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Effect of Scents on Gazing Behavior and Choice

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Abstract: Environmental stimuli can have a significant impact on our decisions. Elements of the store atmosphere, such as music, lights and smells, all have effects on choices, but these have been only vaguely investigated. In the present study, we aim to uncover the effect of strawberry scent on the gazing behavior and choices of the 62 recruited participants. A static eye-tracker was used to study the effect of scent, released by a diffuser. In total, 31 participants completed the study under odorless conditions, while another 31 participants had strawberry fragrance sprayed into the air. The objectives of the study were (1) to determine whether the most gazed-upon product in each of the four categories (chocolate, tea, muesli bar, yoghurt) was chosen, (2) whether the presence of the strawberry scent influenced consumer decision making, i.e., whether the strawberry scent influenced more people to choose strawberry-flavored products, and (3) to introduce the application of a fast and easy-to-use technique for the qualitative analysis of strawberry aroma present in the air during eye-tracking measurements. The results show that (1) participants chose the product they had studied the longest, for all four categories, and (2) the presence or absence of the scent had no significant effect on choice, with the same frequencies of choosing each product in the two conditions regardless of the flavor of the products.

Keywords: eye-tracking; odor; fragrance; consumer-decision; sensory

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1. Introduction

Even though consumers' decisions are routine, the stimuli they encounter in the shopping environment can change their initial goals and preferences. People want to get through their daily shopping as quickly as possible, especially at the beginning and end of the shopping day. A good measure of consumers' visual attention is achieved using eye-tracking. It can be observed, for example, whether shoppers look specifically at the products they have planned to buy or also at other product categories [1].

Producers want customers to choose their products. In many cases, customers choose a product not because of what is inside, but because of the way it is packaged or displayed on the shelf, or in advertisements on the Internet or on TV [2,3]. Neuromarketing experts are trying to identify these influencing factors, for which there are already many methods and tools [4]. Several tools are available for producers to drive consumer attention, e.g., packaging, ads, lights, sounds and scents. The use of smells have been identified as a promising area, as olfactory cues have been shown to have a significant effect on our everyday life [5].

1.1. Environmental Scents

As previous studies have shown, the sense of smell plays an important role in the perception of taste and the acceptance of food [3,4]. It is important to note that there are individual differences in odor sensitivity. Previous research has revealed that factors such as age [6,7], hunger/thirst [8], personality traits [9], as well as environmental factors [10] contribute to differences in odor sensitivity. Environmental scents also influence consumer behavior in a number of ways [11]. A pleasant smell enhances the evaluation of the product and the retailer, causing a change in purchasing behavior (longer stay, better mood, memories and purchase) [12]. It also affects body states and decision making. Gagarina and Pikturnienė [13] identified the relationship between environmental odors and decision-making heuristics when it comes to risk. They manipulated the type (vanilla vs. peppermint) and intensity of ambient fragrance concentrates sprayed in the room. The risk was perceived as significantly lower in the high-intensity scent condition, compared to unscented or lightly scented environments. The results are consistent with the reported properties of peppermint scent, as it increases alertness, captures attention and speeds up physiological processes.

Managers use environmental scents as an important strategic element in different service environments, especially food-related scents. Biswas and Szocs investigated the impact of food-related environmental scents on food purchase/choice of children and adults. The results show that prolonged (more than two minutes) exposure to an environmental scent associated with enjoyable foods (e.g., cookie scent) leads to a lower purchase of unhealthy foods than no environmental scent or an environmental scent associated with non-enjoyable foods (e.g., strawberry scent). The effects appear to be driven by cross-modal sensory compensation, whereby prolonged exposure to a pleasurable/rewarding food odor causes pleasure in the reward circuit, which in turn reduces the desire to consume the pleasurable food [14]. Sensory marketing, which is defined as "*marketing that engages the consumers' senses and affects their perception, judgment and behavior*" [15], can be used to create subliminal triggers that characterize consumers' perceptions of abstract concepts. Among the elements of the shop atmosphere, there has been research on music [16–18], smells [19–21] and color [22,23].

1.2. Gazing Behavior

Eye tracking has long been a widely applied technique to study visual attention in individuals, with the most common method being pupil-centered corneal reflectance (PCCR). Eye-trackers track all of the eye movements of a participant, i.e., where the person looks and for how long, where they looked first and how much time they spend looking at that particular product. There have been many studies on the "*love at first sight*" choice. Some have argued that choice can be predicted by which product the subject fixated on first, but Danner and colleagues have refuted this claim [24]. With an eye-tracker, we can measure the followings: gaze direction and gaze point, detection of eye presence, eye position, eye identification, eyelid closure and pupil dilation and size [25].

In their 2013 paper, Orquin and Mueller Loose [26] reviewed studies on eye movements in decision making and compare their observations with theoretical predictions about the role of attention in decision making. An important conclusion of this review is that attention plays an active role in decision making. In contrast to the assumption of passive information acquisition, attention has been shown to be driven not only by information demands, but also by bottom-up processes and interactions with working memory. The final decision is shaped by complex interactions between stimuli, attentional processes, working memory and preferences, and it is, therefore, reasonable to conclude that attention plays a constructive role in decision-making. It can also be inferred that the cognitive processes that drive eye movements during decision making are not consistently different from those in similar tasks. Attentional processes, such as top-down or bottom-up attention capture or learning effects on fixations, play similarly important roles in decision making, problem solving, visual search and scene viewing. Rojas and colleagues focused their research on using eye-tracking as a method to understand children's consumer preferences. The results support the use of visual attention measures as an implicit tool to analyze children's decision making and preferences. Additionally, their results also revealed that stimuli determine the largest amount of fixations and that viewing times are different across genders [27].

