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Emotional effects of product scents are increasingly being advertised on the packaging of cosmetics. In fact, there are various odors that have psychophysiological effects on people. These effects may already be subconsciously associated with specific smells, potentially amplifying their true impact. In this study, we used a variation of the implicit association test (IAT) to investigate whether odors of either fruity or herbal smelling commercial products evoke stronger associations with refreshing or relaxing adjectives. It was found that the participants needed significantly less time to assign emotional adjectives to the effect categories when the category 'fruity' was combined with 'refreshing' and 'planty, non-fruity' with 'relaxing'. In addition, the error frequencies in the IAT were lower for these combinations. This indicates cognitive associations of certain odors with refreshing or relaxing effects. The data can provide valuable insights for product development and marketing, aiding in the selection of appropriate fragrance claims or scent choices aligned with desired emotional effects. However, we were able to identify differences between the odors within an odor category as well as individual differences. Therefore, it is essential to investigate the specific associations of a target audience more closely to optimize consumer acceptance and purchasing behavior for a given product.

Introduction

Smells and their subconscious effect on our emotional state

Numerous cosmetic products, e.g. bath or shower products, contain odor-active substances such as essential oils. The added fragrances mask less appealing matrix odors of the formulations and improve product perception. Human olfactory perception is closely linked to emotional experience, with scents being more capable than any other sense of evoking memories [*Herz* 1998], as well as triggering emotions and influencing moods [*Kadohisa* 2013, *Kontaris et al*. 2020]. Neurologically, this can be explained by the early processing of odors in the hippocampus, the memory center, and in the amygdala, the emotion center. Additionally, olfactory signals are transmitted directly to these areas without first passing through the center of consciousness, the thalamus [*Lundstrom, Boesveldt and Albrecht* 2011]. As a result, reactions to smells are subconscious and immediate. Furthermore, the stimulation of nasal receptors by inhaled fragrances induces various psychophysiological effects in humans [*Herz* 2009; *Angelucci et al*. 2014], including mood alterations [*Herz* 2002; *Schiffman et al*. 1995]. A detailed systematic overview of psychophysiological reactions to fragrances can be found in [*Loos et al.* 2020].

Perceptions of odors, particularly in terms of familiarity and pleasantness, are strongly shaped by individual factors and experiences [*Rouby et al*. 2009; *Distel et al.* 1999], leading to subjectively varied responses to olfactory stimuli. Beside inter-individual variability, also cultural differences in olfactory perception have been documented [*Ayabe-Kanamura et al*. 1998]. For example, in Germany, citrus scents are more commonly associated with cleanliness in cleaning products, whereas in Southern European countries like Spain, the scent of chlorine is linked to hygiene [*Müller-Grünow* 2018]. However, subjective differences and personal preferences within cultures are generally more pronounced than cross-cultural differences [*Arshamian et al.* 2022].

Nonetheless, there are scents which are consistently perceived and classified similarly by a majority of the population. Vanilla, for example, is generally rated as pleasant by most people [*Arshamian et al*. 2022; *Pangborn et al*. 1988]. One of the most well-known relaxing scents, lavender, has demonstrated calming effects in numerous studies. This includes the reduction of salivary stress markers [*Toda and Morimoto* 2008], improved sleep quality upon waking [*Hirokawa et al.* 2012], and decreases in anxiety levels [*Kutlu et al*. 2008]. Further, sandalwood is recognized for its calming properties [*Sheen* 2001], while citrus scents such as grapefruit are classified as refreshing [*Dosoky and Setzer* 2018], to name just a few examples.

Emotional effects in the cosmetics industry

Emotional effects of product fragrances are increasingly being promoted on cosmetic packaging and in advertising: for example, there are products that have a demonstrably stress-reducing or calming effect. In one of our placebo-controlled studies, a method was developed to assess the stress-relieving effect

of a plant extract in a face cream on 25 healthy women, using emotional, hormonal, and EEG (electroencephalography) data. The facial cream with extract demonstrated a significant reduction in stress compared to the placebo application [*Springer et al*. 2022]. In another study from our group, a balancing effect of the fragrance was observed within a product range of shower gel, bath additive, and bath salts: an activating effect was measured during boredom, and a calming effect during stress [*Springer et al*. 2024]. In principle, emotional responses can be investigated by measuring the participants' reaction to the application of the product (vs. placebo) after an emotional intervention (e.g. using images, film clips or a computer game) [*Freiherr et al*. 2023]. This opens up numerous possibilities for investigating and promoting emotional effects. However, to reduce the number of claims that need to be tested, it is advisable to first evaluate which fragrances are psychologically associated with specific effects before conducting efficacy tests, as this increases the likelihood of demonstrating effectiveness. For example, products with fruity scents like citrus, grapefruit, or peach are often associated with refreshing effects, while products with plant-based but non-fruity scents like pinewood or lavender are typically linked to calming effects. The extent to which these effects are implicitly associated with these scents can be assessed using implicit association tests (IAT).

