ELSEVIER

Trends in Food Science & Technology 11 (2001) 273–283

TRENDS IN FOOD SCIENCE & TECHNOLOGY

Review

Sensory and consumer testing with children

Jean-Xavier Guinard*

Department of Food Science and Technology, University of California, Davis, 1, Shields Avenue, Davis, CA 95616, USA (Tel: +1-530-754-8659; fax: +1-530-752-4759; e-mail: jxguinard@ucdavis.edu)

Many foods and beverages are developed specifically for children, and must be tested with children. Sensory or consumer tests for children must take into account the range of sensory and cognitive abilities of children from infancy to teen age. This review examines what type of sensory or consumer test may be conducted with children, at what age and for what purpose. The many factors that must be considered when designing a sensory or consumer test for children are reviewed

Introduction

The market for children's foods is continuously growing, and children have an increasing influence on food purchase decisions [1]. This has lead to the use of children in product development programs by food manufacturers, to the development of twin target markets for adults and children in many food categories, and to requirements for palatable, healthy and nutritious food for children amidst trends towards convenience foods and demands for responsible nutrition [2]. The sensory properties of foods and beverages are important determinants of their acceptance among consumers, and as a result, the need for sound methodology for sensory testing with children has increased. This review first summarizes the current state of knowledge of chemosensory perceptions and preferences of children, and then examines where sensory and consumer testing methodology for children stands today, and why careful consideration must be given to the design of methods for sensory and consumer testing with children.

Terminology

In this critical review, we will refer to *newborns* (just born), *infants* (0–18 months), *toddlers* (18 months–3 years), *preschoolers* (3–5 years), *early readers* (5–8 years) and *pre-teens* (8–12 years). We will also categorize sensory tests and participants in those tests as follows: *analytical sensory testing* or *sensory analysis* refers to the use of *trained judges* for analyzing the sensory properties of foods and beverages. It includes difference tests (paired-comparison, duo-trio, triangle, etc.) and descriptive analysis (Flavor Profile, QDA, Spectrum Method, Free-Choice Profiling, Time-Intensity, etc.). In basic research, *psychophysical tests* may be conducted with *human subjects* to investigate their sensory perceptions and preferences. *Consumer testing* has *untrained users and likers* of the product, i.e. *consumers*, express their liking or preferences for the product using hedonic and other scales or paired-preference tests.

Applications of sensory testing with children: what is appropriate and what is not

There are three purposes for sensory testing with children: basic research, or understanding sensory perceptions by infants and children; sensory evaluation with children as judges, such as difference testing and/or descriptive analysis; and consumer testing with children as consumers. In this review, we offer the opinion that the first and last purposes are justified and encouraged, whereas the second one is not. Difference testing and/or descriptive analysis are best left to adults who have similar perceptions to those of children, and yet greater cognitive abilities, as required to carry out difference testing, scaling and descriptive analysis. Consumer tests are conducted routinely with children nowadays, but the results of such studies typically remain the property of the companies who order them. Partial results may sometimes be published in the literature [3].

Sensory perceptions of children

The human fetus appears to have specialized taste cells at the seventh or eighth week of gestation, with structurally mature taste buds visible at 13–15 weeks [4], and there is evidence that fetal taste receptors are

0924-2244/01/$ - see front matter
PII: S0924-2244(01)00015-2

stimulated by chemicals present in the amniotic fluid [5–7]. Infants may have up to five times the amount of total taste buds adults have (10,000 vs. 2,000), and their foliate papillae are larger and more abundant, but this may not lead to a heightened taste sensitivity because the innervation of taste papillae in infants is not as developed and functional as in adults [8]. The development of the taste apparatus carries on through childhood. Studies of taste thresholds of children have produced a relatively confusing outcome, probably because it is difficult to eliminate the influence of cognitive variables in those protocols. Some studies reported that children as young as 5–7 years of age have similar detection thresholds as adults [9], but most found young children to have a lower sensitivity than adults [10–12].

In contrast with a highly functional gustatory system at birth, olfaction shows significant development postnatally. There is little doubt, however, that human neonates detect odors within hours of birth, as shown by changes in respiration or salivation upon olfactory stimulation [13,14]. An infant will reliably orient towards the breast pad of his/her mother [15]. Although the neonate is capable of detecting highly concentrated odorants, there is evidence that olfactory sensitivity increases over the first few days of life [16]. It is not clear whether this change in response is due to (a) a stimulus-independent post-natal maturation of peripheral or central chemosensory receptors or neurons including a change from mouth breathing to nasal breathing; (b) the induction of sensitivity contingent on odor exposure; or (c) the development of a more coordinated response system [16].

Cognitive abilities of children

ASTM'S Committee 18 on sensory testing methods is currently developing guidelines for sensory testing with children. They have compiled children's cognitive abilities as a function of age as shown in Table 1.

Children can be classified into Piaget's stages of cognitive development [17]. Between the ages of 2 and 7, children are 'preoperational', which means they are perception bound and limited in their logical thinking abilities. The concept of 'centration' (e.g. the child's ability to pay attention to only one aspect of a situation at one time) is particularly important (and limiting) at that stage. It is evident in the context of food sensory testing, with young children often focusing on one attribute of a food, such as appearance, in making their judgements, rather than taking all sensory attributes into consideration. Other limitations in the cognitive abilities of children pertinent to sensory testing include limited verbal skills, short attention span, and difficulties in task comprehension [18].

Children's limited verbal skills require that special consideration be given to the phrasing of the questions (children tend to repeat adults' statements and to respond affirmatively to a positively-phrased question) and the vocabulary used, particularly when referring to sensory attributes (e.g. the well-documented sour-bitter confusion by adults is even more of a problem with children). Children aged 5–7 years are either preliterate or may have rudimentary reading skills, thus requiring personal interviews [19], which are more time-consuming and expensive than traditional sensory tests.

