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Original Research Report

A Role for Identification in the Gradual Decline in the Pleasantness of Flavors With Age

Katherine M. Appleton and Eleanor Smith

Department of Psychology, Bournemouth University, Poole, UK.

Correspondence should be addressed to Katherine M. Appleton, PhD, Department of Psychology, Bournemouth University, Poole House, Fern Barrow, Poole BH12 5BB, UK. E-mail: k.appleton@bournemouth.ac.uk.

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Abstract

Objectives: This study investigated a possible role for identification in the decline in flavor pleasantness with age.
Methods: Two hundred sixty-four individuals aged from 16 to 85 years tasted 6 flavored drinks of varying identity and ease of identification, and rated each on pleasantness, a range of other characteristics and identified all flavors.
Results: Using regression, firstly, pleasantness was inversely associated with age (β = –0.22, $p < .01$). Secondly, the decline in pleasantness with age was associated with poorer identification (β = 0.30, $p < .01$), lower perceptions of sweetness (β = 0.01, $p < .01$), lower strength of flavor (β = 0.00, $p = .02$), lower familiarity (**β** = 0.01, $p < .01$), and a lower frequency of usual drink consumption (β = 0.04, $p < .01$). Thirdly, improved identification with age was associated with increased drink familiarity (β =< 0.01, $p < .01$), coloration compared with no color (β = <0.06, $p < .01$), and correct compared with incorrect coloration (β = <0.27, $p < .01$).
Discussion: These findings demonstrate a clear role for identification in the decline in flavor pleasantness with age. These findings thus provide clear evidence for a cognitive and perceptual element to these hedonic processes. Our findings suggest that likings for flavors in older individuals may be increased/maintained through the use of improved visual cues, easily recognizable foods, and/or identity labels.

Keywords: Aging—Cognitive—Flavor—Hedonic—Identity—Taste

Under-nutrition is currently reported in 10%–40% of adults over the age of 65 years in the U.K., Europe, and the United States (Cowan, Roberts, Fitzpatrick, While, & Baldwin, 2004; Elia & Russell, 2009; Finch et al., 1998; Fulgoni, 2008; Russell & Elia, 2014), with resultant negative impacts on health and well-being. Under-nutrition in older adults is associated with increased risk of fractures, falls, infection and hospital stays, decreased mobility, independence and wellbeing, and increased morbidity and mortality (Cowan et al., 2004; Elia & Russell, 2009; Russell & Elia, 2014; Wolfe, 2012).

This under-nutrition is a result, at least in part, of low levels of consumption (Cowan et al., 2004; Leslie, 2011). Liking is a strong determinant of consumption in older adults (Appleton, McGill, Neville, & Woodside, 2010; Best & Appleton, 2013; Leslie, 2011), but various reports demonstrate lower ratings for liking or the pleasantness of food items in older compared with younger individuals (de Graaf, Polet, & van Staveren, 1994; de Graaf, van Staveren, & Burema, 1996). These lower likings have been strongly linked to decreases in chemosensory abilities (de Graaf et al., 1994, 1996; Kalviainen, Roininen, & Tuorila, 2003). The intensity or strength of specific tastes, including sweetness, saltiness, and bitterness, and the perception of specific odors and flavors, such as orange and vanilla are often lower in older compared with younger individuals

(de Graaf et al., 1994, 1996; Duffy, Cain, & Ferris, 1999; Enns & Hornung, 1988; Kremer, Bult, Mojet, & Kroeze, 2007b; Kremer, Mojet, & Kroeze, 2007; Mojet, Heidema, & Christ-Hazelhof, 2003; Philipsen, Clydesdale, Griffin, & Stern, 1995).

