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Review

Consumers' emotions elicited by food: A systematic review of explicit and implicit methods

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ABSTRACT

Background: The increased interest in consumer and sensory research to focus on total consumer experience when examining the relationship between food and consumer, has led to the development of a number of instruments to capture emotional responses elicited by food, beyond sensory liking.

Scope and approach: This systematic review identified 70 studies that applied both a food preference measurement (e.g. sensory evaluation, acceptance, liking, hedonic or preference measurements) and a measurement of emotion elicited by food. The narrative synthesis provides an overview of the methods, measurements and instruments that are currently applied in consumer and sensory research to measure emotions in relation to food. Based on how emotional responses are assessed, two types of methods are distinguished: explicit and implicit methods. All studies are categorized into these two methods and structured by the applied measurement with their specific instrument.

Key findings and conclusions: The results confirm the dominance of explicit methods to investigate emotional responses in relation to food. Although implicit measurements are only limitedly applied in consumer and sensory research, the increase and evolution of (often interdisciplinary) techniques have created new, promising approaches to capture emotional responses.

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1. Introduction

The scientific need to better conceptualize consumers' experience with food has led to an increased interest in integrating emotions into consumer and sensory research (Gutjar et al., 2015b; King, Meiselman, & Carr, 2013; Meiselman, 2015; Mojet et al., 2015; Walsh, Duncan, Bell, O'Keefe, & Gallagher, 2017b). The effect of emotional responses to for example food acceptability, intention to purchase, food choice, attitudes or behavior have been examined in various ways (Walsh et al., 2017b; Wardy, Sae-Eaw, Sriwattana, No, & Prinyawiwatkul, 2015). Whereas the influence of emotions on food choice and food intake has been examined more often (for reviews, see Canetti, Bachar, and Berry (2002); Gibson (2006); Macht (2008)), the opposite direction, i.e. food consumption influencing mood and emotion, has only recently gained attention in consumer and sensory research (Bhumiratana, Adhikari, & Chambers, 2014; Cardello et al., 2012; Dalenberg et al., 2014;

Desmet & Schifferstein, 2008; King, Meiselman, & Carr, 2010; Ng, Chaya, & Hort, 2013a). In the last 5 years there is an increased focus on the impact of food on emotions and how this is related to food acceptance (Piqueras-Fiszman & Jaeger, 2014a, 2014b). Evidence shows that consumers' emotional associations with food products can add additional information beyond overall acceptance (Cardello et al., 2012; Gutjar et al., 2015b; King & Meiselman, 2010; Ng et al., 2013a; Schouteten et al., 2015a; Spinelli, Masi, Dinnella, Zoboli, & Monteleone, 2014; Thomson, Crocker, & Marketo, 2010) and even significantly improve food choice prediction (Dalenberg et al., 2014; Gutjar et al., 2015a). Therefore the main reasons to include an emotional measurement in studies were product discrimination (Ng et al., 2013a; Schouteten et al., 2015b) and the need for a better understanding of consumers' food experiences and intake (Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Piqueras-Fiszman, Kraus, & Spence, 2014).

This rising attention to emotion in consumer and sensory research has led to the introduction of many emotional instruments to capture consumers' emotions elicited by food (Dalenberg et al., 2014). Depending on how emotional associations are assessed, these instruments can generally be divided into explicit and

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implicit methods. Explicit methods are either verbal or visual self-reported measurements that ask participants to report their feeling, emotions upon consumption, smelling or seeing food products. The former uses an emotional lexicon, which is a questionnaire format with a list of emotional terms or a set of emotional descriptors or a list of sentences (such as the Emosemio by Spinelli et al. (2014)) that can be checked (e.g. Check-all-that-apply, CATA) or rated (e.g. RATA or 5 – point rating scale). The CATA scale asks the consumers to check all applicable terms. The RATA scale is a variant of the CATA scale which asks the consumers to rate or indicate the intensity of the applicable term (Ares et al., 2014). The emotional lexicon can also be predefined (e.g. the ESense Profile® by King and Meiselman (2010)) or consumer-defined (e.g. product-specific lexicons for blackcurrant squashes (Ng et al., 2013a), chocolate (Thomson et al., 2010), hazelnut spreads (Spinelli, Masi, Zoboli, Prescott, & Monteleone, 2015), fruit salads (Manzocco, Rumignani, & Lagazio, 2013) and cheese (Schouteten et al., 2015a)). Ng et al. (2013a) were the first to compare predefined and consumer-defined emotional lexicons. Visual self-reported methods use images to depict different emotions rather than emotional terms. Several instruments have been developed, of which the Product Emotion Measurement Instrument (PrEmo) is one of the most well-known measurements (Desmet, 2003). PrEmo was originally designed for more technical products, such as cars (Desmet, Hekkert, & Jacobs, 2000), but has been recently applied in food products, such as breakfast drinks (Dalenberg et al., 2014), gingerbread and chocolates (den Uijl, Jager, de Graaf, Waddell, & Kremer, 2014) and odors (He, Boesveldt, de Graaf, & de Wijk, 2016). Unlike the verbal self-reported method, the visual self-reported methods are easily used in other languages as translation is not necessary (Koster & Mojet, 2015).

Although explicit measurements are quick and user-friendly they can be cognitively biased (Dalenberg et al., 2014; Danner, Haindl, Joechl, & Duerrschmid, 2014a; de Wijk, He, Mensink, Verhoeven, & de Graaf, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012; Lamote, Hermans, Baeyens, & Eelen, 2004; Verhulst, Hermans, Baeyens, Spruyt, & Eelen, 2006). This is why implicit measurement of emotions has been included in studies and has recently gained increased attention. These measures are indirect and non-self-reported and register emotions while participants are consuming, smelling or looking at food, without the need of a cognitive translation after the experience by the consumer (Danner et al., 2014a; De Houwer & Moors, 2007; Mojet et al., 2015). Most implicit measurements are registered continuously while explicit methods obtain data at certain points in time (e.g. filling in a questionnaire during or after consumption).

Interdisciplinary research (psychology, food science and medical science) has created new approaches to measure emotions in an implicit manner (Walsh et al., 2017b) through physiological, expressive and implicit behavioral task measures (Lamote et al., 2004). First, physiological measures are designed to tap into the underlying biological responses that accompany emotions, such as cardiovascular responses (i.e. heart rate, blood pressure), respiratory responses (i.e. respiration rate), electrodermal responses (i.e. skin conductance response, skin conductance level), brain responses (i.e. frontal alpha asymmetry) and pupillary responses (i.e. pupillary reflex) (Kreibig, 2010).

Second, expressive measures target expressive reactions, such as facial expression, that accompany emotion (Desmet, 2003; Ekman & Friesen, 1971; Ekman, 1993). Instruments that measure facial expression capture the facial muscle movements that go along with emotion (for a review, see Wieser and Brosch (2012)), either automatically (FaceReader, nViso, Affdex) or by trained coders. Another instrument that measures facial expressions is facial electromyography (EMG), which records movements of two

facial muscles, the corrugator muscle (associated with positive emotion) and zygomatic muscle (associated with negative emotion) (Bailey, 2016).

Third, implicit behavioral task measures, such as the affective priming paradigm (APP), have been frequently used in psychology to register implicit attitudes and emotional responses (Klauer, Musch, Musch, & Klauer, 2003). They are generally based on measuring reaction times. Faster reactions are assumed to imply affective congruent relationships (Verhulst et al., 2006).

Given the aforementioned differences in emotion measurement that are applied in various scientific fields, the aim of this review is to provide a comprehensive overview of methods, measurements and instruments that have been applied in consumer and sensory research to measure emotion implicitly and explicitly in relation to food in the context of food behavior (including consumption and attitudes). This overview serves as a baseline for future reference as it provides an overview of the methods for various studies. To our knowledge, this is the first systematic review on measurements of emotions elicited by food.

2. Study search and selection

2.1. Eligibility criteria

Peer reviewed articles found in ISI Web of Knowledge and PubMed databases that investigated (1) food preferences and (2) emotion were eligible for systematic review. Additional and more specific inclusion and exclusion criteria were used to narrow down to the relevant articles. To be included in the systematic review, a study had to be written in English, had to include a sensory modality (flavor, aroma, appearance, texture, auditory) of a food product and needed to report a measurement of emotion elicited by food. As such, studies that only conducted a measurement of preference (e.g. hedonic testing), i.e. without any measurement of emotion, were excluded (for an overview of such studies, see Booth (2014) and Pool, Sennwald, Delplanque, Brosch, and Sander (2016) for a review on liking). Inclusion and exclusion criteria are shown in Supplementary Table 1.

2.2. Study screening

The search for articles was carried out in June 2016. The syntax is developed in line with common search strategies in consumer and sensory research (Booth, 2014) and in line with studies on emotion in the field of psychology (Mauss & Robinson, 2009). The search included an a priori limit for only human studies and no restrictions were made regarding publication year. The search syntax was developed by use of the PICOS framework: Population, Intervention, Comparison, Outcome, Setting (Supplementary Table 2). The population of interest was limited to consumers, experts, or panels (of consumers/experts). Any intervention that involved evaluation of food, taste (sweet, sour, salt, bitter or umami) or flavor and reported outcomes on sensory evaluation, acceptance, liking, hedonic or preference measurements and outcomes on emotion, mood or arousal were considered valuable. This review focused on research studies that describe preference and emotional responses to food with no limitation in setting. As this review aims to compare different methods of emotion measurements, no exclusions were made based on comparison. Key terms within the PICOS elements were combined using the Boolean operator 'OR' and between elements using the Boolean operator 'AND'. This resulted in the combination of the following keywords: (Consumer* OR Panel* OR Expert*) AND (sensory OR Accepta* OR Lik* OR Hedonic OR Pref*) AND (food OR sweet* OR sour* OR salt* OR bitter* OR umami* OR tast* OR flav*) AND (emotion* OR mood OR arousal). This search

syntax was used in Web of Knowledge. For the search in PubMed this syntax was combined with the following MeSH terms: (“Food preferences” [MeSH]) AND “Emotions” [MeSH].

