (*active touch*)	$N = 146$ adults			**Preference:** Liking rating of same chocolate cream samples: Only medium and high sensitivity cluster distinguished samples regarding liking. Food choice, hard versus soft: Liquid food (ns), solid food: high sensitivity cluster preferred hard, low sensitivity cluster preferred soft solid food **Diet and food intake behavior:** Food neophobia (ns)
32	Puleo et al. (2021)	Food model	Hardness in jelly *Perceived intensity of attribute "hardness"* (fracture stress: *120–694 kPa*): *gLMS* *Oral cavity* (*active touch*)	$N = 248$ adults			**Preference:** Liking rating of same jelly samples: high hardness sensitivity cluster preferred softer samples more, while middle and low sensitivity group preferred harder samples more.

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
33	Puleo et al. (2020)	Food model	Particle texture in cocoa-based cream *Perceived intensity of attribute "graininess" (D_{90}: 19.5–41 μm): gLMS* *Oral cavity (active touch)*	$N = 59$ adults			**Preference:** Liking rating of same cocoa-based cream samples: particle texture sensitive cluster preferred finer sample while low discriminating and not discriminating cluster liked samples equally.
4	Rabitti et al. (2021)	Instrument	Grating orientation with custom-made 1 cm^2 stamps *Threshold (groove width: 0.1–1.25 mm): R-Index for each width* *Tongue: anterior (passive touch)*	$N = 70$ adults	Individual thresholds ranged from lowest to highest groove widths (<0.1–>1.25 mm) Test protocol recommendations (e.g., orientation indication with hand instead of verbally)		
16	Ross et al. (2022)	Questionnaire	Food texture sensitivity *Frequency and binary rating by caregiver (items describe hypersensitive affective and behavioral responses to food texture, for example, "My child limits self to certain textures", 3 items from oral sensitivity subscale of the SSP): 5-point Likert scale and Yes/No* *Oral and other (active and passive touch)*	$N = 2063$ children (0–12 y.o.) (4 studies, some included children living with down syndrome)	Food texture sensitivity prevalence: 22% children (4–36 m.o.), 15.8% children (4–58 m.o.) w/o down syndrome versus 36.9% children (4–58 m.o.) w/down syndrome, 20.6% children (5–12 y.o.)	ns (1&2)	**Diet and food intake behavior:** Tasting of food products (observational data): lower willingness to taste, liking and amount eaten in texture sensitive group in young children (11–58 m.o.) Food fussiness (subscale CEBQ): food texture sensitive children 5–12 y.o.) were fussier
		Instrument	Grating orientation with 3D printed 1 cm^2 stamps *Recognition (groove width: 0.5 mm): R-Index* *Tongue (passive touch)*	$n = 987$ children (5–12 y.o.)			
A3	Santagiuliana et al. (2019)	Instrument	One-point pressure with monofilaments	$N = 92$ female adults $n = 47$ Dutch, $n = 45$ Chinese	Discrimination between respondents: limitation through floor effect, lowest	ns (1&2)	

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
			Detection threshold (weight: 0.008–0.392 g): adaptive staircase w/2-AFC *Tongue (passive touch)*		filament weight detected by majority		
		Food model	Particle texture in quark and processed cheese *Discrimination threshold for attribute "grittiness" (D_{av}: 50–780 μm): 2-AFC, constant reference w/o microparticles* *Oral cavity (active touch)*		Food model: thresholds differed between the two food models (lower in quark than processed cheese)		
46	Schimmel et al. (2017)	Instrument	One-point pressure with monofilaments *Detection threshold (weight: 0.025–52.2 g): adaptive staircase* *Lip: right and left, mucosa of cheek, tongue (passive touch)*	*N* = 54 adults *n* = 27 stroke patients, *n* = 27 control			**Oral processing:** significant effect of one-point pressure (average of measurement places and on tongue) on mastication performance in pooled sample of stroke and control in linear regression model including other variables (e.g., stroke)
		Instrument	Two-point discrimination *Distance threshold (distance: 0–15 mm): descending staircase, static pressure* *Lip: right and left side, tongue: right, left, mid of tip (passive touch)*				**Oral processing:** significant effect of one-point pressure (average of measurement places and on tongue) on mastication performance in pooled sample of stroke and control in linear regression model including other variables (e.g., stroke)
63	Shupe et al. (2019)	Instrument	Letter recognition with confectionary letters *Recognition (size not indicated): forced-choice* *Tongue (active touch)* *Ref*: Shupe et al. (2018)	*N* = 117 adults		nS (aggregated 1 + 2 + 3&4)	**Oral processing:** Mastication behavior (chewing pattern, chewing movements, overall number of chewing cycles): high sensitive group showed more unpredictable

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
							chewing pattern and a lower overall number of chewing cycles
		Instrument	Shape recognition with 3D printed raised and recessed shapes *Recognition* (*size raised*: *3 & 5 mm, size recessed*: *4 & 8 mm*), *forced choice w/visual answer key* *Tongue* (*active touch*) *Ref*: Shupe et al. (2018)				
		Instrument	Bite force sensitivity with foams *Discrimination* (*Hardness not indicated*): *2-AFC* *Teeth* (*active touch*) *Ref*: Shupe et al. (2018)				
		Food model	Hardness and elasticity in gummy *Discrimination* (*maximum bite force*: *1.75–2.54 N, ratio of samples original height 66%–79%*): *triangle tests* *Oral cavity* (*active touch*)	*n* = 20 top-25% tactile sensitive, *n* = 21bottom-25% tactile sensitive			
11	Shupe et al. (2018)	Instrument	Letter recognition with confectionary letters *Recognition* (*size not indicated*): *forced-choice* *Tongue* (*active touch*)	*N* = 98 adults *n* = 34 young (20–25 y.o.), *n* = 31 middle (35–45 y.o.), *n* = 28 old (>62 y.o.)		s (1&2)	**Oral processing:** Mastication performance (ns)
		Instrument	Shape recognition with 3D printed raised and recessed shapes *Recognition* (*size raised*: *3 & 5 mm, size recessed*: *4 & 8 mm*), *forced choice w/visual answer key* *Tongue* (*active touch*)				**Oral processing:** Mastication performance (ns)

(Continues)

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
		Instrument	Bite force sensitivity with foams *Discrimination* (*Hardness not indicated*): *2-AFC* *Teeth* (*active touch*)				**Oral processing:** Mastication performance (ns*) *Significant interaction age group x bite force sensitivity on mastication performance: positive effect for young and medium age, negative effect for old age group
1	Steele et al. (2014)	Instrument	Letter recognition *size threshold* (*2.5–8 mm*): *adaptive staircase w/8 reversals, Teflon strips* (*7 letters*) *active oral touch* *Ref*: Essick et al. (1999)	$N = 78$ adults $n = 39 < 40$ y.o., $n = 37 > 60$ y.o.	Reversals: three reversals sufficient in young and five in older age group.		
17	Surette et al. (2021)	Questionnaire	Food texture sensitivity *Frequency and binary rating by caregiver* (*items describe hypersensitive affective and behavioral responses to food texture*, for example, *"My child limits self to certain textures"*, *3 items from oral sensitivity subscale of the SSP*): *5-point Likert scale and Yes/No* *Oral and other* (*active and passive touch*)	$N = 227$ children (11–60 month o.) $n = 111$ with $n = 107$ without down syndrome			
36	Zhou et al. (2021)	Instrument	One-point pressure with monofilaments *Detection* (*weight: 0.008, 0.02 g*): *R-Index* *Tongue* (*passive touch*)	$N = 94$	Discrimination between respondents: wider distribution for 0.008 than 0.02 g.		

TABLE 1 (Continued)

ID	Reference	Measurement via	Method	Sample and subsamples	Results related to method	Associations between methods (s, ns)	Associations to food preferences and behavior (oral processing, preference, diet and food intake behavior)
53	Yackinous and Guinard (2001)	Instrument	One-point pressure with monofilaments *Detection* (*weight*: *0.008, 0.02 g*): *R-Index* *Tongue*: *four quadrants* (*passive touch*)	$N = 147$	Measurement location: front of tongue more sensitive than mid of tongue (R-Index averaged over two filament weights)		
57	(Zickgraf et al., 2022)	Questionnaire	Sensory Over-responsivity (SensOR), texture subscale further divided into oral and non-oral group Binary evaluation (*items describe hypersensitive affective and behavioral responses, for example, distress or discomfort felt with lumpy food* (*oral*), *distress or discomfort felt getting a haircut* (*non-oral*)): *Yes/No* *Oral and other* (*active and passive touch*) Ref: Schoen et al. (2008)	$N = 1170$ $n = 263$ children unselected (5–17 y.o.) $n = 179$ children (5–17 y.o.) with anxiety/obsessive spectrum disorders $n = 185$ children (4–17 y.o.) with autism spectrum disorder[1] $n = 534$ college students (18–22 y.o.)	Internal consistency: oral subscale $\alpha \geq .77$, non-oral subscale $\alpha = .94$		**Diet and food intake behavior:** Picky eating: oral texture sensitivity (controlling for olfactory sensitivity, age, and gender) predicted picky eating in each subsample
55	Zulkifli and Rahman (2021)	Questionnaire	Short sensory profile (SSP), *tactile sensitivity subscale* *Frequency rating by caregiver* (*items describe hypersensitive affective and behavioral responses*): *5-point Likert scale* *Whole body* (*active and passive touch*) *Ref*: McIntosh et al. (1999) (*commercial questionnaire*)	$N = 63$ children (3–6 y.o.) treated for Autism			**Diet and food intake behavior:** Problematic feeding behavior of children living with autism: tactile sensitivity correlated to feeding behavior

recognition task (size thresholds) to children (7–10 y.o.) (Lukasewycz & Mennella, 2012) recommending protocol adaptions such as offering respondents a visual answering sheet of the whole alphabet to decrease cognitive load which also came into application in a study with adults (Bangcuyo & Simons, 2017). There was a low number of children who had to be excluded due to difficulties with the task (4%), the task duration (7.5 min average) and threshold ranges (2.5–7.5 mm) were comparable to adults.