Oram's research provides important information on the development of children's vocabulary as it pertains to the description of food attributes, such as textural characteristics [20,21]. A case study on ice cream reported by Moskowitz [22] provides an interesting perspective on differences between children and adults in the use of sensory descriptors and the importance of attributes in the formulation of a hedonic judgement. Adults differentiated better among the sensory attributes of the ice creams, and clearly divided their perception into appearance, taste and texture, respectively. Children, however, tended to smear the attributes, confusing taste and texture, but not appearance, as well as confusing sweet and tart. It has been hypothesized that children show more field dependence, a characteristic of being influenced in one's judgement of a target stimulus by the background of the target [23]. It results that children are more strongly affected than adults by irrelevant dimensions of complex stimuli, as shown by evoked cortical potentials [24]. Yet, in a study of the effects of color and odor on judgements of sweetness of beverages [25], children did not show the expected effect of darker red colors raising sweetness intensity ratings. Moskowitz [22] also concluded that to a child, if the product looked good then it would be uprated. So would it to an adult, but the strongest leverage for adults came from making the product taste better, and (even more so) have a better texture.

To deal with potential comprehension problems, we recommend taking the child through the test protocol using visual stimuli before having him/her taste the actual test foods or beverages. An example of that approach is found in Kimmel et al. [26], and is illustrated in Table 2. Children performed a variety of sensory tests with pictures of foods, before performing them with actual foods. The foods pictured were chosen to enable the experimenter to check that the child understood the task (e.g. doughnuts vs. hot dogs for a paired-comparison for sweetness intensity — the child was expected to pick the doughnut as the sweeter food; or chocolate cake and green beans for hedonic scaling — the child was expected to give a higher rating to the chocolate cake).

In a similar approach, Thomas and Murray [27] checked that children understood the 'same–different' test principle with blocks before having them perform the test with food stimuli. Other investigators have recommended using a group demonstration on the

Table 1. Cognitive skills of children from infancy to teen age (from ASTM's Committee 18 on Sensory Evaluation)

Skill/behaviour	Infant Birth–18 months	Toddler 18 months–3 years	Pre-school 3–5 years	Early readers 5–8 years	Pre-teen 8–12 years	Teenage 12–15 years
Language—Verbal, reading/written language vocabulary	Pre-verbal. Rely on facial expressions. Cannot read. Cannot write. Uses sounds, very few words.	Begining to vocalize, adult interpretation still required. Cannot read. Cannot write. Early word usage developing.	Early language development. Can observe facial expressions, respond to questions and pictures. Generally, reading and writing skills are just begining, if present.	Moderately developed verbal and vocabulary skills; understanding increases. Early reading and writing skills, may still require adult assistance for some tasks.	Very verbal—able to express themselves adequately. Reading and written language skills increase rapidly and are sufficient for most self-administered tasks	Strong language and vacabulary skills. Reading and written language skills continue to increase. Adult level in most respects.
Attention span	Gauged by eye contact	Gauged by eye contact or involvement with task, bodily movement.	Limited, but increasing. Bright colors, movement are effective.	Limited by understanding of task and interest level, challenge.	Potential attention span is increasing, but holding interest is critical.	Similar to adults, involvement and interest subject to peer pressure.
Reasoning	Limited to pain and pleasure.	Limited, but concept of 'no' becoming a factor.	Limited, but beginning to be able to know what is liked and what is not.	Developing with increased learning, cause/effect concepts	Full ability for understanding and reasoning, capable of decision making	Reasoning skills are fully developed and similar to adults.
Decision making	Does not make complex decisions	Does not make complex decisions, but 'yes'/'no' can be decisive	Limited, but concepts of what is liked and what is not strengthen. Able to choose one thing over another.	Ability to decide is increasing, but influence of adult approval is evident.	Capable of complex decisions, peer influences a factor	Fully capable of adult decision processes, subject to peer influences
Understanding scales	Does not understand scales	Does not understand scales	Understanding of simple scales beginning, sorting or identification tasks more effective	Scale understanding increasing, simple is best.	Capable of understanding scaling concepts with adequate instruction	Similar to adults
Motor skills	Possesses some gross motor skills, no fine motor skills	Rapid gains in gross motor skills, fine motor skills still limited.	Development of both gross and fine motor skills increasing.	Gross motor skills developed, fine skills becoming more refined	Hand to eye and other fine motor skills developed.	Similar to adults
Recommended evaluation techniques	Behavioral observations. Diaries. Consumption or duration measurements		Previous, plus: Paired comparison. Sorting and matching. Limited preference. Ranking. One-on-one interviews	Previous, plus: Simple attribute ratings. Liking scales—pictorial or simple word scales. Group discussions. Concept testing	Previous, plus more abstrat reasoning tasks. Hedonic scales. Discrimination tasks. Attribute scaling and ratings.	Capable of all adult evaluation techniques.
Adult involvement	Primary caregiver. Trained observer. Experimenter			Previous, plus: Self administered		Adult participation not required, unless appropriate to evaluation technique.

Table 2. Games played with pictures of foods to illustrate the principle of each test [26]

Type of test	Foods pictured	Results: Aged 2–3 years ($n=2\times26$)	4–5 years ($n=2\times32$)	6–7 years ($n=2\times24$)	8–10 years ($n=2\times29$)
Discrimination		**No. of children choosing**			
Paired-comparison (Sweetness-intensity)	Ice cream vs green beans	43[a] vs 8	53[a] vs 11	43[a] vs 5	55[a] vs 3
	Doughnut vs hot dog	30 vs 20	51[a] vs 13	42[a] vs 6	55[a] vs 3
		No. of correct answers			
Duo–trio	Milk vs banana	46[a]	64[a]	48[a]	58[a]
	Bread vs potato chips	45[a]	64[a]	48[a]	58[a]
		Sums of ranks[b]			
Ranking (Sweetness intensity)	Cookie	156c	227b	161b	217d
	Peaches	146bc	159a	142b	178c
	Green beans	102a	127a	96a	108b
	Bread	116a	127a	81a	77a
Consumer		**No. of children choosing**			
Paired preference	ice cream vs corn	30 vs 22	43[c] vs 21	29 vs 19	44[c] vs 14
	Hot dog vs bread	36[c] vs 22	42[c] vs 22	37[c] vs 11	39[c] vs 19
		Mean ratings[d]			
Hedonic scaling	Chocolate cake	5.22a	6.05a	520a	5.74a
	Green beans	5.18a	4.28b	3.71b	3.79b
		Sum of ranks[b]			
Preference ranking	Potato chips	186b	199bc	171c	218cd
	Chocolate cake	165ab	245c	166bc	226d
	Peas	142a	143a	94a	98a
	Milk	129a	203bc	150bc	175bc
	Banana	148ab	170ab	124ab	153b

[a] Significant at $P<0.001$.
[b] Within columns sums of ranks followed by the same letter are not significantly different ($P<0.05$).
[c] Significant at $P<0.01$.
[d] Within columns, means followed by the same letter are not significantly different ($P<0.05$) scale 1 = super bad, 7 = super good.

procedure and one individual training session [28], or a practice evaluation of a simple stimulus (e.g. a cracker or cookie), with known physical and sensory properties, the results of which are then checked for 'appropriateness' to ensure understanding of the tasks [22].

