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Personal Hygiene during Covid-19:  
The influence of odor on visual perception related to hygiene

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## **Abstract**

The current study aimed to investigate the effect of odor on visual perception. Specifically, whether exposure to the scent of deodorant and image context congruency affects visual perception of hygiene. To test this, a visual task was designed. Two groups of participants (experimental vs. control) had to rate perceived cleanliness and dirtiness of two categories of images: shirts (congruent) and dishes (incongruent). Based on prior evidence, it was expected that participants from the experimental group would show higher cleanliness ratings and lower dirtiness ratings of the congruent images after exposure to deodorant, compared to the control group. Contrary to our expectations, the results showed no significant effect of odor nor an interaction effect between odor and image context congruency. The corona pandemic added another angle to this study. The second aim of the study was to collect and compare information about personal hygiene routines before and during the lockdown.

## **Introduction**

Smells are everywhere around us and they play an important role in the way we connect and interact with our environment. Smells are associated with our emotions, memory and environment; they can remind us of a person we love, affect our appetite, or warn us for dangerous situations. And yet, the sense of smell often receives little attention and recognition, especially when compared to visual and auditory perception. For a long time it was believed that other species like dogs and rodents are far superior to humans when it comes to smell abilities. Important new insights into olfaction however, ended the myth that humans have a poor sense of smell and have aroused interest in the topic of olfaction. Although scientists have gained greater understanding of smell over the past few years, it is useful to extend this knowledge. How do smells interact with other senses and influence our behavior, for example? With the current study we aim to explore the influence of odor on visual perception. Specifically, we want to investigate how an olfactory cue can affect perception of semantically congruent visual stimuli related to hygiene. Due to the corona pandemic we conducted remote, online research, which gave the study more applied characteristics. Although the pandemic and remote research created challenges, it also offered us an opportunity to study the unique characteristics of the COVID-19 pandemic and its consequences on personal care and hygiene behavior.

This introduction will highlight several discoveries in olfactory research. Then, the function of odor will be addressed. We emphasize the importance of olfaction in everyday life and the impact of smell on our behavior. Next, the influence of odor on visual perception will be discussed. Lastly, we will provide a brief summary of the aims and methods of the experimental study that was conducted as part of the thesis.

The importance of our ability to smell in everyday life is still widely underestimated. A survey among 7000 youngsters by McCann Worldgroup (2011) revealed that 53% of them would rather give up their sense of smell than lose access to technology. Part of the reason why the sense of smell is considered unimportant might be that humans are still considered as poor smellers compared to animals. The belief that animal olfactory abilities are superior to humans derives from Broca, a 19<sup>th</sup>-century neuroanatomist who classified humans as “non-smellers”. He observed that humans have a relatively small olfactory bulb compared to other mammals and lack olfactory driven behavior (McGann, 2017). However, the idea that humans have a poor sense of smell is an outdated belief. In fact, recent studies have shown that humans have a highly sensitive olfactory system (McGann, 2017; Shepherd, 2004). Humans are able to track a scent through a field like dogs (Porter et al., 2007) and are better at detecting certain odors than mice and dogs (Can Güven & Laska, 2012). Furthermore, research has shown that olfactory sensitivity in humans, mice and spider monkeys vary with different odorants for each species (Sarafchi et al., 2013). These findings demonstrate that human olfaction is far better than we used to believe.

Olfaction plays an important role in how we interact with our environment. Three major functions of olfaction relate to safe food intake, avoidance of danger and hazards and social communication (Stevenson, 2009). The sense of smell helps humans to regulate food intake and identify edible foods (Stevenson, 2009; Zald & Pardo, 1997). Furthermore, odors serve as cues to avoid potential threats like fire or disease sources, which elicit emotions of fear or disgust (Stevenson, 2009). Moreover, olfaction seems to play an important role in social communication. Research has shown that body odors can contain social information about emotions (de Groot, Smeets, Kaldewaij, Duijndam & Semin, 2012; Pause, 2012), health and fitness of potential partners (Olsson et al., 2014) and personality traits (Sorokowska, 2013), which can be picked up by others. In a study by Porter (1999), it was demonstrated that unrelated individuals

were able to recognize family members by their smell. Another study showed that humans often sniff their own hands, and tend to increase this behavior after a handshake with another individual (Frumin et al., 2015). These findings suggest that body odors might serve as an unconscious form of communication through chemical signals.

Thus, our perception of olfactory signals influences the way we feel and behave. Research has shown that odor perception is modified by prior experiences (Pashkovski et al., 2020). When exposed to a novel scent, our brain forms associations between the scent and the contextual environment (De Araujo, Rolls, Velazco, Margot, & Cayeux, 2005). Hence, smelling a familiar scent can evoke memories, moods or behavior previously associated with that odor (Johnson, 2011; Wilson & Stevenson, 2003). For example, a study by Holland, Hendriks and Aarts (2005) found that exposure to a cleaning scent influenced behavior by activating related semantic associations. Participants were more likely to engage in cleaning behavior in the presence of the cleaning scent, even though they were not aware it. This has interesting implications for applied settings in which odors can be used to trigger changes in behavior or moods.

The previous finding demonstrates that information about hygiene can be communicated through scent and that fragrances can be used to influence behavior, so that the perception of something that is not hygienic, is removed or reduced. Certain odors like lemon are often associated with cleanliness. A strong, bad smelling body odor, on the other hand, can be associated with a lack of hygiene. For this reason, many people wear deodorant or use other scented products to prevent a bad body odor. But does this mean that objects or persons that smell clean, also look clean? What is the influence of a ‘clean’ fragrance on visual perception of hygiene? By addressing this question we want to gain a better understanding of cross-modal interactions between olfactory cues and vision.

In everyday life, we are constantly exposed to sensory inputs from multiple sensory modalities. Previous has shown that olfactory and visual information interact and the information we receive through our senses is integrated to form a unified perception of our environment (Schreuder, van Erp, Toet, & Kallen, 2016; Verhagen and Engelen, 2006). Although cross-modal interactions between vision and olfaction have been investigated over the past few years, most studies focused on the effects of visual stimuli on olfactory perception (Jadauji, Djordjevic, Lundström, & Pack, 2012; Demattè, Sanabria, & Spence, 2009; Gottfried & Dolan, 2003) and less on the reverse. The effect of olfactory information on visual perception has received more attention only recently. Studies have shown that unpleasant scents reduce perceived face attractiveness (Demattè et al., 2007) and that scents related to fear can modulate visual emotion perception (Zhou and Chen, 2009). It was also demonstrated that pleasant odors can enable the processing of positive visual stimuli (Leppänen & Hietanen, 2003). Furthermore, research has shown that congruent odors can enhance visual perception and direct attention towards visual stimuli (Seigneuric et al., 2010; Seo, Roidl, Müller, & Negoias, 2010; Zhou et al. 2010). Visual and olfactory stimuli are congruent when semantic associations of the scent are similar to the associations of the visual stimulus. A study by Breckenridge and colleagues (2016) showed that exposure to malodor increased perceived dirtiness of congruent images of toilets. Hence, the scent of deodorant may activate associations such as personal hygiene and clean clothes, and therefore influence the hygiene perception of shirts by focusing mostly on clean aspects of the visual stimulus.

