University Utrecht

Master, Applied Cognitive Psychology

THESIS

# Investigating the interaction between the perception of sound and color and their impact on emotions.

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08-10-2012

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Abstract

Multisensory information plays an important role in the perception of an environment. The current study investigated the interaction between color and sound on emotions. Furthermore, semantically congruent stimuli were tested whether their effects on emotion were stronger than their incongruent counterparts. Participants (N = 60) were recruited through the participant database provided by TNO. Along with Galvanic Skin Response, SAM scales were used to measure emotions before and during a stressful task. The rooms were either colored red or blue with a stressful or relaxing sound playing in the background. The repeated measures MANOVA revealed that participants in the blue room felt more in control when the sound was stressful compared to the relaxing sound. Participants felt more in control being in congruent conditions compared to incongruent conditions, but both findings turned out to be nonsignificant when controlling for age. The limited emotional response to colors and the subjective perception thereof made it difficult to find support for the hypotheses. Future research should therefore focus on sensory stimuli known for universal emotional effects and immune to subjective perception.

# Introduction

Sensory impressions from the environment play an important role in how we feel and behave in that environment. Characteristics like luminosity, the nature and level of ambient noise and acoustics, the presence of specific odors, colors and their shades, the materials, and the allocation of these characteristics over time and in space, all contribute to the specific emotions of the observer (Biggers & Pryor, 1982).

Research stemming from environmental psychology mostly focuses on individual characteristics of the environment and their effect on human behavior and emotions. Much less is known about the interactions between these individual characteristics. Colors, for example, do not contain inherent emotional associations. These associations are the product of cultural, psychological and physical factors (Elliot & Maier, 2012; Tofle, Schwarz, Yoon, & Max-Royale, 2004), which make it important to study colors in an environmental context and not in isolation. Red can mean stop or danger in a traffic setting, but it is rather linked to passion or love in a romantic setting. Following the gestalt principles, the perception of the environment is thus not simply the sum of its individual components, it is rather perceived as a whole (Lin, 2004).

The present study, therefore, focuses on multiple environmental characteristics, and on how they influence emotions when presented together. The emotional impact of both color and sounds have been individually researched extensively (Bellizzi & Hite, 1992; Biggers & Pryor, 1982; Bradley & Lang, 2000; Brengman, 2002; Bruner, 1990; Crowley, 1993; Donovan & Rossiter, 1982; Dubé & Morin, 2001; Fraisse, 1982; Gorn, Chattopadhyay, Yi, & Dahl, 1997; Hevner, 1937; Jacobs & Suess, 1975; Kaya & Epps, 2004; Kemper & Danhauer, 2005; Knight & Rickard, 2001; Kwallek, Woodson, Lewis, & Sales, 1997; Lin, 2004; Milliman, 1982; Rigg, 1940; Scherer & Oshinski, 1977; Suk, 2006; Tofle et al., 2004; Valdez & Mehrabian, 1994; Watson, 1942; Wedin, 1972; Wexner, 1954; Wilson, 1966), and are known to influence emotions. Yet, the combination of both regarding the emotional impact has received little attention. Although sound and color are perceived through different sensory systems, both can have similar effects on human emotion. For instance, both red and music with a fast tempo generally have an exciting property, while a relaxing color such as blue and music with a slow tempo typically have a relaxing effect (Schloss, Lawler, & Palmer, 2008; Tsang & Schloss, 2011).

The purpose of the current study is to investigate whether there is an interaction effect between color and sound in the environment on emotions. To answer this question we first explore, by performing a literature review, what key properties are responsible for eliciting emotions. These

key properties will then be used to select color and sound stimuli based on their similar effects on emotions.

## Literature review

### *Effect of sound on emotion*

The following paragraph explores key properties of sound that elicit emotions, keeping in mind the importance of universal emotional outcomes. Participants will be placed in a stressful context so emotions are more likely to fluctuate in response to the environmental stimuli. In order to successfully relax (stress) individuals it is important to use sound fragments that are known to be consistently rated high (low) on pleasure and low (high) on arousal (Mehrabian, 1995a).