In order to maximize the attention span of the children, the experimenter has to strike the right balance between comfort/familiarity and distraction when designing the test environment. It may be best to help children relax with a fun and colorful reception area [23] and yet to minimize decorations in the testing area because they can be distracting [26].

Development of food preferences

The infant's ability to detect, discriminate and learn positive associations involving smells and tastes as well as chemical cues of maternal diet in the amniotic fluid and in mother's milk set an early stage for the development of food preferences [16,29,30]. There is extensive evidence that taste preferences are innate. Differential fetal swallowing following injections of sweet or bitter substances into the amniotic fluid of pregnant women suggests that fetuses show a preference for sweet and a rejection for bitter [5]. For bitter and sour tastes, infants show negative facial expressions such as grimacing [31].

Olfactory preferences, on the other hand, are mostly learned and develop slowly [32]. In general, exposure drives preference, except in those cases when negative reactions from peers or parents 'teach' young children that a given olfactory stimulus is unpleasant [33]. As a result, a map of preferences for the smells associated with foods mirrors an actual world map [34], because individuals learn to like the smells they are exposed to. This process starts in the womb [35,36], but reliable differentiation in the pleasantness of odors does not occur until the age of 5 years [37–39].

Sensory and consumer testing methodology for children—what can they do, and at what age?

Newborns, infants and toddlers—semi-quantitative approaches

These age groups present a challenge to sensory and consumer researchers because of their inability to communicate verbally. The measures that have been used to assess the taste or olfactory responses of newborns and infants include lateral tongue movements, autonomic reactivity, facial expressions, respiration, heart rate, and differential ingestion and sucking patterns, all of which are hedonically motivated, except for the lateral tongue reflex [16]. Neonates produce consistent, quality-specific facial expressions in response to taste stimuli [31,40]. These facial expressions have been used successfully to demonstrate that taste preferences are mostly innate, whereas olfactory preferences are mostly learned (see above).

The measures listed above may not be adequate for older infants and toddlers. Because this population cannot yet communicate verbally, sensory testing with them requires an indirect approach. Experimenters have had to devise a way to assess subjects' responses based mostly on non-verbal cues such as body movements, vocalizations and facial expressions [38,41]. In a study of the acceptability of a fortified cereal food among toddlers, we resorted to methodology developed by the baby-food industry [42], whereby the primary caretaker (typically the mother) interpreted the behavior of the child as he/she tasted the food, and rated acceptance on a traditional hedonic scale [43]. Having the adult also taste and rate the samples (after the child) provided a control measure as well (e.g. the acceptability of the samples among adults). The results of that protocol are shown in Fig. 1. The study showed that the formulations were liked equally among the infants and toddlers, but not by the mothers. We highly recommend this indirect approach which has the parent interpret the behavior of the child.

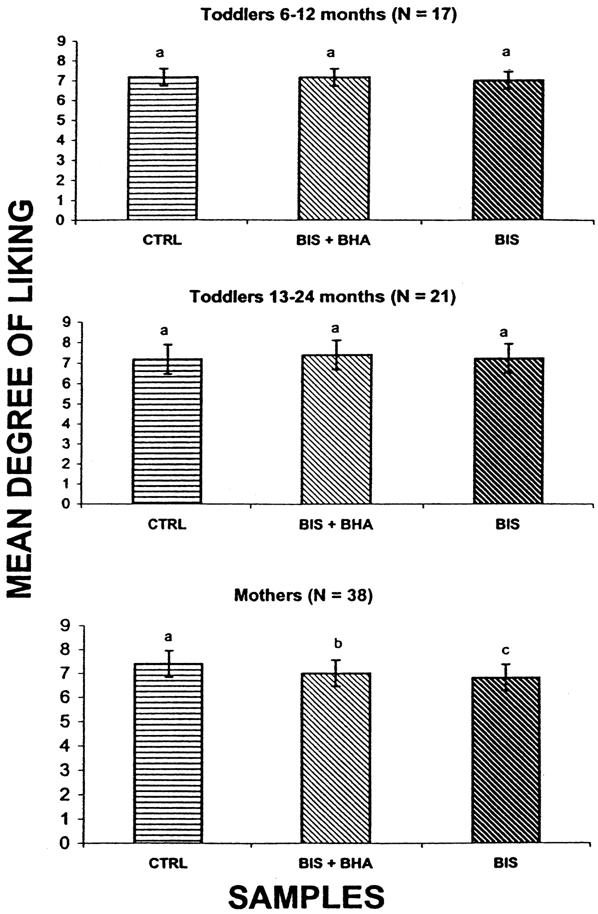

Fig. 1. Mean hedonic responses (+ S.E.M.) of toddlers 6–12 months ($n = 17$), toddlers 13–24 months ($n = 21$) and mothers ($n = 38$) on a nine-point hedonic scale. Subjects completed three replications of each sample evaluation. CTRL, control; BIS, fortified with ferrous bisglycinate; BIS/BHA, fortified with ferrous bisglycinate and containing the antioxidant butylated hydroxyanisole. Means with same letter are not significantly different [43].