One study compared letter recognition (without size threshold) to the shape recognition task finding a correlation between the two stereognosis measurements (Shupe et al., 2018). Further, the only study correlating letter recognition (size threshold) to food models measuring particle texture sensitivity did not find a significant correlation between the measurements (Olarte Mantilla et al., 2022). Shupe et al. (2019) included letter recognition as one of several instrumental measurements to form high and low tactile sensitivity groups which did not differ in their sensitivity to hardness and elasticity in a food model.

So far, only few studies investigated the association with food preferences and behavior. Mastication performance was not associated to letter recognition (without size threshold) (Shupe et al., 2018), although mastication behavior (chewing pattern, movement, overall number of chewing cycles) varied between a high tactile sensitive and low tactile sensitive group built based on three tactile sensitivity measurements (letter recognition, shape recognition and hardness sensitivity) (Shupe et al., 2019). A third study found no associations between letter size thresholds and food texture preferences as well as food neophobia in children (Lukasewycz & Mennella, 2012).

Two-point discrimination (six method descriptions)

The two-point discrimination test was used in six studies determining the narrowest distance that can be sensed as two distinct pressure points via commercially available clinical tools. In all studies the discrimination threshold was determined via staircase procedures (ascending/descending/adaptive) using distance ranges between 0/0.25–8/15 mm. In no study the control for response bias (e.g., via 2-AFC test) was described. The test was most frequently administered in a static way (pressure) while one study included a dynamic measurement (stroke) as well. Measurement places included different places on the tongue, palate, lip, and cheek.

Two studies reported a floor effect where most participants could discriminate the lowest distance of two-points applied (Aktar et al., 2015b; Lv et al., 2020). The place of measurement was linked to different sensitivities in two studies which could then influence the capacities to measure individual differences: the posterior of the tongue was less sensitive and more discriminative between respondents than the anterior (Olarte Mantilla et al., 2022) and the tongue (exact location not specified) more sensitive than the index fingertip (Aktar et al., 2015b).

A study compared respondents two-point discrimination thresholds to size estimation of steel spheres as psychophysical function of actual size without finding a link (Engelen et al., 2004). Three studies compared two-point discrimination thresholds to texture sensitivity in food models, finding a link to particle texture for measurements on the posterior (but not anterior) tongue (Olarte Mantilla et al., 2022). Other studies did not find a link to viscosity (Lv et al., 2020), hardness (Aktar et al., 2015b), and elasticity (Aktar et al., 2015b).

Two studies investigated links to oral processing. In a small sample of healthy respondents two-point pressure sensitivity (on the anterior tongue) was not associated to chewing efficiency (Engelen et al., 2004) while in a pooled sample of stroke patients and control, a significant effect was found for measurements on the lip in a regression model where stroke was included as confounder (Schimmel et al., 2017). So far, no studies investigated into links to texture preference, diet and food intake behavior.

Grating orientation (four method descriptions)

The grating orientation task where respondents determine the orientation of engraved lines (either horizontal or vertical) pressed on their tongue was described in four studies of which three included children. The measurement tools of the studies were tailor made, 3D printed (Appiani et al., 2020; Lee et al., 2022; Rabitti et al., 2021), and machine-cut (Ross et al., 2022). All studies measured orientation identification via R-Index controlling for response biases. The assessed groove widths varied between studies ranging from 0.1 to 1.25 mm.

A methodological study with adults tested groove widths between 0.1 and 1.25 mm finding a large range of individual thresholds between <0.1 and >1.25 mm (Rabitti et al., 2021). For children one study determined larger groove widths (0.75, 1, 1.25 mm) as relevant (Appiani et al., 2020) while two other studies included 0.5 mm (Lee et al., 2022; Ross et al., 2022). Two studies included test protocol recommendations for children, such as that they could indicate the direction with their hand or with a visual answer sheet in order to reduce cognitive load (Appiani et al., 2020; Lee et al., 2022). With adapted test protocols the number of children (5–12 y.o.) who had to be excluded due to difficulties with the task was low (4%) (Lee et al., 2022).

Grating orientation task performance was correlated to one-point pressure sensitivity (Appiani et al., 2020). No further links to other tactile or texture sensitivity measurements were tested in the included studies.

Only one study investigated links to food preference and behavior (food texture preference, food consumption frequency, food neophobia) without finding any significant associations (Appiani et al., 2020).

Shape recognition (three method descriptions)

The stereognosis assessment via shape recognition task required respondents to recognize shapes on their tongue. Geometric shapes (e.g., square, rectangle, triangle, star) were created by 3D printing, raised as well as recessed (Shupe et al., 2018; Shupe et al., 2019) while the third study used plastic shapes without specifying their origin (Calhoun et al., 1992). Recognition was measured by forced-choice tests with a visual answer key of the shapes tested.

The test procedure was able to discriminate between respondents (Calhoun et al., 1992). Further it was noted that some shapes were easier to identify than others (Calhoun et al., 1992).

Shupe et al. (2018) found a significant correlation between shape and letter recognition. Mastication performance was not associated to shape recognition (Shupe et al., 2018), although mastication behavior (chewing pattern, movement, overall number of chewing cycles) varied between a high tactile sensitive and low tactile sensitive group built based on three tactile sensitivity measurements (letter recognition, shape recognition, and hardness sensitivity) (Shupe et al., 2019).

Size estimation (two method descriptions)

The perceived object size rated on a VAS as psychophysiological function of actual size was assessed in two studies. In one study commercial steel spheres were administered in black cups to eliminate visual cues (Engelen et al., 2004). In another study, participants estimated the size of the letter O on the tongue (Bangcuyo & Simons, 2017).

The size estimation of steel spheres was not associated to two-point discrimination (Engelen et al., 2004). In the same study, authors concluded a link to oral processing (chewing efficiency).

Vibration sensitivity (two method descriptions)

In one study, vibratory detection threshold on the tongue was measured via staircase method with a Bio-Thesiometer, 100 Hz, 15-1 V (Lv et al., 2020), in the other study discrimination between vibration versus no-vibration pressure on the lip was assessed with a tuning fork, 256 Hz (Calhoun et al., 1992). The procedure suggested by Calhoun et al. (1992) was not able to discriminate between younger adults which reached a 100% discrimination, while the method was more suitable for older age groups.

Vibration thresholds were correlated to viscosity discrimination thresholds in a food model (Lv et al., 2020).

Roughness sensitivity (two method descriptions)

Lingual surface roughness sensitivity was assessed using metal coupons of different grits which were licked by blind-folded participants using active touch (Linne & Simons, 2017). The study assessed discrimination threshold with a staircase method using 2-AFC to control for response bias as well as intensity perception of roughness in suprathreshold regions on the gLMS.

Roughness sensitivity thresholds were linked to food preference: a higher liking of astringent food versions (unripe banana and dark chocolate).

Bite force sensitivity (two method descriptions)

Bite force sensitivity was measured with tailor-made non-edible foams in 1 cm^2 cubes attached to an applicator in two publications by the same author (Shupe et al., 2018; Shupe et al., 2019). Foam samples of different hardness levels (hardness not indicated) but similar densities were compared via 2-AFC discrimination tests on the participants' preferred side of the back molars. The number of correct responses was used as a measure of sensitivity.

The studies investigated links to oral processing: Mastication performance was not associated to bite force sensitivity in the whole sample. However, there was a significant interaction with age group (Shupe et al., 2018). Further, mastication behavior (chewing pattern, movement, overall number of chewing cycles) varied between a high tactile sensitive and low tactile sensitive group built based on three tactile sensitivity measurements (letter recognition, shape recognition, and hardness sensitivity) (Shupe et al., 2019).

Sharp versus soft discrimination (one method descriptions)

For sharp versus soft discrimination, one-point pressure was applied either with a sharp drafting compass needle or with a soft cotton-tipped applicator on the anterior tongue and the midpalate in repetition and respondents had to differentiate between the two sensations (Calhoun et al., 1992). The method was not suitable to establish individual differences as most respondents (including age groups up to 80 y.o.) were able to discriminate the two sensations.

3.2.2 | Food models

In food models used for sensitivity assessment, texture properties were modified through ingredients, composition and physical processes. In most studies, the intended texture differences were quantified by laboratory analysis.