Older groups thus often prefer higher concentrations of tastes and flavors than younger groups (de Graaf et al., 1994, 1996; Griep, Mets, & Massart, 1997; Kalviainen et al., 2003; Koskinen, Kalviainen, & Tuorila, 2003; Kremer, Bult, et al, 2007b; Mojet et al., 2003; Philipsen et al., 1995), but liking and stimulus strength are not always related (Kremer, Bult, Mojet, & Kroeze, 2007a; Kremer, Bult, et al., 2007b; Mojet, Christ-Hazelhof, & Heidema, 2005). Kremer, Bult, and colleagues (2007b), for example, found no associations between liking and sensory ability in older compared with younger participants, and Mojet and colleagues (2005) found no associations between liking and flavor concentration in older compared with younger participants. Effects also differ dependent on taste, flavor, and odor (de Graaf et al., 1994, 1996; Mojet et al., 2003, 2005), dependent on incorporation or not into different food products (de Graaf et al., 1994, 1996; Enns & Hornung, 1988; Kremer, Mojet, & Kroeze, 2005; Kremer, Bult, et al., 2007a, 2007b; Kremer, Mojet, et al., 2007; Mojet et al., 2003, 2005), and dependent on individual differences (Forde & Delahunty, 2004; Kremer, Bult, et al., 2007a, 2007b; Mojet et al., 2003, 2005). These inconsistent effects suggest that the pleasantness of a taste or flavor depends on more than the strength of and the specific tastes, odors, and flavors involved (Mojet et al., 2005).

Work on food augmentation has investigated the impact of texture (Forde & Delahunty, 2002, 2004; Kalviainen et al., 2003; Kremer et al., 2005; Kremer, Bult, et al., 2007a, 2007b; Kremer, Mojet, et al., 2007) and irritants also (Kremer, Bult, et al., 2007a, 2007b), but work also suggests a role for cognitions in taste and flavor pleasantness (Herz, 2003; Larsson, Finkel, & Pedersen, 2000). Okamoto and colleagues (2009) found increased liking for taste stimuli identified by a name compared with those with no name, and Bensafi, Rinck, Schaal, and Rouby (2007) and Herz (2003) found increased ratings of pleasantness for named compared with unnamed odors. Tuorila, Meiselman, Bell, Cardello, and Johnson (1994) found a positive linear relationship between liking and certainty of product identity.

The identification of flavors involves various cognitive processes, including memory, lexical processing, and semantic processing (Herz, 2003). Flavor identification requires a linking between olfactory, gustatory, and lexical information that is often also linked to memory, affective, and semantic responses (Herz, 2003; Tuorila et al., 1994). Herz and von Clef (2001) and Djordjevic and colleagues (2008) provide evidence for a semantic component to flavor and odor identification, and Larsson and colleagues (2000) also report semantic memory to be a significant predictor of odor identification in a large population sample. These cognitive processes deteriorate with age (Bishop, Lu, & Yankner, 2010), and abilities to identify or name food stimuli have also been found to deteriorate. Kremer, Bult, and colleagues (2007b) and Koskinen and colleagues (2003), for example, found older participants were less able to identify taste stimuli than younger groups, and Larsson and colleagues (2000) found a deterioration in odor identification with age.

Although chemosensory abilities may deteriorate with age and impact on perceptions of pleasantness, abilities to identify flavors may also deteriorate with age and also impact on perceptions of pleasantness. Evidence of a role for identification in flavor pleasantness could suggest the development of identification-based strategies for increasing likings and intakes in older individuals.

This study investigated the impact of flavor identification on the reduction in flavor pleasantness often experienced with age. Determinants of flavor identification were also investigated on an exploratory basis, and while the majority of work in this area also involves clearly separated younger and older aged groups (de Graaf et al., 1994, 1996; Kalviainen et al., 2003; Koskinen et al., 2003; Kremer, Bult, et al., 2007b; Mojet et al., 2005), this work uses individuals of a broad range of ages to investigate relationships.

Method

The study used a correlational design where 264 individuals of a range of ages were asked to taste six flavored drinks of varying identity and ease of identification, and rate each on pleasantness and a range of other characteristics, and identify the flavors. Associations between pleasantness, age, and all drink characteristics were subsequently analyzed by regression.