In order to give a more applied character to the current study, we investigated the extent to which product fragrance plays a role in products that are used by consumers to enhance hygiene. At Unilever there is interest in the role of odor on visual perception in relation to the topic of hygiene. Since they own several branded personal care products, like deodorant, it is useful to know in which way odors can influence the perception of hygiene. Deodorants and

antiperspirants can reduce or prevent the malodor of sweat. It cannot, however, mask the visibility of underarm perspiration stains in clothing, which can be perceived as dirty. A recent study by De Groot and colleagues (2020) found that white t-shirts with stains on it were perceived as cleaner when the scent of detergent was present compared to when the same t-shirts were presented without the scent. Therefore, the first and main aim of the study proposed here is to test whether we will find similar results to the study by de Groot and colleagues in relation to fragrances related to personal care products such as deodorant. We explored whether associations of freshness and cleanliness induced by deodorant scent would affect hygiene perception of stained shirts.

The current corona pandemic provides another angle to this study. A nationwide lockdown was announced in March in which people worked and studied from home and had little or no social contacts. During this pandemic, hygiene regimes became even more important. However, a survey among more than 1500 Dutch people revealed that many people working from home stay in their pyjamas, brush their teeth less often and skip more showers (Panel Inzicht, 2020). They feel that it is less of a problem to skip the shower when no one sees or smells you. Unilever reported a decrease in sales of personal care products because of a drop in demand due to the lockdown of many countries (Porterfield, 2020). This shows the importance of (body) odors and grooming in the perception of hygiene. The second aim of the study is therefore to collect information from participants on their personal hygiene rituals and product use before and during the national lockdown from March until June, to investigate whether people were adhering to or dropping these rituals. In addition to that, this information will be used to further investigate the relationship between hygiene perception and hygiene routines in case we find significant effects in our main analyses. After all, adherence vs. dropping hygiene rituals reflects on the broader mindset of the individual in relation to hygiene which may play a role in visual perception.

The current experiment was conducted to investigate whether exposure to the scent of deodorant and image context congruency affects visual perception of hygiene. Based on previous literature (de Groot et al., 2020; Breckenridge et al., 2016), it was expected that exposure to the scent of deodorant affects perceived cleanliness of visual stimuli. Moreover, it is explored whether there is an interaction between odor and image context congruency. Does odor affect visual perception of images congruent with the scent of deodorant, but not incongruent images? A visual task was designed in which two groups of participants (experimental vs. control) had to rate perceived cleanliness and dirtiness of two categories of images. The first category of images was semantically congruent with the scent of deodorant (shirts), the second category consisted of incongruent images (plates) and served as a control category for which no effect of odor was expected. The experimental group was instructed to apply deodorant before the task so that they would be exposed to the scent of deodorant/antiperspirant, whereas the control group performed the task in absence of deodorant scent.

It was expected that (I) participants from the experimental group would show higher cleanliness ratings and lower dirtiness ratings of the shirt images after exposure to deodorant compared to the control group. Secondly, we expected (II) no significant differences in perceived cleanliness and dirtiness of images of soiled dishes between the experimental and control group, because the context of these images is thought to be incongruent with the scent.



## Method

### Participants

The sample size was computed with G\*Power (Faul, Erdfelder, Lang & Buchner, 2007)  $N = 64$  for a mixed analysis of variance (ANOVA) with two groups and two measurements. A power of 90%,  $\alpha = .05$  and  $\eta_p^2 = .1$  which was the smallest effect size in prior related research (Breckenridge et al., 2016). Of the 108 participants that were recruited from Utrecht University and through social media, a total of 77 participants, 51 female and 25 male (aged 20-48 years  $M = 26.16$ ,  $SD = 5.00$ ) participated in the experiment. They were told that the purpose of the experiment was to investigate personal care routines and hygiene prior to and during the COVID-19 pandemic. Participants were randomly assigned to two conditions, an experimental group (odor) ( $n = 38$   $M = 26.18$ ,  $SD = 5.06$ ) and control group (non-odor) ( $n=38$   $M = 26.13$ ,  $SD = 5.01$ ).

### Design

Participants enrolled in a 2 x 2 design using olfactory condition (2 levels: deodorant, non-odor) as between-subject factor and context congruency (2 levels: shirts (congruent) vs plates (incongruent)) as within-subjects factor. Shirts refers to the experimentally relevant category of shirts, congruent with the scent of deodorant; plates to the control category for which no effect of odor condition is expected.

### Stimuli and measures

#### *Odor*

Since the study had to be conducted from home, it was necessary to use a fragranced personal care product that most people have at home. Deodorant or antiperspirant were used as olfactory stimuli by the experimental group. Participants from this group were instructed to

apply their own deodorant before the visual task as they normally would. The scent of deodorant is associated with personal hygiene and freshness. Since all participants used their own odorant it was assumed that they would judge the scent to be pleasant.

### *Visual stimuli*

A set of 50 images consisting of 25 images of white shirts with yellow armpit stains and 25 images of dirty dishes were used as visual stimuli for both groups. The images were retrieved from several websites and selected based on characteristics such as resolution, background and noticeable stains in order to prevent great differences between the images that could affect perception or make them incomparable. Some images were edited in Photoshop in order to make stains less or more visible. The stimuli were presented using the Gorilla experiment tool ([www.gorilla.sc](http://www.gorilla.sc)). The order of presentation was completely randomized among participants. All visual stimuli were pilot-tested within the research team prior to the main research to ascertain which images were suitable for inclusion in the task. The images can be seen in Appendix D.

### *Subjective measure*

Visual Analogue Scales (VAS) were used to rate perceived cleanliness or dirtiness. The two scales ranged from 0 to 100 (0 = “Not clean/dirty at all” and 100 = “Very clean/dirty”) and were placed under the presented visual stimuli in a counterbalanced fashion between participants to control for order effects.

### *Screening questions*

The following questions were used to determine whether people could participate and if they could be placed in the experimental group.

1. How often do you normally use deodorant or/and antiperspirant? \**Antiperspirant prevents/reduces sweating*  
*Never, Sometimes (a few times per month), Regularly (a few times per week), Often (almost) every day).*
2. Do you currently have deodorant or antiperspirant at hand that you could use?  
*Yes (deodorant), Yes (antiperspirant), Yes (both deodorant and antiperspirant), No.*

### *Questionnaires*

A general questionnaire was completed to collect demographic data such as age, gender and living and work situation. Furthermore, participants were asked about their personal care routines prior to and during the months in which the intelligent lockdown was active, to investigate to which extent the corona pandemic impact these routines, and to gain insight into whether adhering to or dropping these habits influence hygiene perception. The participants were also asked about the use of personal care products and their motives to use them (see Appendix A).