Particle texture (eight method descriptions)

Sensitivity to particle texture was measured in solid (powdered sugar, chocolate), semi-solid (soft cheese, custard) as well as liquid (yoghurt, chocolate cream) food models—most often measuring discrimination between different particle sizes and in one case particle concentrations—but also to measure detection by adding particles to a smooth food model. The different food models as well as particle texture indicators used in the studies limit comparability between studies. Further, response measurements and test protocols differed. Three studies measured discrimination via attribute-specific 2-AFC for the attribute "grittiness" in chocolate (Breen et al., 2019) and "finer particles" in powdered sugar (Kremer et al., 2007) as well as with the attribute-unspecific triangle test (Pellegrino et al., 2021). One study measured discrimination thresholds in quark and processed cheese via 2-AFC tests using a sample without particles as constant reference (Santagiuliana et al., 2019). One study measured detection of particles in yoghurt via two CATA attributes ("particle" and "drying") (Olarte Mantilla et al., 2022). Further, the perceived intensity of particle texture was assessed in two studies: in a study with custard desserts two attributes "particle size" and "roughness after-feel" were evaluated on a VAS (Engelen et al., 2005) and in a study with cocoa-based cream the texture attribute "graininess" was evaluated on a gLMS (Puleo et al., 2020).

Several studies explored associations to instrumental methods. One-point pressure detection thresholds were not associated with particle texture discrimination and discrimination thresholds (Breen et al., 2019; Santagiuliana et al., 2019) while the measurement of one-point discrimination thresholds was associated to particle texture discrimination (Breen et al., 2019). Further, two-point discrimination thresholds but not to letter recognition size thresholds were associated to the detection of particles in yoghurt sample via CATA attributes (Olarte Mantilla et al., 2022). One study explored the association between two intensity ratings of particle texture: perceived particle size was negatively correlated to roughness after-feel (Engelen et al., 2005). Further, differences in particle texture discrimination were compared between a high and low touch sensitive group assessed by the touch subscale of the Sensory perception quotient questionnaire without finding a significant difference.

One study explored associations to preference patterns: consumer groups differing in perceived graininess intensity showing distinct preference patterns for the same cocoa-based cream samples (Puleo et al., 2021).

Hardness and/or elasticity (five method descriptions)

Sensitivity to hardness and elasticity was measured in food models of semi-solid jellies or gummies differing in gelling agent concentration or bloom strength. While similar food models were used, the quantification of hardness and elasticity varied limiting comparability between studies. Further, response measurements and test protocols differed. Three studies measured discrimination; one study measured discrimination thresholds for hardness and elasticity of the same samples (Aktar et al., 2015b) with attribute-specific Same/Different tests for the attributes "firmness" and "elasticity" and two studies measured discrimination via attribute-unspecific triangle tests (Pellegrino et al., 2021; Shupe et al., 2019). Further, Puleo et al. (2021) measured perceived "hardness" intensity on a gLMS. Aktar et al. (2015b) compared hardness and elasticity discrimination thresholds on fingers and in mouth finding lower elasticity but not hardness thresholds in the mouth than on fingers.

Two studies assessed if hardness and elasticity discrimination capability of food models was linked to tactile sensitivity measured via instrumental methods (one-point pressure and two-point-discrimination (Aktar et al., 2015b), letter, shape recognition, and bite force sensitivity combined (Shupe et al., 2019)) but found no significant associations. Further, hardness sensitivity was compared between a high and low touch sensitive group assessed by the touch subscale of the Sensory perception quotient questionnaire without finding a significant difference.

One study explored associations to preference patterns: consumer groups differing in perceived hardness intensity showing distinct preference patterns for the same samples (Puleo et al., 2021).

Viscosity (five method descriptions)

Viscosity sensitivity was measured in different liquid food models (soup, fruit juice, syrup, and chocolate cream) by varying thickener concentrations, differences were either expressed in thickener concentrations, dynamic viscosity measurements (mPa s) or stress overshoot. Three studies assessed discrimination thresholds by comparison to a constant reference of the lowest viscosity level with attribute-specific tests where respondents either evaluated "viscosity" in the case of syrup/maltodextrin solutions or "thickness" in the case of soup (Aktar et al., 2015a; Lv et al., 2020; Lyu et al., 2021). One study measured discrimination with the attribute-unspecific triangle test in fruit-flavored beverages (Pellegrino et al., 2021) and one study perceived "flowability" intensity of chocolate cream via gLMS (Puleo et al., 2021). One study compared viscosity discrimination thresholds on fingertips and tongue finding lower thresholds on the tongue. The tongue measurement were however confounded by differences in sweet taste corresponding to syrup concentration which poses a limit to the oral assessment of this food model (Aktar et al., 2015a).

When comparing viscosity discrimination thresholds to those measured by other instrumental methods, significant associations were found to vibratory detection thresholds (Lv et al., 2020), however, associations to one-point pressure detection (Aktar et al., 2015a; Lv et al., 2020) or two-point discrimination thresholds (Lv et al., 2020) were no significant. Furthermore, viscosity discrimination thresholds differed significantly between a high and low touch sensitive group assessed by the touch subscale of the Sensory perception quotient questionnaire (Pellegrino et al., 2021).

One study explored associations to preference and diet: consumer groups differing in perceived flowability intensity showed distinct preference patterns for the same samples and differed in their hard versus soft texture preference of solid but not liquid food items while their food neophobia level did not differ significantly (Puleo et al., 2021).

Fatty texture (one method descriptions)

The measurement of fatty texture sensitivity is not straightforward as most fats are perceived via the somatosensory system as well as chemosensory receptors (and aroma receptors which could be controlled for by using a nose clip, however). Heinze et al. (2018) investigated the effect of fat discrimination thresholds using different fats, paraffin oil as example of exclusive texture perception. According to the authors, paraffin oil is composed of hydrocarbons and therefore a taste sensation evoked by free fatty acids (FFAs) from triacylglycerols (TAG) can be ruled out. Paraffin oil is non-toxic and applied as laxative (Speight, 2020), but not naturally occurring in food, presenting a somewhat artificial food matrix. In the study, fatty texture discrimination threshold via a 3-AFC with a constant reference at the lowest concentration was measured in milk-based food models. The study found associations to diet measured via food diaries.

3.2.3 | Questionnaires

The questionnaires identified included validated scales and subscales consisting of tactile cues (items or stimuli) where the response was assumed to differ systematically between tactile sensitive and non-sensitive individuals. Apart from the "Sensory perception quotient," the questionnaires collected mainly affective and behavioral responses which built on the concept of sensory processing. Sensory processing connects neurological thresholds (high vs. low) and behavioral response (active vs. passive) leading to different sensory processing patterns: low registration (high threshold and passive response), sensation seeking (high threshold and active response), sensory sensitivity (low threshold and passive response), and sensation avoiding (low threshold and active response) (Dunn, 1997). Most questionnaires assessed general tactile rather than food texture sensitivity but were applied in a food-related context assuming a relationship between general tactile sensitivity and food texture sensitivity.

Sensory profile, short sensory profile, and adolescent/adult sensory profile (13 method descriptions)

The sensory profile (SP) questionnaires are commercially available validated scales that assess processing patterns across sensory domains of which the tactile domain is one (Dunn, 1999). Items are rated on a 5-point frequency Likert scale. Ten food-related studies assessed children's tactile sensitivity via caregiver report with a selection of low neurological threshold items from the original SP questionnaire, for example, "Avoids going barefoot, especially in sand or grass" (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015b) reporting internal consistency of $\alpha \geq .75$ or a shortened version developed for screening and research, the short sensory profile (SSP) (McIntosh et al., 1999) reporting internal consistencies between $\alpha = .69$. and $\alpha = .75$, two studies using a validated Spanish version (Navarrete-Muñoz et al., 2019; Navarrete-Muñoz et al., 2020). Further, three studies used a sub-selection of the adolescent/adult sensory profile scale (AASP) (Brown & Dunn, 2002) tactile dimension items for adult respondents that corresponded to low neurological threshold, for example, "I dislike having my back massaged" reporting somewhat lower internal consistency of $\alpha > .60$ (Coulthard, Abdullahi, et al., 2022; Coulthard, Aldridge, & Fox, 2022; Coulthard & Sahota, 2016). The food-related questionnaires came into application both with neurotypical populations as well populations with a diagnosis that could lead to heightened sensitivity such as autism.

Three studies investigated the association with tactile play/subjective tactile sensitivity. Two studies with children concluded no associations (Coulthard & Thakker, 2015a; Nederkoorn et al., 2015) while one study with children and their parents found associations (Coulthard & Sahota, 2016).

Many of the studies tested associations to diet and food intake behavior, concluding significant associations to picky eating (Coulthard, Abdullahi, et al., 2022; Zickgraf et al., 2022), food neophobia (Coulthard, Aldridge, & Fox, 2022; Coulthard & Blissett, 2009; Coulthard & Sahota, 2016), fruit and vegetable consumption (Coulthard & Blissett, 2009; Coulthard & Thakker, 2015b), adherence to Mediterranean diet (in Spain) (Navarrete-Muñoz et al., 2019) and feeding problems in children living with autism (Panerai et al., 2020a; Zulkifli & Rahman, 2021). Two studies with lower sample sizes ($N \leq 70$) did not find significant associations to food neophobia (Coulthard & Thakker, 2015b) as well as picky eating and food variety (Nederkoorn et al., 2015). One study further found a relationship to food preference, tactile sensitivity reducing willingness to taste food with edible changes compared to normal food (Coulthard, Abdullahi, et al., 2022).