When working with advertisements, it has been shown that "*sniffing a scent while viewing a print ad diverts visual attention* (total gaze duration) *to a visual object in the ad when the object is semantically congruent with the scent, controlling for total time spent looking at the ad*" [20]. This effect was more pronounced in direct scenarios (e.g., lemon scent and lemon picture) compared to indirect ones (citrus scent and cleanser).

Several studies have demonstrated that visual cues affect olfactory performance [28–30]. For example, when an odor is correctly paired with a color, participants perceive it as more pleasant than when they are incorrectly paired [31]. It was also shown that looking at congruent pictures increased the intensity of odors and made them more pleasant than incongruent pairing [32]. In addition, several studies have investigated the ability of odors to modulate the behavior of participants in response to visual stimuli [33–36].

Morquecho-Campos and colleagues [37] investigated how subliminal exposure to odors influences the choice of snacks with similar taste characteristics and whether this is modulated by visual attention. The test used odors that were associated with salty/savory or sweet food. Their results showed that the participants fixated first on the product that could be paired with the particular odor: if they smelled salty/savory, most people fixated on salty/savory snacks first, and vice versa for sweet snacks. However, they fixated on sweet snacks more often and for longer periods of time, and chose them more often, regardless of which odorant was released. Participants spent more time looking at incongruent snack products during the first fixation. These results suggest that scent affects visual attention but does not influence final choice.

1.3. Odor Perception

The olfactory sensory receptors are located in the posterior-anterior part of the nasal cavity, embedded in the olfactory bulb. The projection from the olfactory bulb runs directly into the olfactory cortex. It is probably in this part of the cortex that olfactory sensations are conscious. From here, the information is transmitted to the orbitofrontal cortex and directly to parts of the limbic system, one of which is responsible for the affective effects of olfactory sensations and is involved in behavioral responses. This very direct connection suggests that the "decoding" of the stimulation of primary sensory neurons takes place in the olfactory bulb itself [38]. It has been shown that odorants can affect behavioral performance through their stimulatory or sedative properties on attention and arousal [39] and can modify mood and emotional states, and thereby, affect information processing [40].

In recent decades, there has been increasing interest in cross-modal integration, focusing on the links between hearing and vision. The cross-modal interaction between olfaction and vision is observed in two opposing ways: the effect of visual inputs on odor processing and the effect of odors on visual perception [41]. There are studies suggesting that the perception of odors can be strongly influenced by vision. In such studies, participants are most often required to perform one or more olfactory tasks (e.g., hedonic appraisal or identification) while exposed to a visual stimulus [42].

In Gottfried and Dolan's study, participants were shown a picture while being sprayed with a fragrance. The associative relationship between odor and image was either congruent (image and odor are paired) or incongruent (image and odor are not paired). Odor perception was easier for congruent trials than for incongruent trials. In comparison, congruent and incongruent pairs differentially activated the anterior hippocampus, which is thought to be involved in relational processing between multiple sensory sources and in mediating the activation of cross-modal semantic representations [43].

1.4. Measurement of Aromas

Strawberry aroma is not a distinct, specific aroma, rather a collection of different compounds, each perceived as strawberry but in a different way [44]. Interestingly, over 360 volatile compounds have already been identified in strawberries [45]. A complex mixture of esters, aldehydes, ketones, alcohols, terpenes, furanones and sulfur compounds determines the perception of strawberry aroma. Even though many of the components are present in low concentrations, they have a significant influence on strawberry aroma. Esters have been identified as the most prevalent class of these compounds, both quantitatively and qualitatively, with over 131 esters identified in strawberry aroma [46]. For example, Fan and colleagues' [47] study on esters, especially methyl and ethyl esters, accounts for 25–90% of the total amount of volatiles in strawberry and contribute fruity aromas. Out of esters, there are several volatile compounds with different concentrations that impact the development of the strawberry aroma, containing a variety of aromatic notes, such as caramel, fruity, sour, flour, buttery and grassy [48].

Several different techniques have been used to measure volatiles in foods. Starowitz [49] stated that the most commonly used techniques for fraction separation are solid-phase microextractions (SPME) and stir bar sorptive extractions (SBSE), while the analysis of active compounds is usually conducted using gas chromatography with olfactometry detectors (GC-O) or solvent-assisted flavor evaporation (SAFE). Volatiles are mostly separated on GC systems, while detection is done by mass spectrometry for chemical compound identification. However, HS-SPME in conjunction with GC-MS has been proven to be one of the most helpful tools in detecting volatile components of various food aromas [50].

1.5. Hypotheses

Based on the above, the hypotheses of the present study are:

Hypothesis 1 (H1). *In each of the four categories (chocolate, tea, muesli bars, yoghurt), participants choose the product they have looked at most often.*

Hypothesis 1 (H2). *Strawberry scent influences consumer decision making.*

Hypothesis 1 (H3). *Rapid GC-MS analysis of essential oils in the air supports eye-tracking studies.*

2. Materials and Methods

2.1. Location

The measurement was carried out at the Buda Campus of the Hungarian University of Agricultural and Life Sciences, in an approximately 18 m^2 room located in a quiet, but central part of the campus. The room was 6 m long and 3 m wide, with 2.60 m inner height. This was a positive factor, as it was easier to recruit participants for the study, yet it could be carried out without disturbance. The table with the computer was placed in the middle of the room. The light in the room was provided by an LED panel (6500 K, 1600 lm) mounted on the ceiling above the table. Since the research was conducted to investigate the influence of strawberry scent on decision making, a pleasant strawberry scent was sprayed into the air using MAYAM elements essential oil and a Sencor SHF 920BL (Ricany, Czech Republic) humidifier. The size of the room allowed for a uniform distribution of the odor and easy control of its intensity. The level of strawberry fragrance was continuous and adjusted to be pleasant, yet not overpowering. Details of the preparation of the aroma solution are presented in Section 2.6.2.