### **Procedure**

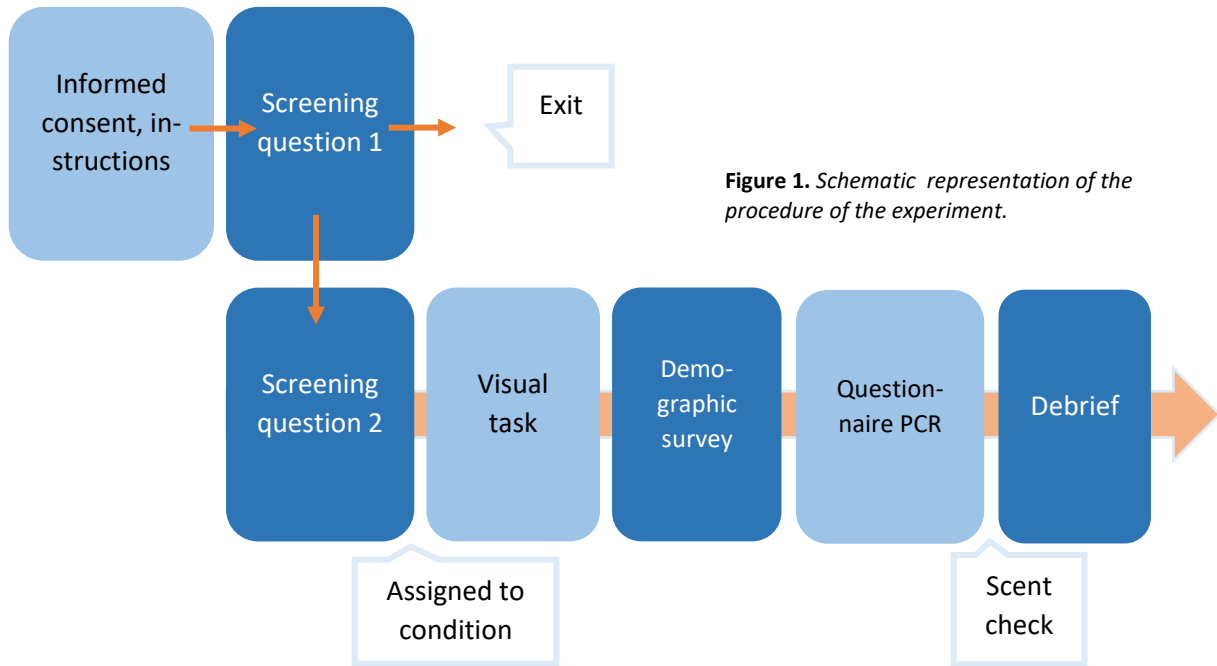
All participants first read and signed informed consent (Appendix B). After that, they filled out two screening questions. The first question “How often do you normally use deodorant or/and antiperspirant?”. was used to determine whether someone could participate in the main experiment. In case the answer was “No”, they were redirected to the demographic questionnaire followed by the personal care routine survey (Appendix C). If the participants responded with “yes”, they received the second screening question: “Do you currently have deodorant or antiperspirant at hand that you could use?” Participants who did have deodorant/AP at hand were randomly assigned to either the Odor condition (experimental group) or

Non-odor condition (control group). Participants who did not have deodorant/AP at hand were assigned to the Non-odor condition.

The experimental group was then asked to apply their own deodorant/AP and continued to read the instructions for the visual task (Appendix C). The control group did not apply deodorant/ap and received the instructions directly after the screening questions. During the visual task, the participants were asked to rate 25 images of white stained shirts and 25 soiled dishes (plates) on perceived cleanliness and dirtiness using Visual Analogue Scales (VAS) ranging from 0 to 100 (0 = “Not clean/dirty at all” and 100 = “Very clean/dirty”; e.g., “This shirt/plate is...”). The two scales were used to compare the ratings of perceived cleanliness and dirtiness and to assess whether the terms could be interchangeable. Participants were presented with either the cleanliness VAS first or the dirtiness VAS first in a counterbalanced fashion. The images were presented in a randomized order among the participants and they had the time to evaluate and rate the image as long as they needed.

Next, they continued to fill out demographic questions and a questionnaire on personal care routines and the use of personal care products, before and during the corona crisis. At the end of the task, the experimental group was asked to what extent they were aware of the scent during the visual task. They also rated the pleasantness of the scent on a 5 point Likert scale (See Appendix C).

Finally, after finishing the survey, the participants were debriefed about the objectives of the study and received an explanation of the hypotheses that were tested. The study took approximately 10 to 15 minutes. Figure 1 shows a schematic representation of the procedure of the experiment. The study was registered and conducted conforming the ethical standards of the Ethics Review board of the Faculty of Social and Behavioral Sciences of Utrecht University (FERB).



**Figure 1.** Schematic representation of the procedure of the experiment.

## Statistical analysis

To analyse the hygiene perception data, a mixed ANOVA was conducted, using Olfactory Condition (2 levels: deodorant, non-odor) as the between-subjects factor and Context Congruency (2 levels: shirts vs plates) as the within-subjects factor. The VAS scores for cleanliness and dirtiness served as the dependent variable. Statistical analyses were performed with IBM SPSS.

It was tested whether there is a main effect of olfactory condition and a interaction effect between olfactory condition and context congruency. It was expected that due to exposure to deodorant, the experimental group perceives images of stained shirts as cleaner and less dirty compared to the control group and no differences in perceived cleanliness and dirtiness of soiled plates were expected between the experimental and control group.

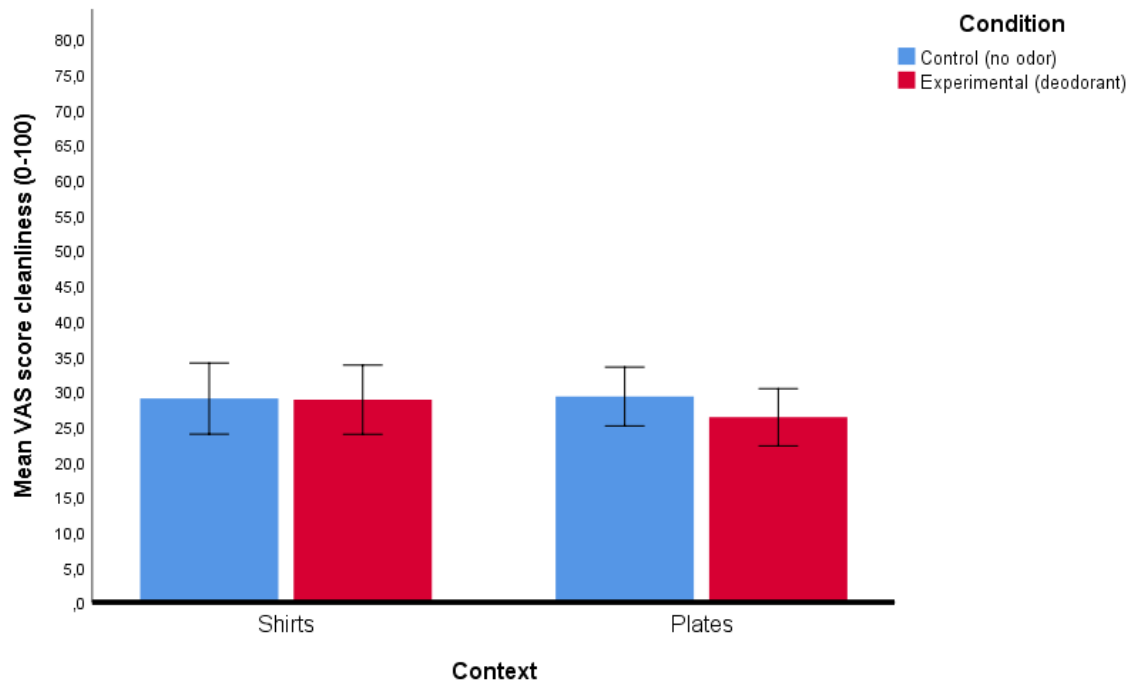
## Results

### *Data preparation*

Eight participants reported a reduced sense of smell, their data was excluded. The results of the questionnaire about hygiene routines are included in appendix A, but these are not part of the analyses related to the main goal of the thesis, as no significant effects were found.