All papers retrieved were subsequently merged into one database (version X7, Thomson Reuters, NY, USA) and duplicates were removed. Two researchers conducted the search independently using the same databases and all findings were merged and discussed. The first step was based on title search for existence of important key words related to research question. Secondly, an abstract screening was conducted to review the additional relevance of the studies and finally all relevant articles were subjected to an in-depth critical full article review.

The search strategy for this systematic review is depicted in Fig. 1. The search resulted in an initial total of 616 records, of which 362 records were found in Web of Knowledge and 254 records were found in PubMed. A total of 9 duplicates were removed, resulting in 607 records. Based on title search for existence of important key-words related to research question, 484 were removed and 123 records were subject to abstract screening. Based on abstract

screening, a total of 74 articles were included and 49 were excluded. Full-text paper was not accessible for 7 articles, which resulted in 67 articles subjected to an in-depth critical full article review and eligibility assessment.

After screening and full-text assessment 18 articles were found not eligible for inclusion based on the following criteria: no study ($n = 6$), no emotion measurement elicited by food ($n = 4$), no flavor or other sensory modality involved ($n = 4$), not food related ($n = 2$), no usage of but only focus on development of emotional lexicon ($n = 2$). A total 49 articles were selected for analysis.

2.3. Data extraction

To have a comprehensive understanding of the characteristics of the studies, data extraction sheets were developed. Information extracted from the studies included two broad categories: sensory and emotional measurement. For the emotional measurement a typology was developed to structure the variety of applied measurements (Table 1). The typology consisted of three categories. The

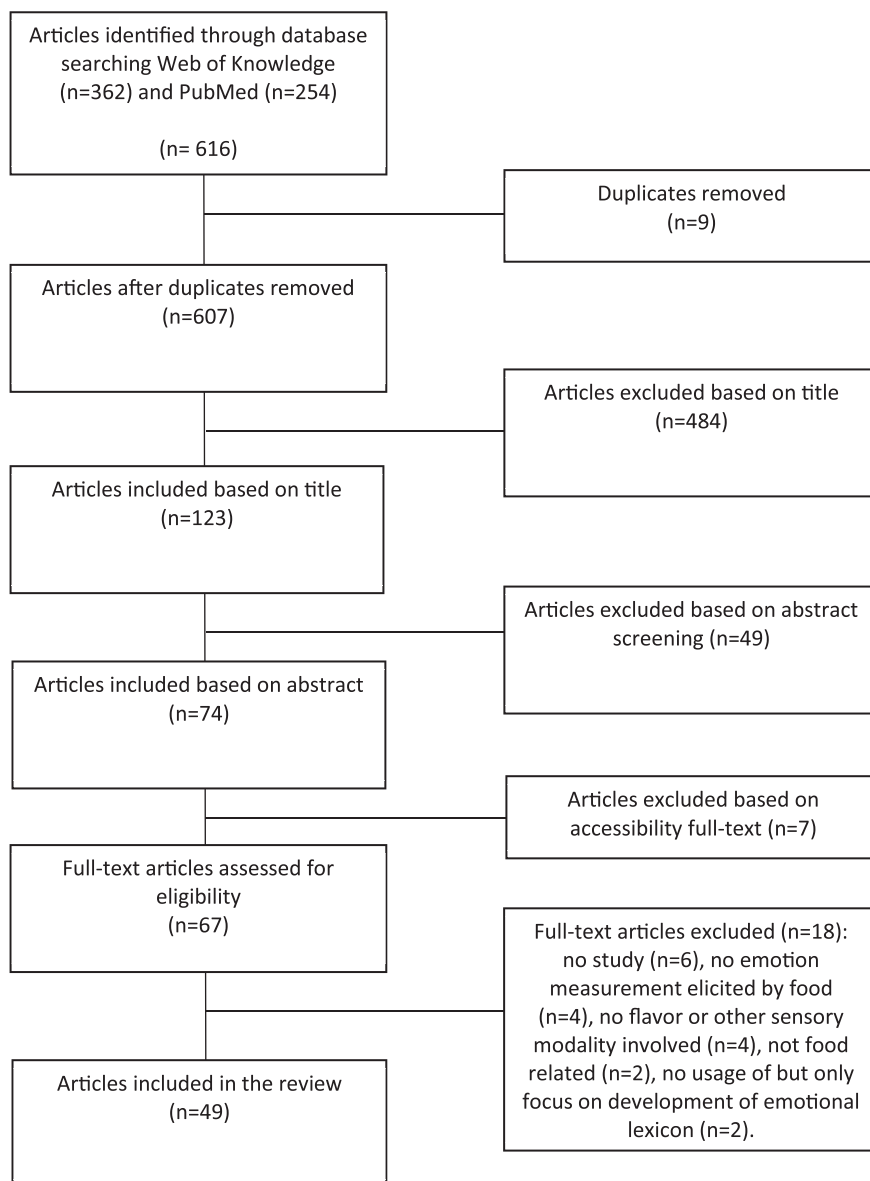


Fig. 1. Flow chart of search and selection of studies.

Table 1
Typology of consumers' emotions elicited by food according to method, measure and instrument.

Method	Measure	Instrument
Explicit method	Verbal – verbal self-report measures	Emotional lexicon
	Non-verbal – visual self-report measures	PrEmo
Implicit method	Physiological measures	Cardiovascular, respiratory, electrodermal measures, brain responses, pupillary responses
	Expressive measures	Facial expressions
	Implicit behavioral tasks measures	Affective Priming Paradigm (APP), Implicit Association test (IAT)

first category is based on the method of emotion measurement: explicit (self-reported and direct measures of emotion) versus implicit methods (non-self-reported and indirect measures of emotion). The second category identified the type of measure, while the last category looked at the instruments used.

Next to the emotional measurement typology, the studies were categorized by sensory measurement based on the sensory modality (flavor, aroma, appearance, texture, auditory) involved in the study and were then categorized based on product category. The scale and timing of registration of the emotion measurement and the scale and timing of the sensory measurement were also extracted. Furthermore, product information (namely product category, amount of products) and general information about the study (namely country, state, setting) were extracted just like sample characteristics (namely sample size, age, gender, recruitment method, target group characteristics, type of consumer group, providing incentive for participation, ethical approval of the study).

For simplification and consistency purposes the terms 'emotions' or 'emotional response' are used throughout the review to refer to a wide range of affective concepts, associations or conceptualizations. Especially for the explicit method and measurements it needs to be made clear that it is not assumed that the emotion terms reflect experienced emotions, but rather emotional associations or emotional conceptualizations associated with the food product. However, this review adopted the terminology commonly used in this type of research and used these terms for consistency reasons.

3. Study characteristics and outcomes

The 49 articles selected for review represent a total of 72 studies, of which 38 articles have included one study, as compared to a small number of articles reporting two (6 articles), three (3 articles), six (1 article) and even seven studies (1 article). Of those 72 studies, two studies were excluded. One study was excluded because it did not include an emotion measurement, while only using a qualitative descriptive analysis (QDA) with a trained panel (Spinelli et al., 2014). The other study was removed for review because participants were only presented with food names and not the food product itself. Thus no sensory modalities, such as flavor, aroma or appearance, were examined in that study (Jaeger, Cardello, & Schutz, 2013). The focus of the review will therefore be on those 70 studies itself, rather than the publications in which they are presented.

3.1. General characteristics

3.1.1. Study characteristics

Most studies (51 out of 70) performed their tests at a central location such as a sensory laboratory. In one study participants conducted the test at home (Home Use Test – HUT). Seven studies only report collecting responses online without requiring a specific setting for the participants. No specific setting was mentioned for 11 studies. As emotional response is likely to be context-dependent it is important to take setting under consideration. Dorado, Chaya, Tarrega, and Hort (2016a), for example, used a written scenario in a

central location test to increase the relevance of the emotional response profile. Piqueras-Fiszman and Jaeger (2014a, 2014b, 2014c) instructed participants to think about an imaginary consumption setting. Some other studies have simulated a more real-life environment by carrying out the tests in a kitchen (Labbe, Ferrage, Rytz, Pace, & Martin, 2015), lounge setting (Bhumiratana et al., 2014) or a simulated restaurant or cafeteria setting (Dalenberg et al., 2014; Gutjar et al., 2015a).

Sample sizes varied among the 70 studies from 12 participants to 1046 participants (MED = 100). When taking the setting into account, sample sizes varied between 12 and 303 for central location tests (CLT) (MED = 96) and between 168 and 1046 for online questionnaires (MED = 123). Smaller sample sizes were noted for implicit methods, ranging from 19 to 153 (MED = 34) and for implicit methods combined with explicit methods ranging from 12 to 161 (MED = 40).