Tactile play and subjective tactile sensitivity (four method descriptions)

Tactile play or subjective tactile sensitivity were measured in experimental setups where participants were asked to feel stimuli expected to evoke negative responses in hypersensitive individuals with their hands while their affective response to the textures was assessed through a questionnaire with Likert scale ratings. Two studies used exclusively edible samples which were visible to the respondents (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015b) and two studies used food as well as non-food items that were not visible to the respondents (Nederkoorn et al., 2015; Nederkoorn et al., 2019). The internal consistency was reported in one study ($\alpha = .5$) (Nederkoorn et al., 2019). Most studies were conducted with children (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015b; Nederkoorn et al., 2015) while two involved adults (Coulthard & Sahota, 2016; Nederkoorn et al., 2019). The studies that included children introduced the task like a game and used either an adapted smiley scale to assess children's self-reported affective response (4–10 y.o. children) (Nederkoorn et al., 2015) or observation on enjoyment by parents and researchers (2–5 y.o. children) (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015b). The studies tested associations to tactile sensitivity assessed via the Sensory profile described above.

All studies tested associations to diet and food intake behavior, concluding a decreased enjoyment of touching textures for individuals with heightened picky eating (Nederkoorn et al., 2015; Nederkoorn et al., 2019) or neophobia traits (Coulthard & Sahota, 2016; Coulthard & Thakker, 2015b). The studies did not find a significant associations to fruit and vegetable consumption (Coulthard & Thakker, 2015b) and food variety (Nederkoorn et al., 2015).

Food texture sensitivity (two method descriptions)

The food texture sensitivity questionnaire was developed to classify children as food texture sensitive or non-sensitive based on five items of which three were derived from the "Short Sensory Profile" from the oral sensitivity (not tactile sensitivity) domain (e.g., "My child limits self to certain textures"). Further, two additional questions related to picky eating and food neophobia of textures were included (Ross et al., 2022). The questionnaire is filled-in by a caregiver of the respective child using a 5-point frequency Likert scale that ranges from "almost always" to "almost never" for four of the items as well as a binary answer (yes, no) for one. The two studies that have developed and used the scale included children living with and without down syndrome (Ross et al., 2022; Surette et al., 2021) classifying approximately 20% of children as texture sensitive, with higher ratios in children living with down syndrome (Ross et al., 2022).

No associations to the instrumental method grating orientation was found (Ross et al., 2022). Regarding food preference and diet, food texture sensitivity limited young children's (11–58 m.o.) willingness to taste and enjoyment of tasting food. Further increased food fussiness was reported for children (5–12 y.o.) (Ross et al., 2022).

Sensory perception quotient (two method descriptions)

The Sensory perception quotient (SPQ) questionnaire includes exclusively perceptual (opposed to affective and behavioral) items. The questionnaire was developed for adults with and without autism aiming to measure hyper- and hyposensitivity across five sensory domains, for example, "I notice the weight and pressure of a hat on my head" (Tavassoli et al., 2014). The degree of agreement to the statements is rated on a 4-point Likert scale. The Sensory perception quotient questionnaire contains touch sensitivity questions related to sensitivity to pressure, vibration, temperature, and pain and is mostly not focused on the eating domain. Two eating-related studies used the scale with neurotypical participants, reporting a good internal consistency $\alpha = .71$ and adherence to normal distribution (Pellegrino et al., 2021; Pellegrino & Luckett, 2020).

In those studies, neurotypical adults were grouped according to high or low subjective sensitivity in the SPQ touch modality (Pellegrino et al., 2021; Pellegrino & Luckett, 2020). Subjective touch sensitivity (high and low SPQ group) was associated with discrimination ability of viscosity in a liquid food model, but not in semi-solid (discrimination of particle amount) and solid (discrimination of hardness) food models (Pellegrino et al., 2021). Further, the tactile sensitivity group put more weight on motivators (unpleasantness, anticipation of consequences, other factors) and the sensory modalities texture, flavor and aroma as reasons for rejecting food.

Sensory over-responsivity (one method description)

The sensory over-responsivity (SensOR) scales assess discomfort or distress in seven sensory domains, including texture (Schoen et al., 2008). The scale is binary and includes a caregiver-reported version and is thus applicable to measure children's and adults' sensory over-responsivity. The food-related study included in this review Zickgraf et al. (2022) applied the texture scale with children and adults, further splitting texture items into an oral (e.g., "lumpy food") and non-oral (e.g., "getting haircut") reporting good internal consistency for both subscales (oral subscale $\alpha \geq .77$, non-oral subscale $\alpha = .94$).

Oral and non-oral texture sensitivity predicted participants' picky eating in each sub-sample: representative sample of children, children diagnosed with anxiety disorder, children diagnosed with autism spectrum disorder (ASD), representative sample of young adults. For the ASD sub-sample, a different questionnaire was used which is not reported in this review due to insufficient documentation.

4 | SYNTHESIS OF RESULTS AND DISCUSSION

4.1 | Sensitivity methods to study individual differences in food related consumer behavior

This review paper focuses on mapping what tactile sensitivity methods are available to study individual differences in food related consumer behavior (as described in Section 3.2. and Table 1), if the test protocols of methods are used consistently across studies and what are the main differences among methods.

4.1.1 | Test protocols within identified methods

This review included more established methods which were used in several studies across different research groups. However, these methods were often heterogenous in their implementation reducing comparability between the studies. For established instrumental methods (one-point pressure, two-point discrimination, letter identification, and grating orientation) the response measured, and testing procedure used varied (staircase methods, discrimination tests in threshold region, intensity). Food models further varied in the food matrix assessed, structural difference introduced, quantification of structural differences as well as sensory description of the texture attribute. For questionnaires, the Sensory profile (SP and adaptations SSP, AASP) was used among several studies with slight variations in the selection of tactile items. Some studies only included items representing low neurological thresholds to measure tactile sensitivity while other authors used the whole tactile subscale of the shortened version (SSP). Further, cultural aspects as well as translations might have introduced variability, studies in Spain referring to validation studies for Spanish translations (Beaudry-Bellefeuille, 2015; Román-Oyola & Reynolds, 2010).

For thresholds, the measurement in the relevant threshold region to assess individual differences was not always achieved, both in established as well as less established methods. For one-point pressure detection and two-point discrimination, several studies with healthy adults as respondents reported bottom effects where most respondents were able to detect/discriminate the lowest level. In both methods, pressure is applied to a small surface and several studies showed difference in sensitivity between measurement locations, which could explain why in some studies, authors concluded bottom effects while others did not. In food models, the design of a reproducible food matrix and structural differences that are relevant to measure individual differences is challenging, for example, one study showed that particle texture thresholds may depend on the food matrix (Santagiuliana et al., 2019). Further methodological studies are needed to standardize and validate procedures with a focus of assessing individual differences relevant for tactile/texture sensitivity in the food context. For letter recognition, most studies referred to a common test protocol by (Essick et al., 1999) leading to a more homogenous implementation. In this review two recent methodological studies were identified, for one-point pressure (Etter et al., 2020) and grating orientation (Rabitti et al., 2021) could guide further harmonization of methods. Etter et al. (2020) described a one-point pressure test protocol based on discrimination instead of detection which showed a higher discriminability between respondents. The same protocol was used in a second study where discrimination but not detection threshold was significantly associated to particle texture sensitivity in a food model (Breen et al., 2019).

4.1.2 | Main differences among identified methods

Measurement approaches included instrumental measurements, food models and questionnaires. Instrumental measurements, particularly with commercial measurement tools and standardized test protocols, can guarantee high reproducibility. Many instrumental methods require a researcher/lab assistant to administer the stimulus to the respondent which is time intensive, limiting the measurement on larger samples. Further, many methods assessed passive touch through the administration of the stimulus to the respondent, excluding the kinesthetic sense which might measure a different sensitivity than active touch perception (Lederman & Klatzky, 2009) relevant for food texture perception. In this sense, the measurement of food models might be less time intense and more ecologically valid as concluded by Liu et al. (2022). However, the definition of a relevant food model as well as reproducibility require careful consideration. Questionnaires can be administered to large samples and are a highly reproducible measurement tool. However, only few questionnaires were specifically designed for the food context and the items included often described affective or behavioral responses to tactile experiences (further discussed in next paragraphs). Added to this, most questionnaires were originally developed for special populations such as individuals living with autism. It is unclear to which degree the defined items are relevant to neurotypical populations.

Responses collected to measure sensitivity can be grouped into three categories: thresholds (often based on test designs that consider guessing probability), intensity (such as ratings on gLMS or VAS), and affect/behavior (rating of items/stimuli assumed to evoke disliking or avoidance in sensitive individuals) which indicates a wide definition of the term sensitivity. Table 2 classified the methods identified in this review into these classes. The instrumental measurements and food models as well as the SPQ questionnaire reviewed in this work aimed to measure sensitivity on the perceptual level including threshold as well as intensity. On the other hand, questionnaires with the

TABLE 2 Methods according to measurement approach and response category assessed. Number of studies is indicated in brackets. If applicable, methods are further classified according to texture category (mechanical, geometrical, and surface) and dynamic stage of food ingestion ([1]touch/manipulation with hand, [2]oral processing, [3]residual).