### *Perceived cleanliness ratings*

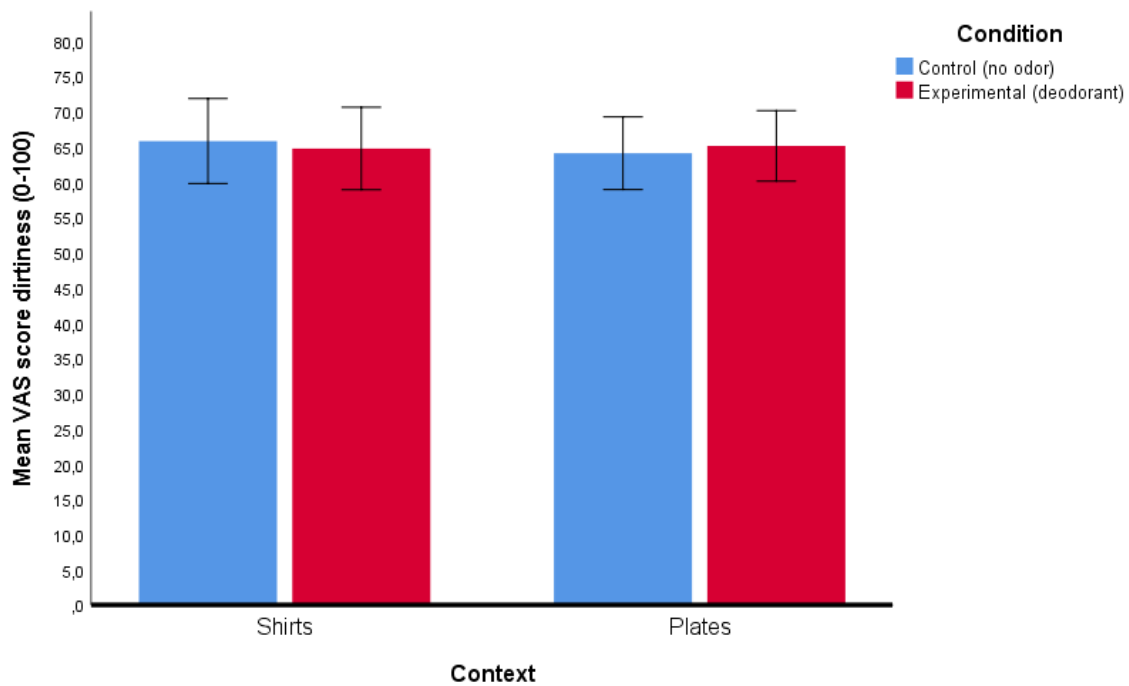
To test whether there were differences in cleanliness ratings between the experimental and control group, a repeated measures ANOVA was conducted with between-subjects factor Olfactory condition (deodorant, non-odor) and within-subjects factor context congruency (shirts, plates). The results showed that there was no main effect for Olfactory Condition:  $F(1,66) = .30, p = .59$ , nor for Context Congruency:  $F(1,66) = .53, p = .47$ . No Olfactory Condition x Context Congruency interaction was found:  $F(1, 66) = .853, p = .36$ .



**Figure 2.** Average (+SD) rating of cleanliness on a 0-100 VAS scale.

### *Dirtness ratings.*

A repeated measures ANOVA was conducted to test whether there were differences in dirtiness ratings between conditions (deodorant, non-odor) and within-subjects factor Context Congruency (shirts, plates). The results showed that there was no main effect for Olfactory Condition:  $F(1,66) = .21, p = .65$ , nor for Context Congruency:  $F(1,66) = .52, p = .48$ . No Olfactory Condition x Context Congruency interaction was found,  $F(1, 66) = .00, p = .99$ .



**Figure 3.** Average (+SD) ratings of dirtiness on a 0-100 VAS scale.

**Table 1:** Means and standard deviations of VAS scores.

	<i>N</i>	Cleanliness shirts	Cleanliness plates	Dirtness shirts	Dirtness plates
Experimental	35	28.6 (12.1)	26.3 (10.0)	64.7 (16.2)	65.1 (13.6)
Control	33	28.9 (16.7)	29.2 (13.8)	65.8 (18.5)	64.1 (16.0)
Total	68	28.8 (14.4)	27.7 (12.0)	65.3 (17.2)	64.6 (14.7)

We measured both cleanliness and dirtiness ratings to investigate whether these measures could be used interchangeably. In this study, the results show that cleanliness ratings are virtually complementary to the dirtiness ratings and therefore seem to be interchangeable. The means and standard deviations of the VAS scores are displayed in table 1.

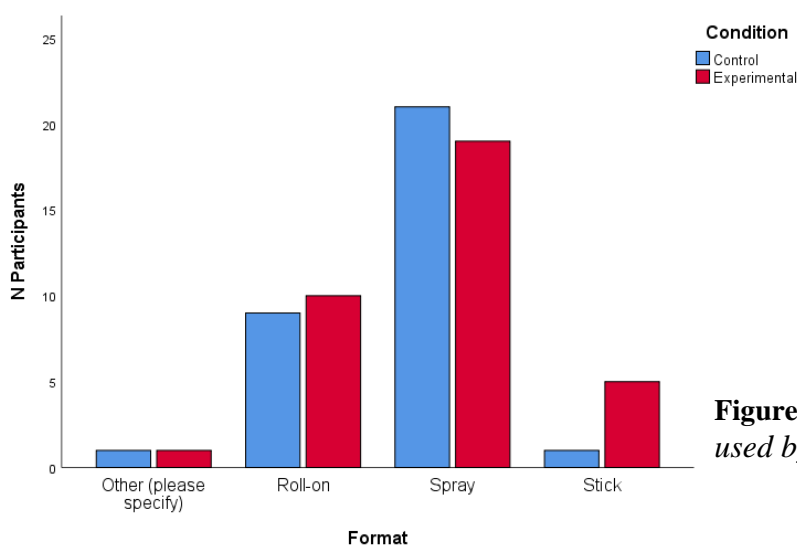
Furthermore, additional ANOVA analyses were performed to test whether there were differences in cleanliness and dirtiness ratings between male and female participants. No main effect of Gender was found for cleanliness nor dirtiness ratings:  $F(1,66) < 1.0$ .

### *Questionnaire results*

To analyze the questionnaire data, descriptive analysis were performed. Results related to the main analyses that may provide useful insights and explanations are presented in this section, other results are included in Appendix A.

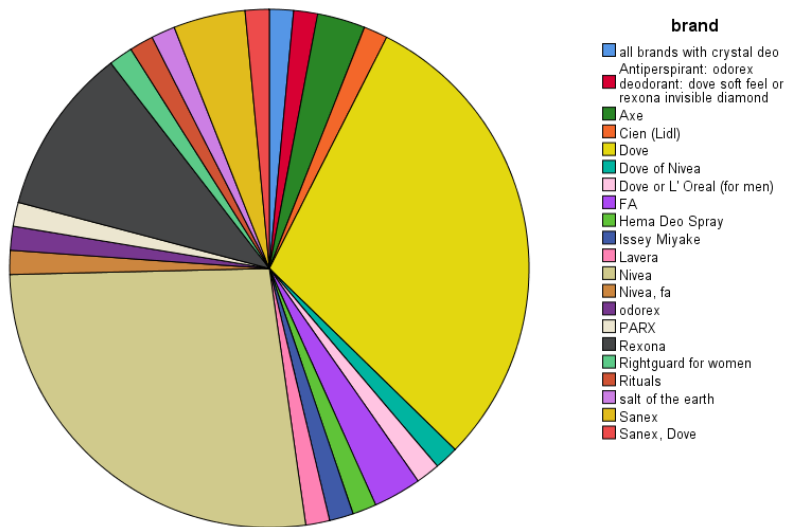
### **Type of deodorant**

Participants used different formats of deodorant (Fig.4). The spray format was used by most participants in the experimental and the control group. Furthermore, participants were asked to report which brand of deodorant they used. (Fig. 5).