Preschoolers, early readers and pre-teens — quantitative methods

Table 3 is a compilation of sensory testing protocols that may be used with children (from preschoolers to

Table 3. Appropriateness of sensory testing methods for use with children 2–10 years old

Sensory tests	Age group (years) 2–3	4–5	6–7	8–10
Discrimination				
Paired comparison	No [26]	Yes [26]	Yes [26]	Yes [12,26]
Duo–trio	No [26]	No [26]	Yes [26]	Yes [26]
Same–different	–	Yes [27]	Yes [27]	Yes [27]
Intensity ranking	No [26]	Yes [26]	Yes [26]	Yes [26]
Intensity scaling	–	–	Yes [50]	Yes [50]
Hedonic/preference				
Paired preference	Yes [26,44,45]	Yes [26] No [19,49]	Yes [26,49] No [19]	Yes [19,26,49]
Preference ranking	–	Yes [26,46] No [49]	Yes [26,49]	Yes [26,49]
Hedonic scales				
3-point	–	Yes [28,47,48]	–	–
5-point	–	Yes [48,51]	Yes [50]	Yes [50]
7-point	No [26]	Yes [19,26,48]	Yes [19,26,48]	Yes [19,26]
9-point	–	Yes [19]	Yes [19]	Yes [19]

pre-teens), as published in the literature. The key conclusions from these studies are summarized below.

The first type of tests children may be asked to perform as human subjects, and in some limited instances, as trained judges, are sensory evaluation tests such as difference or scaling tests. We tested the ability of children 2–10 years of age to perform a paired-comparison test, a duo-trio test and a ranking test for sweetness intensity using a fruit-flavored beverage sweetened with various concentrations of sucrose [26]. Results are presented in Table 4. Children in the 4–5, 6–7 and 8–10 age groups were reasonably able to perform a paired-comparison for sweetness, but not children in the 2–3 age group. Even though the differences were not significant most of the time, the three older age groups correctly picked the sweeter of the two beverages more often. The same conclusion was reached for the intensity ranking task. The data for the duo–trio test was inconclusive. The task completed with pictures of foods before the actual sensory test provides some insights as to whether children in the 2–3 year age group could not perform the paired comparison because of limitations in sensory

Table 4. Sensory tests with food stimuli [26]

		Results				
Type of test	**Stimuli**	**Ages 2–3 years ($n=2\times26$)**	**4–5 ($n=2\times32$)**	**6–7 ($n=2\times29$)**	**8–10 ($n=2\times29$)**	**Adult panel ($n=2\times27$)**
Discrimination		**No. of subjects choosing**				
Paired-comparison (sweetness intensity)	110 g sucrose/l vs 100 g sucrose/l, in Kool-aid® friut punch	24 vs 28	36 vs 28	29 vs 19	30 vs 28	29[a] vs 5
	120 g sucrose/l vs 100 g sucrose/l in fruit punch	28 vs 23	32 vs 32	29 vs 19	33 vs 25	29[a] vs 5
	130 g sucrose/l vs 100 g sucrose/l in fruit punch	22 vs 30	35 vs 29	29 vs 19	42[a] vs 16	33[a] vs 1
		No. of correct answers				
Duo–trio	0.56 g aspartame/l vs 100 g sucrose/l in fruit punch	25	32	28	35	24[b]
	125 g sucrose/l vs 100 g sucrose/l in fruit punch	23	38	33[a]	35	27[a]
		Sums of ranks[c]				
Ranking (sweetness intensity)	75 g sucrose/l, in fruit punch	130a	150a	80a	101a	34a
	90 g sucrose/l, in fruit punch	119a	150a	130a	126a	69b
	105 g sucrose/l, in fruit punch	143a	151a	145b	169b	113c
	120 g sucrose/l, in fruit punch	130a	189b	152b	184b	124c
Consumer		**No. of subjects choosing**				
Paired-preference	Kraft® single vs Borden® light cheese	27 vs 25	36 vs 28	26 vs 22	28 vs 30	
	Kraft singles vs Kraft light cheese	30 vs 22	35 vs 29	27 vs 21	30 vs 28	
	Kraft singles vs Kraft free cheese	29 vs 23	35 vs 29	23 vs 25	33 vs 25	
		Mean rating[d]				
Hedonic scaling	Vanilla ice cream	5.41a	5.58a	5.48a	5.76b	
	Chocolate ice cream	4.93a	5.84a	5.04b	6.10a	
	Strawberry ice cream	5.13a	5.58a	5.60a	5.09c	
	Peach ice cream	5.04a	4.90b	4.54c	4.36d	
		Sums of ranks[c]				
Preference ranking	Orange Kool-aid	128a	138a	103a	114a	
	Lemon-lime Kool-aid	135a	153a	116a	146ab	
	Grape Kool-aid	122a	194b	128a	144ab	
	Berry Blue Kool-aid	135a	155a	133a	176b	

[a] Significant at $P<0.001$.
[b] Significant at $P<0.05$.
[c] Within columns, rank sums followed by the same letter are not significantly different ($P<0.05$).
[d] Within columns, means followed by the same letter are not significantly different ($P<0.05$) scale: 1 = super bad, 7 = super good

ability or in cognitive ability. In Table 2, we can see that they correctly identified (pictures of) ice cream as being sweeter than green beans, but they did not pick a doughnut as being significantly sweeter than a hot dog (whereas children 4–10 years of age generally answered correctly). This means some children in the 2–3 year age group had difficulties understanding the task or were unfamiliar with the foods being pictured. Furthermore, the paired-comparison for sweetness performed with actual stimuli was more challenging (100 g sucrose/l of Kool-aid vs. 110, 120 or 130 g/l). We concluded that cognitive ability was at issue in the 2–3 year age group. To measure taste detection thresholds in 8–9 year old boys, James et al. [12] had the children perform a forced–choice paired comparison with no reported problems. Thomas and Murray [27] found that children ages 5 to 8 years could perform another type of difference test—the 'same–different' test—reliably.

The degree to which children can give psychophysical intensity ratings for complex food stimuli, and thus provide descriptive data on the intensities of individual attributes remains unknown because the literature is largely inconclusive. Zandstra and de Graaf [50] reported that children aged 6–12 years could scale the perceived intensity of sweet, sour and orange flavors of orange-flavored beverages. However, the sweetness psychophysical functions were flatter than those of adults, consistent with Kimmel *et al.'s* [26] observation that children were less able than adults to discriminate among sucrose solutions, but contrary to Enns *et al.'s* [52] finding that children's magnitude estimates of sweetness produced steeper slopes than those of adults. Differences in scaling methodology (category vs. magnitude) were suggested as one possible source of this discrepancy [25]. We see the use of magnitude estimation as inappropriate with young children, given the greater cognitive complexity of the task it represents (compared to category scaling), and given the natural tendency for subjects to use magnitude scales as category scales [53].