Participants

A total of 264 adults, attending various University open days and public engagement events from February to November 2014 took part in the study. Participants had no known taste impairments, food allergies, or intolerances, but no other exclusion criteria were included to allow as many individuals as possible to participate. The study was given ethical approval by The Research Ethics Committee of Bournemouth University prior to commencement, and was run in accordance with the Ethical Guidelines of the British Psychological Society, and the Declaration of Helsinki (2000). All participants provided informed consent.

Identity and Ease of Identification

Identity and ease of identification were manipulated using two different fruit flavored drinks, that were either uncolored, colored correctly, or colored incorrectly.

Flavored drinks were selected as a food type that is likely to be familiar to all ages, that can be found commercially in a variety of flavors (de Graaf et al., 1994, 1996; Kremer, Mojet, et al., 2007), and that have previously

been used in studies such as these (de Graaf et al., 1994, 1996; Forde & Delahunty, 2004; Koskinen et al., 2003; Mojet et al., 2003; Shankar, Levitan, & Spence, 2010; Zampini, Sanabria, Phillips, & Spence, 2007). The two different flavored drinks were strawberry flavored—*Volvic Touch of Strawberry (Danone Waters, France)*, and orange and peach flavored—*Volvic Touch of Orange and Peach (Danone Waters, France)*. Strawberry, orange, and peach flavors are also likely to be familiar to all ages, and have previously been used in studies similar to this one (de Graaf et al., 1994, 1996). Strawberry, orange, and peach foods are also naturally differently but consistently colored, and differently but consistently colored when represented in food products (Shankar et al., 2010; Spence, Levitan, Shankar, & Zampini, 2010; Zampini et al., 2007).

Both flavored drinks were presented to participants in three forms: colorless; with correct coloration (red for the strawberry-flavored drink and orange for the orange- and peach-flavored drink) or with incorrect coloration (orange for the strawberry-flavored drink, red for the orange- and peach-flavored drink). Repeated studies demonstrate impairments in identification following incorrect coloration (Shankar et al., 2010; Spence et al., 2010; Zampini et al., 2007), and deliberate manipulation of ease of identification encouraged large differences in identification ability for all drinks. Colors were produced using flavorless red and yellow food coloring (Dr Oetker (UK) Ltd., Leeds, UK). Eight drops of red coloring, and three drops of red and eight drops of yellow coloring per 500 ml of colorless drink were used, to create red- and orange-colored drinks, respectively. Piloting was carried out prior to the study to ensure color, similar brightness, and clear discrimination between colors (Shankar et al., 2010).

Measures

Identification was assessed using six open response questions, one per drink—"Please write the flavor of drink A [B, C, D, E, F] or tick the box if you are unsure." Open ended questions were used to avoid biasing responses by providing options (Shankar et al., 2010). Identity data were scored as correct (e.g., strawberry for the strawberry-flavored drinks)—score = 1; semi-correct (incorrect but correctly colored flavor, e.g., raspberry or cherry for the strawberry-flavored drinks)—score = 0.5; or incorrect/don't know—score = 0 for analysis.

Pleasantness was measured using a 100 mm visual analogue scales (VAS) requesting "How pleasant is this drink?" (anchors: "*not at all*"–"*extremely*").

Age was assessed using a direct question—"How old are you?".

Sweetness, strength of flavor, and familiarity were also assessed using 100 mm VAS—"How sweet is this drink?", "How strong is the flavor of this drink?", "How familiar is this drink?" (anchors: "*not at all*"–"*extremely*") respectively, as was thirst—"How thirsty are you?" (anchors: "*not at all*"–"*extremely*"). Sweetness, strength, and familiarity were assessed to allow inclusion of these known determinants of pleasantness in analyses (de Graaf et al., 1994, 1996; Okamoto et al., 2009; Herz, 2003). Only sweet taste (and not saltiness, bitterness, or sourness) was measured as only sweet taste was deemed relevant to the fruit flavors (Mojet et al., 2003). VAS are a commonly used and validated methodology for the investigation of concepts such as those of interest here (Blundell et al., 2010). Thirst at the time of testing is also known to impact on the perceived pleasantness of drinks (Appleton, 2005; King, Appleton, Rogers, & Blundell, 1999). Experience was also measured using a general question requesting "How often do you usually drink colorful fruity drinks?" (response options: "*never*," "*1–2 times/week*," "*3–4 times/week*," "*5–6 times/week*," and "*every day*," scored 0, 0.2, 0.5, 0.8, and 1, respectively).