The Implicit Association Test (IAT)

The emotional effect of scents can be investigated explicitly using questionnaires or indirectly using psychophysiological measurements. However, it is equally intriguing to explore the extent to which implicit associations – immediate cognitive connections between scents and emotional effects – already exist, independent of whether these effects actually occur. These subconscious cognitive links between scents and their expected emotional impact can be assessed using the IAT. Initially developed in social psychology to detect individual differences in automatic responses to semantic or evaluative associations [*Greenwald et al*. 1998], the IAT has since been applied in other fields such as consumer research and market analysis to evaluate implicit attitudes [*Brunel et al*. 2004; *Gregg and Klymowsky* 2013; *Maison et al*. 2004]. The IAT measures mental associations between two dimensions (e.g. vanilla smell/fish smell and good/bad). For this purpose, participants are presented with stimuli (e.g. pictures, words, odors), which must be categorized correctly via keypress (for more detailed explanations, see the method section). During the evaluation, the reaction times and error frequencies of individual test blocks are compared with each other (see statistical analysis). A faster response time and fewer errors in the assignment indicate a stronger association and thus a better fit between the combined dimensions. This method can provide valuable insights into customer and consumer behavior [*Niemand et al*. 2014], aiding the development of marketing strategies.

The IAT has already been applied to test implicit associations with scents. It was found that people who prefer scented products have positive associations with the odor concept [*Bulsing et al*. 2007]. While this study used scent-related words (e.g., aroma or nose) rather than actual olfactory stimuli, other studies have used real scents as stimuli. A variation of the implicit olfaction test revealed implicit associations between scents and colors [*Demattè et al*. 2006] as well as scents and texture [*Demattè et al*. 2007]. Furthermore, implicit tests showed that in direct comparison, menthol is associated with energizing effects, while vanilla is linked to calming effects. These associations were also observed in fine fragrances (*Lemercier-Talbot et al*. 2019; *Cereghetti et al*. 2024).

Study to investigate implicit associations with the odors of cosmetic products

The IAT approach offers a valuable method for examining whether merely smelling a product evokes stronger cognitive associations with one emotional state over another. In this study, our aim was to investigate whether the scents of cosmetic products in the categories 'fruity' and 'planty, non-fruity' are implicitly associated with the emotional states 'invigorating' and 'relaxing'. For this purpose, we selected products available on the market (bath or shower products and an essential oil for room scenting) that specifically claimed one of these two effects. Additionally, we assessed whether each product's scent had a stronger implicit association with the claimed effect category.

Method

Product selection (odors)

For this study, commercially available products (bath or shower products and an essential oil for room scenting) were selected based on their ingredients, allowing for classification into either the scent category 'planty, non-fruity' or 'fruity'. Additionally, products were chosen based on their labels or product descriptions, which classified the products as either 'relaxing' or 'refreshing' (emotional state). Specifically, the 'planty, non-fruity' products were categorized as 'relaxing', while the 'fruity' products were categorized as 'refreshing'. In the IAT study, the categories were shortened and displayed in English with the terms 'fruit', 'plant', 'refreshing' and 'relaxing', as almost all participants preferred the English language.

Product	Odor according to product description	Effect according to label / product description	Odor category	Congruent effect category
1	Patchouli, sandalwood	Deep relaxation and inner peace	Plant	Relaxing
2	Swiss stone pine, amyris	Relaxation	Plant	Relaxing
3	Lavender, bergamot, West Indian sandalwood	Soothing	Plant	Relaxing
4	Lemon	Refreshing	Fruit	Refreshing
5	Grapefruit, passion fruit, orange	Fresh energy	Fruit	Refreshing
6	Peach	Fruity vitalizing	Fruit	Refreshing

Table 1: Products used in the study, their odor descriptors and claimed emotional state as well as classification into odor and congruent effect category for this study.