The acoustic properties of sound partly determine specific sounds are perceived as pleasant and others as annoying. Along with loudness, properties known as “sharpness” and “roughness” have a substantial influence on sound pleasantness (Fastl, 1997; Terhardt, Stoll, & Seewann, 1982). Sharp sounds are characterized by the proportion of energy located at high frequencies, with frequencies of two to four kHz being the most annoying (Kumar, Forster, Bailey, & Griffiths, 2008). Roughness is a characteristic which can be identified by screeching sounds, including the scraping of fingernails on a blackboard. In general, rougher sounds tend to be less pleasant (McDermott, 2012). This notwithstanding in a large internet-based experiment (Cox, 2008a) the most horrible sound was that of someone vomiting, a sound which is not particularly sharp or rough. Without a doubt, the participant’s associations with vomiting must have contributed to this finding. The aversion to roughness is partially context-dependent as the use of distortion in rock music is considered enjoyable.

Music is known for expressing and conveying emotion, making it ideal for eliciting emotions. The following paragraph will discuss key factors which partly determine the emotional effects of music. Familiarity is one of the factors that increases the liking of a musical piece (Hargreaves, 1987; Hargreaves, Messerschmidt, & Rubert, 1980). Even repeating unfamiliar music, thus making it familiar, increases the liking of the unfamiliar music (Ali & Peynircioğlu, 2010; Gilliland & Moore, 1924), even in different styles such as modern classical (Mull, 1957) or Pakistani (Heingartner & Hall, 1974). Other factors affecting mood that have been researched extensively are tempo and mode. Listeners tend to associate faster tempi and major modes with happiness, and slower tempi and minor modes with sadness (Crowder, 1984; Dalla Bella, Peretz, Rousseau, & Gosselin, 2001; Gagnon & Peretz, 2003; Gerardi & Gerken, 1995; Gregory, Worrall, & Sarge, 1996; Grundlach, 1935; Hevner, 1935, 1937; Hunter, Schellenberg, & Schimmack, 2008; Juslin, 1997; Kastner & Crowder, 1990;

Peretz, Gagnon, & Bouchard, 1998; Rigg, 1937, 1939, 1940; Scherer & Oshinski, 1977; Webster & Weir, 2005; Wedin, 1972). In addition, moderately complex music pieces tend to be preferred over pieces with lower or higher complexity (Heyduk, 1975; North & Hargreaves, 1995, 1996; Radocy, 1982; Voss & Clarke, 1975). Complexity and aesthetic preference is proposed to be related via an inverted U-curve shape (Berlyne, 1971), in which repeated exposure decreases the complexity (and the corresponding pleasure level) of a musical piece (Schellenberg, Peretz, & Vieillard, 2008; Smith & Cuddy, 1986; Szpunar, Schellenberg, & Pliner, 2004).

Music is very subjectively perceived and very dependent on the factors mentioned above. For example, affective ratings for classical music will likely be biased for individuals showing a personal preference for this music genre. Therefore it is interesting to look for sounds that have a more stable connection to standardized emotional outcomes. In an endeavor to standardize auditory stimuli, the International Affective Digitized Sounds (IADS-2; Bradley & Lang, 2007) has been developed, a database which contains 167 sound fragments. These fragments have been individually rated on pleasure and arousal. A scatterplot of the sound fragments on the dimensions pleasure and arousal shows a wide range of emotional outcomes for noises and music. Comparing affective ratings for music and noise, Gomez & Danuser (2004) found the sound of a little stream with bird twitter to be rated very high on pleasure and low on arousal, while the sound of jackhammers was rated low on pleasure and high on arousal, making it an ideal counterpart. Furthermore, they found that the contrast between high and low levels of pleasure and arousal was more pronounced with noises compared to music.