Procedure

Participants were presented with and asked to taste and rate all six drinks at one time. Drinks were labeled using letters A–F, and presented to participants in clear 50 ml containers so that colors were easily visible. Participants were first asked to record their thirst and then taste and rate each of the drinks independently, in a random order, on measures of pleasantness, sweetness, strength, and familiarity. Following tasting and rating for all drinks, participants were asked to retaste and identify each drink. Participants were aware that they would be required to identify all drinks at the start of the study via the study information sheet, thus we can not be sure whether this process occurred after or during initial tasting, or both. Finally, participants completed their age and the question on usual frequency of drink consumption. Tasting was undertaken as in everyday life (i.e., allowing the interaction of flavor and odor stimulants) to enhance the ecological validity and generalizability of the study (de Graaf et al., 1994; Duffy et al., 1999; Kremer, Mojet, et al., 2007). Participants were free to consume as much of each drink as they required in order to make all ratings.

Analysis

Data for all drinks were analyzed together using clustered regression, where participant ID acted as the cluster variable. Use of clustered regression allowed all data from all six drinks to be considered for all participants, resulting in the inclusion of 1,584 data points for analysis. All participants provided complete data for all measures. In Model 1, pleasantness was predicted by age. In Model 2, pleasantness was predicted by age, identity, sweetness, strength, familiarity, thirst, and usual consumption frequency. In Model 3, pleasantness/age was predicted by identity, sweetness, strength, familiarity, thirst, and usual consumption frequency. Pleasantness/age was used to describe the age–pleasantness association due to the inverse association found in Model 1. Pleasantness/age describes the relative change in

pleasantness with age, where higher numbers demonstrate a lesser reduction in pleasantness with age compared with lower numbers. Following initial analyses, where an effect of identification was found, predictors of identification were also explored using the data on drink characteristics available here. In Model 4, identification was predicted by sweetness, strength, familiarity, pleasantness, flavor (strawberry/orange and peach), coloration (presence/absence) and correct coloration (correct/incorrect), and in Model 5, identification/age was predicted using these same drink characteristics. Identification/age again describes the relative change in identification with age following an inverse association between identification and age (Model 4), where higher numbers again demonstrate a lesser reduction in identification with age compared with lower numbers. All variables were included in all analyses as continuous variables. Age was analyzed using age in years provided, and all VAS measures were analyzed as a score from 0 to 100 mm. Initial analyses revealed no concerns due to multicolinearity (largest $r = .57$). Preliminary analyses revealed no systematic differences in the order of drinks sampled, thus order was not included in analyses. Analyses were conducted in Stata (Stata Corp, Inc.).

Results

Participants of a wide range of ages took part in the study. Ages ranged from 16 to 85 years, with 20% of the sample in their teens, 26% in their twenties, 9% in their thirties, 12% in their forties, 15% in their fifties, 7% in their sixties, 8% in their seventies, and 3% of the sample in their eighties. Details of ratings for all drinks are given in Table 1. Participants had a mean (standard deviation [*SD*]) thirst at time of testing of 52 (22) mm, range = 0–100 mm, and consumed fruit-flavored colored drinks such as those provided on approximately 2 days/week (mean [*SD*] = 0.3 [0.3], range = 0–1). Participants rated all drinks around a central 50/100 mm or slightly below for pleasantness, sweetness, strength, and familiarity, but employed the full length of the ratings scales (range = 0–100 mm). Flavor identification of the correctly colored drinks was significantly more accurate than for incorrectly and noncolored drinks ($\chi^2 = 13.43$, $df = 2$, $p < .05$), and semi-correct flavor identification was significantly more likely for correctly colored drinks than for incorrectly colored and noncolored drinks ($\chi^2 = 7.33$, $df = 2$, $p < .05$).