**Figure 4.** *Formats of deodorant used by the participants.*

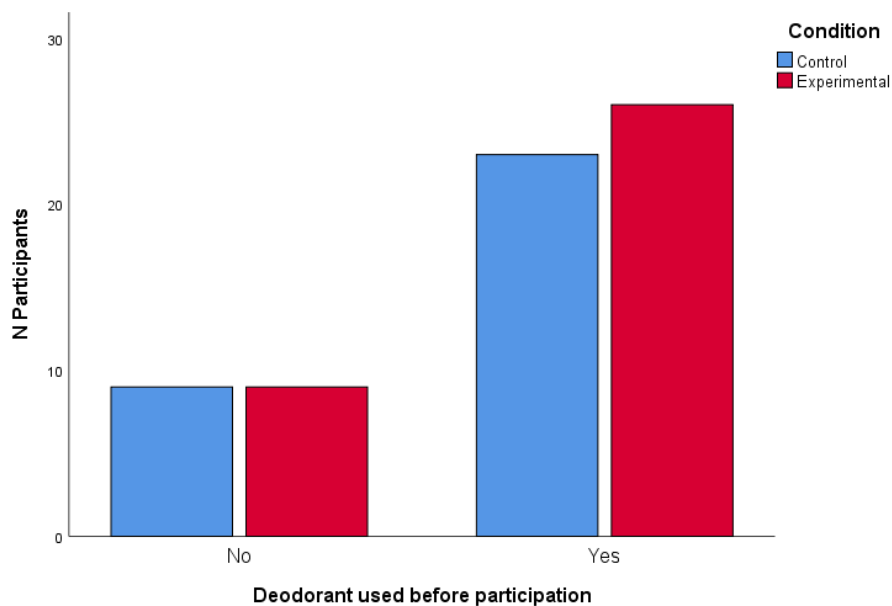




**Figure 5.** Brands of deodorant used by the participants.

### Deodorant use prior to the experiment

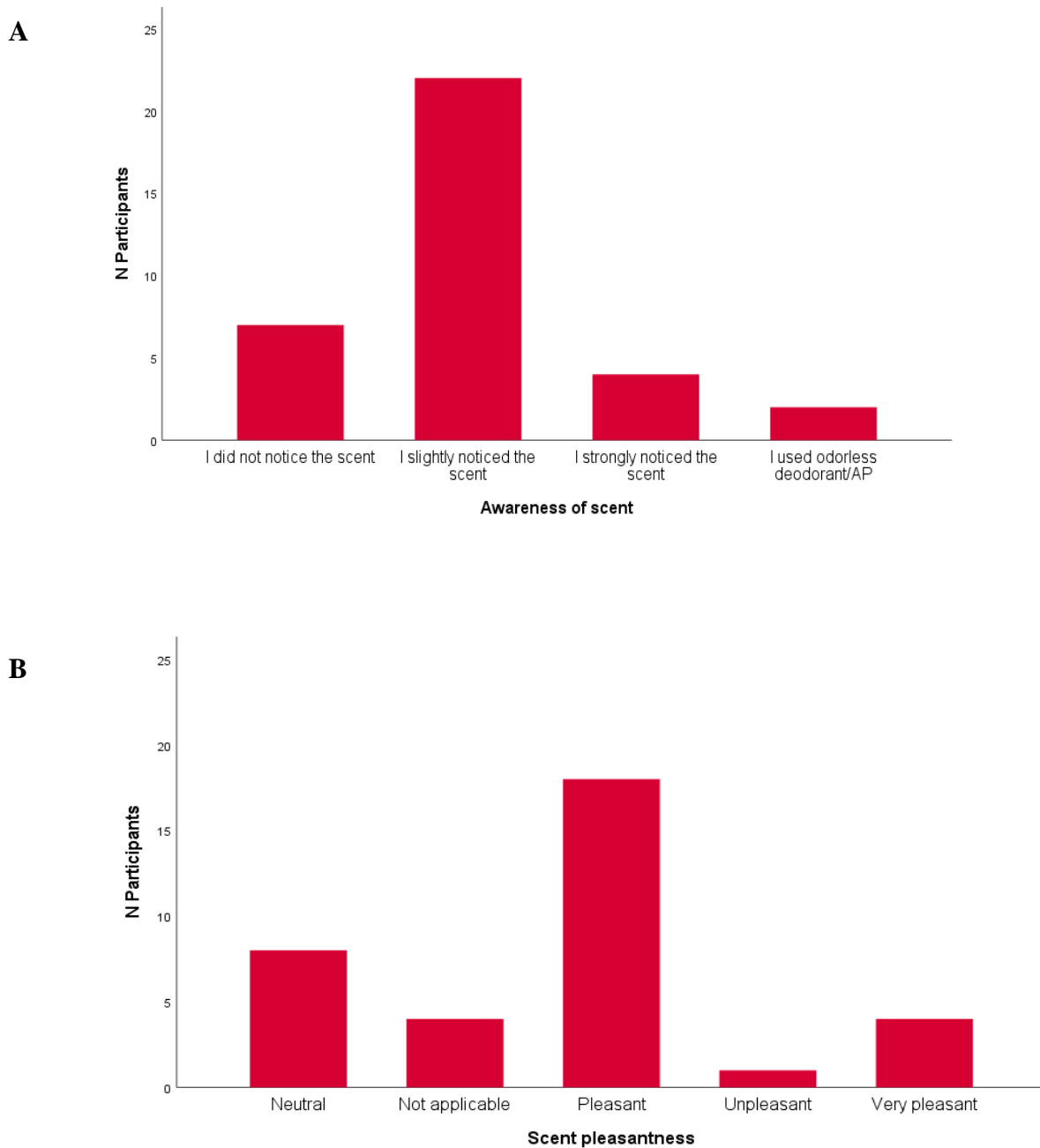
The amount of participants from both conditions that had used deodorant prior to their participation in the study is shown in figure 6. Most participants reported that they were already wearing deodorant.



**Figure 6.** Amount of participants that did or did not use deodorant prior to participating.

## Odor awareness and hedonics

Participants from the experimental group were asked whether they were aware of the scent during the visual task. Most participants slightly noticed the scent and a few participants reported that they had used odorless deodorant. Most participants that were aware of the scent perceived it as pleasant or neutral, some however perceived the scent as unpleasant.



**Figure 7.** Responses to questions whether participants were aware of the scent during the visual task (A) and whether they found the scent pleasant (B).

## Discussion

The main aim of this study was to investigate whether exposure to odor affects visual perception related to hygiene. More specifically, we examined the effect of deodorant scent on perceived cleanliness and dirtiness of congruent and incongruent visual stimuli. Based on prior research it was hypothesized that the scent of applied deodorant would cause the experimental group to perceive images of stained t-shirts (congruent) as cleaner compared to the control group (I) and that there would be no differences in cleanliness and dirtiness ratings of images of soiled plates (incongruent) between the experimental and the control group (II).

Contrary to our expectations the results did not support hypothesis I as the ratings of the experimental group did not differ from the control group for the congruent image category. The scent of deodorant did not seem to affect visual perception of hygiene. It cannot be concluded with certainty however if findings are due to the absence of an effect or limitations of the study such as external factors that were not controlled for. It is possible that results might have been different in a more controlled setting. It is known that effects measured in a lab setting are not always found in the “real world”. Another possible explanation for the findings is that the scent might have been not salient enough to influence perception. In addition to that, research has shown that unpleasant odors have a stronger modulating effect on visual perception than pleasant odors (Castle, Van Toller, & Milligan, 2000; Demattè, Österbauer, & Spence, 2007). Another factor that was considered to have influenced the results is the gender of the participants. Research has shown both differences in sensitivity and responses in perception of odor and hygiene between sexes (Kerr, Rosero, & Doty, 2005). Studies have shown that women perform better in specific olfactory threshold measurements than men (Brand and Millot 2001, Doty and Cameron 2009). After analysing the data however, we found that gender did not affect differences in scores.