In most studies participants were consumers of the food products that were evaluated (54 out of 70 studies). Four studies also included non-consumers or low-frequency consumers. Other target group characteristics were used in 40 studies, next to consumer status. Most studies focused on a young adult population. One study targeted children between 8 and 10 years old, while two studies investigated older populations. Although most studies targeted mixed gender groups, the proportion of women was often higher than the proportion of men participating in the studies. Women were targeted in 4 studies. For recruitment some studies used participants who were members of specific panels, such as consumer or online panel. Incentives were given to participants in 36 studies. While incentives are common in sensory research and are used to motivate participants (Lawless & Heymann, 2010), they may affect participants' behavior, as shown in willingness-to-pay studies (De Steur et al., 2014, 2016). Ethical approval was explicitly mentioned in 18 studies, whereas 19 studies informed the reader about the use of an informed consent. A total of 33 studies did not give information about ethical approval in the article. An overview of the study characteristics can be found in Table 2.

3.1.2. Food products

A wide range of food products were used in the selected studies. For this review these products were categorized into a total of 6 food product categories: snacks, fruits, drinks, dairy, meat and odors. In general, the most used product categories were snacks (24 studies of which 18 featured only snacks and 6 featured snacks and another product category) and drinks (21 studies of which 17 studies featured only drinks and 4 featured drinks and another product category) (Fig. 2a). As most studies focus on snacks and drinks, such as chocolates and fruit juices, that have a high level of acceptance, little attention is paid to food products with low levels of acceptance or with negative effects. Nevertheless, some of the reviewed studies investigated product categories with low acceptance or negative effects. Olsen, Rossvoll, Langsrud, and Scholderer (2014) investigated the explicit emotional response to rare versus well-done hamburgers using an emotional lexicon instrument. Hermans, Baeyens, Lamote, Spruyt, and Eelen (2005) used a negative odor as unconditional stimulus in an implicit priming

Table 2

Overview of key study characteristics categorised per method, measurement and instrument of emotion measurement.

	General study characteristics		Sample characteristics					Ethical approval	Reference	
	Setting	Sample size (<i>n</i>)	Consumer group	Panel Member	Age (<i>years</i>)	Men-Women	Incentive			
Method: EXPLICIT										
Measure: Verbal self-reported										
Emotional lexicon										
Predefined										
• EsSense Profile®	ND	64	all	no	18–69	22–42	yes	informed consent	Jaeger et al. (2013)	
	ND	89	all	no	19–50	35–53	yes	informed consent	Jaeger et al. (2013)	
	CLT	100	C	no	ND	ND	ND	ND	Ng et al. (2013a)	
	CLT*~	103	C	no	M = 25.6	51–52	ND	yes	Gutjar et al. (2015a)	
	ND	24	C	no	18–69	10–14	yes	informed consent	Jaeger et al. (2013)	
	CLT*	192	C	no	equivalently distributed	similarly distributed	yes	informed consent	Piqueras-Fiszman and Jaeger (2014c)	
	Online	207	C	online panel	equivalently distributed	similarly distributed	yes	ND	Piqueras-Fiszman and Jaeger (2014c)	
	CLT*	115	C	no	18–60	48:52%	yes	informed consent	Piqueras-Fiszman and Jaeger (2014a)	
	Online	302	C, low C	online panel	20–64	C: 45:55% Low C: 41:59%	yes	informed consent	Piqueras-Fiszman and Jaeger (2014a)	
• Modified EsSense Profile®	CLT*	188	C	no	M = 38.7	37:63%	yes	informed consent	Piqueras-Fiszman and Jaeger (2014a)	
	CLT*	41	all	no	18–25	8–33	ND	yes	Walsh, Duncan, Potts, and Gallagher (2015)	
	CLT°	84	all	no	18–70	40–44	ND	ND	Dorado et al. (2016b)	
• Based on literature	CLT°	157	C	university panel	20-50 ⁺	73–84	yes	informed consent	(Piqueras-Fiszman & Jaeger, 2014b)	
	CLT*	141	C	no	20–65	47–94	yes	informed consent	Jaeger et al. (2013)	
	CLT*	96	C	recruitment panel		ND	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	CLT*	89	C	recruitment panel		ND	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
• PANAS	Online	1046	C	consumer panel	45	ND	yes	ND	Olsen et al. (2014)	
	CLT°	52	C	no	63–80	24–28	ND	ND	Narchi, Walrand, Boirie, and Rousset (2008)	
• Emotions in Food Experience' Scale	CLT*~	303	C, non-C	e-mail panel	18–55	ND	yes	ND	Kuesten, Chopra, Bi, and Meiselman (2014)	
	CLT°	101	C	no	25–65	58–43	yes	yes	Lease, MacDonald, and Cox (2014)	
Consumer defined										
• Based on pre-test	CLT°	100	C	no	ND	ND	ND	ND	Ng et al. (2013a)	
	CLT*	173	C	recruitment panel		ND	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	CLT*	162	C	recruitment panel		ND	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	CLT°	138	C	no	18–70	73–65	ND	ND	Dorado et al. (2016b)	
	CLT	ND	C	no	ND	ND	ND	ND	Thomson et al. (2010)	
	CLT*	100	C	no	19–58	45–55	ND	ND	Ng, Chaya, and Hort (2013b)	
	CLT§	60	C	no	18–60	30–30	yes	informed consent	Labbe et al. (2015)	
	ND	300	C	no	18–60		ND	ND	Manzocco et al. (2013)	
	CLT°	60	C	no	M = 29	0-60%	ND	ND	Rousset, Deiss, Juillard, Schlich, and Droit-Volet (2005)	
	Online	199	C	online panel	20–70	48-52%	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	Online	200	C	online panel	20–70	48-52%	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	Online	417	C	online panel	20–65	48-52%	yes	informed consent	Piqueras-Fiszman and Jaeger (2015)	
	• EmoSensory® Wheel	CLT°	130	C	no	M = 34	45.4–54.6%	ND	ND	Schouteten et al. (2015b)
		CLT*	95	C	university panel	M = 25	64.2–35.8%	ND	ND	Schouteten et al. (2015b)
		CLT°	B: 77 I: 65	C	no	B: 45 I: 44	B: 40 I: 60	ND	ND	Schouteten et al. (2015b)
		CLT*	129	C	university panel	M = 24.9	46.6–53.4%	ND	ND	Schouteten et al. (2015a)

Table 2 (continued)

	General study characteristics		Sample characteristics					Ethical approval		Reference
	Setting	Sample size (n)	Consumer group	Panel Member	Age (years)	Men–Women	Incentive			
• Beer-specific emotional lexicon	CLT*	200	C	no	18–51	78–122	yes	yes		Dorado et al. (2016a)
• EmoSemio predefined + consumer defined	CLT	120	C	no	25–45	50–50%	yes	informed consent		Spinelli et al. (2015)
• EsSense Profile® (39) + focus group	CLT*	48	C	no			ND	ND		Bhumiratana et al. (2014)
• EsSense Profile® + EmoSemio	CLT§	96	C	no	18–70	32–64	ND	ND		Bhumiratana et al. (2014)
• EsSense Profile® + EmoSemio Predefined or consumer defined	ND	238	C	no	25–45	50–50%	yes	ND		Spinelli et al. (2014)
• Emotional terms	ND	37	C, low-freq. C	no	M = 22	0–37	ND	ND		Macht and Dettmer (2006)
Other Verbal self-reported measures										
Free association/listing Statements	ND	41	all	no	ND	ND	ND	ND		Jaeger et al. (2013)
• Based on literature	CLT	119	all	no	40–49 (50%)	0–119	ND	ND		Miyaki, Retiveau-Krogmann, Byrnes, and Takehana (2016)
• Profile of Mood States	HUT	62	C	no	ND	ND	yes	ND		Radin, Hayssen, and Walsh (2007)
• NA	Online	168	C	e-mail panel	ND	ND	ND	ND		Moskowitz, Silcher, Beckley, Minkus-McKenna, and Mascuch (2005)
• Based on literature	CLT	100	C	trained + university panel	M = 21	50–50	ND	informed consent		Seo et al. (2009)
Interview										
• Modified Repertory Grid	ND	75	C	no	25–45	37–38	yes	ND		Spinelli et al. (2014)
Measure: Non-verbal self-reported										
Affect Grid + PrEmo2	CLT*	227	C	no	M = 30.8 (young), M = 67.5 (normosmic), M = 68.2 (hyposmic)	ND	ND	yes		den Uijl et al. (2016)
Measure: Verbal + non-verbal self-reported										
Emotional lexicon + non-verbal self-reported measures										
<i>Predefined</i>										
• Thomson and Crocker (2011)	CLT*~	217, 219, 216	C	no	M = 20.9	60–159	yes	ND		Collinsworth et al. (2014)
+ My Pictures										
• EsSense Profile® + PrEmo	CLT*§	123	C	no	18–55	33–90	yes	yes		Dalenberg et al. (2014)
	CLT*§	123	C	no		33–91	yes	yes		Gutjar et al. (2015b)
Method: IMPLICIT										
Measure: Expressive										
Facial expression	CLT'	39	C	no	17–49	17–22	ND	yes		Ahn and Picard (2014)
	CLT'	40	all	no	M = 24.2	12–28	ND	yes		Garcia-Burgos and Zamora (2013)
	CLT*	153	C	no	M = 23	71–82	ND	ND		Danner et al. (2014b)
Measure: Expressive + physiological										
Facial expression + ANS	CLT*	19	all	consumer panel	M = 30 (women), M = 36 (men)	9–10	yes	yes		de Wijk et al. (2014)
	CLT*	31	C	partly consumer panel	M = 9.25 (children), M = 22 (young adults)	13–18	yes	yes		de Wijk et al. (2012)
Facial expression + brain activity	CLT*	22	C, non-C	no	ND	7–15	ND	ND		Horska, Bercik, Krasnodebski, Matysik-Pejas, and Bakayova (2016)
Facial expression + eye movements	CLT*	8 QDA, 30 C test, 30 FE, 40 ET	C	no	M = 23	7–21	ND	ND		Kostyra, Wasiak-Zys, Rambuszek, and Waszkiewicz-Robak (2016)