	Threshold	Intensity	Affect/behavior
Instrumental measurements	***Mechanical*** One-point pressure[1,2] (14) Vibration sensitivity[2] (2) Bite force sensitivity[2] (2) Sharp versus soft discrimination[2] (1) ***Geometrical*** Two-point discrimination[2] (6) Grating orientation[2] (4) Letter recognition[2] (8) Shape recognition[2] (3) Oral perception of object size[2] (1) ***Surface*** Surface roughness[2] (1)	***Mechanical*** One-point pressure[2] (1) ***Geometrical*** Oral Perception of Object Size[2] (1) ***Surface*** Surface roughness[2] (1)	-
Food models	***Mechanical*** Hardness[1,2] (4) Elasticity[1,2] (2) Viscosity[1,2] (4) ***Geometrical/Surface*** Particle texture[2] (5) ***Surface*** Fatty texture[2,3] (1)	***Mechanical*** Hardness[2] (1) Viscosity[2] (1) ***Geometrical/Surface*** Particle texture[2,3] (2)	-
Questionnaires	Sensory perception quotient (SPQ) (2)		Sensory profile (SP), Short sensory profile (SSP) and Adolescent/Adult Sensory Profile (AASP) (13) Food texture sensitivity (2) Sensory Over-Responsivity Scales (1) Subjective tactile sensitivity/tactile play[1] (4)

Note: Stage of food ingestion (investigated in the specific study; could potentially also be applied at other stages).

[1] **Touch/manipulation with hand**: One-point pressure on hand, hardness, elasticity and viscosity evaluation with fingers, subjective tactile sensitivity/tactile play with hands.

[2] **Oral processing**: Most instrumental measurements and food models.

[3] **Residual**: Roughness after-feel of particle texture, fatty texture assessment likely included residual.

exception of the SPQ, assessed sensitivity on the affective and behavioral level, either self-reported or answered by caregivers, referring to sensory processing theory which links neurological thresholds to different affective and behavioral responses (Dunn, 1997). So far only one study assessed if sensory processing was related to neurological thresholds measured via instruments or food models: Ross et al. (2022) compared Sensory texture questionnaire sensitivity to instrumental grating orientation sensitivity in children without finding significant associations. Further studies are needed to assess if the sensitivity assessment according to sensory processing theory is connected to thresholds relevant for food texture perception.

Instrumental measurements and food models measured specific aspects of food texture perception defined by Szczesniak (2002), while questionnaires were often not designed to assess specific eating/sensing experiences but combined items spanning different somatosensory domains and dynamic components. The modeling of food preferences and behaviors might be improved if sensitivity methods are selected according to the texture properties relevant for oral processing, rejection of certain textures and diet. In an open-ended questionnaire about sensory reasons of food rejection Pellegrino and Luckett (2020) found mainly mechanical texture properties (as well as oily = surface) as drivers of rejecting food while Chow et al. (2022) highlighted geometrical aspects as relevant for children's food rejection. Geometrical texture aspects have been proposed to be important for the adjustment of the mastication and swallowing by detecting the size and shape (stereognosis) of the initial food structure as well as the bolus formed (Engelen et al., 2004) which could explain their relevance in populations such as children and elderly where mastication of certain textures poses challenges. Therefore, Table 2 aimed to classify the methods (if applicable) into food texture aspects: mechanical, geometrical, and surface, as well as the dynamic stage of ingestion: 1. touch/manipulation with hand, 2. oral processing, 3. Residual (after-swallowing sensations).

4.2 | Tactile sensitivity related to food preferences and food behavior

The number of subjects tested as well as statistical testing varied widely among the revised studies limiting the comparability of results. Many of the papers did not include in their objectives concluding on associations with food preferences or food behavior, and were instead centered in assessing measuring protocols, comparing instrumental methods among each other or with food model approaches. Those studies aiming at concluding on the links to food behavior or food preferences were not always successful in finding relations or aligned in their conclusions. Table 3 summarizes the main associations tested in different studies and if their statistical significance.

4.2.1 | Links to oral processing

Studies focusing on food models might be considered more ecologically valid, particularly when it comes to oral processing, as food models represent sensory experiences closer to real food-related experiences, but working with food models may be challenging and difficult to generalize, as some authors pinpoint tactile sensitivity may vary with the food matrix. For instance, Santagiuliana et al. (2019) found that discriminations thresholds measured in two dairy food matrixes were different, suggesting that thresholds would vary with product properties. At the same time, they did not find significant differences in tactile sensitivity between ethnicities (Dutch vs Chinese) or relations to participant's characteristics as PROP status, fungiform papillae density, neither links to the instrumental measurement via point pressure threshold on the tongue. On the contrary, when segmenting participants into high and low sensitivity groups based on detection and discrimination thresholds for oral point pressure with Von Frey Hairs (Breen et al., 2019) found an association with particle size discrimination in chocolate samples.

4.2.2 | Links to preferences

Most of the reviewed papers failed to find correlations of tactile acuity with preferences, in line which was concluded in the review by Liu et al. (2022). Puleo et al. (2020) succeeded in segmenting participants in three groups (high sensitivity; moderate sensitivity; low sensitivity) based on their graininess perception in cocoa-based cream, however they found only small differences in terms of liking scores. Olarte Mantilla et al. (2022) found some participants that were more able to detect differences in particle size in yoghurt models, potentially driven by various aspects of their oral physiology (FP count and density, and higher tactile sensitivity), reported yoghurt texture preferences (liked thick and cohesive yogurts), and personality (openness).

4.2.3 | Links to diet and food intake behavior

Some of the studies explored if tactile sensitivity influenced food behavior and diet. Heinze et al. (2018) found a positive correlation between fat detection thresholds (using milk based food models) and the intake of high-fat food, however they worked with only 30 subjects in their study. By using behavioral measures (sensitivity questionnaires) Coulthard, Aldridge, and Fox (2022) linked an enhanced tactile sensitivity with higher food neophobia, while Coulthard, Abdullahi, et al. (2022) connected it to picky eating. However, Appiani et al. (2020) did not find significant associations among texture preferences nor food consumption with lingual tactile sensitivity in children or adults, not significant differences among those populations, but only a weak positive correlation between lingual tactile sensitivity using Von Frey filaments and food neophobia in young children, suggesting those with higher neophobic characteristics could react more strongly to textural cues. This may be related to food intake, with neophobic and picky eaters having lower intakes and less varied diets (Pellegrino & Luckett, 2020). Nevertheless, the potential link between tactile sensitivity and satiety perception or food intake has not been explored in any of the reviewed papers.

TABLE 3 Summary of the main associations tested in different studies and if their statistical significance.

		Methodology		Associations to food preferences and behavior		
		Measurement	**Response measured**	**Oral processing**	**Preference and willingness taste**	**Diet and food intake behavior**
Instrumental	Mechanical	One-point pressure	Thresholds	**Significant:** - Mastication performance (in pooled sample of stroke patients and control), N = 54 (Schimmel et al., 2017) - Preferred oral processing behavior (firm vs. soft), N = 152 (Cattaneo et al., 2020)	**Not significant:** - Liking of yoghurt samples, $N = 152$ (Liu et al., 2021) - Food texture preference, $N = 217$ (Appiani et al., 2020)	**Not significant:** - Food consumption frequency, $N = 217$ (Appiani et al., 2020) - Food neophobia, $N = 217$ (significant positive correlation between R-Index to the finest Von Frey filament and food neophobia in the youngest age group of children) (Appiani et al., 2020)
			Intensity			**Not significant:** - Spicy food usage, $N = 25$ (Ludy & Mattes, 2012)
		Pain sensitivity	Intensity			**Not significant:** - Spicy food usage, $N = 25$ (Ludy & Mattes, 2012)
		Bite force sensitivity	Thresholds	**Not significant:** - Mastication performance (significant Interaction with age groups), N = 98 (Shupe et al., 2018)		
	Geometrical	Two-point discrimination	Thresholds	**Significant:** - Mastication performance (in pooled sample of stroke patients and control), $N = 54$ (Schimmel et al., 2017) **Not significant:** - Mastication indicators, $N = 22$ (Engelen et al., 2004)		
		Grating orientation	Thresholds		**Not significant:** - Food texture preference, $N = 217$ (Appiani et al., 2020)	**Not significant:** - Food consumption frequency, $N = 217$ (Appiani et al., 2020) - Food neophobia, $N = 217$ (Appiani et al., 2020)
		Letter recognition	Thresholds	**Not significant:** - Mastication performance, $N = 98$ (Shupe et al., 2018)	**Not significant:** - Food texture (hardness and particles) preference, $N = 104$ (Lukasewycz & Mennella, 2012)	**Not significant:** - Food neophobia, $n = 49$ children (Lukasewycz & Mennella, 2012) - Negative reaction to food, $n = 49$ children (Lukasewycz & Mennella, 2012)

(Continues)

TABLE 3 (Continued)

		Methodology		Associations to food preferences and behavior		
		Measurement	**Response measured**	**Oral processing**	**Preference and willingness taste**	**Diet and food intake behavior**
		Shape recognition	Thresholds	**Not significant:** - Mastication performance, $N = 98$ (Shupe et al., 2018)		
		Size estimation	Thresholds	**Significant:** - Chewing efficiency, $N = 22$ (Engelen et al., 2004)		
	Surface	Roughness sensitivity	Thresholds		**Significant:** - Liking of astringent food version (e.g., unripe banana or dark chocolate), $N = 30$ (Linne & Simons, 2017)	
Food model	Mechanical	Hardness	Intensity		**Significant:** - Liking of same jelly samples as assessed for hardness intensity, $n = 248$ (Puleo et al., 2021)	
		Viscosity	Thresholds			**Not significant:** - Chili consumption frequency, $N = 47$ (Lyu et al., 2021)
			Intensity		**Significant:** - Liking of same chocolate cream samples as assessed for viscosity intensity, $N = 146$ (Puleo et al., 2021) - Food choice: hard versus soft food choice in solid food, $N = 146$ (Puleo et al., 2021) **Not significant:** - Food choice: hard versus soft food choice in liquid food, $N = 146$ (Puleo et al., 2021)	**Not significant:** - Food neophobia, $N = 146$ (Puleo et al., 2021)
	Geometrical	Particle texture	Intensity		**Significant:** - Liking of same cocoa-based cream samples as assessed for graininess intensity, $N = 59$ (Puleo et al., 2020)	