2.2. Participants

The subjects of the study were recruited on the Buda Campus. The total number of volunteering participants was 70, mean age of the odorless group is 22.85 years (SD = 6.55) and the odor group is 22.8 years (SD = 2.97). Eight participants were excluded due to low (<80%) gaze sampling. Detailed demographic information of the participants is given in Table 1.

Among the visual disorders, farsightedness and nearsightedness were the most common, and three participants reported squinting. At the end of the questionnaire, six participants reported that they had experienced a partial loss of smell, and two participants had a partial loss of taste, due to post-COVID symptoms. These post-COVID symptoms have passed completely according to the participants, and therefore, they did not affect the measurement.

Table 1. Demographic profile of the participants in the odor and odorless conditions (%).

			Odorless	Odor
Gender	male		19.4	22.6
	female		30.6	27.4
place of living	male	capital city	11.3	14.5
		large city	3.2	1.6
		small town	3.2	1.6
		rural	1.6	4.8
	female	capital city	8.1	3.2
		large city	4.8	3.2
		small town	9.7	12.9
		rural	8.1	8.1
education	male	graduate	3.2	1.6
		undergraduate	16.1	21.0
	female	graduate	8.1	6.5
		undergraduate	22.6	21.0
visual aid	male	contact lenses	1.6	3.2
		glasses	4.8	6.5
	female	contact lenses	1.6	4.8
		glasses	8.1	3.2

2.3. Eye-Tracker and Software

Information on the eye-tracking procedure has been added following the guidelines published in [51]. During the study, eye movements were tracked with a Tobii Pro X2-60 (Tobii Pro AB, Danderyd, Sweden) desktop eye-tracker and the timelines (image sequences) were presented using the Tobii Pro Lab v.1.171 (Tobii Pro AB, Danderyd, Sweden) software. The eye-tracker illuminates the eye with a near-infrared pattern, and then captures high-resolution images of it. The image processing algorithms search for characteristic details and reflection patterns in the user's eyes and use these to calculate the gaze point and position of the eyes using a 3D eye model algorithm. An advantage of this type of eye-tracker is that it is small, unobtrusive, does not disturb the participant during the measurement and allows a certain freedom of movement of the head. The ideal viewing angle is $\leq 65°$ and the appropriate distance between the eye and the camera is 60–65 cm.

2.4. Process

The measurement was carried out with two groups. First, it was done with the control (odorless) group of 31 participants, whose eye movements and food choices were tested in an odor-free environment. This was followed by the odor group of 31 participants, where strawberry scent was sprayed into the air. The measurement procedure was the same for both groups, except that the odorless control group did not smell strawberries in the air.

First, participants were asked to sit in a comfortable position in front of the computer, then they were asked not to change their position during the measurement and were informed about the measurement procedure and the eye-tracker. The next step was to calibrate the eye-tracker, and after successful calibration, we started the timelines installed in the software. The measurement started with an initial slide containing the instructions. After reading the instructions, participants proceeded by clicking with the left mouse button. At the beginning of the timelines, trial slides (four lemonades made from different fruits: forest fruit, lemon, orange and peach) were used for practice and to familiarize the participants with the process. Participants were asked to select the product they liked the most from the four alternatives and then to press any key on the keyboard. After that, the mouse (which was hidden up until now) cursor appeared on the screen. They were then asked to click on the chosen product and press another key to move on to the next choice set. The two conditions (odorless and odor) saw identical timelines, and the decision making was not time-bound.

2.5. Visual Stimuli

Participants were shown five different sets of images, out of which the first were the trial slides. The trial slides were not included in the data analysis. The remaining four choice sets were identical in structure, but the order of the product groups and the order of the products was randomized. The image sequences covered four product groups—muesli bar, chocolate bar, tea and yoghurt—and there were always four product alternatives to choose from (Figure 1). The visual stimuli consisted of product alternatives from the same brand, with only one strawberry-flavored product. Each variation was preceded by a slide with a fixation cross presented in the middle of the screen for 2 s, so that the gaze always started from the center. The visual stimuli were presented on an LG W2452V-PF 24″ Full HD LCD monitor at 1366 × 768 resolution. Areas of interests were defined as the presented products. The distance between AOIs were maximized to avoid any overlap between them. Identification by velocity threshold (I-VT) filter method was used that incorporated interpolation across gaps (75 ms), reduced noise (median), used velocity threshold at 30°/s and merged adjacent fixations (<0.5°) between fixations (<75 ms) and discarded short fixations (<60 ms).

Figure 1. The four presented choice sets from top left to bottom right: chocolate, tea, muesli bar, yoghurt.

2.6. Headspace Analysis of Essential Oil

2.6.1. Essential Oil

In total, 200 µL essential oil (MAYAM, Elemental, Oradea, Romania) was pipetted into a 20 mL headspace (HS) vial. After 30 min of equilibrium time, solid-phase microextraction (SPME) was inserted into the HS vials. The sampling time was 1 min at room temperature.

2.6.2. Sensory Testing Room

An essential oil solution was prepared as follows: 1.5 mL essential oil was added to 3.5 mL distilled water to achieve 20-fold dilution. An ultrasonic humidification device (Sencor SHF 920BL, Ricany, Czech Republic) was used to release the aroma into the air. SPME sampling was done 30 min, 60 min and 90 min after the device was switched on. Sampling time was 30 min at room temperature.