Effect category	Word stimuli					
Relaxing	Comforting	Resting	Cozy	Restful	Chilling	Calming
Refreshing	Energizing	Exciting	Lively	Awake	Stimulating	Renewing

Table 2: Word stimuli per impact category used in the study.

In a preliminary study with 11 normosmic (= normal sense of smell) participants, it was verified that the smell of the products could also be clearly assigned to one of the two categories. Based on these results, six products were selected (see **Table 1**) and used as odor stimuli in phases 1-7 of the IAT, which was carried out using an olfactometer. In addition, a further preliminary study with 10 normosmic participants was conducted to identify the dilution ratios at which the odors of the products were perceived as equally intense and equally pleasant.

Word selection

For the emotional states (effect categories) 'relaxing' and 'refreshing', six-word stimuli were used for each category (see Table 2). The selected adjectives were of approximately equal length and were either synonyms or belonged to the same word family as the respective effect category. This ensured that the stimuli were semantically aligned with the intended emotional states.

Study design

Participants in the study had no chronic or mental illnesses and were normosmic. They had not consumed any alcoholic beverages for at least 7.5 h before the experiment and no caffeinated beverages for at least 4 h beforehand. On the day of the experiment, they did not use any perfumed cosmetics. In addition, it was checked immediately before the study that the participants had no critical allergies or olfactory impairments. At the end of the study, the Montreal Cognitive Assessment Test [MoCA; *Nasreddine et al*. 2005] and the Sniffin' Sticks Identification Test [*Kobal et al*. 1996] were carried out to test the cognitive functions and odor identification ability of the participants. The study was conducted at the Fraunhofer Institute for Process Engineering and Packaging IVV and approved by the ethics committee of the Friedrich-Alexander Universität Erlangen-Nürnberg (FAU).

IAT: Before the IAT, the participants were presented with all odor and word stimuli and their categories so that the assignment was clear and any comprehension problems could be solved. The subsequent IAT consisted of 7 phases in which the participants were asked to assign word or odor stimuli to their categories on the computer by pressing the 'e' or 'i' key on the keyboard. Word stimuli were presented in the center of the screen. The odor presentation was carried out using an olfactometer [*Lundström et al*. 2010] for time-precise and standardized application of the odors. The participants had nose pieces to perceive the odors directly. To ensure that the participants inhaled during the application of the odor but also word stimuli, a countdown appeared before the stimulus presentation, which counted down from the number 3 before the participants were asked to inhale. The categories to which the stimuli were to be assigned were located in the upper left corner (for