The responses to the questionnaires provide some possible explanations. Although it was a small number, not all participants had used deodorant with a scent and therefore the effect of odor was not measured. Some participants were strongly aware of the scent whereas others did not notice it at all. We also found that many participants already applied deodorant that day, prior to the experiment. Since odor delivery was not controlled for, this may have affected the outcomes. Also, the perceived pleasantness of the scent differed among participants. If the scent was perceived as unpleasant, it might have caused the opposite of the desired effect. Furthermore, the format of deodorant might determine the intensity and saliency of the scent. A spray format might diffuse the scent more than a stick or roll-on deodorant.

Based on these results it cannot be concluded whether exposure to deodorant odor affects visual perception of hygiene.

### *Limitations*

The findings of this study should be considered in the light of some limitations. The first limitation concerns the study setting. The current approach was taken because of the corona pandemic which made it impossible to invite participants to a laboratory and control for external factors. Exposure to uncontrollable and unintended variables lowers the internal validity of the outcomes. One limitation of remote research is having limited control over the environment in which the research takes place. Disturbing factors such as noise, other smells, screen settings and resolution may influence the results. Participants used different types of deodorant and devices. Furthermore, it cannot be verified whether participants did actually apply deodorant or antiperspirant when they were asked to. At the beginning of the task participants were asked to apply deodorant and tick a box to confirm the appliance before continuing (Appendix C1). At the end of the experiment they were asked about the awareness and pleasantness of the scent, but there was no control question at the end to double-check whether the participants had indeed

applied the deodorant. Since the purpose of the study was not told beforehand, the importance of the appliance might have been underestimated by the participants and therefore they might have skipped this step. Another factor that has not been controlled for is the effect of applying deodorant. Ideally, we would want to distinguish between the influence of fragrance associated with hygiene such as deodorant, and the influence of the application – grooming. In a lab setting, this would have been possible if there was a condition in which deodorant is applied by the participants themselves or an experimental leader, and a condition in which deodorant is not applied at all, but the scent of their own deodorant is spread via an olfactometer.

Another limitation of the study is that absence of effects may lie on methodological issues. It is possible that there was a lack of sensitivity of the task, where the degree of staining of the presented images was not sufficient to pick up minor effects. The selected images were slightly adjusted and pilot-tested within the research team. However, it cannot be ruled out that the quality of the images might have been insufficient to measure effects.

Furthermore, participants were asked to report whether they had a reduced sense of smell. However, it was not tested whether all participants had normal olfactory function. This is especially relevant during this pandemic since studies have shown that the coronavirus can affect the sense of smell.

Lastly, participants may have been biased by knowing the purpose of the experiment which may have influenced their responses. We intended to reduce the effects of bias by defining a clear alternative purpose and to use a diverse and large enough sample. In addition to that, we wanted to ask participants whether they were aware of the real purpose and hypotheses of the study, but unfortunately the answers to this question were not recorded because the question was not properly included into the updated version of the experiment. This mistake was only discovered after completion of the data collection and therefore we had no data available about this.

### *Strengths*

The current approach made it possible to examine the effect of scent on behavior in a realistic, natural setting. A field setting provides a higher level of realism which enhances the external validity of the results, as opposed to controlled laboratory environments. Findings from controlled experiments cannot always be generalized to real life settings. Although the current study did not find a significant effect, it does provide insights that can be useful for future studies in this research area.

Furthermore, the unusual circumstances caused by the corona pandemic provided a unique opportunity to collect information about personal hygiene routines and hygiene perception. Despite the limitations and challenges it created, we managed to create a remote experiment and collect useful information.

Lastly, the current study has addressed a topic that has received little attention in research yet. Knowledge about the influence of odor on visual perception of hygiene can be useful, for example for companies that sell personal care products.

### *Suggestions for future research*

To further investigate how odor of personal care products influences visual perception, more research is needed. Future studies could focus on a more controlled context to explore the effects of deodorant scent on visual perception. For example by using pre-validated odors and using an olfactometer for odor delivery to ensure that all participants are exposed to the same type and intensity of odor. Furthermore, it could be useful to use eye-tracking to investigate whether the scent of deodorant affects visual attention and if people, for example, examine stains more actively.

The current study design focused on the possible effect of scent on hygiene perception but not on the appliance of the product. It might be the case that applying deodorant and the

feeling of wearing it could affect hygiene perception. It would be interesting to examine the effect of tactile sensations of applying personal care products on visual perception of hygiene. Furthermore, subsequent research should examine the effect of scent with different categories of personal care products since it can be relevant for all sorts of products and companies that sell them.

It would be interesting to investigate the crossmodal effects of incongruent odor and image combinations. The current study focused on the congruency of deodorant and visual hygiene of shirts. However, a study by Hörberg, Larsson, Ekström, Sandöy, Lundén and Olofsson (2020) demonstrated an “olfactory dominance” effect for incongruent pairings.

## **Conclusion**

In sum, it was hypothesized that participants would perceive shirts with stained armpits as cleaner and less dirty when exposed to the scent of deodorant compared to participants that were not exposed to that scent. The current findings did not show a difference between the experimental and control group. Furthermore, no differences in cleanliness and dirtiness ratings of incongruent images of plates were expected between the experimental and control group, which was confirmed by the results. There were some limitations to the current approach which was taken because of the corona pandemic. It cannot be concluded whether the results are due to the absence of an effect of fragrance or limitations of the study. Further research in a more controlled environment is needed to explore the effects of interactions between olfactory and visual perception and the semantic congruence effect of visual and olfactory cues. Nevertheless, the present study may provide useful knowledge about online research, the effects of olfactory cues in real life instead of a lab setting and personal hygiene routines in times of a pandemic.



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## Appendix A

In addition to the main aim of the study, we collected some information about the deodorant use and personal care routines of the participants. The following graphs show the responses.