2.6.3. Rapid GC-MS Analysis

Determination of aroma compounds was performed on an Agilent 6890N gas chromatograph (Agilent Technologies, Santa Clara, CA, USA) coupled to an Agilent 5973 Mass Spectrometer (Agilent Technologies, USA).

After extraction, aroma compounds were thermally desorbed into the injector heated at 250 °C and equipped with an SPME liner (0.75 i.d., Supelco Inc., Bellefonte, PA, USA).

Separation was done on an HP-5MS capillary column (10 m × 0.1 mm i.d. × 0.4 µm df). Hydrogen was used as carrier gas under constant flow at 1 mL min^{-1}.

An earlier published rapid GC temperature program [52] was used with slight modifications: 45 °C (2 min), 80 °C (30 °C min^{-1}), 100 °C (60 °C min^{-1}), 150 °C (30 °C min^{-1}), 250 °C (80 °C min^{-1}) and 250 °C (1 min). The temperature of the GC oven was kept constant at 250 °C. The total run time was 7.94 min.

Mass spectra in the 35 to 350 *m/z* range were recorded. The chromatography and spectral data were evaluated using Agilent Mass Hunter Software (Agilent Technologies, USA). Volatile compounds were identified with the NIST17 database (NIST, Gaithersburg, MD, USA) and by retention indices. Hydrocarbon standards (C8 to C20 in hexane, Sigma-Aldrich, Darmstadt, Germany) were injected to determine the retention indices using a modified Kováts method [52]. Every sample was analyzed in triplicate.

2.7. Data Analysis

Choice frequencies were tested using Chi-squared statistics. The effects of choice and scent on the gazing behavior were tested using repeated measures analysis of variance (RMANOVA), where the eye-tracking variables served as within-subject factors, while choice and scent served as between-subject factors. The following eye-tracking parameters were used during the data analysis:

- Time To First Fixation (TTFF, time elapsed between the appearance of a stimuli and the user fixating their gaze first on an alternative in seconds);
- First Fixation Duration (FFD, length of the first fixation on an alternative, in seconds);
- Fixation Duration (FD, total length of fixations on an alternative, in seconds);
- Fixation Count (FC, number of fixations on an alternative, count);
- Dwell Duration (DD, time elapsed between the user's first fixation on a product and the next fixation outside the product, in seconds);
- Dwell Count (DC, number of "visits" on an alternative, count).

Data were recorded using Tobii Pro Lab v.1.171 (Tobii Pro AB, Danderyd, Sweden). Statistical data analysis was done using IBM SPSS Statistics Version 16.0. (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. Choice Frequency

Each product was chosen at least eight times, and statistically significant differences in the choice frequency were found for two out of four product sets (Figure 2). In the case of chocolate, strawberry and raspberry alternatives received ~14% of choices, while peanut was chosen over 40% of the time. For teas, there was a significant difference between the choice frequency of the strawberry- and cherry-flavored alternatives, 36.7% and 15.9%, respectively.

3.2. Eye-Tracking Measures

The results of the Repeated Measures Analysis of Variance (RMANOVA) showed that for the tea product group, the product had a significant effect on gazing behavior (Table 2). Product choice showed no significant effect in any of the four categories, while odor also showed no significant effect for any of the product categories. A significant interaction between product and choice was found for all four product categories, indicating that the product chosen was gazed at differently than those not chosen.

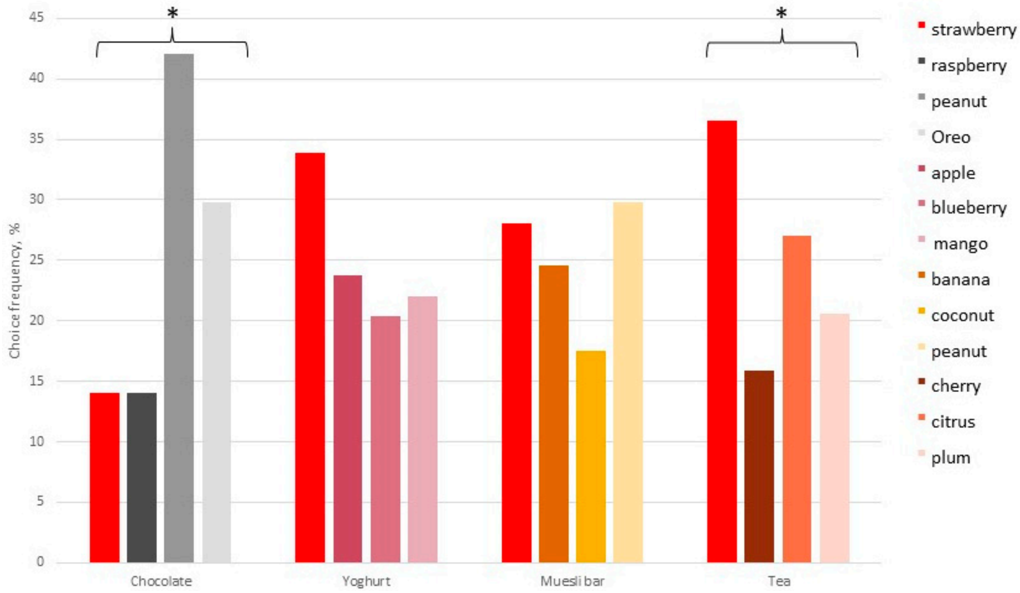

Figure 2. Frequency of choice for all four choice sets with each four alternatives. * indicates a significant effect at a level of $p < 0.05$. Product categories had different flavors; only the strawberry flavor was common, which is colored in red.