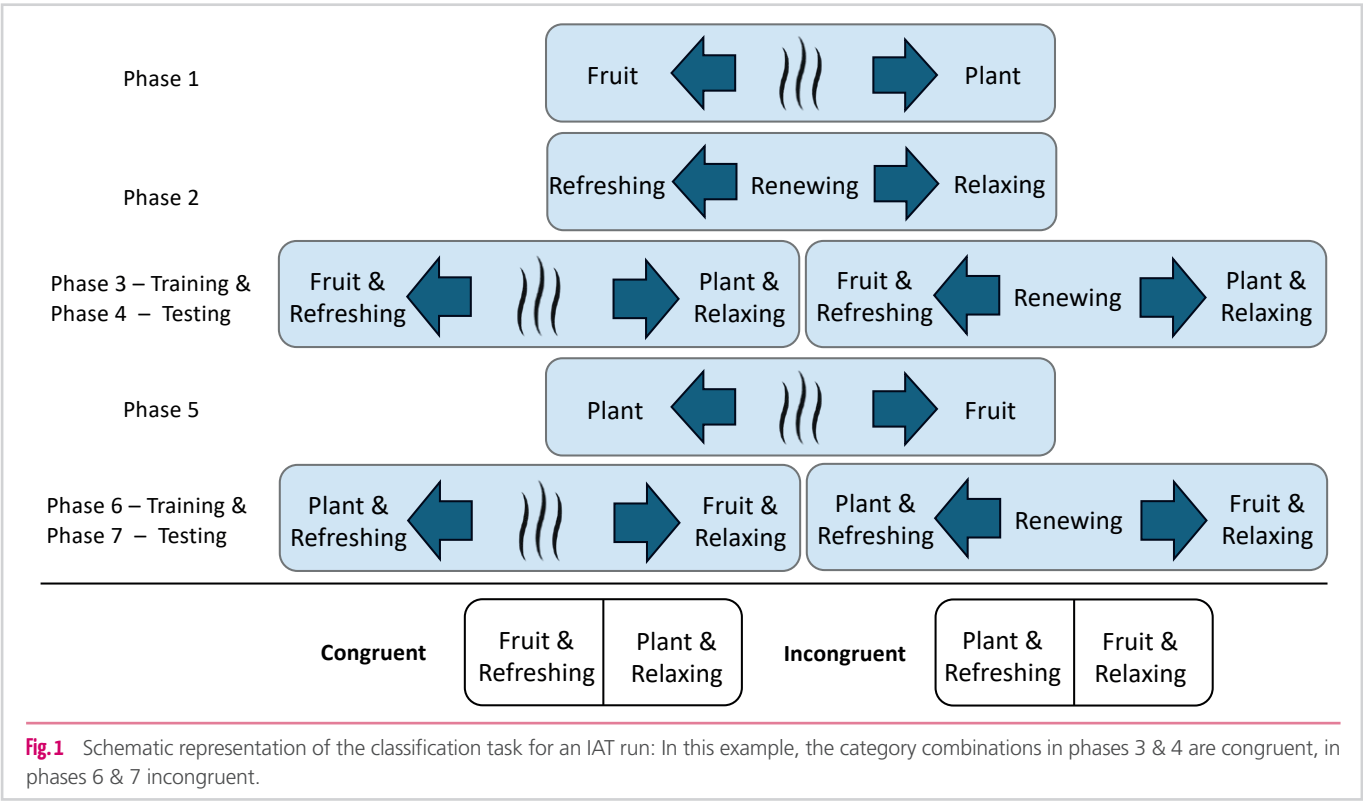

Fig. 1 Schematic representation of the classification task for an IAT run: In this example, the category combinations in phases 3 & 4 are congruent, in phases 6 & 7 incongruent.

the e button) or upper right corner (for the i button) of the screen (see **Figure 1**). Odors were to be assigned to the odor categories, words to the effect categories. If the assignment was incorrect, a red 'X' appeared and the participants could make another assignment. If the assignment was correct, the current stimulus disappeared and the countdown for the next one began.

- **Phase 1:** In phase 1, the participants assigned the odor stimuli of the various products to selected odor categories. For example, 'planty, non-fruity' odors were to be sorted to the left and 'fruity' odors to the right. For each odor category, 10 stimuli were presented randomly, i.e. each odor was presented 3 or 4 times.
- **Phase 2:** In phase 2, the participants assigned the word stimuli to their emotional impact categories. For example, 'relaxing' odor names were to be sorted to the left and 'refreshing' to the right. For each effect category, 10 stimuli were presented randomly, i.e. each word was presented once or twice.
- **Phase 3:** In phase 3, both odor stimuli of the products and word stimuli were presented randomly. Thus, the odor categories and effect categories with the same key assignment as in phases 1 and 2 were also available for selection. Phase 3 served as training; 5 stimuli were presented per category.
- **Phase 4:** Phase 4 was similar to phase 3, only 10 stimuli per category were presented. This was a test phase.
- **Phase 5:** Phase 5 was identical to phase 1, except that the odor categories switched sides. In this example, 'planty, non-fruity' odors were now positioned on the right and 'fruity' on the left.
- **Phases 6** and **7**: Phases 6 and 7 were identical to phases 3 and 4, but the key assignment was the same as in phases 5 and 2. Phase 7 was also a test phase.

The original directions of the assignments in phases 1 and 2 were pseudorandomized. Thus, half of the participants first assigned stimuli to congruent combinations of effect and odor categories and then to incongruent combinations, while the other half of the participants already had incongruent combinations in phases 3 and 4.

Congruent combinations in this study were when 'planty, non-fruity' and 'relaxing' stimuli were to be assigned to the same button, or 'fruity' and 'refreshing' stimuli. The combinations 'planty, non-fruity' and 'refreshing' as well as 'fruity' and 'relaxing' were labeled as incongruent in this study **(Figure 1)**.

Odor characteristics

After the IAT, all odors were presented to the participants once again and the participants rated them according to their pleasantness and intensity on a scale from 0 (very unpleasant; not perceptible) to 100 (very pleasant; very strong).

Questionnaire

The participants then completed a questionnaire which asked, among other things, whether smells make them sleepy or which ones they find exciting. The following attributes were available to choose from: cooking smell, flowery smell, fruity smell, earthy aroma, woody aroma and other. Only one choice was possible in each case.