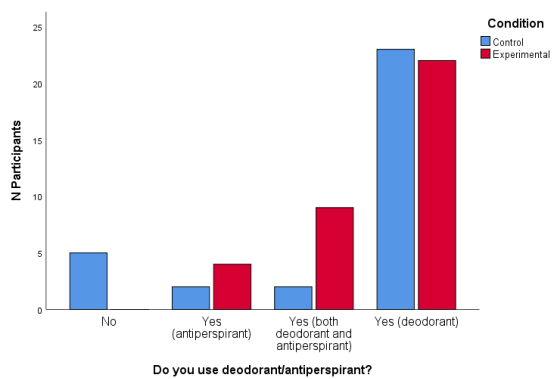


Figure A1. Responses to screening question 1

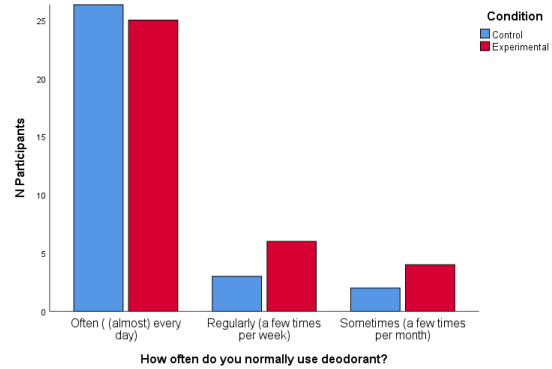
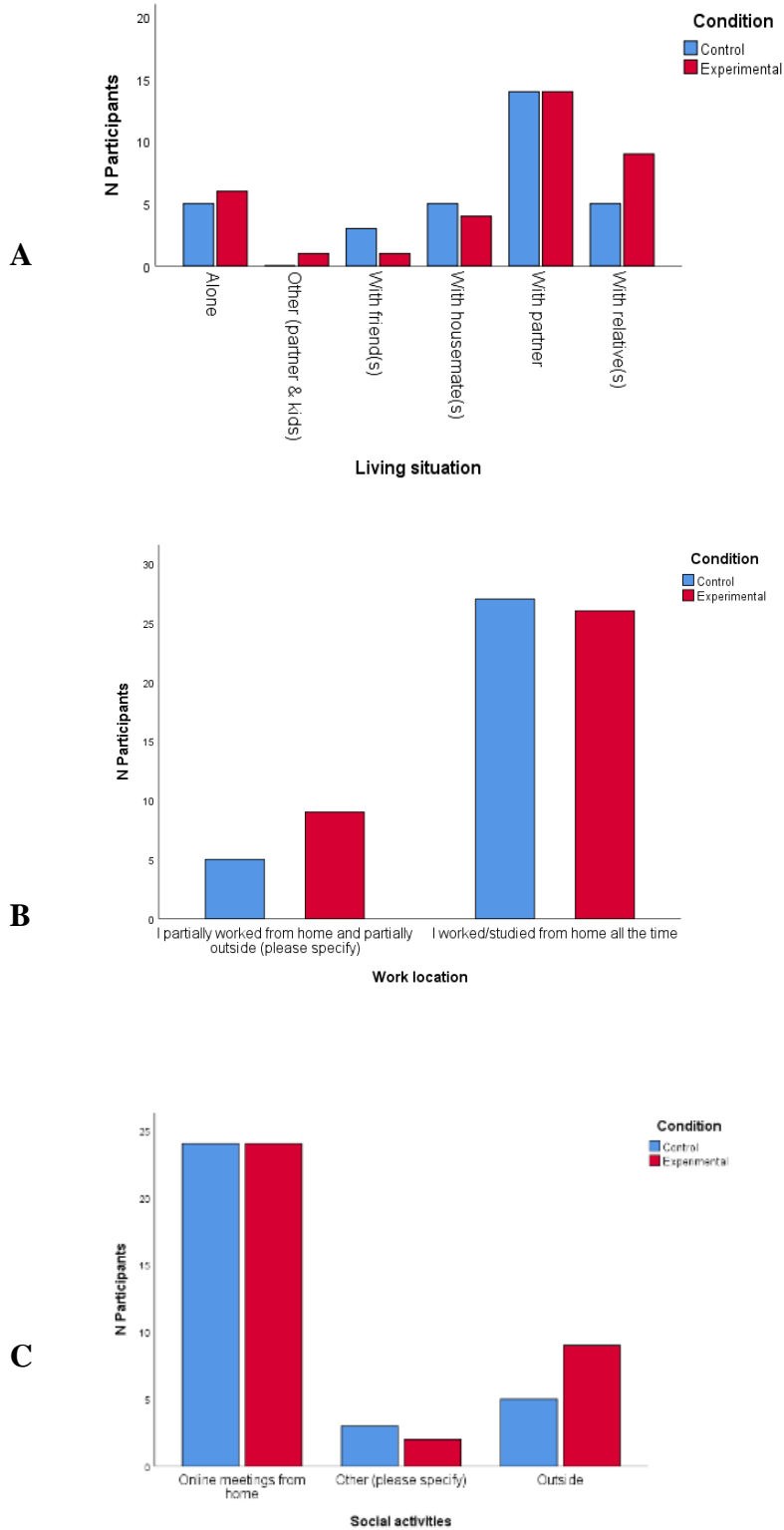


Figure A2. Responses to screening question 2

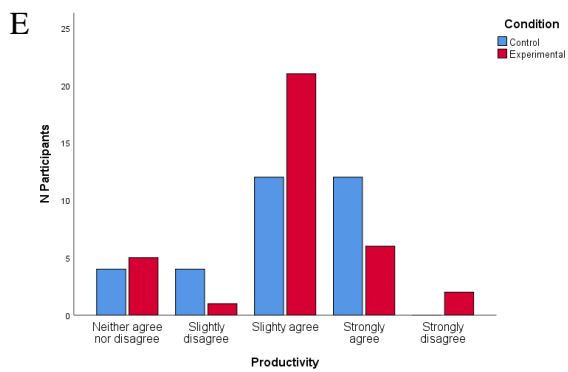
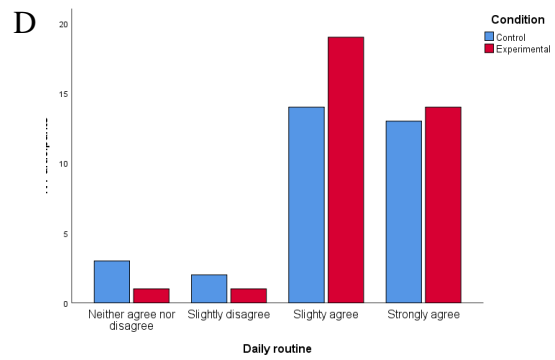
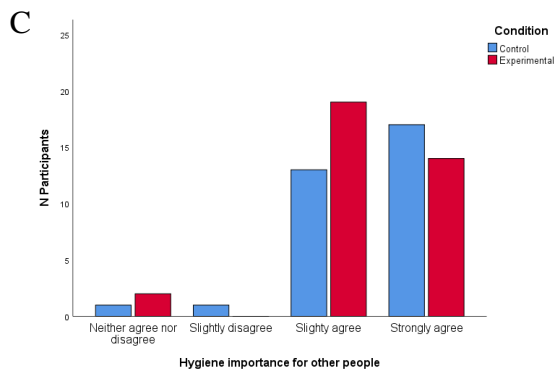
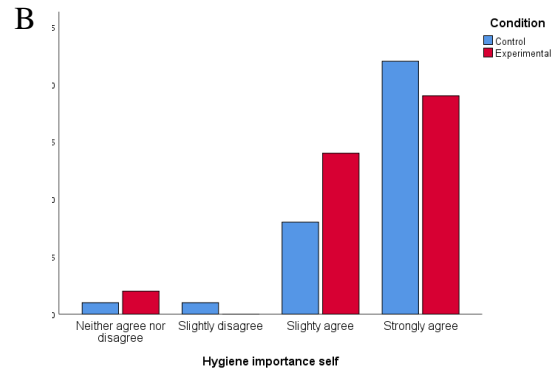
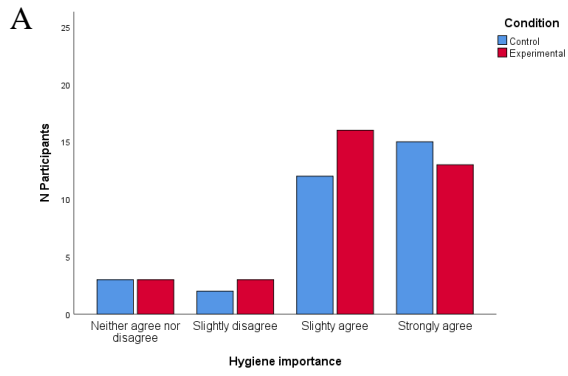


**Figure A3.** Responses to personal care routine questionnaire.

“Which of the following best describes your current living situation?” (A)

“Thinking of the period half March until June during the corona outbreak, where did your main activities such as work / studying take place?” (B)

“Thinking of the period half March until June during the corona outbreak, where did your social activities mostly take place?”(C)



**Figure A4.** Responses to personal care routine questionnaire.

“Hygiene routines are important to me.”(A)

“I use personal care products because I want to feel clean.” (B)

“I use personal care products to look and smell clean for others.”(C)

“I maintain a daily hygiene / personal care routine “(D)

“Hygiene impacts my productivity” (E)



## Appendix B

### *Informed consent & debriefing letters*

## Welcome!

Thank you for your interest in this study! Please read this information letter and consent form carefully before deciding to participate in this study.