The second type of tests children may be asked to perform, this time as consumers, are paired-preference, preference ranking or hedonic scaling tests. More studies have focused on their ability to perform these tests. Kimmel *et al.* [26] evaluated the suitability of the paired-preference test, hedonic scaling and preference ranking with 2- to 10-year-olds. Children over the age of 2 could reliably perform a paired-preference test, and children as young as 4 years old could use a seven-point hedonic scale with descriptive categories of 1 = 'super bad' and 7 = 'super good', as shown by significant differences in liking among the ice cream samples presented (Table 4). Chen *et al.* [48] also found that children 3–6 years of age were able to express their degree of liking of food samples using 3-, 5- or 7-point hedonic scales anchored with the words 'super-bad' and 'super-good', respectively. Examples of facial hedonic scales used with preschoolers are shown in Fig. 2.

Kroll [19] assessed the relative merit of different rating scales with children between the ages of 5 and 10 years—a standard hedonic scale, a face scale, a child-oriented verbal scale and paired comparison, and found that the child-oriented verbal scale performed better than the hedonic or face scale in terms of discrimination.

Léon *et al.* [49] investigated the reliability of three non-verbal methods for measuring food liking- paired-comparison, ranking by elimination and hedonic categorization, according to three criteria: discrimination of products, repeatability of the responses and validity of the methods. One hundred and sixty-nine children, ages 4–10 years, evaluated five cookies dressed with different jams (apricot, banana, lemon, raspberry and strawberry). Surprisingly (because inconsistent with findings regarding discrimination testing with adults), products were discriminated slightly better with hedonic categorization than with comparative methods. Logically, familiar products were preferred to new products, and color also influenced children's choices, but more strongly so in comparative than in monadic presentation. That study took an interesting look at the reproducibility of children's responses. Results were slightly more reproducible with hedonic categorization than with comparative methods. As shown in Table 5, children aged 4–5 years did not give reproducible results, but children older than 5 years made fairly reproducible choices with all three methods.

We did not find significant differences in the reproducibility of paired-preference responses or hedonic ratings of children 2–10 years of age [26].

A way to assess the reliability of children's responses is to measure correlations among methods In the Léon *et al.* [49] study, correlations between paired-preference and ranking-by-elimination were slightly higher than those between either comparative method and hedonic categorization. The highest consistency was observed with children aged 8–10 years, and no consistency was found among the three methods in children aged 4–5 years (Table 6).

An alternative to measuring the preferences of children is to have them rate liking of photographs of the food samples [54]. The use of photographs as 'prompts' rather than having the children tasting the samples reduces influences of the preparation method and makes the schools and parents more willing to allow the children to participate, yet it is not a valid test of the sensory experience for the child.

Sometimes, children may have difficulties distinguishing between test protocols and may confuse intensity and hedonic rating tasks. For example, when children were tested with two different types of tests sequentially (paired-preference and paired-comparison), some children