In Model 1, pleasantness was inversely associated with age (β = −0.22, 95% confidence interval [CI] = −0.31 to −0.12, $p < .01$). This relationship is clearly demonstrated in Figure 1.

In Model 2, pleasantness was significantly positively associated with sweetness (β = 0.26, 95% CI = 0.16–0.37, $p < .01$), familiarity (β = 0.29, 95% CI = 0.21–0.36, $p < .01$), and frequency of usual drink consumption (β = 0.43, 95% CI = 0.21–0.64, $p < .01$).

In Model 3, pleasantness/age was significantly positively associated with identification (β = 0.30, 95% CI = 0.12–0.43, $p < .01$), sweetness (β = 0.01, 95% CI = 0.01–0.02, $p < .01$), strength (β = 0.00, 95% CI = 0.00–0.01, $p = .02$), familiarity (β = 0.01, 95% CI = 0.01–0.02, $p < .01$), and frequency of usual drink consumption (β = 0.04, 95% CI = 0.02–0.06, $p < .01$).

Results of all regression analyses are given in Table 2.

In Model 4, identification was significantly positively associated with familiarity (β = <0.01, 95% CI = <0.01 to <0.01, $p < .01$), almost associated with pleasantness (β = <0.01, 95% CI = −<0.01 to <0.01, $p = .07$), with color compared with no color (β = 0.06, 95% CI = 0.02–0.01, $p < .01$), and with correct compared with incorrect coloration (β = −0.27, 95% CI = −0.31 to −0.22, $p < .01$).

In Model 5, identification/age was also significantly positively associated with familiarity (β ≤ 0.01, 95% CI = <0.01 to <0.01, $p < .01$), almost associated with pleasantness (β ≤ 0.01, 95% CI = −<0.01 to <0.01, $p = .07$), with color compared with no color (β ≤ 0.01, 95% CI = <0.01 to <0.01, $p < .01$), and with correct compared with incorrect coloration (β = −0.01, 95% CI = −0.01 to −0.01, $p < .01$).

Results of all regression analyses are given in Table 3.

Discussion

Three important findings emerge from this study. Firstly, age was associated with a decrease in the reported pleasantness of the drinks in a linear manner. Repeated previous studies demonstrate lower pleasantness ratings in older consumers compared with younger consumers (de Graaf

Table 1. Mean, Standard Deviation and Range of Pleasantness, Sweetness, Strength and Familiarity (mm), and Number of Correct and Semi-Correct Identifications for All Six Drinks

	Pleasantness (mm)			Sweetness (mm)			Strength (mm)			Familiarity (mm)			Identification (%)	
Drink	Mean	*SD*	Range	Mean	*SD*	Range	Mean	*SD*	Range	Mean	*SD*	Range	Correct	Semi-correct
Strawberry colorless	50	22	0–100	52	22	0–100	42	23	0–98	45	27	0–100	23.5	8.0
Strawberry correctly colored	50	23	0–99	49	20	0–100	44	21	0–92	46	25	0–95	35.2	18.9
Strawberry incorrectly colored	47	23	0–100	47	22	0–100	43	23	0–100	40	26	0–98	9.8	8.3
Orange and peach colorless	47	23	0–97	49	22	0–100	47	23	0–98	43	26	0–98	18.6	3.4
Orange and peach correctly colored	45	22	0–99	49	21	3–100	45	22	0–100	41	25	0–100	40.2	10.2
Orange and peach incorrectly colored	45	22	0–96	50	21	7–100	48	23	0–100	44	26	0–100	15.9	4.5