What we can learn from the above mentioned research is that properties of music (e.g. complexity, tempo, mode) are prone to subjective perception, while noises are less subjectively perceived and have a more pronounced effect on emotional ratings. The IADS-2 offers a collection of standardized sounds with relatively stable ratings in the affective domain which serves as a starting point for the selection of sound stimuli. Based on their affective ratings it is possible to select contrasting noises which can be either relaxing (e.g. sound of a little stream with bird twitter) or stressful (e.g. sound of jackhammers).

*Effect of color on emotion*

Following the same procedure of the previous section, in order to successfully relax (stress) individuals, colors must be consistently rated high (low) on pleasure and low (high) on arousal to match the criteria for the sound selection. General color associations will be discussed first, following a more in depth overview of color properties such as value (lightness) and saturation (chroma).

Research tends to focus on affective associations people have with various colors without considering its context. Wexner's (1954) study for example investigated associations between color samples and words that describe feelings. One of his findings was that the color red was associated with "exciting" and "stimulating," both of which imply high arousal. Blue was associated with "secure/comfortable" and "tender/soothing," which imply low arousal. It appears that “overall, warm colors, especially red, are physically and emotionally arousing, exciting, and distracting; cool colors, especially blue, are relaxing, peaceful, calm, and pleasant” (Bellizzi & Hite, 1992). It is, therefore not surprising that people exposed to blue were more relaxed while waiting for a web page to load than being exposed to red (Gorn, Chattopadhyay, Sengupta, & Tripathi, 2004).

In reaction to the use of colors in advertisements, respondents being exposed to red report stronger feelings of excitement, and those exposed to blue reported experiencing greater feelings of relaxation (Gorn et al., 1997). Further evidence linked higher anxiety scores with red and yellow than with blue and green (Jacobs & Suess, 1975; Valdez & Mehrabian, 1994). These findings can be partially explained by the association of red with failure or danger and green with success (Moller, Elliot, & Maier, 2009). Wilson (1966) also speculates that colors with a more extreme wavelength (red and violet) are associated with danger and therefore evoke greater activation.

In a cross-cultural study similarities have been found in color associations (Madden, Hewett, & Roth, 2000). The respondents from their culturally representative countries (Austria, Brazil, Canada, Colombia, Hong Kong, PRC, Taiwan and the United States) have been asked for their association with common colors used in a product logo. The results show that blue, green, and white are strongly associated with "peaceful", "gentle" and "calming". Red is perceived uniquely in terms of its meaning as it was consistently associated with "active", "hot" and "vibrant" across all countries. This indicates that consumers exhibit similarities in color meaning which appear to be cross-cultural.

The aforementioned research has mainly focused on the associations with hue alone, which covers only one of the three color properties according to color theory. The other two color properties value (lightness) and saturation (chroma) can change the expressive power of a color. Valdez & Mehrabian (1994) have even demonstrated that pleasure and arousal can be determined by brightness and saturation alone. They found that brighter and more saturated colors were more pleasant, with brightness being the most important determinant. Arousal was strongly affected by saturation and negatively related to brightness. This may account for the common findings that red has arousing properties. It might rather be the high saturation of the red color samples used, rather than its hue that accounts for the arousing effects of red. Further evidence supports these findings, as participants exposed to ads containing higher value (lightness) colors report greater feelings of

relaxation, but no differences in the level of felt excitement were found. Participants exposed to ads containing higher choma felt more excited, but not more relaxed (Gorn et al., 1997).

Incorporating the effects of lightness and saturation, Suk (2006) found that across all hue categories, the vivid tones elicited the strongest effects on pleasure and arousal levels. Vivid tones correspond with specific lightness and chroma levels for each hue. He also found that affective ratings for the blue category were rated more positive, less exiting and more dominant than the other hue categories. A comparison between the blue and red hues revealed a significant contrast between pleasure, arousal and dominance levels. Similar to the stressful and relaxing sounds, blue is often found to be relaxing while red is linked to higher arousal and its stressful effects. These findings resulted in the selection of vivid red and vivid blue as the color stimuli.