Statistical analysis

To analyze the IAT, phases 4 and 7 were considered and classified into congruent and incongruent combinations, and analyzed separately for word and odor stimuli. Reaction times faster than 300 ms and slower than 10 s were excluded for all further analyses [*Greenwald et al*. 2022]. The reaction times per category (odor, word) were then standardized (i.e. the data has been transformed so that the mean is '0' and the standard deviation is '1') separately for each participant in order to compensate for individual differences in reaction time for words and odors. A directional dependent Wilcoxon rank sum test was used to test for significant differences in the standardized reaction times and error frequencies between the congruent and incongruent combinations. The hypotheses were that reaction times and error frequencies would be lower for congruent combinations. Alpha values were Holm-Bonferroni corrected.

We also investigated the respective effect associations of each product. To do this, we compared the standardized reaction times and error frequencies for the different products using pairwise Wilcoxon rank sum tests between congruent and incongruent combinations per odor stimuli. Here, we used undirected tests to better visualize differences between the products. Alpha values were Holm-Bonferroni corrected.

Furthermore, the IAT effect was calculated for each participant using the Wpr90 value, which uses the worst-performance rule and winsorizes at the 90th percentile [*Richetin et al*. 2015; *Ratcliff et al*. 2008]. The R package IATscores version 0.2.3 was used for this. A Wpr90 value of 0.14 was used as a limit for a slight automatic association of the categories within the congruent combinations. Based on the Wpr90 value, the participants were divided into two groups: those with a Wpr90 value greater than 0.14 and those with a Wpr90 value below 0.14. These two groups were qualitatively compared with each other based on the results of the questionnaires.

Results

Participants: In total, data from 52 participants were included. Of these, 21 were male (age: 26.6 +/- 5.2 years, Sniffin' Sticks: 13.4 +/- 1.1, MoCA: 28.6 +/- 1.5) and 30 were female (age: 25.8 +/- 3.7 years, Sniffin' Sticks: 13.5 +/- 1.4, MoCA: 28.4 +/- 1.6), one person did not provide any information (age: 23 years, Sniffin' Sticks: 13, MoCA: 30). The participants were international (the most represented countries of origin were: Germany (n = 15), China (n = 15) and Indonesia (n = 5)).

Odor characteristics: All odors were perceived as pleasant (all means are above 60), but the fruity odors were perceived as significantly more pleasant than the planty, non-fruity odors (p = .005). The odors were rated as clearly perceptible in intensity (all mean values are above 60). Overall, there were no significant differences between the fruity and planty, non-fruity odors (p = .399).

Reaction time: In the incongruent phases, participants took significantly longer than in the congruent phases to assign the word stimuli to the categories (p = .028). There were no significant differences for the assignment of the odor stimuli (p = .689; **Figure 2**).

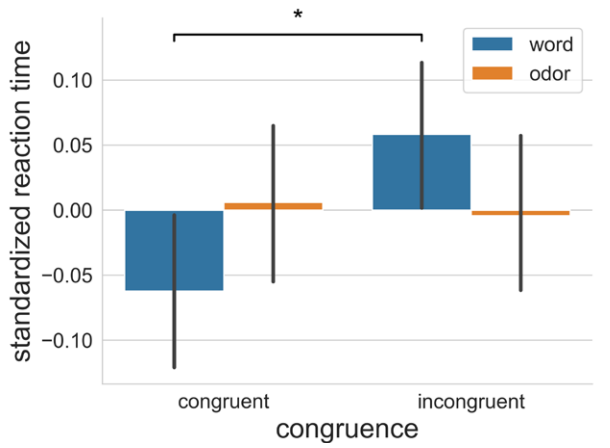

Fig. 2 Standardized reaction times for odor and word stimuli in congruent and incongruent test phases. Word stimuli were classified significantly faster when the category combinations were congruent. This confirms a stronger association of fruity odors with invigorating effects and planty, non-fruity odors with relaxing effects. * p < .05

Error frequency: In the incongruent phases, participants made significantly more errors than in the congruent phases in classifying the word stimuli (p = .015). There were no significant differences for the odor stimuli (p = .134; **Figure 3**).