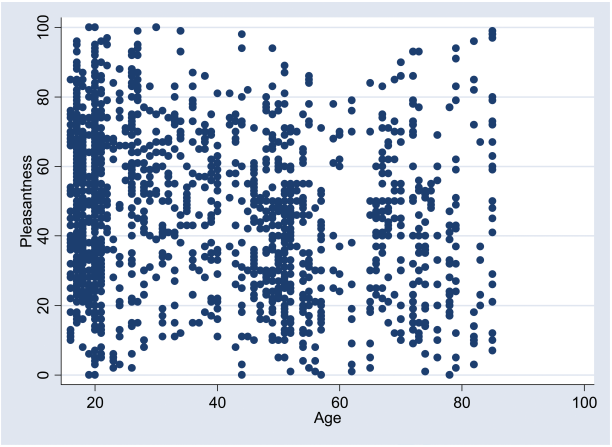

Figure 1. The relationship between perceived pleasantness and age across all drink samples (β = −0.22, 95% CI: −0.31 to −0.12, $p < .01$).

Table 2. Results of All Regression Analyses Investigating Pleasantness (mm)

Predictor	Beta	95% CI	Significance
Model 1—pleasantness			
Age (16–78)	−0.22	−0.31 to −0.12	<.01
Model 2—pleasantness			
Age (16–78)	0.03	−0.06 to 0.11	.57
Identification (0–1)	1.82	−0.76 to 4.40	.17
Sweetness (0–100)	0.26	0.16 to 0.37	<.01
Strength (0–100)	0.09	−0.01 to 0.19	.07
Familiarity (0–100)	0.29	0.21 to 0.36	<.01
Thirst (0–100)	0.01	−0.05 to 0.07	.74
Frequency of usual consumption (0–1)	0.43	0.21 to 0.64	<.01
Model 3—pleasantness/age			
Identification (0–1)	0.30	0.12 to 0.43	<.01
Sweetness (0–100)	0.01	0.01 to 0.02	<.01
Strength (0–100)	0.00	0.00 to 0.01	.02
Familiarity (0–100)	0.01	0.01 to 0.02	<.01
Thirst (0–100)	−0.00	−0.01 to 0.00	.13
Frequency of usual consumption (0–1)	0.04	0.02 to 0.06	<.01

Note: CI = confidence interval.

et al., 1994, 1996; Duffy et al., 1999; Enns & Hornung, 1988; Kremer, Bult, et al., 2007b; Kremer, Mojet, et al., 2007; Mojet et al., 2003), but this study also demonstrates a continuous linear pattern.

Secondly, a lesser reduction in pleasantness with age was associated with better identification of the drinks sampled, greater reported sweetness and strength of flavor of the drinks, greater reported familiarity with the drinks, and greater usual frequency of colored fruity drink consumption. These findings demonstrate a clear role for identification in the decline in pleasantness with age, where, as individuals become less able to identify drink flavors, those drinks are less pleasant. A role for identification in the pleasantness of

Table 3. Results of All Regression Analyses Investigating Identification (0–1)

Predictor	Beta	95% CI	Significance
Model 4—identification (0–1)			
Sweetness (0–100)	<0.01	−<0.01 to <0.01	.42
Strength (0–100)	<0.01	−<0.01 to <0.01	.67
Familiarity (0–100)	<0.01	<0.01 to <0.01	<.01
Pleasantness (0–100)	<0.01	−<0.01 to <0.01	.07
Flavor (strawberry/orange and peach)	0.01	−0.04 to 0.05	.84
Coloration (colorless/colored)	0.06	0.02 to 0.01	<.01
Correct coloration (correct/incorrect)	−0.27	−0.31 to −0.22	<.01
Model 5—identification/age			
Sweetness (0–100)	<0.01	−<0.01 to <0.01	.40
Strength (0–100)	<0.01	−<0.01 to <0.01	.36
Familiarity (0–100)	<0.01	<0.01 to <0.01	<.01
Pleasantness (0–100)	<0.01	−<0.01 to <0.01	.07
Flavor (strawberry/orange and peach)	−<0.01	−<0.01 to <0.01	.61
Coloration (colorless/colored)	<0.01	<0.01 to <0.01	<.01
Correct coloration (correct/incorrect)	−0.01	−0.01 to −0.01	<.01