TABLE 3 (Continued)

		Methodology		Associations to food preferences and behavior		
		Measurement	**Response measured**	**Oral processing**	**Preference and willingness taste**	**Diet and food intake behavior**
	Surface	Fatty texture	Thresholds			**Significant:** • Food consumption frequency (highest vs. lowest tertile), $N = 30$ (Heinze et al., 2018)
Questionnaire		Sensory profile (SP), Short sensory profile (SSP) and Adolescent/ Adult Sensory Profile (AASP)	Affect/ behavior		**Sign.:** • Willingness to taste food with edible changes, $N = 232$ (Coulthard, Abdullahi, et al., 2022) **Not sign.:** • Willingness to taste food with non-edible changes, $N = 232$ (Coulthard, Abdullahi, et al., 2022) • Tasting and liking of food items (behavioral test for picky eating), $N = 44$ (Nederkoorn et al., 2015)	**Sign.:** • Food neophobia, $N = 534$ (Coulthard, Aldridge, & Fox, 2022 • Picky eating, $N = 232$ (Coulthard, Abdullahi, et al., 2022) • Fruit and vegetable consumption, $N = 70$ (Coulthard & Thakker, 2015b) • Adherence to Mediterranean diet (in Spain), $N = 583$ (Navarrete-Muñoz et al., 2019) • Problematic feeding behavior of children living with autism, $N = 63$ (Zulkifli & Rahman, 2021); $N = 111$ (Panerai et al., 2020b) **Not sign.:** • Food neophobia, $N = 70$ (Coulthard & Thakker, 2015b) • Picky eating, $N = 44$ (Nederkoorn et al., 2015) • Food variety, $N = 44$ (Nederkoorn et al., 2015)
		Sensory Over-responsivity (SensOR)	Affect/ behavior			**Sign.:** • Picky eating, $N = 1170$ (subsamples evaluated separately) (Zickgraf et al., 2022)
		Food texture sensitivity	Affect/ behavior		**Sign.:** • Tasting of food products (observational data), $N = 224$ (Ross et al., 2022)	**Sign.:** • Food fussiness subscale of CEBQ, $N = 224$ (Ross et al., 2022)
		Tactile play and subjective tactile sensitivity	Affect/ behavior		**Sign.:** • Tasting and liking of food items (behavioral test for picky eating),	**Sign.:** • Food neophobia, $N = 70$ (Coulthard & Thakker, 2015b);

(Continues)

TABLE 3 (Continued)

	Methodology		Associations to food preferences and behavior		
	Measurement	**Response measured**	**Oral processing**	**Preference and willingness taste**	**Diet and food intake behavior**
				N = 44 (Nederkoorn et al., 2015), *N* = 87 (Nederkoorn et al., 2019)	*N* = 63 (Coulthard & Sahota, 2016) • Picky eating, *N* = 87 (Nederkoorn et al., 2019), *N* = 44 (Nederkoorn et al., 2015) **Not sign.:** • Variety food products, *N* = 44 (Nederkoorn et al., 2015) • Fruit and vegetable consumption, *N* = 70 (Coulthard & Thakker, 2015b)
	Sensory perception quotient (SPQ)	Thresholds/ intensity		**Sign.:** • Reasons for food rejection: motivators (unpleasantness, anticipation of consequences, other factors) and sensory modalities (texture, flavor and aroma), *N* = 473 (Pellegrino & Luckett, 2020). **Not sign.:** • Reasons for food rejection: sensory modalities (appearance, sound,), *N* = 473 (Pellegrino & Luckett, 2020).	

4.3 | Limitations

In this review, papers coming from areas of knowledge not related to foods were not considered, those may include potential testing methods that could be relevant to use in the food area.

Deviation form protocol: some papers were included after the literature review, as outlined in Figure 1, because of their high relevance (e.g., Liu et al., 2022).

5 | OUTLOOK AND CONCLUSION

The literature in this relatively young area is still very fragmented. From the sources studied in this review, it is difficult to have a clear picture of best practices or recommendations for the measurement of tactile sensitivity in the food context, and what are the implications of the individual differences encountered in tactile sensitivity when it comes to food oral processing, food behavior, or preferences.

Different approaches have been used (instrumental, food models, questionnaires), with differing methods and protocols, measuring one or some of the dimensions of texture perception (mechanical, geometrical, and surface properties), and utilizing different responses (thresholds, perceived intensity, affective or behavioral). The reviewed studies have been performed with varying groups of subjects regarding number or type. Harmonized protocols are needed and it has to be considered that some of the reviewed methods are difficult to apply with large population samples.

Mostly geometrical, mechanical, and surface properties have been addressed by instrumental methods and food models. There has been much less focus on trigeminal sensations, mouthfeel, smoothness, and other surface properties related lubrication or the interaction of food with saliva-coated surfaces in the mouth. With the quick growing area of tribology in the food domain (see for an overview Sarkar and Krop (2019)) we expect to see new developments in this still very under researched area in the years to come.

Further, some of the studies have been directed to assess perception issues, or sensitivity out of the norm (e.g., hypo/hypersensitivity) and one can argue that sensitivity may be defined differently in the food texture context when it comes to explaining differences in preferences or eating behavior.

When it comes to food models, they may be difficult to develop and standardize but are more ecologically valid, meaning more representative or real-life perception, that is, studying tactile sensitivity via model samples is closer to what a consumer may experience when eating a food, as opposed to what instruments can measure. However, food models measures can be challenging to generalize, as some authors pinpoint tactile sensitivity may vary with the food matrix. For instance, Santagiuliana et al. (2019) found that discrimination thresholds measured in two dairy food matrixes were different, suggesting that thresholds would vary with product properties. Food models can also be more representative for active touch, involving the kinesthetic sense, being more adequate when it comes to measure also sensitivity related to dynamics of texture perception. They could also be designed to go further than current instrumental methods, including for example lubrication properties.

Approaches with the use of questionnaires seem in principle an easy way of characterizing large groups of subjects, and they can potentially span several dimensions of tactile sensitivity. However, so far, the most used questionnaires have covered mostly affective responses (not directly comparable to instrumental measurements or food models) and in some cases they are only available commercially (for a payment) so they have not been widely used. Added to this, validation with different populations is still missing in the most used ones. The development of a food texture perception questionnaire that covers not only affective responses but also links to eating behavior and perception thresholds, and that covers a wide range of food categories and properties, is missing.

No single study has focused on methodological harmonization or optimization for application in the food behavior area, with a design of experiment that combines multiple different aspects of tactile sensitivity to food, or covering the whole spectrum of tactile perceptions, including the dynamics of texture perception. Food texture sensitivity assessment needs a multidimensional approach. To this end classification into dimensions and processing dynamics could be used to model individual differences in texture aspects of interest more specifically. Satiety and food intake have been widely linked to texture perception but there are currently no studies trying to link satiety perception to tactile sensitivity.

Future studies should aim to further methodological harmonization of protocols for their application in the food behavior area; ideally, with a design of experiment combining different aspects of tactile sensitivity to food. Such studies should focus on thresholds and perceived intensity of textural parameters as well as on affective and behavioral responses and covering the whole spectrum of tactile perceptions (mechanical, geometrics, and surface). Added to this, future research should include aspects related to dynamics of perception. It could be desirable to have a toolbox with a set of measures that characterize subjects in an objective and reproducible way (e.g., instrumental) and a set of validated questionnaires that can assess their eating behavior. These could be then combined either with studies on model or real foods that could link product characteristics to their perception (i.e., product description, preferences, or food intake) or to eating habits measurements that could inform about dietary implications.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they do not have any conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT

This study does not involve any human or animal testing.

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ENDNOTE

[1] The significant correlation is only indicated in result text while the abstract concluded «no correlation».

REFERENCES

Aktar, T., Chen, J., Ettelaie, R., & Holmes, M. (2015a). Evaluation of the sensory correlation between touch sensitivity and the capacity to discriminate viscosity. *Journal of Sensory Studies*, *30*(2), 98–107. https://doi.org/10.1111/joss.12141

Aktar, T., Chen, J., Ettelaie, R., & Holmes, M. (2015b). Tactile sensitivity and capability of soft-solid texture discrimination. *Journal of Texture Studies*, *46*(6), 429–439. https://doi.org/10.1111/jtxs.12142

Appiani, M., Rabitti, N. S., Methven, L., Cattaneo, C., & Laureati, M. (2020). Assessment of lingual tactile sensitivity in children and adults: Methodological suitability and challenges. *Food*, *9*(11), 1954. https://doi.org/10.3390/foods9111594

Bangcuyo, R. G., & Simons, C. T. (2017). Lingual tactile sensitivity: Effect of age group, sex, and fungiform papillae density. *Experimental Brain Research*, *235*(9), 2679–2688. https://doi.org/10.1007/s00221-017-5003-7

Beaudry-Bellefeuille, I. (2015). Cultural adaptation for Spain of the Spanish version of the short sensory profile using cognitive interviews.