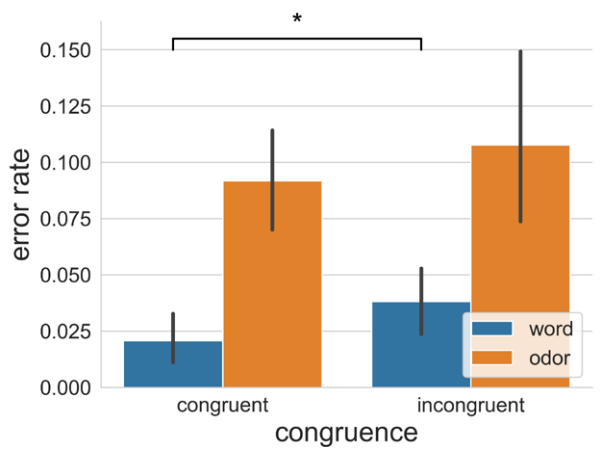

Fig. 3 Error frequencies for odor and word stimuli in congruent and incongruent test phases. For word stimuli, significantly fewer errors were made when the category combinations were congruent. This confirms a stronger association of fruity odors with an refreshing effect and planty, non-fruity odors with a relaxing effect. * p < .05

Product-specific differences: The odor of product 5 was the only odor to show a significantly longer reaction time with congruent phases than with incongruent phases (p = .018; **Figure 4**) and thus an opposite effect than expected (stronger association with 'relaxing'). In contrast, the odor of product 1 was the only odor to show a strong trend towards a difference in

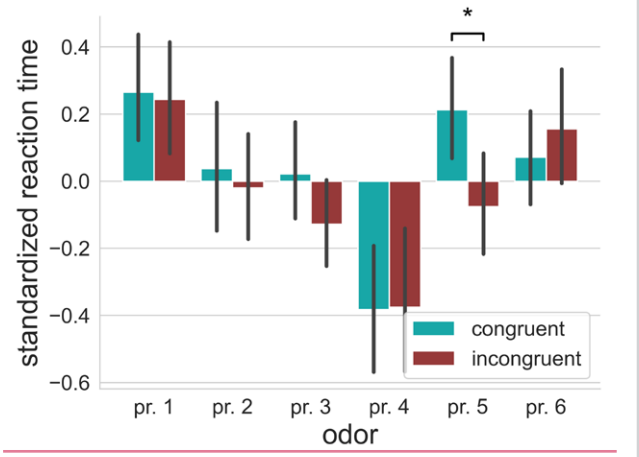

Fig. 4 Standardized reaction times per product odor and split into congruent and incongruent phases. The odor of product 5 was classified significantly faster if the category combinations were incongruent. This is contrary to the expected association. * p < .05

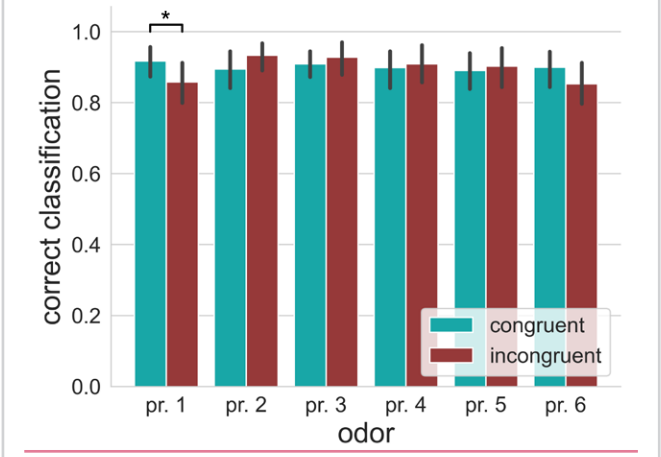

Fig. 5 Correct assignments per product odor and split by congruent and incongruent phases. There was a strong trend that the odor of product 1 was correctly assigned more often if the category combinations were congruent. This corresponds to the expected association. * p < .06

error frequency between congruent and incongruent phases (p = .054; **Figure 5**). This corresponds to the expected effect, i.e. that the odor of this product in particular is associated with relaxing adjectives.

Individual differences: 32 participants (male: 10, female: 22, age: 26.6 +/- 5.0 years) had a Wpr90 value greater than 0.14, which speaks for an existing IAT effect, i.e. these participants had associations between the odor categories and the effect categories in accordance with the hypothesized congruences. For 5 participants (male: 4, female: 1, age: 27.6 +/- 3.8 years), the Wpr90 value was between -0.14 and 0.14, meaning that no association was detectable in our study. 15 participants (male: 7, female: 7, not specified: 1, age: 24.6 +/- 1.5 years) had a Wpr90 value less than -0.14, which suggests an effect in the opposite direction.