Table 2. Repeated measures ANOVA presenting the F-values of the three main effects and two of their interactions for the four product groups.

Effect	Chocolate	Yoghurt	Muesli Bar	Tea
Product	3.068	1.057	3.999	**5.181 ***
Choice	0.854	0.974	0.923	1.919
Odor	6	1.762	1.908	0.533
Product × Choice	**1.673 ***	**1.527 ***	**1.723 ***	**1.134 ***
Product × Odor	0.702	**2.667 ***	0.78	1.329

Bold and * indicates significant effect at a significant level of $p < 0.05$.

3.3. Product Effects on Gazing Behavior

Analyzing the significant effects in more detail, univariate tests show that the product had a significant effect on FC in the muesli bar category and DC in the chocolate category (Table 3). Between product and choice, TTFF and FFD showed no significant effect, supporting appropriate randomization. Significant interactions were found for FD, FC and DD for all four product categories, and for DC for chocolate, yoghurt and muesli bars. There was also no significant interaction between product and odor for TTFF, but there was a significant interaction for FFD for the yoghurt, muesli bar and tea product categories. For the DC indicator, significant results were obtained only for the yoghurt product category.

RMANOVA gives similar results in all four product categories, so we will only present them through the example of the yoghurt product group. The RMANOVA results of the other three product groups can be found in the supplementary materials (Figures S1–S3). Figure 3 shows whether participants chose the product that received the most visual attention. The figure shows that for all four products, participants chose the product that they spent the longest time looking at.

Yoghurt, tea and muesli bars have a faint smell compared to chocolate. When we see a product photo of a strawberry yoghurt, the smell of strawberries comes to mind. Figure 4 clearly shows that the strawberry scent significantly increased ($p < 0.05$) the FFD for the strawberry- and mango-flavored yoghurts.

Table 3. Results of the repeated measures ANOVA (RMANOVA). Factor choice is not stated due to no significant effects observed in RMANOVA.

	Eye-Tracking Parameter	Chocolate	Yoghurt	Muesli Bar	Tea
Product	TTFF	2.015	1.442	1.658	2.206
	FFD	1.144	1.338	1.089	1.326
	FD	2.577	1.956	1.589	1.445
	FC	2.083	1.069	**3.057** *	2.698
	DD	2.257	1.631	1.852	1.313
	DC	**4.410** *	0.995	1.039	1.873
Product × Choice	TTFF	1.213	0.369	0.392	0.636
	FFD	0.395	0.737	0.86	1.173
	FD	**4.472** *	**2.881** *	**3.219** *	**2.005** *
	FC	**3.989** *	**3.282** *	**3.124** *	**2.261** *
	DD	**4.607** *	**3.094** *	**3.449** *	**2.163** *
	DC	**6.459** *	**3.720** *	**2.540** *	1.211
Product × Odor	TTFF	0.13	0.651	0.107	1.642
	FFD	0.433	**2.326** *	**2.466** *	**3.284** *
	FD	0.321	0.472	0.41	1.75
	FC	0.144	0.778	0.252	1.361
	DD	0.264	0.377	0.272	1.643
	DC	0.269	**2.270** *	0.44	0.343

Bold and * indicates significant effect at a significant level of $p < 0.05$. TTFF: Time To First Fixation; FFD: First Fixation Duration; FD: Fixation Duration; FC: Fixation Count; DD: Dwell Duration; DC: Dwell Count.

Figure 3. Dwell counts of the four yoghurt product alternatives.

The length of the first fixation did not influence other eye-tracker parameters, so no higher values were recorded for FD, FC, DD and DC when the strawberry odor was present. However, the choice frequency of products was partially influenced by the odor in the case of chocolates (χ^2 = (3,6) = 13.675, $p < 0.05$) and yoghurts (χ^2 = (3,6) = 110,077,703, $p < 0.001$). For chocolate products, strawberry-, raspberry- and Oreo-flavored alternatives received higher choice frequencies when the odor was present, while the peanut-flavored alternative was chosen less frequently. For yoghurts, participants chose strawberry- and blueberry-flavored alternatives with a higher frequency under the odor condition. Tea and muesli products showed no significant differences between the odor and odorless conditions (Figure 5).