Bondu, C., Salles, C., Weber, M., Guichard, E., & Visalli, M. (2022). Construction of a generic and Evolutive wheel and lexicon of food textures. *Food*, *11*(19), 3097. https://doi.org/10.3390/foods11193097

Breen, S. P., Etter, N. M., Ziegler, G. R., & Hayes, J. E. (2019). Oral somatosensatory acuity is related to particle size perception in chocolate. *Scientific Reports*, *9*(1), 7437. https://doi.org/10.1038/s41598-019-43944-7

Brown, C., & Dunn, W. (2002). *Adolescent/adult sensory profile*. Psychological Corporation.

Calhoun, K. H., Gibson, B., Hartley, L., Minton, J., & Hokanson, J. A. (1992). Age-related changes in oral sensation. *Laryngoscope*, *102*(2), 109–116. https://doi.org/10.1288/00005537-199202000-00001

Cattaneo, C., Liu, J., Bech, A. C., Pagliarini, E., & Bredie, W. L. P. (2020). Cross-cultural differences in lingual tactile acuity, taste sensitivity phenotypical markers, and preferred oral processing behaviors. *Food Quality and Preference*, *80*, 103803. https://doi.org/10.1016/j.foodqual.2019.103803

Chamberlain, C. K., Cornell, J. E., Saunders, M. J., Hatch, J. P., Shinkai, R. S., & Yeh, C. K. (2007). Intra-oral tactile sensation and aging in a community-based population. *Aging Clinical and Experimental Research*, *19*(2), 85–90. https://doi.org/10.1007/bf03324672

Chow, C. Y., Skouw, S., Bech, A. C., Olsen, A., & Bredie, W. L. P. (2022). A review on children's oral texture perception and preferences in foods. *Critical Reviews in Food Science and Nutrition*, *1-19*, 1–19. https://doi.org/10.1080/10408398.2022.2136619

Coulthard, H., Abdullahi, N., Bell, K., & Noon, E. (2022). Understanding disgust-based food rejection in picky and non-picky eaters: Willingness to touch and taste familiar foods with changes. *Food Quality and Preference*, *97*, 104442. https://doi.org/10.1016/j.foodqual.2021.104442

Coulthard, H., Aldridge, V., & Fox, G. (2022). Food neophobia and the evaluation of novel foods in adults; the sensory, emotional, association (SEA) model of the decision to taste a novel food. *Appetite*, *168*, 105764. https://doi.org/10.1016/j.appet.2021.105764

Coulthard, H., & Blissett, J. (2009). Fruit and vegetable consumption in children and their mothers. Moderating effects of child sensory sensitivity. *Appetite*, *52*(2), 410–415. https://doi.org/10.1016/j.appet.2008.11.015

Coulthard, H., & Sahota, S. (2016). Food neophobia and enjoyment of tactile play: Associations between preschool children and their parents. *Appetite*, *97*, 155–159. https://doi.org/10.1016/j.appet.2015.11.028

Coulthard, H., & Sealy, A. (2017). Play with your food! Sensory play is associated with tasting of fruits and vegetables in preschool children. *Appetite*, *113*, 84–90. https://doi.org/10.1016/j.appet.2017.02.003

Coulthard, H., & Thakker, D. (2015). Enjoyment of tactile play is associated with lower food Neophobia in preschool children. *Journal of the Academy of Nutrition and Dietetics*, *115*(7), 1134–1140. https://doi.org/10.1016/j.jand.2015.02.020

Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants & Young Children*, *9*(4), 23–35. https://journals.lww.com/iycjournal/Fulltext/1997/04000/The_Impact_of_Sensory_Processing_Abilities_on_the.5.aspx

Dunn, W. (1999). *Sensory profile*. Psychological Corporation.

Engelen, L., de Wijk, R. A., van der Bilt, A., Prinz, J. F., Janssen, A. M., & Bosman, F. (2005). Relating particles and texture perception. *Physiology & Behavior*, *86*(1), 111–117. https://doi.org/10.1016/j.physbeh.2005.06.022

Engelen, L., van der Bilt, A., & Bosman, F. (2004). Relationship between oral sensitivity and masticatory performance. *Journal of Dental Research*, *83*(5), 388–392. https://doi.org/10.1177/154405910408300507

Essick, G. K., Chen, C. C., & Kelly, D. G. (1999). A letter-recognition task to assess lingual tactile acuity. *Journal of Oral and Maxillofacial Surgery*, *57*(11), 1324–1330. https://doi.org/10.1016/s0278-2391(99)90871-6

Essick, G. K., Chopra, A., Guest, S., & McGlone, F. (2003). Lingual tactile acuity, taste perception, and the density and diameter of fungiform papillae in female subjects. *Physiology & Behavior*, *80*(2–3), 289–302. https://doi.org/10.1016/j.physbeh.2003.08.007

Etter, N. M., Breen, S. P., Alcala, M. I. M., Ziegler, G. R., & Hayes, J. E. (2020). Assessment of midline lingual point-pressure Somatosensation using Von Frey hair monofilaments. *Journal of Visualized Experiments*, *156*, e60656. https://doi.org/10.3791/60656

Heinze, J. M., Costanzo, A., Baselier, I., Fritsche, A., Frank-Podlech, S., & Keast, R. (2018). Detection thresholds for four different fatty stimuli are associated with increased dietary intake of processed high-caloric food. *Appetite*, *123*, 7–13. https://doi.org/10.1016/j.appet.2017.12.003

Jeltema, M., Beckley, J., & Vahalik, J. (2016). Food texture assessment and preference based on mouth behavior. *Food Quality and Preference*, *52*, 160–171.

Kim, S., & Vickers, Z. (2020). Liking of food textures and its relationship with oral physiological parameters and mouth-behavior groups. *Journal of Texture Studies*, *51*(3), 412–425.

Kremer, S., Mojet, J., & Kroeze, J. H. A. (2007). Differences in perception of sweet and savoury waffles between elderly and young subjects. *Food Quality and Preference*, *18*(1), 106–116. https://doi.org/10.1016/j.foodqual.2005.08.007

Laureati, M., Sandvik, P., Almli, V. L., Sandell, M., Zeinstra, G. G., Methven, L., Wallner, M., Jilani, H., Alfaro, B., & Proserpio, C. (2020). Individual differences in texture preferences among European children: Development and validation of the Child Food Texture Preference Questionnaire (CFTPQ). *Food Quality and Preference*, *80*, 103828.

Lederman, S. J., & Klatzky, R. L. (2009). Haptic perception: A tutorial. *Attention, Perception, & Psychophysics*, *71*(7), 1439–1459. https://doi.org/10.3758/app.71.7.1439

Lee, J., Russell, C. G., Mohebbi, M., & Keast, R. (2022). Grating orientation task: A screening tool for determination of oral tactile acuity in children. *Food Quality and Preference*, *95*, 104365. https://doi.org/10.1016/j.foodqual.2021.104365

Linne, B., & Simons, C. T. (2017). Quantification of oral roughness perception and comparison with mechanism of astringency perception. *Chemical Senses*, *42*(7), 525–535. https://doi.org/10.1093/chemse/bjx029

Liu, J., Bech, A. C., Stolzenbach Waehrens, S., & Bredie, W. L. P. (2021). Perception and liking of yogurts with different degrees of granularity in relation to ethnicity, preferred oral processing and lingual tactile acuity. *Food Quality and Preference*, *90*, 104158. https://doi.org/10.1016/j.foodqual.2020.104158

Liu, J., Cattaneo, C., Papavasileiou, M., Methven, L., & Bredie, W. L. P. (2022). A review on oral tactile sensitivity: Measurement techniques, influencing factors and its relation to food perception and preference. *Food Quality and Preference*, *100*, 104624. https://doi.org/10.1016/j.foodqual.2022.104624

Ludy, M. J., & Mattes, R. D. (2012). Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users. *Appetite*, *58*(1), 19–27. https://doi.org/10.1016/j.appet.2011.09.018

Lukasewycz, L. D., & Mennella, J. A. (2012). Lingual tactile acuity and food texture preferences among children and their mothers. *Food Quality and Preference*, *26*(1), 58–66. https://doi.org/10.1016/j.foodqual.2012.03.007

Lv, C., Lou, L., Mosca, A. C., Wang, X., Yang, N., & Chen, J. (2020). Effect of tongue temperature on oral tactile sensitivity and viscosity discrimination. *Food Hydrocolloids*, *102*, 105578. https://doi.org/10.1016/j.foodhyd.2019.105578

Lyu, C., Schijvens, D., Hayes, J. E., & Stieger, M. (2021). Capsaicin burn increases thickness discrimination thresholds independently of chronic chili intake. *Food Research International*, *149*, 110702. https://doi.org/10.1016/j.foodres.2021.110702

Malhi, P., Saini, S., Bharti, B., Attri, S., & Sankhyan, N. (2021). Sensory processing dysfunction and mealtime behavior problems in children with autism. *Indian Pediatrics*, *58*(9), 842–845.

McIntosh, D. N., Miller, L. J., Shyu, V., & Dunn, W. (1999). Overview of the short sensory profile (SSP). In W. Dunn (Ed.), *The sensory profile: Examiner's manual* (pp. 59–73). The Psychological Corporation.

McCrickerd, K., & Forde, C. G. (2016). Sensory influences on food intake control: Moving beyond palatability. *Obesity Reviews*, *17*(1), 18–29.