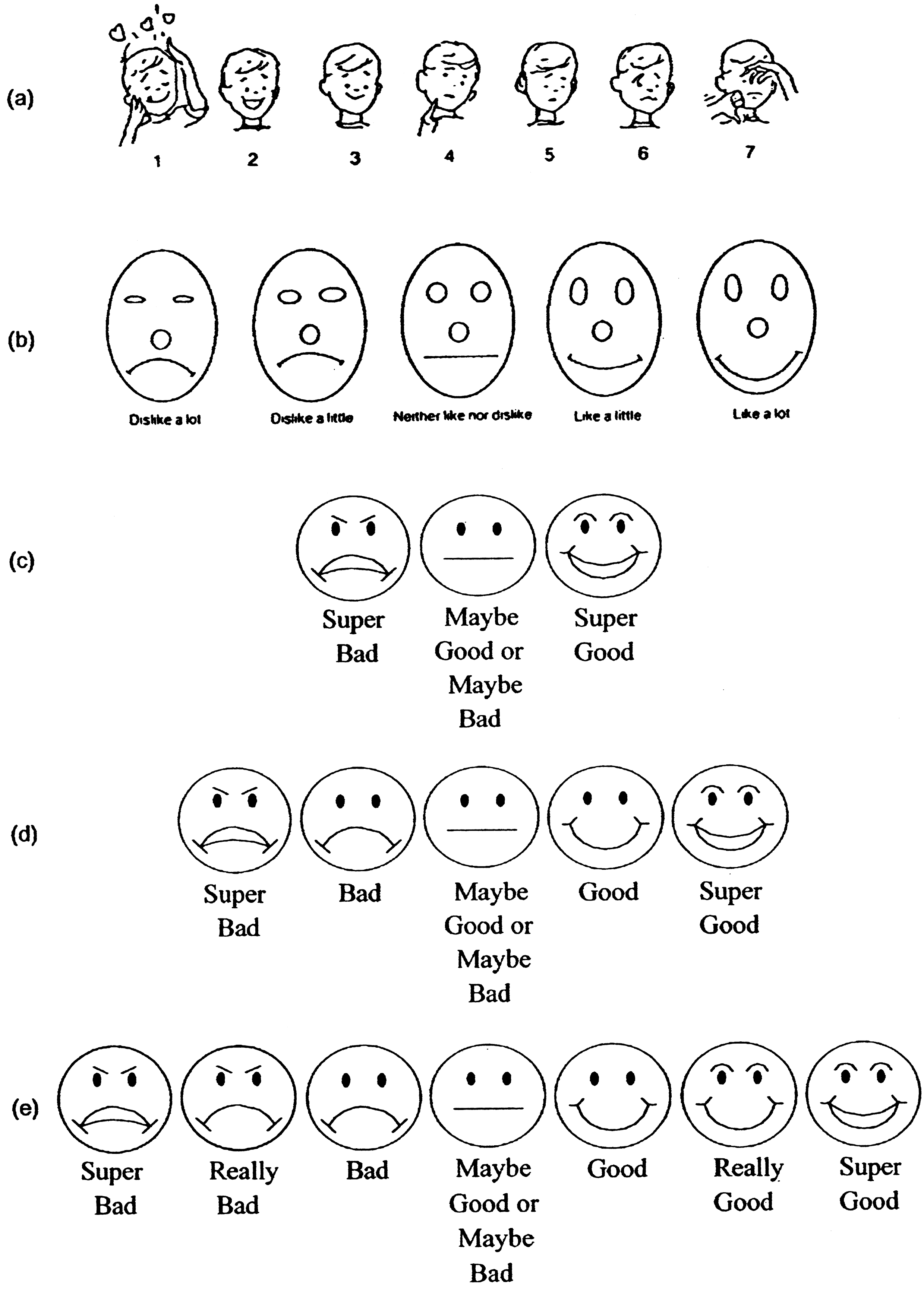

Fig. 2. Examples of facial hedonic scales used for hedonic ratings with children [18].

2–5 years of age experienced difficulty in switching to the new test protocol and would perform the paired-comparison (second test in the sequence) based on preference rather than intensity, after having performed the paired-preference test first [26]. To our knowledge, however, no experiment has been performed to assess children's confusion when only one test is conducted, i.e. would they complete a paired-comparison when they should be doing a paired-preference or vice-versa.

Qualitative methods—Focus groups and ethnography

Quantitative methods such as those described above (i.e. preference ranking, hedonic scaling) may not always be the best approach to consumer testing because of their inherent biases. Qualitative methods such as focus groups or observation-based ethnography can provide useful and reliable information to market researchers and product developers, particularly with children. The use of focus groups with children for product development has been described by Younkin [55], in the case of confectionery products. Because of the need for advanced communication abilities, focus groups are typically limited to pre-teens and older children, even though some researchers have run groups with younger children, using child-oriented tests. The first step is to recruit children who possess attributes such as sociability, articulateness, awareness of and interest in new products and trends, natural leadership qualities, creativity and the ability to interact effectively with adults. Upon completing the screening process, children are invited to assess new products and ideas for manufacturers of children's products. Children focus groups can be used at the ideation stage of product development in two ways: to form kids-only synectics-type teams (with an adult facilitator) and to work as part of mixed adult-and-kid brainstorming roundtables. Core ideas generated at this stage are then translated to rough concept descriptions, which are then returned to the panel for concept refinement and pre-prototype visualization. This process works well because children respond exceptionally well (better than adults) to the challenge of being partners in the process [55].

Observation-based methods are also being used increasingly with children. Such observation may be conducted in usability laboratories or even better, in the child's own environment, in the course of normal, everyday routines. In usability laboratories, the children play, eat, drink and interact under the scrutiny of trained observers whose task it is not only to record what happens but also to understand what it means [56]. When the manufacturers of a leading breakfast cereal observed their customers in their daily routine, they found that breakfast was not necessarily the main purpose for which some households were using the cereal. Parents of young children were actually more interested in the fact that the pieces could be easily bagged, carried

Table 5. Inter-session repeatability of three methods[a] (correlation of Kendall) [49]

Age (years)	Paired-preference	Hedonic categorization	Ranking-by-elimination
4–5	0.18a	0.18ab	0.17a
5–6	0.54bd	0.44ab	0.43ab
6–7	0.33abc	0.51bc	0.38ab
7–8	0.29ac	0.21a	0.44b
8–9	0.54d	0.68c	0.43b
9–10	0.47bcd	0.72c	0.50b
Total	0.40	0.50	0.40

[a] Within columns, correlation coefficients sharing the same letter are not significantly different ($P < 0.05$).

Table 6. Correlations between the responses obtained with three methods[a] (Spearman) [49]

Age (years)	Paired-preference/hedonic categorization	Paired-preference/ranking by-elimination	Hedonic categorization/ranking by-elimination
4–5	0.23a	0.32a	0.16a
5–6	0.62bdc	0.68bc	0.54bc
6–7	0.50bc	0.61bc	0.65bc
7–8	0.47ab	0.49ab	0.50b
8–9	0.81d	0.69bc	0.74c
9–10	0.70cd	0.76c	0.75c
Total	0.58	0.61	0.58

[a] Within columns, correlation coefficients followed by the same letter are not significantly different ($P < 0.05$).

and handed out or picked one by one as a tidy snack anytime, anywhere by restless toddlers [57].

Other factors

Ethics—Human Subjects protocols

Sensory testing with children requires approval from proper committees overseeing the use of human subjects in research. Because the subjects are minors, parental consent is required and children (who can write) sign an assent form, whereas their parent or guardian signs a consent form that typically includes a description of the study, a statement of its purpose, the procedures involved, alternatives to participation, risks, benefits, assurances of confidentiality, costs or compensation, right to refuse or withdraw, disclosure of the investigator's personal and financial interests (if that applies) and signatures of both parties. The parent or guardian is then given a copy of the signed forms and of an experimental subject's bill of rights.

Facilities

In addition to the usual requirements for facilities used for sensory testing with adult consumers, testing children may require a specially-designed environment. It is best to have individual rooms to conduct individual interviews with each child, but if that is not possible, a large room allowing for several child-investigator pairs to be working at the same time will work. Young children are used to kid-size furniture in their school and home environments. That type of furniture should also be available if young children are to be tested. Colorful decorations, which act as distractions, should be minimized in the testing area, and should be confined to waiting areas. Influences from the parent or caregiver should be minimized during testing, ideally by having them wait in another room. A room with a one-way mirror may be useful, to reassure the parent, and to give investigators the opportunity to observe the child's behavior during the test. A video camera may also be used to record the testing process.

Other

The experimenter's relationship with the child is critical. There must be appropriate tone and body language so that the child is comfortable with the experimenter, and the expressions and movements of the experimenter do not influence the child.

Whenever written questionnaires are used, they must be child-friendly (e.g. large fonts, limited number of questions and pages, large spaces for the children to fill their answers, etc.).