Note: CI = confidence interval.

flavors has previously been suggested (Bensafi et al., 2007; Herz, 2003; Okamoto et al., 2009; Tuorila et al., 1994), but as far as we are aware, the value of this role for the older population has never been previously elucidated. Effects of identification were also found, independent of the other often related constructs of familiarity and experience (Herz, 2003; Okamoto et al., 2009). From a theoretical perspective, these findings demonstrate the impact of cognitive processes on food liking and consumption, provide a clear demonstration of an interaction between cognitive, perceptual, and hedonic processes, and demonstrate the potential importance of cognitive processes in the deterioration in food liking and consumption with age. An impact of cognitive processes on food liking and consumption, and similar interactions between cognitive, perceptual, and hedonic processes have previously been reported. Likings for flavors and odors increase when products are named compared with unnamed (Bensafi et al., 2007; Herz, 2003). Likings for flavors and odors also increase when stimuli are labelled as pleasant compared with unpleasant (Djordjevic et al., 2008; Herz & von Clef, 2001). Confusion as a result of a reliance on semantic information is also easily found in the studies investigating identity, flavor, and color mismatches (Shankar et al., 2010; Spence et al., 2010; Zampini et al., 2007). The potential impact of cognitive processes independent of chemosensory perceptions and independent of familiarity and experience in the deterioration of food likings and food consumption with age however is interesting. Whether these

effects are a result of a deterioration in cognitive abilities in general, or a result of a deterioration in a specific ability, such as memory, remain unknown. Some evidence suggests a particular role for semantic memory in a decline in odor identification with age (Larsson et al., 2000), and similar investigations in taste would be of interest.

From a practical perspective, these findings suggest that increased identification of flavors and foods may lead to increased liking and increased consumption particularly for older adults (de Graaf et al., 1996; Mojet et al., 2005). In hospital and care home settings in the U.K., for example, mass food provision is rarely accompanied by identifying information, such as product labels or menus, but there may be considerable benefit to these for older adults. Alternatively increased use of familiar flavors and familiar foods or flavors and foods that are otherwise easily recognizable and identified may be of benefit. The analysis of identification (while exploratory) suggests a clear role for familiarity in improved (more correct) identification. Improved identification was associated with increased familiarity, (increased pleasantness), colored as opposed to uncolored samples and correct as opposed to incorrect coloration, and a lesser reduction in identification with age was associated with these same variables. These findings suggest that individuals are better able to identify the drinks that are more familiar to them, (that they find more pleasant), that are colored, and that are correctly colored, and that these drink characteristics become more important with age. A role for familiarity in identification is unsurprising as experience and familiarity are likely to contribute significantly to representations and memories as required for identification (Bishop et al., 2010). Kobayashi & Kennedy (2002) and Kobayashi and colleagues (2006), for example, found increased recognition of umami taste following 10 days of experience, and a reversion of the effect once consumption ceased (Kobayashi et al., 2006). A role for pleasantness is also unsurprising given the value of positive valencies in forming memories (Bishop et al., 2010). The importance of color in flavor identification is again demonstrated in the studies using flavor and color mismatches (Spence et al., 2010). Philipsen and colleagues (1995) also demonstrate a greater confusion by older compared with younger participants when incorrect colors are used. These studies demonstrate the importance of visual cues in flavor and food liking (Philipsen et al., 1995; Spence et al., 2010), and suggest a particular reliance on visual cues by older compared with younger participants (Philipsen et al., 1995). Mojet and colleagues (2005) also suggest that liking may be based less on chemosensory properties in elderly compared with younger participants, and Forde and Delahunty (2004) suggest that older participants may rely more on a complete sensory experience when eating (smell, taste, vision, texture, mouthfeel, etc.) compared with younger individuals. The importance of color and visual cues may also suggest a role for color or visual augmentation to improve intakes in older individuals. Importantly, however, "correct" coloration as well as coloration was found to be important, thus augmentation should enhance natural/usual coloration, as opposed to focus on simply adding color.