(continued on next page)

Table 2 (continued)

	General study characteristics	Sample characteristics					Ethical approval		Reference	
	Setting	Sample size (n)	Consumer group	Panel Member	Age (years)	Men-Women	Incentive			
Measure: Implicit behavioral task										
Implicit free association										
• based on Ekman CLT pictures		56	C	no		26–30	yes	yes	Silva et al. (2016)	
Implicit priming paradigm (IPP)	CLT'	26	C	no	M = 36.96	9–17	ND	ND	Lamote et al. (2004)	
	CLT'	29	C	no	M = 19.55	4–25	yes	ND	Lamote et al. (2004)	
	ND	62	all	no	M = 20.25	22–40	yes	ND	Verhulst et al. (2006)	
	CLT'	36	all	no	ND	11–25	ND	ND	Hermans et al. (2005)	
Method: EXPLICIT + IMPLICIT										
Measure: Verbal self-reported + expressive										
Emotional lexicon + facial expression										
Predefined										
• Modified EsSense Profile® + facial expression	CLT*	30	C	consumer panel	20–60	9–22	ND	yes	Leitch et al. (2015)	
	CLT*	12	all	no	18–25	more women	ND	yes	Walsh et al. (2015)	
Measure: Non-verbal self-reported + expressive										
PrEmo + facial expression	CLT'	26	all	no	M = 22.6	0–26	ND	yes	He et al. (2016)	
Measure: Verbal self-reported + Implicit behavioral task										
Approach-avoidance procedure (AAP)	CLT*	50	C	university panel	M = 25	20-30%	ND	yes	Piqueras-Fiszman et al. (2014)	
Affective association measure + implicit priming paradigm (IPP)	ND	161	all	no	M = 23.6	41-59%	yes	yes	Walsh and Kiviniemi (2014)	
Food emotional response questionnaire + implicit priming paradigm (IPP)	ND	119	C	no	M = 23.03; M = 22.70	ND	yes	yes	Yen et al. (2010)	

C = consumer, ND = not determined, NA = not applicable, CLT = central location test, * sensory booth or sensory facilities, ° individual room or individual booth, ° university facilities, ~room = laboratory, § other: (simulated) eating setting, HUT = home use test, ANS = autonomic nervous response, M = mean.

paradigm. Participants of the study of He et al. (2016) were exposed to unpleasant fish odors while their facial expressions were registered. Facial expressions were also registered in response to universally disliked bitter flavors (Garcia-Burgos & Zamora, 2013) and for personally disliked foods (de Wijk et al., 2012). As such, implicit measurements seem to be used more frequently for food products with low acceptance level. For a more detailed overview of the studies categorized by product category and sensory modality see Supplementary Table 3.

The number of products varied widely across sensory modalities: products for tasting varied between 1 and 11, for odors between 2 and 9 (with maximum 6 samples evaluated at the same time) and for visual information between 1 and 36 images. Based on previous suggestions for emotional research by King et al. (2013) the number of products tested for emotional measurement is important. King et al. (2013) showed that the number of significant difference in emotions increased with the number of products in a central location test and for explicit measurement of emotions when using the EsSense Profile®.

3.2. Emotional measurement

3.2.1. Method type

An explicit method for measurement of emotion was the most commonly used method (52 out of 70 studies). An implicit method was applied in 12 studies and a total of 6 combined explicit and implicit methods. In Table 3 all studies are categorized by type of method used to measure emotion. Following the typology (see Table 1), the methods are further classified by type of measurement

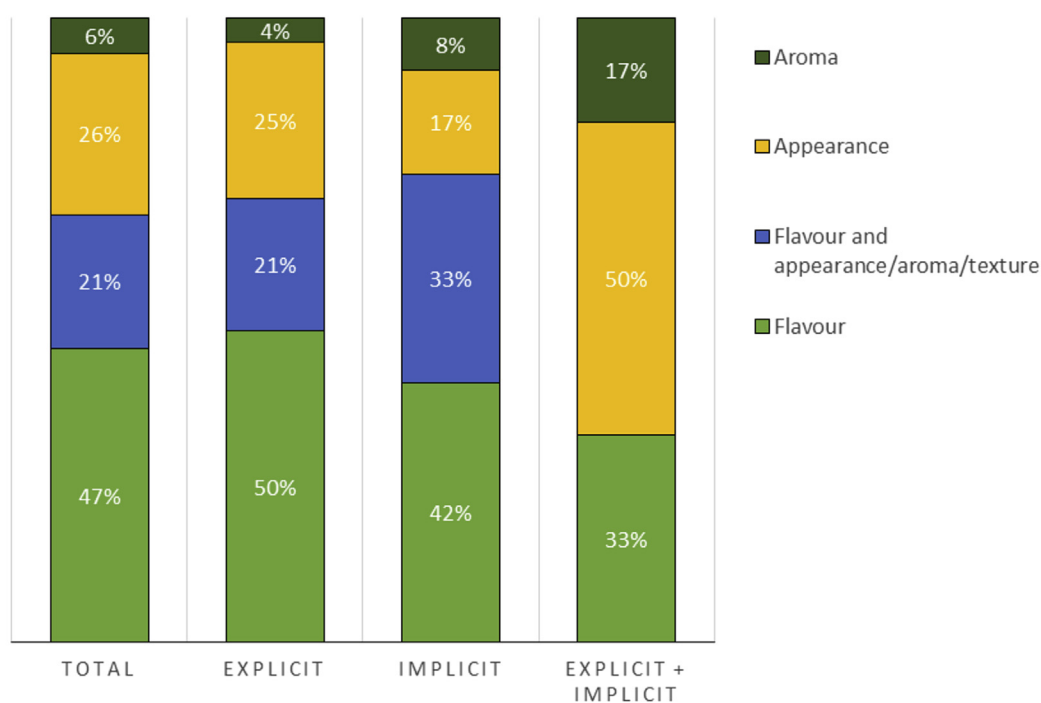
and instrument used to measure emotion. For the explicit method, three categories of measures were found: verbal self-reported measures, non-verbal self-reported measures and a combination of verbal and non-verbal self-reported measures. Also three measure categories for the implicit method were listed: expressive measures, expressive and physiological measures, and implicit behavior task measures. For the studies that combined the explicit and implicit method also three categories were recognized: verbal self-reported and expressive measures, non-verbal self-reported measures and expressive measures, and verbal self-reported measures and implicit behavioral task measures.

3.2.2. Explicit instruments (52 studies)

Explicit measurement of emotion was most frequently applied through an emotional lexicon, a questionnaire format with a list of emotional terms (or sentences) that can be checked (e.g. Check-all-that-apply, CATA) or rated (rate-all-that-apply (RATA) or 5-point rating scale) (46 out of 52). The studies applying the emotional lexicon were divided into three categories: predefined (24 studies), consumer-defined (19 studies) and a combination of predefined and consumer-defined (3 studies).

The EsSense Profile® questionnaire is considered as 'the' illustrative example of explicit measurement method. In the reviewed studies the EsSense Profile® by King and Meiselman (2010) (either modified or not) was mostly applied in explicit emotion research (19 studies). Other predefined emotional lexicons used in the reviewed studies were PANAS (1 study), Emotions in food experience' scale (1 study), Profile of Mood states (1 study) and lexicons based on existing literature (4 studies).

(a)



(b)

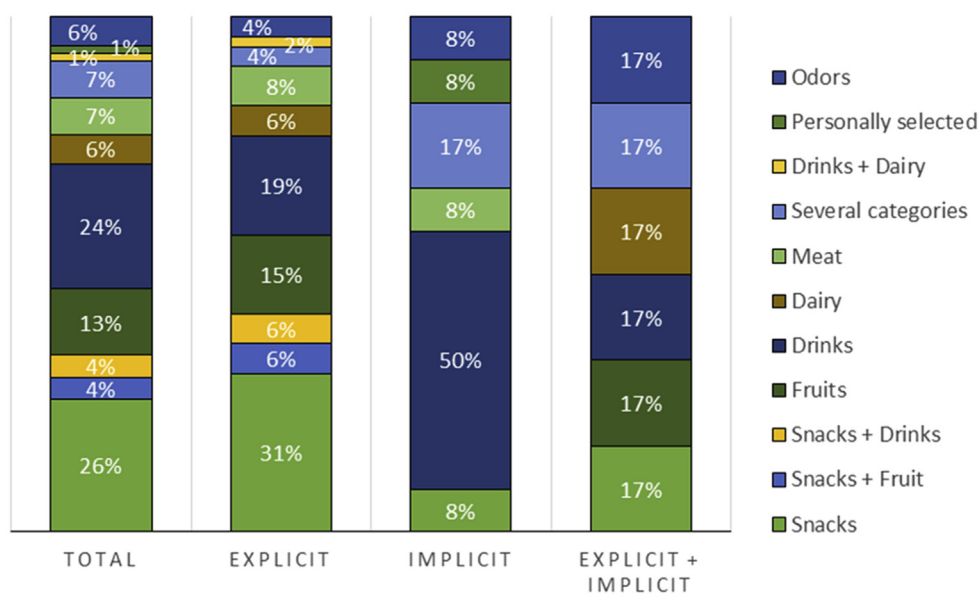


Fig. 2. Overview of the number of studies (in %) for product category (a) and each sensory modality (b) for each method.