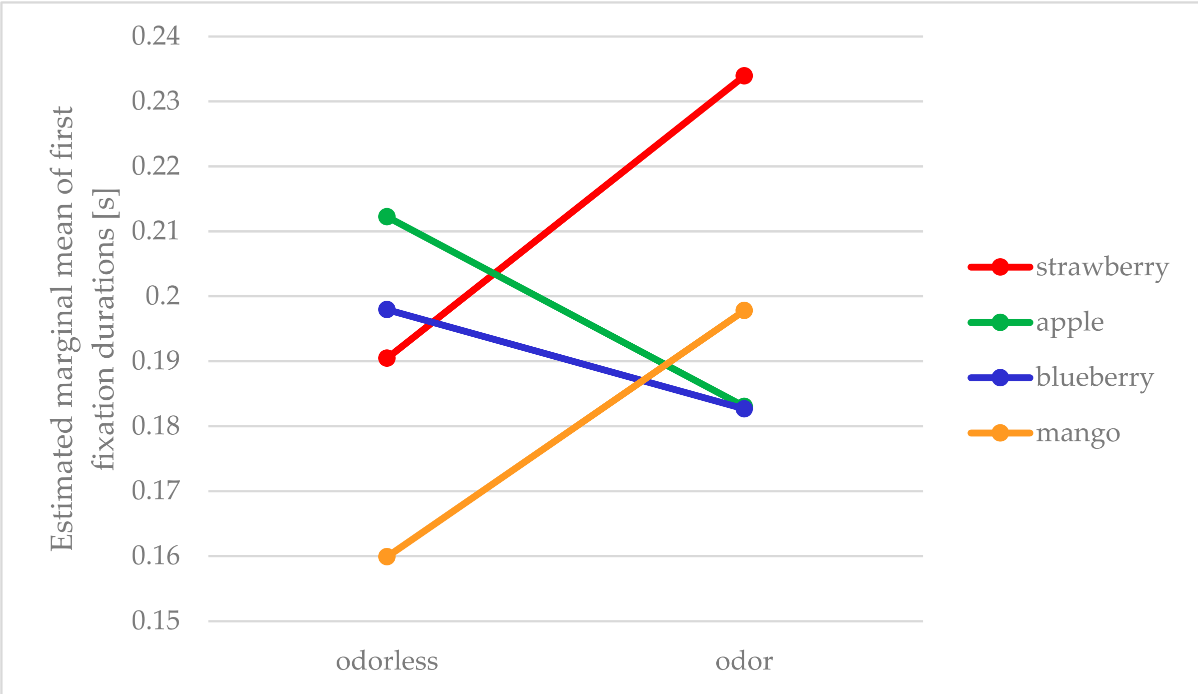

Figure 4. First fixation durations between the odor and odorless conditions for the yoghurt product group.

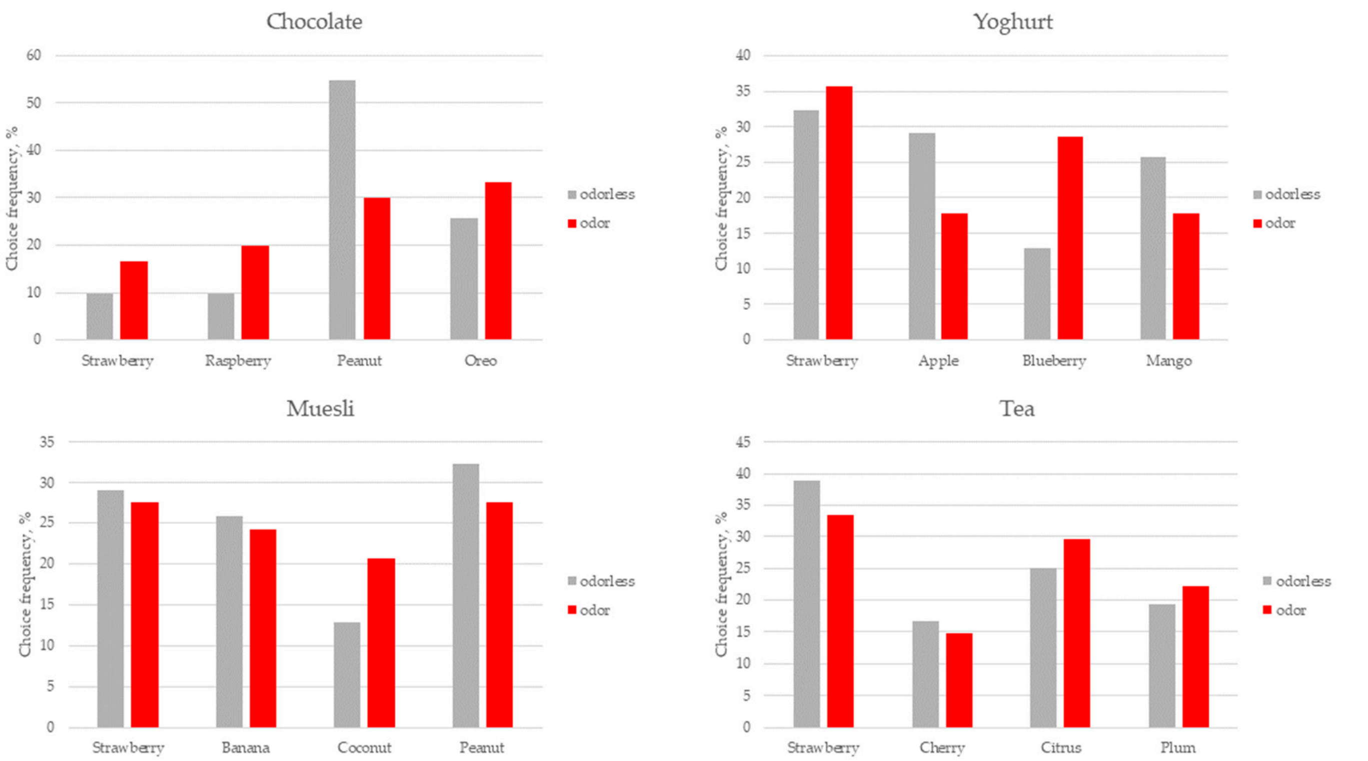

Figure 5. Frequency of choice for all four choice sets with each four alternatives by the two conditions.

3.4. Monitoring the Volatiles in the Air

Different aroma products might cause different sensory perceptions depending on the origin, producer, etc. of the aroma product. Not only the used aromas, but also their concentrations can affect the perceived strawberry odor in the air. In order to characterize and map the essential oil compounds in the air, the aroma profile of the commercially available essential oil was analyzed with GC-MS (Figure 6).