The impacts of sweetness, strength, familiarity, and experience in the decline in drink pleasantness with age suggest that the sweeter, the stronger, the more familiar, and the more experience one has with a drink, the less the decline in pleasantness with age. Repeated work suggests a role for sweet taste, strength of flavor, familiarity, and experience in pleasantness ratings (Appleton, 2013; Herz & von Clef, 2001). Experience and familiarity with tastes and flavors as a result of experience has been strongly linked to liking, pleasantness, and consumption (Herz, 2003; Okamoto et al., 2009), and exposure to increase familiarity is commonly used to increase liking and consumption with success (Davis, Cullen, Watson, Konarik, & Radcliffe, 2009; Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010; Lakkakula et al., 2011) even in older adults (Appleton, 2013). Research also suggests high levels of pleasantness in older adults for foods and food products that are sweeter, stronger, more familiar and with which individuals have more experience (de Graaf et al., 1994, 1996; Griep et al., 1997; Kalviainen et al., 2003; Koskinen et al., 2003; Kremer, Bult, et al., 2007b; Mojet et al., 2003; Philipsen et al., 1995). The importance of these characteristics as individuals age has also been suggested (de Graaf et al., 1994, 1996; Griep et al., 1997; Kalviainen et al., 2003; Koskinen et al., 2003; Kremer, Bult, et al., 2007b; Mojet et al., 2003; Philipsen et al., 1995).

An absence of effects due to thirst has most plausibly resulted from the average levels of thirst reported by the majority of participants in this study (participants undertook ratings as part of their general day), whereas previous studies have involved more extreme changes in thirst (Appleton, 2005; King et al., 1999).

Methodology is unlikely to explain the effects found. All participants were provided with similar instructions, and were given enough time and enough of each drink to make all ratings. All participants were required to report no known taste impairments prior to participation, but we took no account of illnesses, medication use, dentition, oral health or other similar factors that may impact on taste without a participant being aware (Duffy et al., 1999; Griep et al., 1997; Leslie, 2011; Koskinen et al., 2003; Kremer, Bult, et al., 2007b, Kremer, Mojet, et al., 2007). Furthermore, illness, medication use, etc, are likely to increase with age, thus our effects of age may be due to increased illness, etc, as opposed to advanced years (Kremer, Mojet, et al., 2007c), but the practical implications of this distinction are negligible. All participants also were required to provide informed consent, but we took no account of verbal abilities. To identify drink flavors, participants were required to recognize a flavor and subsequently name it (Herz & von Clef, 2001), but we made no distinction between these two processes. Our recruitment process may also have resulted in a more educated sample than the average population, thus a sample who

may have been more able to recognize flavors and verbalize flavor names, but this would be likely to reduce the size of effects found as opposed to inflate them. Our study is cross-sectional, thus we can not separate out effects of age from generational or historical effects (Koskinen et al., 2003; Larsson et al., 2000), and different effects may of course also be found for different flavors or food products (Koskinen et al., 2003; Larsson et al., 2000).

In conclusion, this study demonstrates a clear role for identification in the decline in pleasantness for flavors with age, where better identification is associated with a lesser reduction in flavor pleasantness with age. Improved identification furthermore was associated with increasing familiarity, increasing experience, color cues, and correct compared with incorrect color cues. These findings provide clear evidence for a cognitive and perceptual element to these hedonic processes, and suggest that likings for flavors in older individuals may be increased/maintained through the use of improved visual cues, easily recognizable foods, and/or identity labels.

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Conflicts of Interest

The authors declare no conflicts of interest.

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