- *NOTE: To ensure that everything runs smoothly, it is required to use a laptop/desktop or tablet for this study.*

## The study

The corona crisis has caused drastic changes in only a few weeks and this has impacted the daily life of people in many ways. Most activities now take place at home. This study intends to find out to what extent personal hygiene routines and hygiene perception are influenced by the corona pandemic.

The current study is part of a Master's thesis at Utrecht University. We ask you to evaluate images and answer some questions about your personal hygiene routines prior to and during the corona pandemic. It should take approximately 15 minutes to complete.

## Consent

The data that will be collected from you will only be used for this study's purpose. All data will be treated confidentially and answers can never be traced back to individual participants, as the research data will be stored separately from any personal information. Furthermore, no personal information will ever be shared with third parties and it will be deleted once the study is completed.

Participation in this study is entirely voluntary and you may withdraw from this study at any time, without any explanation and without any consequences. In case you end your participation, data that has been collected up to that point may be used for the study's purpose.

In case of any questions or complaints please contact the researchers or complaint officer:

- *Study conductor* : n.geldof@students.uu.nl (Nina Geldof)
- *Principal researcher* : m.a.m.smeets@uu.nl (Prof Monique Smeets, department of Social, Health & Organizational Psychology)
- *Complaint officer*: klachtenfunctionaris-fetcsocwet@uu.nl

### **Please check the box below to continue.**

I hereby declare that I am 18 years old or above, I have read and understood the information letter and give my consent to participate in this study.

# Thank you!

## ***Dear participant,***

You have just participated in a study of Utrecht University. The information letter we provided you before participating in this study did not cover the full purpose of this study, given that this might have affected the way you responded.

The purpose of this study is to investigate whether the presence of deodorant scent influences visual perception of hygiene, as measured by your responses to the questions (i.e. "How clean is this item").

Furthermore, we wanted to investigate whether there is a relationship between the degree to which people maintain their hygiene routines during a pandemic on one hand, and their perception of cleanliness of odor-related items (t-shirts), and odor-unrelated items (dishes) on the other hand.

Half of the participants were asked to apply deodorant before the visual task, the other half (the control group) were not. All participants were assigned the same questions and task and were exposed to the same pictures.

The study's hypothesis, based on earlier research, is that the presence of deodorant scent is causally related to a higher degree of cleanliness perception of context-congruent items (t-shirts), but not of context-incongruent items. It is also expected that a higher maintenance of hygiene routines strengthens the effect of odor on perception - but again only in a context congruent with the odor.

We kindly ask you to not share the purpose of this study with anyone else who might participate later. In case you have any questions after this study, feel free to contact the researcher. Thank you again for participating.

Study conductor: [n.geldof@students.uu.nl](mailto:n.geldof@students.uu.nl)

Principal researcher: [m.a.m.smeets@uu.nl](mailto:m.a.m.smeets@uu.nl)

Complaints officer: [klachtenfunctionaris-fetcsocwet@uu.nl](mailto:klachtenfunctionaris-fetcsocwet@uu.nl)

## Appendix C

*Instructions and questionnaires.*

### **C1. First task!**

Do you have a deodorant or antiperspirant product at hand, and if so, can you fetch it?  
We are going to do something with the product!

We now ask you to apply your deodorant or antiperspirant in the way you normally would do. In case you have both, please use deodorant!

Once you have applied your deodorant, please check the box below to continue.

Applied

### **C2. Demographic survey**

*Please fill out the following questions.*

**1.**

What is your age?

**2.**

What is your gender?

- Male
- Female
- Non-binary
- I prefer not to answer

**3.**

Which of the following best describes your current living situation?

- Alone
- With relative(s)
- With partner
- With friend(s)
- With housemate(s)
- Other (please specify)

**4.**

Which of the following categories best describes your employment status? (Select all that apply)

- Student
- Not employed
- Employed (part-time)

- Employed (full time)
- Other (please specify)

5.

Thinking of the period half March until June during the corona outbreak, where did your main activities such as work / studying take place?

- I worked/studied from home all the time
- I partially worked from home and partially outside (please specify)

6.

Thinking of the period half March until June during the corona outbreak, where did your social activities mostly take place?

- Online meetings from home
- Outside
- Other (please specify)

### *C3. Personal Hygiene Routines Questionnaire*

The following questions focus on your hygiene routines. Please answer the questions as honestly as possible.

1.

When do you normally apply deodorant/antiperspirant? (Select as many as applicable)

- Morning
- Afternoon
- Evening
- Before/after stressful events
- Before/after sports
- Before leaving the house
- Other (please specify)

2.

Did you apply deodorant/antiperspirant today? (Before participating in this experiment)

- Yes
- No

3.

What brand deodorant/antiperspirant do you currently use?

4.

What format is your deodorant/antiperspirant?

- Spray
- Roll-on
- Stick
- Other (please specify)

**5.**

Which factors do you consider important when using deodorant/antiperspirant?

Rank the following factors by dragging the options and placing them in order of importance, in which the top one would be the most important.

- Fragrance
- Prevents sweat stains
- (Natural) ingredients
- To prevent wetness
- Ease of use
- Leaves no marks on clothes

**6.**

The following questions will be about your hygiene routines prior to (before march) and during the COVID-19 pandemic (half March until June). We are interested if there are any changes to your routine.

Please evaluate the following personal care habits and choose whether you would say you maintain these habits less frequently, more frequent or whether there is no change between the period before and during the corona pandemic.

<b>Take a shower</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Wash hair</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Use deodorant</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Brush teeth</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Wash hands</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Use handsanitizer</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Do laundry</b> _____	0 Less frequently 0 No change 0 More frequently
<b>Dress up</b> _____ (leave open if not applicable)	0 Less frequently 0 No change 0 More frequently
<b>Use makeup</b> _____	0 Less frequently 0 No change 0 More frequently

**7.**

Read the following statements and choose the option that applies to you.

Hygiene impacts my productivity.

- Strongly agree
- Slightly agree
- Neither agree nor disagree

- Slightly disagree
- Strongly disagree

Hygiene routines are important to me.

- Strongly agree
- Slightly agree
- Neither agree nor disagree
- Slightly disagree
- Strongly disagree

I use personal care products because I want to feel clean.

- Strongly agree
- Slightly agree
- Neither agree nor disagree
- Slightly disagree
- Strongly disagree

I use personal care products to look and smell clean for others.

- Strongly agree
- Slightly agree
- Neither agree nor disagree
- Slightly disagree
- Strongly disagree

I maintain a daily hygiene / personal care routine.

- Strongly agree
- Slightly agree
- Neither agree nor disagree
- Slightly disagree
- Strongly disagree

Do you (currently) have a reduced sense of smell due to a cold, allergies or other causes?

- Yes
- No

#### 4C. Scent control questions

***At the beginning of this experiment, we asked you to put on deodorant. For the following questions, please consider the deodorant you used.***

Were you aware of the scent of your deodorant/antiperspirant during the experiment?

- I strongly noticed the scent
- I slightly noticed the scent
- I did not notice the scent
- I used odorless deodorant/AP

How would you rate the scent of the deodorant/AP during the experiment?

- Very pleasant
- Pleasant
- Neutral
- Unpleasant
- Not pleasant at all
- Not applicable

## Appendix D

### *Visual stimuli*



**Figure D1** Example image of a plate that was used in the experiment instructions



**Figure D2** Example image of a shirt that was used in the experiment instructions