*Interaction between sound and color on emotion*

Perception is multimodal, meaning that information from the different modalities is integrated into rich, coherent perception of the environment. Among others, visual and auditory cues can alter this impression to form a different perception of an event. The gestalt theory mentioned earlier already emphasized the importance of studying the environment as a whole. The emotional reaction to the whole environment differs from the summation of the individual components. Optimal arousal theory, for example, suggests that minor changes in the environment, such as adding a low level of scent or playing background music, increase the environment's perceived novelty and pleasantness (Berlyne, 1971; McClelland, Atkinson, Clark, & Lowell, 1953). When exposed to either auditory or visual stimuli with similar semantic content (e.g. cow, sound of a cow, weapons, sound of a gunshot), subjects' pleasure and arousal ratings are located very close together in affective space (Bradley & Lang, 2000). It can be assumed that both audio and visual information activate a concept from which the affective ratings are derived. Another experiment combined an image of fingernails on a chalkboard, or a dentist, while listening to the corresponding sound, which yielded a worse rating for the sound (Cox, 2008b). Thus the congruence of audiovisual stimuli strengthens a concept, making the experience more vivid.

Although sound and color are perceived through different sensory systems, both can have similar expressive qualities. The semantic congruence of both barking and a seeing a dog produces greater gamma band activity (GBA)[1] than the semantic incongruence of a meowing dog (Schneider,

[1] According to a popular theory, gamma waves may be implicated in creating the unity of conscious perception (Buzsaki, 2006; Pollack, 1999; Singer & Gray, 1995).

Debener, Oostenveld, & Engel, 2008). Similar effects are found with congruent symbols and sounds on GBA (Widmann, Gruber, Kujala, Tervaniemi, & Schröger, 2007). This process of multisensory integration can be quite staggering:

> For example, multisensory neurons in the S[uperior]C[olliculus] display overlapping sensory receptive fields, one for each modality (A[udiory], V[isual], T[actile]) to which they respond. When two or more sensory cues occur in close temporal and spatial proximity, the response of these neurons can be substantially enhanced, sometimes exceeding 12-fold enhancements in firing rate beyond that expected by summing the impulses exhibited by each unimodal input in isolation. (Calvert & Thesen, 2004, p. 194)

The process of response depression in multisensory integration is known as the weakening of the response of one modality by another incongruent modality (Calvert & Thesen, 2004).

In the current experiment, the congruence of cues is defined as the degree of fit among characteristics (i.e. relaxing/stressful) of a stimulus (i.e. color combined with sound). It is anticipated that the emotional impact of sound in combination with a corresponding color is stronger due to the semantic congruence of sensory inputs. Looking at the aforementioned literature, blue has semantic overlap with the sound excerpt of bird twitter. In a similar fashion, red is associated with danger or avoidance (Elliot, Maier, Binser, Friedman, & Pekrun, 2009) which corresponds with sounds of dangerous machinery such as jackhammers or edge cutters.

In order to quantify the effects of color and sound, it is important to induce stress in which a stressful or relaxing sound or color will have an effect on the perceived stress in the environment. This allows us to determine whether relaxing and stressful stimuli are transferred to the overall affective response.

$H_1$: There is an interaction effect between color (relaxing or stressful) and sound (relaxing or stressful) on physical arousal, pleasure, arousal and dominance.

$H_2$: Semantically congruent conditions yield a greater impact on pleasure, arousal, dominance and physical arousal than the incongruent conditions.

The stressful color or sound is expected to cause a higher amount of physical arousal and self-reported arousal, and lower self-reported pleasure and dominance. Whereas a relaxing color or sound will have the opposite effect on the above mentioned outcomes. In the case of a congruent sound and color (i.e. both relaxing or both stressful) the impact on emotions will be stronger than presenting an incongruent sound and color.