A total of 19 studies applied consumer-defined lexicons developed mostly via pretest in which consumers need to define the emotional terms that will be used in the evaluation of the product.

Three studies applied an emotional lexicon with non-verbal representations. The EsSense Profile[®] was combined with PrEmo in two studies and another study combined the lexicon developed by Thomson and Crocker (2011) with Image Measurement of Emotion and Texture (IMET), which is an instrument where

participants are asked to create their own 'My pictures board' with self-selected images representing 12 different emotions (Collinsworth et al., 2014).

The number of emotional terms used in a lexicon varied from 5 (fear, disgust, pleasure, interest and surprise; Olsen et al. (2014)) to 47 for the predefined lexicons, whereas the number of terms for the consumer-defined lexicons varied from 10 to 50. An emotional lexicon also typically holds terms that can be classified as positive,

Table 3

Overview of studies that applied an emotional and sensory measurement. Instruments of emotion measurement categorised per method and measure.

	Emotional measurement		Sensory measurement			Reference
	Scale	Timing of registration	Sensory modality	Liking scale	Timing of sensory measurement	
Method: EXPLICIT						
Measure: Verbal self-reported						
Emotional lexicon						
Predefined						
• EsSense Profile®	rating 5-point scale	after flavor	flavor	9-point scale	before emotion	Jaeger et al. (2013)
					before emotion	Jaeger et al. (2013)
					before emotion	Ng et al. (2013a)
					after emotion	Gutjar et al. (2015a)
		after flavor	flavor + texture	after emotion	after emotion	Jaeger et al. (2013)
		after appearance	flavor + appearance	no liking*	after emotion	Piqueras-Fiszman and Jaeger (2014c)
		after appearance	appearance	no liking*	after emotion	Piqueras-Fiszman and Jaeger (2014c)
					after emotion	Piqueras-Fiszman and Jaeger (2014a)
					after emotion	Piqueras-Fiszman and Jaeger (2014a)
					after emotion	Piqueras-Fiszman and Jaeger (2014a)
					after emotion	Piqueras-Fiszman and Jaeger (2014a)
• Modified EsSense Profile®	CATA	after flavor	flavor	9-point scale	before emotion	Walsh et al. (2015)
	rating 5-point scale				before emotion	Dorado et al. (2016b)
	rating 5-point scale	after appearance	appearance	no liking*	after emotion	Piqueras-Fiszman and Jaeger (2014b)
	best-worst scaling	after flavor	flavor	9-point scale	before emotion	Jaeger et al. (2013)
• Based on literature	CATA	after flavor	flavor	no liking*	after emotion	Piqueras-Fiszman and Jaeger (2015)
		after flavor	flavor	no liking*	after emotion	Piqueras-Fiszman and Jaeger (2015)
	CATA	after appearance	appearance	no liking**	after emotion (separate session)	Olsen et al. (2014)
	rating 5-point scale	after appearance	appearance	5-point scale	simultaneously	Narchi et al. (2008)
• PANAS	rating	after aroma	aroma	rating	before emotion	Kuesten et al. (2014)
• Emotions in Food	rating 5-pionot scale	after flavor	flavor	9-point scale	before emotion	Lease et al. (2014)
• Experience' Scale						
Consumer defined						
• Based on pretest	CATA	after flavor	flavor	9-point scale	before emotion	Ng et al. (2013a)
				no liking*	after emotion	Piqueras-Fiszman and Jaeger (2015)
					after emotion	Piqueras-Fiszman and Jaeger (2015)
	line scale	after flavor		15 cm line scale	before emotion	Dorado et al. (2016b)
	best-worst scaling	ND		ND	ND	Thomson et al. (2010)
	CATA	after flavor	flavor + appearance	9-point scale	before emotion	Ng et al. (2013b)
	line scale	after appearance	flavor + appearance + aroma +	100-mm VAS	before emotion	Labbe et al. (2015)
		before and after	hearing + texture			
	CATA	after appearance	appearance	9-point scale	before emotion	Manzocco et al. (2013)
	rating			5-point scale	ND	Rousset et al. (2005)
	“Bulls-eye” approach	after appearance		no liking*	before emotion	Piqueras-Fiszman and Jaeger (2015)
					before emotion	Piqueras-Fiszman and Jaeger (2015)
					before emotion	Piqueras-Fiszman and Jaeger (2015)

Table 3 (continued)

	Emotional measurement		Sensory measurement			Reference
	Scale	Timing of registration	Sensory modality	Liking scale	Timing of sensory measurement	
• EmoSensory® Wheel	RATA	after	flavor + appearance + aroma + texture	9-point scale 9-point scale 9-point scale 7-point scale	simultaneously simultaneously simultaneously simultaneously	Schouteten et al. (2015b) Schouteten et al. (2015b) Schouteten et al. (2015b) Schouteten et al. (2015a)
• Beer-specific emotional lexicon	rating (line scale)	after flavor	flavor	line scale	after emotion	Dorado et al. (2016a)
• EmoSemio	rating 5-point scale	after flavor	flavor	9-point scale	before emotion	Spinelli et al. (2015)
<i>Predefined + consumer defined</i>						
• EsSense Profile® (39) + focus group	CATA	after flavor		no liking	NA	Bhumiratana et al. (2014)
• EsSense Profile® (39) + focus group	rating 5-point scale	before and after		9-point scale	before emotion	Bhumiratana et al. (2014)
• EsSense Profile® (39) + EmoSemio	rating 5-point scale	after	flavor + aroma	9-point scale	before emotion	Spinelli et al. (2014)
<i>Predefined or consumer defined</i>						
• Emotional terms	rating	fixed time: 5, 30, 60 and 90 min	flavor	7-point scale	after emotion	Macht and Dettmer (2006)
Measure: Other verbal self-reported						
Free association/listing Statements	free listing	after flavor	flavor	no liking	NA	Jaeger et al. (2013)
• Based on literature	rating 5-point scale	after flavor	flavor	9-point scale	before emotion	Miyaki et al. (2016)
• Profile of Mood States	rating 5-point scale	after flavor	flavor	no liking	NA	Radin et al. (2007)
• NA	conjoint	no tasting	flavor Appearance (+aroma + flavor + texture) aroma	FACT Scale	NA	Moskowitz et al. (2005)
• Based on literature	semantic differential scales	after odor	aroma	9-point scale	after emotion	Seo et al. (2009)
<i>Interview</i>						
• Modified Repertory Grid	interview	after flavor after appearance	flavor + appearance	no liking***	before emotion	Spinelli et al. (2014)
Measure: Non-verbal self-reported						
Affect Grid + PrEmo2	rating	after flavor	flavor	9-point scale	before emotion	den Uijl et al. (2016)
Measure: Verbal + non-verbal self-reported						
<i>Emotional lexicon + non-verbal self-reported measures</i>						
<i>Predefined</i>						
• Thomson and Crocker (2011) + My Pictures	CATA	before and after	flavor + texture	9-point scale	begin + during + end	Collinsworth et al. (2014)
• EsSense Profile® + PrEmo	rating 5-point scale	after flavor	flavor	100-mm VAS	after emotion	Dalenberg et al. (2014)
	rating 5-point scale	after flavor	flavor	100-mm VAS	after emotion	Gutjar et al. (2015b)
Method: IMPLICIT						
Measure: Expressive						
Facial expression	human coders	continuous	flavor	9-point scale	during	Ahn and Picard (2014)
	FaceReader	continuous	flavor	9-point scale	during	Garcia-Burgos and Zamora (2013)
	FaceReader	continuous	flavor	9-hedonic scale	after emotion	Danner et al. (2014b)
Measure: Expressive + physiological						
Facial expression + ANS	FaceReader + SCR, FT, HR	continuous	flavor	100-mm VAS	after implicit measurement	de Wijk et al. (2014)
	FaceReader + SCR, FT, HR	continuous	flavor + appearance + aroma	7-point scale	before (preselected)	de Wijk et al. (2012)
Facial expression + brain activity	FaceReader + EEG	continuous	flavor	9-point scale	during emotion registration	Horska et al. (2016)
Facial expression + eye movements	FaceReader + Eye Tracking	continuous	flavor + appearance + texture	9-point scale	during emotion registration	Kostyra et al. (2016)
Measure: Implicit behavioral task						
Implicit free association						
• Based on Ekman pictures	free association		flavor + appearance	no liking	NA	Silva et al. (2016)

(continued on next page)

Table 3 (continued)