Finally, one should not neglect the parents' needs during this process. Timing (mid- to late-afternoons or weekends may be best), parking availability, access to the facilities, feedback after the study, compensation, attention to both children and parents, are all important factors to consider as well.

Summary

Sensory testing with children can provide valuable data in basic research or product development. Children must be treated as a special population, however, and the appropriate testing environment and protocol must be used because children show a wide range of cognitive abilities and attention spans. Semi-quantitative measures such as facial expressions, measures of sucking behavior or behavior interpretation by the primary caretaker, may be used to monitor the responses of newborns, infants and toddlers. Children over the age of two can reliably perform a paired-preference test. More complex tests, such as hedonic scaling, can be conducted with children over the age of 4 years, provided appropriate facial scales with wording for children are used. Children ages 6–10 years can perform discrimination tasks such as the paired-comparison, the duo–trio test and intensity ranking or scaling. Qualitative methods such as ideation sessions, focus groups, usability laboratories or ethnography are also appropriate with children.

References

1. Dziuk-O'Donnell, C. (1999) 'Kids Put Flavor Science to the Test' in *Prepared Foods* 168, 40–42
2. Hunt, J. (1998) 'Children in Charge' in *Food Rev.* 25, 19
3. Ward, C.D.W., Stampanoni-Koeferli, C., Piccinali-Schwegler, P., Schaeppi, D. and Plemmons, L.E. (1999) 'European Strawberry Yogurt Market Analysis with a Case Study on Acceptance Drivers for Children in Spain Using Principal Component Analysis and Partial Least Squares Regression' in *Food Qual. Pref.* 10, 387–400
4. Bradley, R.M. and Stern, I.B. (1967) 'The Development of the Human Taste Bud During the Foetal Period' in *J. Anat.* 101, 743–747
5. Liley, A.W. (1972) 'Disorders of the Amniotic Fluid' in *Pathophysiology of Gestation. Fetal Placental Disorders, Vol. 2* (Assali, N.S., ed), pp. 157–206, Academic Press, New York
6. Misretta, C.M. and Bradley, R.M. (1975) 'Taste and Swallowing *in Utero*: a Discussion of Fetal Sensory Function' in *Br. Med. Bull.* 31, 80–84
7. Misretta, C.M. and Bradley, R.M. (1977) 'Taste *In Utero*: Theoretical Considerations' in *Taste and Development. The Genesis of Sweet Preference*, (Weiffenbach, J.M. ed.), pp. 51–64, US Department of Health, Education and Welfare, Bethesda, MD
8. Plattig, K.-H. (1984) 'The Sense of Taste' in *Sensory Analysis of Foods* (Piggott, J.R., ed), pp. 1–22, Elsevier Applied Science Publishers, London
9. Anliker, J.A., Bartoshuk, L.M., Ferris, A.M. and Hooks, L.D. (1991) 'Children's Food Preferences and Genetic Sensitivity to the Bitter Taste of 6-n-propylthiouracil (PROP)' in *Am. J. Clin. Nutr.* 54, 316–320
10. Glanville, E.V. and Kaplan, A.R. (1964) 'Age, Sex and Taste Sensitivity' in *J. Gerontol.* 19, 474–478
11. Yasaki, T. (1976) 'Study on Sucrose Taste Thresholds in Children and Adults' in *Jpn. J. Dental Health* 26, 20–25
12. James, C.E., Laing, D.G. and Oram, N. (1997) 'A Comparison of the Ability of 8–9-year-old Children and Adults to Detect Taste Stimuli' in *Physiol. Behav.* 62, 193–197

13 Engen, T. and Lipsitt, L.P. (1965) 'Decrement and Recovery of Responses to Olfactory Stimuli in the Human Neonate' in *J. Comp. Physiol. Psychol.* 59, 312–316

14 Engen, T., Lipsitt, L.P. and Kaye, H. (1963) 'Olfactory Responses and Adaptation in the Human Neonate' in *J. Comp. Physiol. Psychol.* 56, 73–77

15 Russell, M.J. (1976) 'Human Olfactory Communication' in *Nature* 260, 520–522

16 Beauchamp, G.K., Cowart, B.J. and Schmidt, H.J. (1991) 'Development of Chemosensory Sensitivity and Preference' in *Smell and Taste in Health and Disease* (Getchell, T.V., Doty, R.L., Bartoshuk, L.M., Snow, J.B., eds), pp. 405–416, Raven Press, New York

17 Wadsworth, B.J. (1984) *'Piaget's Theory of Cognitive and Affective Development'* (3rd ed), Longman, New York

18 Resurreccion, A.V.A. (1998) 'Affective Testing with Children'. In *Consumer Sensory Testing for Product Development*, 165–176, Aspen Publishers, Gaithersburg, MD.

19 Kroll, B.J. (1990) 'Evaluating Rating Scales for Sensory Testing with Children' in *Food Technol.* 44, 78–86

20 Oram, N. (1998) 'Texture and Chemical Feeling Terms That 6–11 Year Olds and Adults Associate with Food in the Mouth' in *J. Text. Stud.* 29, 185–197

21 Oram, N. (1998) 'Association of Perceptual Feel and General Descriptors with Food Categories by 8–11 Year Olds and Adults' in *J. Text. Stud.* 29, 669–680

22 Moskowitz, H.R. (1994) 'Children vs. Adults' in *Food Concepts and Products. Just-in-Time Development*, pp. 293–332 Food & Nutrition Press, Trumbull, CT

23 Moskowitz, H.R. (1985) 'Product Testing with Children' in *New Directions for Product Testing and Sensory Analysis of Foods*, pp. 147–164 Food & Nutrition Press, Westport, CT

24 Berman, S. and Friedman, D. (1995) 'The Development of Selective Attention as Reflected by Event-related Brain Potentials' in *J. Exp. Child Psychol.* 59, 1–31

25 Lavin, J.G. and Lawless, H.T. (1998) 'Effects of Color and Odor on Judgements of Sweetness Among Children and Adults' in *Food Qual. Pref.* 9, 283–289

26 Kimmel, S., Sigman-Grant, M.J. and Guinard, J.-X. (1994) 'Sensory Testing with Young Children' in *Food Technol.* 48, 92–99