## Method

### *Participants*

Participants were recruited via an announcement at the Universiteit Utrecht and through the participant database provided by Toegepast Natuurwetenschappelijk Onderzoek (TNO) for a reward of €20,- or 1.5 research credit. People with certain heart problems, color blindness or hearing loss were excluded from the study. Participants were instructed not to smoke or consume any caffeinated drinks three hours before the experiment. Resulting in a total of 60 participants (26 male) with a mean age of 37.90 (SD=17.13).

### *Materials*

Galvanic Skin Response (GSR) was used as a physiological measure for arousal. The measurement was done by bipolar placement of silver-silver chloride sensors on top of the index and middle finger. The sensors were connected to a G.tec® USBamp, which was connected to a computer recording the signal. All the GSR equipment was placed on a trolley, allowing for participant mobility and a continuous measurement of the GSR signal.

The Self-Assessment-Manikin (SAM) was used to measure self-reported Pleasure, Arousal and Dominance using a single graphical representation for each of the corresponding 9-point scales (Lang, 1980, see figure 1). The figures ranged from frowning, unhappy to smiling, happy for the pleasure dimension. For the arousal dimension the figures ranged from relaxed to excited. For the dominance dimension the figures ranged from lack of control to in control (Bradley & Lang, 1994). The portrait version of the Pleasure scale (Suk, 2006) was used as it put more emphasis on the facial expression which was the key factor for this scale.

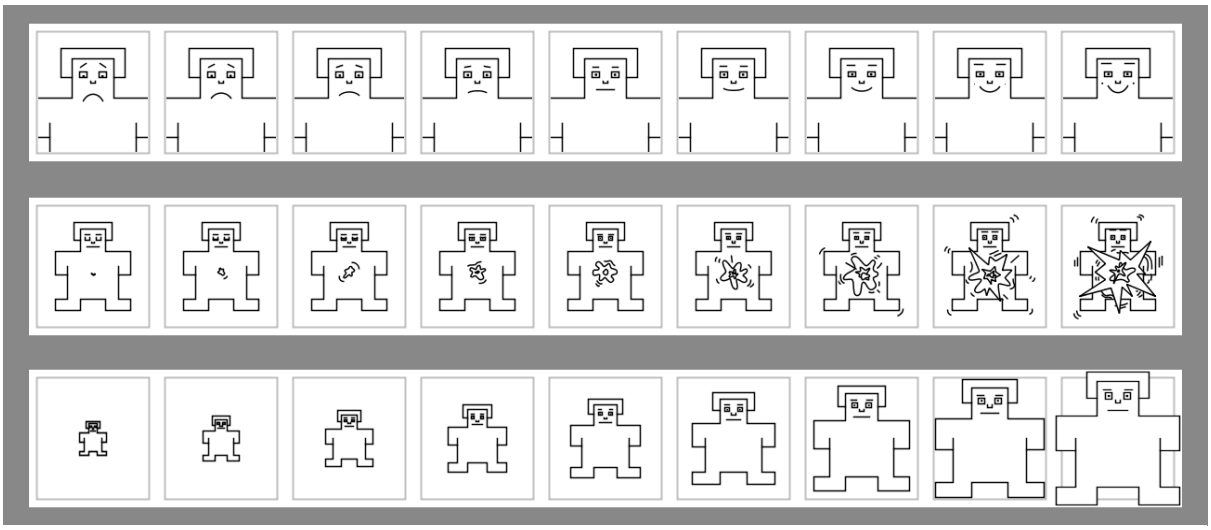

*Figure 1*. SAM scales used to measure Pleasure, Arousal and Dominance

An initial questionnaire was used to measure the baseline SAM ratings, which also included control items for use of substances that could influence the GSR measurement. Participants were asked their age and sex for explorative analysis.