	Emotional measurement		Sensory measurement			Reference
	Scale	Timing of registration	Sensory modality	Liking scale	Timing of sensory measurement	
Implicit priming paradigm (IPP)	reaction time	after flavor after appearance during appearance	appearance	NA	NA	Lamote et al. (2004)
	reaction time	during appearance	appearance	NA	NA	Lamote et al. (2004)
	forced choice	NA	flavor + appearance	21-point rating scale	NA	Verhulst et al. (2006)
	reaction time	NA	aroma	NA	NA	Hermans et al. (2005)
Method: EXPLICIT + IMPLICIT						
Measure: Verbal self-reported + expressive						
Emotional lexicon + facial expression						
<i>Predefined</i>						
• Modified EsSense Profile® + facial expression	CATA + FaceReader	after flavor + continuous	flavor	9-point scale	before emotion	Leitch et al. (2015)
	CATA + FaceReader	after flavor + continuous	flavor	9-point scale	before emotion	Walsh et al. (2015)
Measure: Non-verbal self-reported + expressive						
PrEmo + facial expression						
	rating 5-point scale + FaceReader	after aroma + continuous	aroma	100-mm VAS	before emotion	He et al. (2016)
Measure: Verbal self-reported + Implicit behavioral task						
Approach-avoidance procedure (AAP)						
	100-mm VAS + reaction time	after AAP/during appearance + during appearance	appearance	100-mm VAS	after AAP	Piqueras-Fiszman et al. (2014)
Affective association measure (~lexicon) + implicit priming paradigm (IPP)	8-point scale + reaction time	before and after priming + during appearance	appearance	no liking***	after IPP	Walsh and Kiviniemi (2014)
Food emotional response questionnaire + implicit priming paradigm (IPP)	4-likert scale + reaction time	before IPP + during appearance	appearance	NA	NA	Yen et al. (2010)

* = appropriateness to eat, ** = likelihood to eat, *** = forced choice, NA = not applicable, ND = no determined, CATA = check-all-that-apply, RATA = rate-all-that-apply, VAS = visual analog scale, SCR = skin conductance response, FT = finger temperature, HR = heart rate, EEG = electroencephalogram, ANS = autonomic nervous response.

negative or neutral. Most reviewed studies tended to use more positive (average of 17.17 terms) than negative terms (average of 8.25 terms) in the lexicon. The general idea that food elicits positive emotions (hedonic asymmetry) might explain that dominance of positive emotional terms in the emotional lexicons (Table 4).

Other explicit instruments for emotion measurement applied in the reviewed studies were free listing (2 studies), statements (2 studies), semantic differential scales (1 study), interview (1 study) and non-verbal representations (1 study).

In most studies the timing of the emotional measurement took place after sensory perception of the product (46 studies). Macht and Dettmer (2006) conducted emotion measurements at fixed intervals (5, 30, 60 and 90 min) after tasting. Only three studies did an emotional assessment before as well as after tasting.

3.2.3. Implicit instruments (12 studies)

Of the 70 studies reviewed, only 12 studies used implicit methods, either expressive and physiological measures or implicit behavioral task measures. The registration of facial expressions was most popular (7 out of 12). Facial expressions were mostly automatically registered via FaceReader software, which automatically encodes the facial expressions into the six basic emotions defined by Ekman (1993) (6 out of 7). Three studies only used the facial expression instrument, whereas other studies combined it with physiological measures, either registration of autonomic nervous responses (ANS) (two studies), brain responses (1 study) or eye movements (1 study). In these studies emotional responses were registered continuously. Besides expressive and physiological

measures, implicit association and priming approaches were also applied (5 out of 12). An implicit free association method was used in one study which applied the five basic emotion pictures of Ekman (1993). The implicit priming paradigm was applied in 4 studies where reaction time was measured.

3.2.4. Studies combining explicit and implicit instruments (6 studies)

A total of 6 studies combined both explicit and implicit methods for measuring emotion elicited by food. The explicit method using an emotional lexicon (modified EsSense Profile®) was combined with the implicit method of facial expression (2 studies), while the latter was also combined with the non-verbal, visual self-reported measure, PrEmo (1 study). Another implicit instrument was applied by Piqueras-Fiszman et al. (2014) who used the approach avoidance procedure (AAP) which measures people's approach and avoidance tendencies towards the presented foods in an implicit way by using a joystick based AAP. Participants were instructed to push or pull the joystick when a food stimulus was presented while reaction time was registered.

In 2 studies, the implicit priming paradigm was combined with a verbal self-reported explicit instrument, namely the affective association measure or the food emotional response questionnaire. While in the former participants were prompted with the sentence "When I think about eating fruit and vegetables, I feel ..." followed by 7 positive emotional term and 7 negative emotional terms, the latter targeted 4 statements related to perceived emotions.

As measures of facial expression are registered in a continuous

Table 4

Comparison of emotional lexicon instrument based on number of emotional terms used categorized in total number, number of positive, negative and neutral terms.

	Number of emotional terms				Reference
	total	positive	negative	neutral	
Emotional lexicon					
Predefined					
• EsSense Profile®	39	25	3	11	Gutjar et al. (2015a); Jaeger et al. (2013); Ng et al. (2013a); Piqueras-Fiszman and Jaeger (2014a, 2014c)
• Modified EsSense Profile®	ND	ND	ND	ND	Walsh et al. (2015)
	38	24	3	11	Dorado et al. (2016b)
	36	24	2	10	Piqueras-Fiszman and Jaeger (2014b)
	16–21	ND	ND	ND	Jaeger et al. (2013)
• Based on literature	47	balanced pos/neg	balanced pos/neg	ND	Piqueras-Fiszman and Jaeger (2015)
	47	balanced pos/neg	balanced pos/neg	ND	Piqueras-Fiszman and Jaeger (2015)
	5	2	2	1	Olsen et al. (2014)
	19	8	11	0	Narchi et al. (2008)
• PANAS	20	10	10	0	Kuesten et al. (2014)
• Emotions in Food Experience' Scale	18	11	7	0	Lease et al. (2014)
• Profile of Mood States	30	ND	ND	ND	Radin et al. (2007)
Consumer defined					
• Based on pretest	36	16	19	1	Ng et al. (2013a)
	20	10	10	0	Piqueras-Fiszman and Jaeger (2015)
	18	9	9	0	Piqueras-Fiszman and Jaeger (2015)
	12 cat	ND	ND	ND	Dorado et al. (2016b)
	24	ND	ND	ND	Thomson et al. (2010)
	34 (blind); 38 (pack); 50 (informed)	15 (blind); 24 (pack); 26 (informed)	18 (blind); 14 (pack); 23 (informed)	1 (blind); 0 (pack); 1 (informed)	Ng et al. (2013b)
	39	ND	ND	ND	Labbe et al. (2015)
	29	14	11	4	Manzocco et al. (2013)
	26	ND	ND	ND	Rousset et al. (2005)
	26	balanced pos/neg	balanced pos/neg	ND	Piqueras-Fiszman and Jaeger (2015)
	27	balanced pos/neg	balanced pos/neg	ND	Piqueras-Fiszman and Jaeger (2015)
	10	5	5	0	Piqueras-Fiszman and Jaeger (2015)
• EmoSensory® Wheel	17	ND	ND	ND	Schouteten et al. (2015b)
	14	7	7	0	Schouteten et al. (2015b)
	15	7	7	1	Schouteten et al. (2015b)
	13	6	6	1	Schouteten et al. (2015a)
• beer-specific emotional lexicon	10 cat	ND	ND	ND	Dorado et al. (2016a)
• EmoSemio	23	ND	ND	ND	Spinelli et al. (2015)
Predefined + consumer defined					
• EsSense Profile® + focus group	118	ND	ND	ND	Bhumiratana et al. (2014)
	86	64	11	11	Bhumiratana et al. (2014)
• EsSense Profile® + EmoSemio	39	25	3	11	Spinelli et al. (2014)
	23	ND	ND	ND	
Predefined or consumer defined					
• Emotional terms	11	ND	ND	ND	Macht and Dettmer (2006)
Emotional lexicon + non-verbal representation					
Predefined					
• Thomson and Crocker (2011) + My Pictures	12	5	5	2	Collinsworth et al. (2014)
• EsSense Profile® + PrEmo	39	25	3	11	Dalenberg et al. (2014)
	39	25	3	11	Gutjar et al. (2015b)
Emotional lexicon + facial expression					
Predefined					
• Modified EsSense Profile®	43	26	6	12	Leitch et al. (2015)
	ND	ND	ND	ND	Walsh et al. (2015)

Cat = categories, ND = not determined.

way, there was no specific order in performing the explicit and implicit measure. For the studies that used an implicit behavioral measure as implicit measurement, the reaction time of the participant was measured from the onset of the stimuli (appearance) until the response of the participant. Therefore the implicit emotional measurement was registered during the appearance of the product and the explicit emotional measurement was

registered before and/or after the implicit behavioral task during the appearance of the same products used in the implicit behavioral task. Walsh and Kiviniemi (2014) measured the explicit affective associations at baseline (before) and post-priming, whereas Yen et al. (2010) assessed the food emotional response only before priming. Piqueras-Fiszman et al. (2014) asked the participants to rate each food image that was used as a stimulus during the AAP

after the implicit measurement.

3.3. Sensory measurement

In most studies (48 out of 70) participants were asked to taste a food product. Only 15 studies combined flavor with another sensory modality, 33 studies focused on flavor alone. A total of 22 studies did not include flavor and examined another sensory modality. Here, mostly visual information or appearance of the food products, such as food pictures or images of food, were given (18 out of 22) (Fig. 2b). Four studies provided an aroma as a stimulus to the participants.

In most studies (48 out of 70) participants were asked to taste a food product. Some studies focused only on flavor (33 studies) whereas others combined flavor with other sensory modalities (aroma, appearance, texture) (15 studies). Notable is the dominance of only flavor, as flavor has been described as one of the most important factors when making product choices (Köster, 2003; Leitch et al., 2015; Schifferstein, Fenko, Desmet, Labbe, & Martin, 2013) (Table 3).