Navarrete-Muñoz, E. M., Fernández-Pires, P., Mubarak-García, C., Espinosa-Sempere, C., Peral-Gómez, P., Juárez-Leal, I., Sánchez-Pérez, A., Pérez-Vázquez, M. T., Hurtado-Pomares, M., & Valera-Gran, D. (2020). Association between body mass index and sensory processing in childhood: InProS study. *Nutrients*, *12*(12), 3684. https://doi.org/10.3390/nu12123684

Navarrete-Muñoz, E. M., Fernández-Pires, P., Navarro-Amat, S., Hurtado-Pomares, M., Peral-Gómez, P., Juárez-Leal, I., Espinosa-Sempere, C., Sánchez-Pérez, A., & Valera-Gran, D. (2019). Association between adherence to the antioxidant-rich mediterranean diet and sensory processing profile in school-aged children: The Spanish cross-sectional InProS project. *Nutrients*, *11*(5), 1007. https://doi.org/10.3390/nu11051007

Nederkoorn, C., Houben, K., & Havermans, R. C. (2019). Taste the texture. The relation between subjective tactile sensitivity, mouthfeel and picky eating in young adults. *Appetite*, *136*, 58–61. https://doi.org/10.1016/j.appet.2019.01.015

Nederkoorn, C., Jansen, A., & Havermans, R. C. (2015). Feel your food. The influence of tactile sensitivity on picky eating in children. *Appetite*, *84*, 7–10. https://doi.org/10.1016/j.appet.2014.09.014

Olarte Mantilla, S. M., Shewan, H. M., Shingleton, R., Hort, J., Stokes, J. R., & Smyth, H. E. (2022). Oral physiology, sensory acuity, product experience and personality traits impact consumers' ability to detect particles in yoghurt. *Food Quality and Preference*, *96*, 104391. https://doi.org/10.1016/j.foodqual.2021.104391

O'Mahony, M. (1992). Understanding discrimination tests: A user-friendly treatment of response bias, rating and ranking r-index tests and their relationship to signal detection. *Journal of Sensory Studies*, *7*(1), 1–47. https://doi.org/10.1111/j.1745-459X.1992.tb00519.x

Panerai, S., Ferri, R., Catania, V., Zingale, M., Ruccella, D., Gelardi, D., Fasciana, D., & Elia, M. (2020). Sensory profiles of children with autism spectrum disorder with and without feeding problems: A comparative study in sicilian subjects. *Brain Sciences*, *10*(6), 336. https://doi.org/10.3390/brainsci10060336

Pellegrino, R., & Luckett, C. R. (2020). Aversive textures and their role in food rejection. *Journal of Texture Studies*, *51*(5), 733–741. https://doi.org/10.1111/jtxs.12543

Pellegrino, R., McNelly, C., & Luckett, C. R. (2021). Subjective touch sensitivity leads to behavioral shifts in oral food texture sensitivity and awareness. *Scientific Reports*, *11*(1), 20237. https://doi.org/10.1038/s41598-021-99575-4

Pramudya, R. C., & Seo, H. S. (2019). Hand-feel touch cues and their influences on consumer perception and behavior with respect to food products: A review. *Food*, *8*(7), 259. https://doi.org/10.3390/foods8070259

Puleo, S., Miele, N. A., Cavella, S., Masi, P., & Di Monaco, R. (2020). How sensory sensitivity to graininess could be measured? *Journal of Texture Studies*, *51*(2), 242–251. https://doi.org/10.1111/jtxs.12487

Puleo, S., Valentino, M., Masi, P., & Di Monaco, R. (2021). Hardness sensitivity: Are old, young, female and male subjects all equally sensitive? *Food Quality and Preference*, *90*, 104118. https://doi.org/10.1016/j.foodqual.2020.104118

Rabitti, N. S., Appiani, M., Cattaneo, C., Ford, R., & Laureati, M. (2021). Assessment of spatial lingual tactile sensitivity using a gratings orientation test. *Journal of Visualized Experiments*, *175*, e62898. https://doi.org/10.3791/62898

Román-Oyola, R., & Reynolds, S. E. (2010). Validating the response process of the Spanish version of the short sensory profile: A pilot study using cognitive interviews. *Journal of Occupational Therapy, Schools, & Early Intervention*, *3*(3), 197–206. https://doi.org/10.1080/19411243.2010.515189

Ross, C. F., Surette, V. A., Bernhard, C. B., Smith-Simpson, S., Lee, J., Russell, C. G., & Keast, R. (2022). Development and application of specific questions to classify a child as food texture sensitive. *Journal of Texture Studies*, *53*(1), 3–17. https://doi.org/10.1111/jtxs.12627

Santagiuliana, M., Marigomez, I. S., Broers, L., Hayes, J. E., Piqueras-Fiszman, B., Scholten, E., & Stieger, M. (2019). Exploring variability in detection thresholds of microparticles through participant characteristics. *Food & Function*, *10*(9), 5386–5397. https://doi.org/10.1039/c9fo01211g

Sarkar, A., & Krop, E. M. (2019). Marrying oral tribology to sensory perception: A systematic review. *Current Opinion in Food Science*, *27*, 64–73. https://doi.org/10.1016/j.cofs.2019.05.007

Schimmel, M., Voegeli, G., Duvernay, E., Leemann, B., & Müller, F. (2017). Oral tactile sensitivity and masticatory performance are impaired in stroke patients. *Journal of Oral Rehabilitation*, *44*(3), 163–171. https://doi.org/10.1111/joor.12482

Schoen, S. A., Miller, L. J., & Green, K. E. (2008). Pilot study of the sensory over-responsivity scales: Assessment and inventory. *The American Journal of Occupational Therapy*, *62*(4), 393–406. https://doi.org/10.5014/ajot.62.4.393

Schwartz, C., Vandenberghe-Descamps, M., Sulmont-Rossé, C., Tournier, C., & Feron, G. (2018). Behavioral and physiological determinants of food choice and consumption at sensitive periods of the life span, a focus on infants and elderly. *Innovative Food Science & Emerging Technologies*, *46*, 91–106.

Shupe, G. E., Resmondo, Z. N., & Luckett, C. R. (2018). Characterization of oral tactile sensitivity and masticatory performance across adulthood. *Journal of Texture Studies*, *49*(6), 560–568. https://doi.org/10.1111/jtxs.12364

Shupe, G. E., Wilson, A., & Luckett, C. R. (2019). The effect of oral tactile sensitivity on texture perception and mastication behavior. *Journal of Texture Studies*, *50*(4), 285–294. https://doi.org/10.1111/jtxs.12451

Speight, J. G. (2020). Chapter 3 – hydrocarbons from crude oil. In J. G. Speight (Ed.), *Handbook of industrial hydrocarbon processes* (2nd ed., pp. 95–142). Gulf Professional Publishing.

Steele, C. M., Hill, L., Stokely, S., & Peladeau-Pigeon, M. (2014). Age and strength influences on lingual tactile acuity. *Journal of Texture Studies*, *45*(4), 317–323. https://doi.org/10.1111/jtxs.12076

Surette, V. A., Bernhard, C. B., Smith-Simpson, S., & Ross, C. F. (2021). Development of a home-use method for the evaluation of food products by children with and without down syndrome. *Journal of Texture Studies*, *52*(4), 424–446. https://doi.org/10.1111/jtxs.12601

Szczesniak, A. S. (1963). Classification of textural characteristicsa. *Journal of Food Science*, *28*(4), 385–389. https://doi.org/10.1111/j.1365-2621.1963.tb00215.x

Szczesniak, A. S. (2002). Texture is a sensory property. *Food Quality and Preference*, *13*(4), 215–225. https://doi.org/10.1016/S0950-3293(01)00039-8

Tavassoli, T., Hoekstra, R. A., & Baron-Cohen, S. (2014). The sensory perception quotient (SPQ): Development and validation of a new sensory questionnaire for adults with and without autism. *Molecular Autism*, *5*(1), 29. https://doi.org/10.1186/2040-2392-5-29

Varela, P., Mosca, A. C., Nguyen, Q. C., McEwan, J. A., & Berget, I. (2021). Individual differences underlying food intake and liking in semisolid foods. *Food Quality and Preference*, *87*, 104023.

Yackinous, C., & Guinard, J. X. (2001). Relation between PROP taster status and fat perception, touch, and olfaction. *Physiology & Behavior*, *72*(3), 427–437. https://doi.org/10.1016/s0031-9384(00)00430-3

Zhou, X., Yeomans, M., Thomas, A., Wilde, P., Linter, B., & Methven, L. (2021). Individual differences in oral tactile sensitivity and gustatory fatty acid sensitivity and their relationship with fungiform papillae density, mouth behaviour and texture perception of a food model varying in fat. *Food Quality and Preference*, *90*, 104116. https://doi.org/10.1016/j.foodqual.2020.104116

Zickgraf, H. F., Richard, E., Zucker, N. L., & Wallace, G. L. (2022). Rigidity and sensory sensitivity: Independent contributions to selective eating in children, adolescents, and young adults. *Journal of Clinical Child and Adolescent Psychology*, *51*(5), 675–687. https://doi.org/10.1080/15374416.2020.1738236

Zulkifli, F. N. A., & Rahman, P. A. (2021). Relationships between sensory processing disorders with feeding behavior problems among children with autism Spectrum disorder. *Malaysian Journal of Medicine and Health Sciences*, *17*(3).

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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