In order to successfully induce stress, motivated participants should be placed in a situation which they perceive as uncontrollable with the threat of social evaluation (Dickerson & Kemeny, 2004). This was done by informing participants that they had 15 minutes to creatively come up with social exercises to help people overcome their social phobia (e.g. “talk to a stranger”). Participants were informed that these challenges had to be clarified during a five minute oral presentation which would be filmed and critically evaluated by a three-headed committee.

The second questionnaire included the SAM scales to measure the effect of the environmental manipulation by comparing these ratings with the baseline SAM ratings. This questionnaire also included items to control for presentation confidence. These items controlled for individual differences towards giving presentations which might act as a moderating variable.

The third questionnaire included qualitative items whether they noticed anything remarkable about the manipulated room. The manipulations of color and sound were rated on the SAM scales as a quantitative measure for their relative effect.

The fourth questionnaire contained the debriefing, which informed participants that the presentation was not required and revealed the true purpose of the experiment. Following the debriefing, the experimenter verbally questioned the believability of the presentation task and whether they were aware of the true purpose of the experiment.

*Stimuli*

One room has been used for either the blue or red color manipulation. A chair and desk were positioned in the room with a camera aimed at the participant to make him/her believe a recording would be made. Three chairs were placed, suggesting a committee would be joining during the presentation. Various objects, in the respective color, including binders, a letter tray with blank paper, a marker, pen, napkins and a Philips© livingcolors lamp were placed on the table. Two information brochures about social phobia were included in the colored binders. In the second questionnaire, the participants were instructed to read these binders.

Dividing walls were placed around the table and covered using three cloths. The shades of blue and red were based on the vivid tones used in Suk (2006) which yielded the strongest effects on emotion (see figure 2). Two construction lamps equipped with the respective color filters were illuminating the cubicle from the top left and right side. Due to the heat production of these lamps, as a control the temperature of the room was measured after the third questionnaire was given.