27 Thomas, M.A. and Murray, F.S. (1980) 'Taste Perception in Young Children' in *Food Technol.* 34, 38–41

28 Birch, L.L. and Sullivan, S. (1991) 'Measuring Children's Food Preferences' in *J. Sch. Health* 61, 212–213

29 Birch, L.L. (1999) 'Development of Food Preferences' in *Annu. Rev. Nutr.* 19, 41–62

30 Mennella, J.A. and Beauchamp, G.K. (1993) 'The Effects of Repeated Exposure to Garlic-flavored Milk on the Nursling's Behavior' in *Pediatric Res.* 34, 805–808

31 Steiner, J. (1973) 'The Gustofacial Response: Observation on Normal and Anencephalic Newborn Infants' in *Fourth Symposium on Oral Sensation and Perception: Development in the Fetus and Infant* (Bosma, G.F., ed), pp. 254–278, U.S. Government Printing Office, Washington DC

32 Schaal, B. (1988) 'Olfaction in Infants and Children: Developmental and Functional Perspectives' in *Chem. Senses* 13, 145–190

33 Birch, L.L. (1992) 'Children's Preferences for High-fat Foods' in *Nutr. Rev.* 50, 249–255

34 Pangborn, R.M., Guinard, J.-X. and Davis, R.G. (1988) 'Regional Aroma Preferences' in *Food Qual. Pref.* 1, 11–19

35 Marlier, L., Schaal, B. and Soussignan, R. (1998) 'Neonatal Responsiveness to the Odor of Maniotic and Lacteal Fluids: a Test of Perinatal Chemosensory Continuity' in *Child Dev.* 69, 611–623

36 Soussignan, R., Schaal, B., Marlier, L. and Jiang, T. (1997) 'Facial and Autonomic Responses to Biological and Artificial Olfactory Stimuli in Human Neonates: Re-examining Early Hedonic Discrimination of Odors' in *Physiol. Behav.* 62, 745–758

37 Engen, T. and McBurney, D.H. (1964) 'Magnitude and Category Scales of the Pleasantness of Odors' in *J. Exp. Psychol.* 68, 435–440

38 Mennella, J.A. and Beauchamp, G.K. (1997) 'Mother's Milk Enhances the Acceptance of Cereal During Weaning' in *Pediatric Res.* 41, 188–192

39 Stein, M., Ottenberg, P. and Roulet, N. (1958) 'A Study of the Development of Olfactory Preferences' in *Arch. Neurol. Psychiatry* 80, 264–269

40 Steiner, J. (1979) 'Human Facial Expression in Response to Taste and Smell Stimulation' in *Advances in Child Development and Behavior, Vol. 13* (Reese, H., Lipsitt, L.P., eds), pp. 257–295, Academic Press, New York

41 Ashbrook, S. and Doyle, M. (1985) 'Infants' Acceptance of Strong- and Mild-flavored Vegetables' in *J. Nutr. Ed.* 17, 5–6

42 Kevin, K. (1995) 'You've Come a Long Way — Baby-food!' in *Food Process* 56, 61–64

43 Bovell-Benjamin, A.C., Allen, L.H. and Guinard, J.-X. (1999) 'Toddlers' Acceptance of Whole Maize Meal Porridge Fortified with Ferrous Bisglycinate' in *Food Qual. Pref.* 10, 123–128

44 Birch, L.L. (1980) 'Effects of Peer Models' Food Choices and Eating Behaviors on Preschoolers' Food Preferences' in *Child Dev.* 51, 489–496

45 Johnson, S.L., McPhee, L. and Birch, L.L. (1991) 'Conditioned Preferences: Young Children Prefer Flavors Associated with High Dietary Fat' in *Physiol. Behav.* 50, 1245–1251

46 Birch, L.L. (1979) 'Dimensions of Preschool Children's Food Preference' in *J. Nutr. Ed.* 11, 77–80

47 Birch, L.L., McPhee, L., Steinberg, L. and Sullivan, S. (1990) 'Conditioned Flavor Preferences in Young Children' in *Physiol. Behav.* 47, 501–505

48 Chen, A.W., Resurreccion, A.V.A. and Paguio, L.P. (1996) 'Age Appropriate Hedonic Scales to Measure Food Preferences of Young Children' in *J. Sensory Stud.* 11, 141–163

49 Léon, F., Couronne, T., Marcuz, M.C. and Köster, E.P. (1999) 'Measuring Food Liking in Children: a Comparison of Non Verbal Methods' in *Food Qual. Pref.* 10, 93–100

50 Zandstra, E.H. and de Graaf, C. (1998) 'Sensory Perception and Pleasantness of Orange Beverages from Childhood to Old Age' in *Food Qual. Pref.* 9, 5–12

51 Fallon, A.E., Rozin, P. and Pliner, P. (1984) 'The Child's Conception of Food: The Development of Food Rejections with Special Reference to Disgust and Contamination Sensitivity' in *Child Dev.* 55, 566–575

52 Enns, M.P., van Itallie, T.B. and Grinker, J.A. (1979) 'Contributions of Age, Sex and Degree of Fatness on Preferences and Magnitude Estimation for Sucrose in Humans' in *Physiol. Behav.* 22, 999–1003

53 Pangborn, R.M., Guinard, J.-X. and Meiselman, H.L. (1989) 'Evaluation of Bitterness of Caffeine in Hot Chocolate Drink by Category, Graphic, and Ratio Scaling' in *J. Sensory Stud.* 4, 31–53

54 Baxter, I.A., Schröder, M.J.A. and Bower, J.A. (1999) 'The Influence of Socio-economic Background on Perceptions of Vegetables Among Scottish Primary School Children' in *Food Qual. Pref.* 10, 261–272

55 Younkin, R.J. (1989) 'New Product Development and the Kids Confectionery Panel' in *Product Testing with Consumers for Research Guidance* (Wu, L.S., ed), pp. 85–90, American Society for Testing Materials, Philadelphia

56 Schraidt, M.F. (1991) 'Testing with children' in *ASTM Standardization News*, March–April 1991, 42–45

57 Leonard, D. and Rayport, J.F. (1997) 'Spark Innovation Through Empathic Design' in *Harvard Bus. Rev.* 75, 102–113