In Fig. 2b, the number of studies is shown for each method for each sensory modality. Investigating only flavor of food products was dominant in both explicit (50% of the 52 studies) and implicit methods (42% of the 12 studies). A focus on flavor and appearance, aroma and/or texture accounted for 21% of the explicit and 33% of the implicit methods. For the combined method (explicit and implicit) mainly visual stimuli of food (appearance) were subject of research (50% of the 6 studies).

4. Discussion

This is the first study that systematically reviews (both explicit and implicit) methods, measurements and instruments that have been applied in consumer and sensory research to measure emotion elicited by food in the context of food behavior. It provides a comprehensive overview and builds on the increased interest in the relationship between food and consumer, which goes beyond sensory liking, by indicating trends and challenges of capturing emotional responses elicited by food. A total of 70 studies were reviewed.

Although there are several ways to measure emotion elicited by food, explicit methods are the most prominent (52 studies). Explicit methods thus remain a popular approach among practitioners in consumer and sensory research, because they are quick in use and the data is easy to process (Dorado, Perez-Hugalde, Picard, & Chaya, 2016b). Besides the fast and easy approach, explicit methods are user-friendly as they do not require much involvement of the participant. Nevertheless, studies mention major limitations and problems of explicit methods. First, explicit methods run the risk of being cognitively biased, which may affect the validity of the emotional assessment (Danner, Sidorkina, Joechl, & Duerrschmid, 2014b; de Wijk et al., 2012). Second, social desirability and self-representation biases can similarly influence the explicit self-reported measures of emotion (Chai et al., 2014; Schwarz & Oyserman, 2001). A third limitation is that explicit methods are to some degree retrospective as emotions are elicited after the experience (Danner et al., 2014a). Fourth, some participants can lack the introspective capacity to correctly identify, recognize and then verbalize the perceived emotion (Köster, 2003; Nisbett & Wilson, 1977).

Within these explicit methods, most studies applied an emotional lexicon as testing instrument (46 studies). A well-known difficulty of the emotional lexicon is the translation problem. When translating emotional terms meaning is lost, which makes it hard to apply in a multicultural setting. Furthermore, cultural differences in

emotional perception and experience can also be problematic in these measurements (van Zyl & Meiselman, 2016). Moreover, some consumers might consider using certain words to describe how they feel rather strange as reported by Jaeger et al. (2013) and might select emotional terms even if they are not really experiencing them before, during or after consumption (Thomson & Crocker, 2015). Because of the problems of the emotional lexicons, non-verbal self-reported measurements are on a rise. Non-verbal self-reported instruments, such as Product Emotion Measurement Instrument (PrEmo) can circumvent these problems, as translation is not necessary. (Koster & Mojet, 2015). However, consumers are not very familiar with these pictograms and possibly uncertain about the meaning of the graphical representations. A possible solution lies in the use of emoji, which have been recently suggested as an alternative way to capture the explicit non-verbal emotions elicited by food products (Jaeger et al., 2017a).

Explicit methods might apply either a predefined or consumer-defined list of terms or visual images. Whereas a predefined list has the advantage that it is easier and more cost-efficient to apply, one should bear in mind that it contains many items in order to ensure that no important emotions are missed (Jaeger et al., 2013; Spinelli et al., 2015). In contrast, a consumer-defined list contains a step to select the most appropriate terms or visual images for the product category under study enabling a shorter list. One should consider that including too many items might hamper the emotional profiling task and consequently lower the quality of the collected data (Jaeger et al., 2013; Ng et al., 2013a). Therefore, a consumer-defined list has been recommended when working with emotion terms based upon research comparing both methodologies (Ng et al., 2013a). Although many studies have worked with a consumer-defined list (Dorado et al., 2016a; Ng et al., 2013a; Piqueras-Fiszman & Jaeger, 2014a; Schouteten et al., 2015b), it is noteworthy to mention that the selection is often not clearly described in the papers. The usage frequency and ability to discriminate between product samples are often mentioned as criteria but most papers do not mention the details of the application such as the exact percentage for the usage frequency. The criteria listed by Jiang, King, and Prinyawiwatkul (2014) could be recommended when selecting the final terms or visual images for a consumer-defined emotion lexicon.

It is important to note that the number of emotional terms used within the emotional lexicons applied in the studies varied greatly, ranging from only 5 to 50. There is a tendency to use long lists of emotional terms as most lexicons consisted of more than 30 terms. Although these lexicons are good to detect differences among products, there is a growing concern about the length of the lexicons. As a result the EsSense Profile® has recently been redesigned into a shorter version limited to 25 terms (Nestrud, Meiselman, King, Leshner, & Cardello, 2016). This reflects two opposing needs in emotional research: obtaining a full characterization which requires sufficient terms contradicts with the need to keep the task as short as possible to make it easier for the consumer. Also, a longer list might lead to the inclusion of redundant terms (e.g. synonyms or closely related terms) which might confuse participants of the emotional profiling task (Jaeger et al., 2013). Overall, it is recommended to keep the burden for the participants as low as possible and as such to limit the number of items in explicit methods. More research is recommended with a broad variety of product categories to examine the impact of the number of terms on the emotional profiling of food products. Moreover, one should also consider the length of the overall task as a longer list of items might be compensated by limiting the number of products under study. Specifically for the widely applied EsSense Profile, it has been recommended to only use two products (King et al., 2013), but this hampers the efficiency of data collection when a broad range of

products needs to be examined and also limits the validity as consumers often choose between more than two products in real life.

Three types of response formats are commonly used for the explicit measurements: (i) rating, (ii) CATA and (iii) RATA. CATA focuses on the use of applicability of the selected terms and is the recommended response format when working with emotions of higher intensity and for the selection of items when establishing a consumer-defined list (Jiang et al., 2014). Given that CATA does not require rating, it has the benefit that it shortens response time and requires a lower cognitive involvement which limits the effect on the emotional measurements (Ares et al., 2014; Vidal, Ares, Hedderley, Meyners, & Jaeger, 2016). RATA and rating scales provide a broader picture as these response formats are more sensitive than CATA. Due to the rating RATA and rating scales can be treated with many statistical methods whereas the statistical analysis of CATA is rather limited as it involves binary data. However, as the cognitive involvement of RATA and rating scales is higher, it could discourage the use of satisfying response strategies by consumers (Schouteten et al., 2017b). RATA scales have the advantage that it requires less time compared to the rating scale. Yet, by asking participants to rate all emotions with for instance the option 'not at all applicable' as foreseen in the EsSense Profile™ (King & Meiselman, 2010) might make the task easier for consumers. Given the advantages and limitations of these response formats, the individual researcher should select the most appropriate response format depending on the goal of the research.

Implicit methods to measure emotion avoid the limitations of the explicit method. As they are indirect and non-self-reported, they are not under the conscious control of the consumer (De Houwer & Moors, 2007; de Wijk et al., 2012). Yet, these methods are only scantily explored in consumer and sensory research. This review found 18 studies, of which 12 studies only applied implicit methods and 6 studies combined explicit and implicit methods. The use of an implicit method was mostly the result of interdisciplinary research as techniques from psychology and medical science are applied. Examples are the priming paradigm and IAT which are frequently used in psychology. Similarly, the measurements of autonomic nervous system (ANS) responses (such as heart rate) and neurophysiological responses (such as brain activity) originate from medicine and have only recently been applied in consumer and sensory research. Three key reasons might explain why few studies use implicit methods: the multidisciplinary character, the amount of training and the interpretation of the data. Although food research tends to be multidisciplinary, few teams include a field where implicit methods are common-place in research. Furthermore, when looking into setting up these implicit methods, finding colleagues of other fields is challenging and time-consuming. Similarly time-consuming is the amount of training required to set up and perform measurements according to an implicit method. Lack of experience, material and the many requirements to obtain valid results call for extensive training. Finally, the data obtained are not as self-explanatory as in explicit research. Data needs many transformations to be readable for researchers. As the data is gathered continuously, datasets are very big and need to be filtered and split. Again, time and effort need to be invested (Dorado et al., 2016b). Despite those challenges, implicit measurement of emotion (in particular expressive and physiological measures) in sensory and consumer research is on a rise as they are increasingly understood by researchers. Looking to the publication years of the reviewed studies, the number of studies using an implicit measurement (expressive and physiological measures) and the number of studies using both explicit and implicit measurement has increased over the last 3 years (Supplementary Fig. 1).

Within the implicit measures expressive measures, in particular

registration of facial expressions, are the most popular. Facial expression measurement was typically carried out using computer software which automatically detects changes of the human facial expression to different emotions (Tian, Kanade, & Cohn, 2005). However, in the case of tasted food the registration of facial expressions is often disturbed by facial movements when chewing of solid foods. This seriously hampers the registration of emotional responses during the consumption of food products. Therefore facial expression registration is the most useful in case of food names instead of tasted foods (Koster & Mojet, 2015). Also for measurements of ANS responses studies have used drinks, such as breakfast drinks (de Wijk et al., 2014) or solutions, such as bitter and sweet solutions (Samant, Chapko, & Seo, 2017), to account for movement artifacts in the data.

Whereas explicit measures cover mostly a large number of emotions, implicit measures generally cover a small number of emotions. For facial expression measurement emotions are limited to the six basic emotions (Ekman, 1993) as physiological measures have been shown unable to distinguish among a large number of different, especially positive, emotions (Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2008). The emotion specificity for ANS response measurements is debated. Some suggest a dimensional approach, such as valence and arousal dimensions, while others proposed discrete emotions (for a review on ANS measures, see Kreibig (2010)).