Thirteen aroma compounds were identified using Agilent NIST 2017 Mass Spectral Library (W9N08 and W10N11). The identification match factor was above 90% in all cases, and the calculated Kováts' retention indexes (RI's) also matched the RI data from NIST WebBook (https://webbook.nist.gov/, accessed on 10 June 2022). Table 4 shows the aroma profile of strawberry aroma and their identification results.

Table 4. List of strawberry aroma's compounds.

rT (min)	Name	CAS	Formula	MW	RI (Calculated)	RI (Literature)	RI Diff
0.96	Ethanol	64-17-5	C_2H_6O	46.1	-	448	-
1.30	ethyl acetate	141-78-6	$C_4H_8O_2$	88.1	612	613	1.0
2.58	**methyl 2-methylbutyrate**	868-57-5	$C_6H_{12}O_2$	116.2	780	780	0.1
2.83	**ethyl butyrate**	105-54-4	$C_6H_{12}O_2$	116.2	805	806	0.9
3.28	**ethyl 2-methylbutyrate**	7452-79-1	$C_7H_{14}O_2$	130.2	857	851	6.4
3.32	ethyl isovalerate (ethyl 3-methylbutyrate)	108-64-5	$C_7H_{14}O_2$	130.2	862	859	2.7
3.33	(cis)-3-hexenol	928-96-1	$C_6H_{12}O$	100.2	863	865	1.6
3.44	1-hexanol	111-27-3	$C_6H_{14}O$	102.2	875	874	0.7
3.50	isoamyl acetate (banana oil)	123-92-2	$C_7H_{14}O_2$	130.2	882	878	3.9
4.33	ethyl hexanoate	123-66-0	$C_8H_{16}O_2$	144.2	999	998	0.7
4.38	(E)-3-hexenol acetate	3681-82-1	$C_8H_{14}O_2$	142.2	1006	1005	1.4
4.41	hexyl acetate	142-92-7	$C_8H_{16}O_2$	144.2	1013	1011	2.2
4.94	iso-amyl isovalerate (apple oil)	659-70-1	$C_{10}H_{20}O_2$	172.3	1106	1105	1.2

MW: Molecular weight, RI: Kováts' retention index, RI diff: the difference between the calculated and determined RI's. Bold letter indicates those compounds which were present in the testing room.

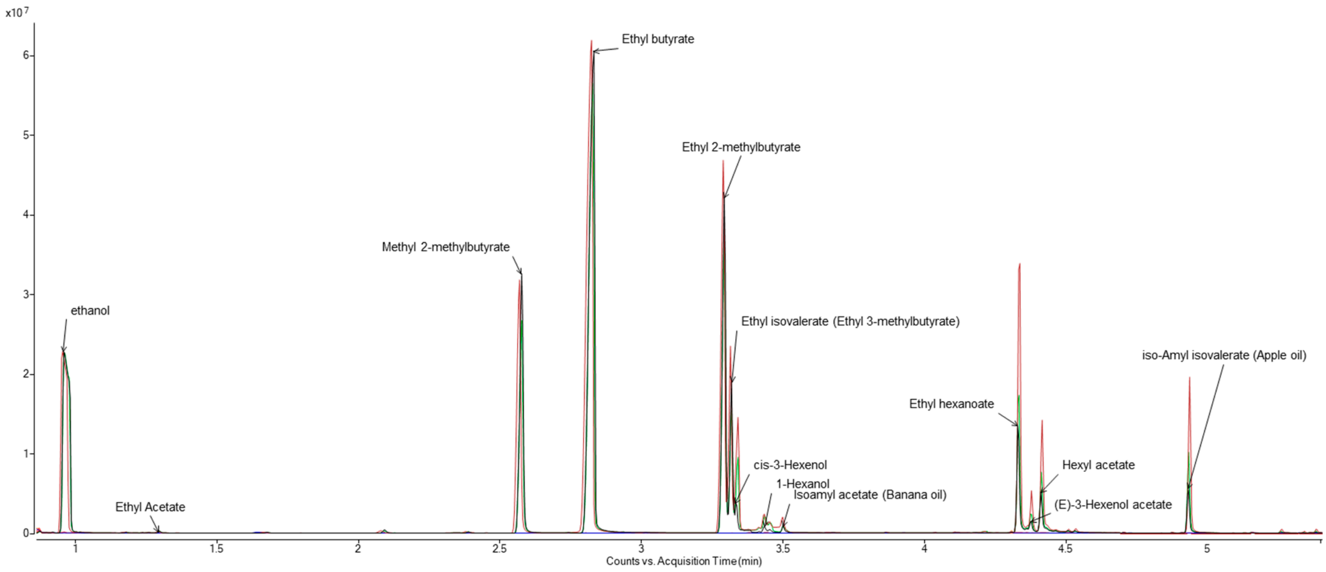

Figure 6. Aroma profile of strawberry essential oil. Total ion chromatograms of three parallel measurements (colored by black, green and red).

Examining the air composition of the sensory testing room, three compounds were clearly coming from the vaporized essential oil (Table 4). Methyl 2-methylbutyrate, ethyl butyrate and ethyl 2-methylbutyrate also showed up in the case of the total ion chromatogram (TIC) of testing room measures.

4. Discussion

It was shown earlier that although odors play a role in human behavior, their effect might be suppressed by other factors, such as music [53]. Ba and colleagues investigated the combined effects of sound and odor in order to study the behavior of crowds with respect to such effects, thereby improving the use of urban spaces. The study was a covert behavioral observation experiment, using the smell of bakery products as the odor source, while urban noise, music and fan noise were applied. There was also a control experiment where no sounds or smells were used. Their results showed that playing music in the absence of odor attracted the crowd, making the crowd's path more concentrated. Mass duration was significantly increased by the presence of odor, but the interaction between sound and odor was not significant [54]. Our results support these findings, as the effect of strawberry odor was not the only factor affecting consumer decisions.