The groups with and without the expected IAT effect differed significantly in their answers from the questionnaire as to which odors made them sleepy or which they found exciting. While only 3% of the group with the expected IAT effect stated that a fruity smell made them sleepy, 53% stated that a woody smell made them sleepy, the figures for the group without or with the opposite IAT effect were 16% and 26% respectively. On the other hand, the fruity smell was described as exciting by 41% of the participants in the group with the expected IAT effect; in contrast to 32% in the other group (see **Figure 6**).

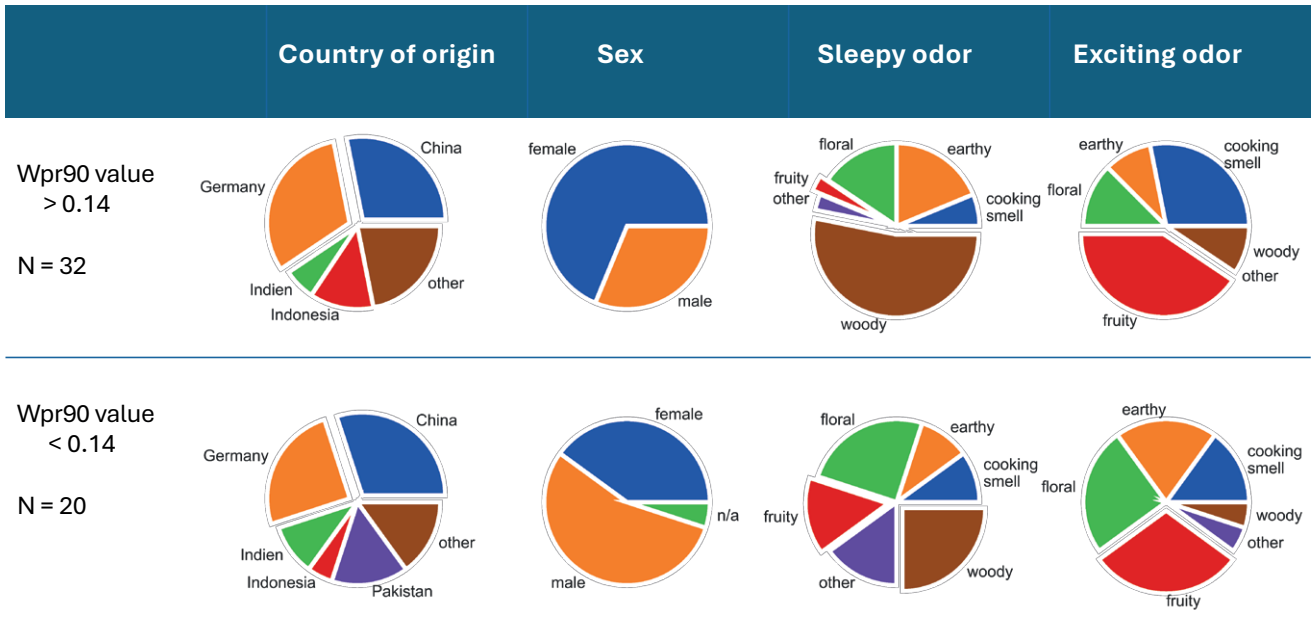

Fig. 6 Differences between the groups of people with expected (Wpr90 > 0.14) and without expected (Wpr90 < 0.14) IAT effect.

Discussion

Implicit associations of odors with emotional categories

In this study, we examined six different cosmetic products (bath/shower products) that claim to have an effect on perceived emotions and moods. It was found that the participants needed significantly less time to assign emotional adjectives to the effect categories when the category 'fruity' was combined with 'refreshing' and 'planty, not fruity' with 'relaxing'. In addition, the error frequencies were lower for these combinations. We were thus able to show cognitive associations with the respective word categories On the other hand, we were unable to find these correlations when we analyzed the reaction times and error frequencies of the runs with odor stimuli.

A potential problem in measuring odor perception with the IAT is determining the accuracy of the true onset time, i.e. the time at which a subject first perceives the odor. On the one hand, the odor stimulus must be applied with precise timing. We used an olfactometer and were thus able to ensure this [*Lundström et al*. 2010]. On the other hand, the subject must inhale at the time of odor presentation. Although we had created a countdown for this, the exact time point of inhalation and the depth of inhalation could have varied and thus led to a delayed odor perception. Since the variability of the times at which the odor was perceived can be high between, but also within participants, there is a risk that these fluctuations are greater than the actual IAT effect. This could be one reason why the associations could not be demonstrated for the odor stimuli, but for the word stimuli. However, the fact that the effects were found for the word stimuli suggests that the associations can therefore be measured via the assignment of the words. This makes it possible to also recognize odor associations using this method.