The combination of an implicit measurement and an explicit measurement was performed in six of the reviewed studies. When combining both methods it is important to understand that most implicit measures, such as facial expression and physiological responses, provide a continuous measurement, whereas explicit measures, such as the emotional lexicon, provide discrete information at a certain point in time about emotional responses elicited by the food product.

The comparison of explicit and implicit measures to demonstrate the convergent validity, has not been done in sensory and consumer research until recently in Samant et al. (2017). This recent study compared facial expression measurement and measurements of autonomic nervous system responses to the self-reported emotional lexicon (EsSense25). The results showed that emotional responses measured using EsSense25 and facial expression analysis along with perceived taste intensity performed best to predict overall liking as well as preference, while ANS measures showed limited contributions (Samant et al., 2017). However, ANS measurements have been used a lot in psychology to assess emotional response to stimuli and are considered the major component of the emotion response in many theories of emotion (Kreibig, 2010). Some researchers suggest ANS measures can be used for measures of arousal or valence (Fernández et al., 2012). Although individual ANS measures appear responsive to dimensions (such as arousal) rather than discrete emotional states. Kreibig et al. (2007) found that the combination of 11 ANS measures differentiated responses to fear-inducing versus sadness-inducing film clips with 85% accuracy. Nevertheless, the emotion specificity is debated and is likely to depend on the nature of the stimuli (for a complete review on ANS measures, see Kreibig, 2010). Findings in food research show mixed results as they are concerned with product development questions with specific products or product attributes (Danner et al., 2014a; de Wijk et al., 2012, 2014; He et al., 2016). Therefore, replications of studies are needed and it will be increasingly important to compare the results of implicit and explicit measurements.

Although flavor dominates as a stimulus in the reviewed studies, it seems that a focus on flavor alone is not sufficient to measure the complete consumer experience as different stimuli (flavor, food name or image) may elicit different kinds and degrees of emotions.

Some studies experimented with food images to measure emotions associated with the product without tasting. Cardello et al. (2012) showed a greater emotional response towards food name than towards the product flavor. They concluded that food names may elicit memories of an emotional experience with food whereas the product flavor may not elicit this strong experience. Tasted foods can vary over time in emotional response due to perceptual variability, changing expectations and preceding appetitive contexts (Cardello et al., 2012). A parallel can be drawn with timing. Most studies, especially when explicit methods are used, measured emotion after sensory perception. As such the method does not measure a natural state or baseline which can account for individual differences. An appetitive context or an overall negative feeling of the day can change reported perception of the emotion. In the latter example a negative feeling could weaken a positive emotion or strengthen a negative one. Implicit methods apply a continuous monitoring of emotion measurement which means a baseline is inherent in the approach. Explicit methods could on the other hand include a baseline measurement to access the mood of the participant before consumption. Explicit methods could on the other hand include a baseline measurement to evaluate the mood of the participant before consumption. Furthermore, the question arises of a general baseline measurement of the mood is sufficient as performed by Danner et al. (2016) or that the same emotional terms or visual representations of the emotions should be used. The latter enables a more thorough overview of the state of mind of each individual's mood when participants evaluate the products while a more general baseline measurement might shorten response time and have a smaller overall impact on the actual mood of the participant.

For explicit methods most often products with high consumer acceptance levels that are often linked to emotion were selected for research. Snack products and especially chocolate were frequently used. When measuring emotions in a recall survey, Desmet and Schifferstein (2008) noted specific emotions for main meal, followed by sweet snacks, alcoholic drinks, chocolate and meat. King and Meiselman (2010) found that chocolate and pizza elicited the strongest emotional associations among participants. In contrast, foods like oatmeal and carrots elicited less emotional associations and are only rarely used in the studies reviewed. When comparing implicit and explicit methods, implicit methods more frequently choose products with low consumer acceptance levels. As such, it can be deduced that researchers assume that emotions elicited by high accepted products are easier to express or scale explicitly and that emotions elicited by low accepted products can be registered implicitly more easily as the body would react more strongly to negative stimuli.

Young adults, mostly women, were most often chosen as study population in the reviewed studies. Women are shown to be more emotionally sensitive to food than men, although this is food specific and reversed for some products (King et al., 2010). Those differences may be associated with gender role, where females tend to express emotions more than men (Kring & Gordon, 1998). Not only for expressed emotion, but also in autonomic nervous system (ANS) responses gender differences are noted (Gomez, von Gunten, & Danuser, 2016). Women's ANS responses revealed enhanced reactivity to unpleasant arousing pictures, whereas men's ANS responses revealed enhanced reactivity to pleasant arousing pictures. Gomez et al. (2016) also noted age differences in emotional processing and in basic autonomic nervous system functioning. A decrease in the strength of heart rate, skin conductance level and pupil size are shown from younger to older age. Age-related factors, such as physiological changes and medication use, also seem to make it more difficult to measure implicit emotions of older consumers through ANS responses or reaction time (den Uijl, Jager,

Zandstra, de Graaf, & Kremer, 2016; Kunzmann, Kupperbusch, & Levenson, 2005; Neiss, Leigland, Carlson, & Janowsky, 2009). Also for self-reported measures, age should be considered as an important factor. In a recent study of den Uijl et al. (2016) older adults scored negative emotions lower in comparison to younger adults. The authors concluded that this age-related positive orientation extends to the rating of food-elicited emotions and even to the emotional experience of the food products. Besides, older individuals seem to use their recalled emotional experiences with the products, rather than their actual elicited emotion (Koster & Mojet, 2015; Thomson et al., 2010). Hence, age should be considered as an important factor when explicit or implicit measurements are used to assess product-elicited emotions and further research is needed to determine the suitability of the measurement or response format (e.g. CATA versus RATA) for specific consumer groups. Specific instruments should be developed for specific consumer groups, e.g. children compared to elderly.

Most of the tests have been carried out in sensory facilities as researchers wanted to control the environmental factors as much as possible (Meilgaard, Carr, & Civille, 2006). Although tests carried out in a sensory laboratory setting are easier to compare when taken place in different locations (e.g. different regions or countries) and on different occasions, this consumption context does not resemble actual food consumption leading to questions regarding the ecological validity (Schmuckler, 2001) of the tests. A series of studies illustrated that when people are thinking about an imaginary consumption setting, the explicit emotional profiling of food products is influenced (Piqueras-Fiszman & Jaeger, 2014a, 2014b, 2014c). A study of Dorado et al. (2016a) has used a written scenario to ensure a more realistic environment. Some other studies have simulated a more real-life environment by testing for example in a kitchen (Labbe et al., 2015), lounge setting (Bhumiratana et al., 2014) or a simulated restaurant or cafeteria setting (Dalenberg et al., 2014; Gutjar et al., 2015a). A study performed by Danner et al. (2016) found that tasting wine in the restaurant context evoked more intense positive emotions compared to the home and laboratory contexts. Another recent study found that the emotional associations of yoghurt samples differed between a laboratory and home context (Schouteten, De Steur, Sas, De Bourdeaudhuij, & Gellynck, 2017a). For implicit measurements, the test always took place in a controlled test setting, where each participant was tested separately in an individual room or booth, as measurements of facial expressions or physiological measures are technically more challenging than a questionnaire. Hence, implicit measurements are more suitable for laboratory environments than for real-life (de Wijk et al., 2014).

Technological advancements should make it possible in the near future to carry out tests in an immersive or virtual context. This would make it possible to have the best of two worlds: product-elicited emotions measured in a laboratory context under controlled circumstances although participants have the feeling they are consuming the food samples in a more realistic consumption context such as at a bar or restaurant.

The focus on consumer and sensory studies which included both sensory preference and emotional measurements of food products hampers the generalizability to the broad emotion research field in particular. This review also did not evaluate the results generated by the different approaches and the impact of sample characteristics on emotional response to food is not further explored through for example meta analysis.

Future research could review the results generated by the different approaches in order to compare and evaluate them, starting from the overview of the approaches in this review. Challenges in consumer and sensory research include the

development of a more complete understanding of drivers of consumers' preferences and hedonic liking (Leitch et al., 2015). Traditional consumer and sensory research is focused on explicit methods of sensory and emotional perceptions through questionnaires and emotional lexicons in a primarily young adult population. Future research would benefit from additional instruments complementary to the existing ones (Gutjar et al., 2015a). Implicit methods are an emerging tool to measure emotion in relation to food and may bring additional support to traditional sensory research for a better understanding of emotional response to food (Walsh et al., 2017b). The use of implicit methods can also help to broaden the research range from products with high to products with low consumer acceptance levels. Furthermore, future research could broaden the sample population to various consumer groups.

This review has aimed to present the state of the art with respect to consumer and sensory research by evaluating and mapping research methods, measurements and instruments in the increasingly interdisciplinary field that is trying to capture the total consumer experience when examining the relationship between food and consumer. While this field of research is rapidly growing (as recent research beyond this study shows, e.g. Beyts et al. (2017); Jaeger et al. (2017a); Jaeger, Vidal, Kam, and Ares (2017b); Walsh, Duncan, Bell, O'Keefe, and Gallagher (2017a); Walsh et al. (2017b)), this systematic review offers a comprehensive overview of the different methods, measurements and instruments to capture emotional associations. The review may prompt researchers to consider measuring the total consumer experience by building appropriate research designs including innovative approaches like interdisciplinary implicit methods.

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.tifs.2017.09.006>.

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