The results showed that the tea product group had a significant effect on gazing behavior. For any of the product categories, product choice and odor showed no significant effects. A significant interaction between product and choice was found for all four product categories, indicating that the product chosen was gazed at longer than those not chosen. These results support the findings of Danner and colleagues [24]. However, a significant interaction between product and odor was only found for yoghurt products, but not in the chocolate, muesli bar or tea product categories.

The univariate tests showed that the product had a significant effect on FC in the muesli bar category and DC in the chocolate category. TTFF and FFD showed no significant effects between product and choice. For TTFF, there was no significant interaction between product and odor, while for FFD, there was a significant interaction for the yoghurt, muesli bar and tea product categories. These results are in accordance with earlier findings, where the authors demonstrate that scents can increase visual attention towards congruent visual stimuli [6]. Our results show that for all four product categories, participants chose the product on which they gazed for the longest time. These results support the notion that the product chosen receives more visual attention, as expressed by the FD, FC, DD and DC indicators, but not the TTFF and FFD indicators. These results support H1, as participants chose the product that they had looked at the most often.

According to previous studies, the length of the first fixation may be influenced by the presence of odor [6,35]. In the present study, this claim holds for the yoghurt, muesli bar and tea product categories, but not for the chocolates (Figures S4–S6). A possible reason is that chocolate has a distinctive, strong smell, which overpowers the smell of strawberries. Therefore, when we see a picture of a strawberry chocolate, it is the smell of chocolate that first comes to mind. Our results also show that strawberry odor significantly ($p < 0.05$) increased the FFD for strawberry- and mango-flavored yoghurts. The mango-flavored yoghurt has received a relatively high attention due to its specificity. The obtained results, therefore, partially support H2, as strawberry scent influenced consumer decision making only in the case of strawberry- and mango-flavored yoghurts.

In the present study, a commercial strawberry aroma product was used and methyl 2-methylbutyrate, ethyl butyrate and ethyl 2-methylbutyrate were identified as its main components. Methyl 2-methylbutyrate has a sweet, fruity and green apple-like odor, while ethyl butyrate is described as fruity, sweet, pineapple, ester-like, strawberry, cheese, fruity and sweet and ethyl 2-methylbutyrate is described as sour, cheesy, sweaty and fruity [55,56]. However, other studies identified different compounds responsible for strawberry odors. For example, uraneol [2,5-dimethyl-4-hydroxy3(2H)-furanone] (DHF) and mesifurane [2,5-dimethyl-4-methoxy-3(2H)-furanone] (DMF) have been identified as the two major contributors to strawberry aroma due to large amounts of them being present in several cultivars [57]. In addition, 2,5-dimethyl-4-hydroxy3(2H)-furanone (Furaneol, DHF) is also considered as one of the essential components of strawberry aroma. It is widely used by food scientists as a synthetic aroma [58].

According to Kim and co-workers [55], four esters can be considered as the key constituents of fresh strawberry, which are ethyl butyrate, ethyl hexanoate, ethyl isovalerate and ethyl 2-methylbutytare. All of these compounds were found in our strawberry aroma (which contains esters dissolved in alcohol). Moreover, ethyl butyrate and ethyl 2-methylbutytare were also identified in the air of the testing room. Our results support H3, as a rapid GC-MS analysis of essential oils in the air supports eye-tracking studies.

The results suggest that the presence of strawberry odor has no significant effect on choice. However, participants did not fixate faster on the strawberry-flavored product, but their first fixation time was found to be longer, similarly to previous results [37].

We should note that the study has some limitations regarding the participants. It is well known that olfactory functions decline with ageing [6]. Over time, people become less sensitive to odors such as personal fragrances [59]. This encourages older people to use more fragrance than before. In contrast, people who are sensitive to fragrances or young people may be uncomfortable with large amounts of fragrance [60]. Due to these documented differences in olfactory sensitivity, the presented results should not be generalized. Additionally, reaction to odors might change over the time of the year. For example, cinnamon odor was shown to be more familiar and pleasant during the Christmas season compared to summertime [61].

5. Conclusions

The results of the study highlight that the smell of strawberries had no significant effect on choice, but it did affect the location of first fixations. However, the strawberry scent can also be triggered by several other volatile components, so taking the SPME measurement into account, we can only conclude that the presence of methyl 2-methylbutyrate, ethyl butyrate and ethyl 2-methylbutyrate did not influence choice. The obtained results, therefore, should not be generalized. Comprehensive analysis of other strawberry aroma compounds is needed to determine if there is any effect on the eye-movements that is specific to the type of the aroma. Our results demonstrate that participants tend to choose the product that receives the most visual attention. However, future studies should aim to involve other age groups and different scents to obtain a more comprehensive knowledge on the effect of scents on the gazing behavior and choice.

From an analytical point of view, further research should focus on the role of other types of aromas (natural, artificial, etc.), the method of evaporation (heat-based diffusion vs. cool diffusion) and the aerial concentration of the aroma compounds as environmental factors with an impact on human perception.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app12146899/s1, Figure S1: Dwell counts of the four muesli bar product alternatives. Figure S2: Dwell counts of the four tea product alternatives. Figure S3: Dwell counts of the four chocolate product alternatives. Figure S4: First fixation durations between the odor and odorless conditions for the muesli bar product group. Figure S5: First fixation durations between the odor and odorless conditions for the tea product group. Figure S6: First fixation durations between the odor and odorless conditions for the chocolate product group.

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