Using the IAT to measure product odors makes it possible to investigate whether the mere smell of a product evokes stronger associations with one particular emotional state than with another. Despite various disadvantages of the IAT, such as the possibility of consciously influencing reactions and thus results, the IAT is a valuable tool for understanding consumers [*Brunel et al*. 2004; *Gregg and Klymowsky* 2013]. The variant presented here offers the possibility of identifying subtle emotional connections evoked by the odor, which could lead to an even more intense effect on the consumer.

Differences between product odors and their effect associations

To investigate this in more detail for the products individually, we analyzed the runs with odor stimuli per product. The error rate was significantly lower for product 1, which had the odor-active ingredients sandalwood and patchouli, when 'planty, not fruity' was combined with 'relaxing'. The odor of this product is therefore more strongly associated with relaxing effects than refreshing effects. Sandalwood [*Sheen* 2001] and patchouli as part of an essential oil [*Siahaan et al. 2014*] were also identified as relaxing or calming in studies that directly investigated the effect.

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Interestingly, the odor of product 5, with grapefruit, passion fruit and orange, did not show the expected but the opposite effect when analyzing the reaction times: the odor was classified significantly faster when 'fruity' was combined with 'relaxing'. This correlation requires further investigation, ideally combined with actual effects.

However, the influencing of emotions by product odors is not necessarily due to implicit associations with the odor. Odors could also subconsciously influence emotions in a direct way, for example through certain ingredients [*Herz* 2009]. It is also possible that other factors such as personal condition or additional sensory impressions play a role. Even without a direct, subconscious association between the odor and a certain emotion, a mood-influencing effect can occur. Our study therefore in no way disproves the claimed effects. Rather, it supplements subconsciously associated mental or emotional states to the product odors.

Individual differences in odor associations

Our study also shows that emotional associations with odors are individual. While the majority of participants showed an expected IAT effect, there were also participants with no effect or even the opposite effect. These different results are reflected in the explicit questions about which odors are perceived as soporific and which are perceived as exciting. In the group of participants who did not experience the expected effect, significantly more participants stated that fruity and floral scents make them sleepy. The

majority of participants who perceived an effect reported woody and earthy scents. These scents, in turn, were mentioned more frequently by participants in the group without an expected IAT effect when exciting scents were to be selected. This group also had a larger proportion of men. The group composition was international and not separated by country of origin. Cultural influences therefore appeared to be less important than individual factors.

While we were able to show that, in general, fruity odors were more strongly associated with an refreshing effect and planty, non-fruity odors with a relaxing effect, this did not apply to all products to the same extent and not to all people. With regard to product development, the target group should therefore always be considered in order to create congruent associations between product odor and intended psychological effect.

Influence of the selected stimuli

It is also important to note that the measured associations are always to be interpreted relatively between the tested categories. A stronger association with a particular category does not mean that there are no stronger associations with other, untested categories. Thus, an essential factor in the creation of the study design is the determination of the categories that are tested against each other. However, these need not only be emotional effect categories. The IAT, as modified here, can also be applied to marketing strategies, for example to test the fit of specific themes, advertising messages or brand values to a product odor. This allows formulation, packaging design and marketing strategies to be adapted during product development. Thereby companies can adjust their advertising campaigns more precisely and elicit more specific emotional responses from their target groups, which can lead to stronger brand loyalty and greater effectiveness of marketing measures.

Conclusion

The cosmetics industry is increasingly making claims about the emotional effects of products. The specific product odor is often responsible for these effects. In fact, different odors can trigger psychophysiological effects. Using the IAT, implicit cognitive associations between categories can be demonstrated. In this study, we were able to show that associations existed between the effect categories ‘refreshing’, ‘relaxing’ and the odor categories ‘fruity’ and ‘planty, non-fruity’. We were also able to show that there are differences in various product odors within an odor category. In addition, despite the overall trend across the entire sample, there were individual differences among the test subjects that corresponded with explicit associations. Implicit associations of a product odor with the claimed and actual effect could lead to better consumer acceptance and should therefore be investigated more closely in product development, but also in scientific research.

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