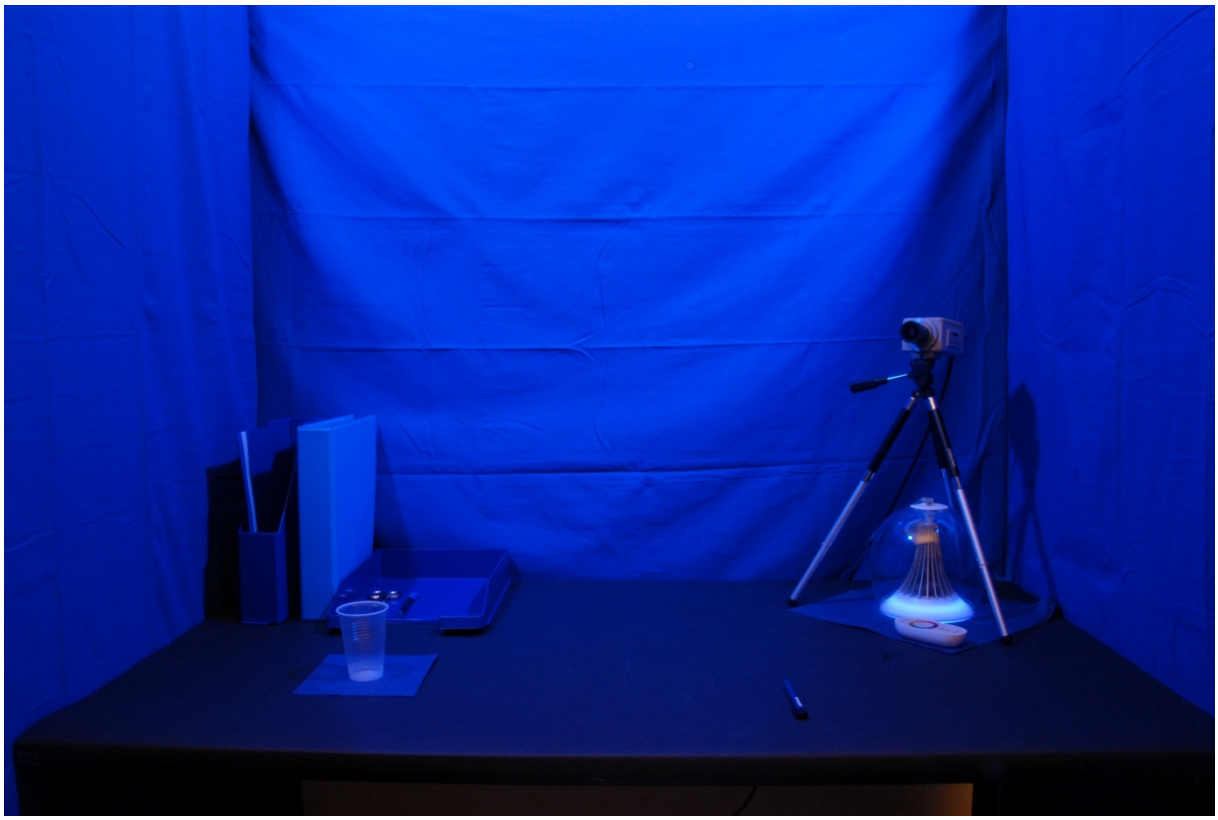

*Figure 2*. Operationalization of the blue color manipulation

The room had a sound system playing the relaxing or stressful sound. The sound system was hidden on the windowsill behind a large curtain, blocking external light coming from the windows. The sound speakers were facing the window to simulate that the sound was coming from the outside

by sound diffusion. The relaxing sound samples originated from a collection of bird sounds (BBC, 1991). The stressful sound samples consisted of construction and gardening fragments (Sounddogs, 2010a, 2010b). The sound fragments were selected according to the natural presence of sounds between July and August at the location of the experiment (Soesterberg, The Netherlands). An initial pretest of all sound samples, via headphones, has been done to select the most relaxing, stressful and realistic sound using the Pleasure and Arousal ratings (figure 1). The initial pretest ($N$ = 7) resulted in the selection of bird twitter and gardeners working as the utilized sound samples.

*Design*

The experiment used a 2 (color: blue or red) x 2 (sound: bird twitter or gardeners working) between-subjects design. The independent variables were the room color and sound type. This results in two congruent conditions (i.e. blue and bird twitter/red and gardeners working) and two incongruent conditions (i.e. blue and gardeners working/red and bird twitter). Self-reported pleasure, arousal, dominance and physical arousal were the dependent variables.

*Analysis*

A repeated measures Multivariate Analysis of Variance (MANOVA) was used to test the hypotheses between the four conditions. Self-reported pleasure, arousal and dominance along with the mean GSR levels have been measured before and during the manipulation serving as the within-subjects factor. In Matlab the GSR scores were averaged using an interval of 100 s for the baseline and 700 s for the manipulation measurement, starting 50 s after the onset of each measurement.

Age, sex, room temperature, presentation confidence, believability of the presentation task were used as covariates in the subsequent repeated measures Multivariate Analysis of Covariance (MANCOVA).

*Procedure*

Upon arrival, participants were invited to take a seat in a neutral room where they received an informed consent containing information about the experiment. After signing the informed consent the two GSR sensors were placed and connected. After finishing the initial questionnaire, the participant was instructed to relax until the GSR baseline measurement was completed. After a successful baseline measurement, the participant was taken to the manipulated room using the trolley to transport the GSR equipment. Participants were asked to take a seat and read the instructions on the second questionnaire. As soon as the instructions were clear, the experimenter instructed the participant to read the information about social phobia in the colored binder. The experimenter then left the room, giving the participant 15 minutes to prepare for the oral

presentation. After 15 minutes, the experimenter knocked on the door, and asked the participant to fill in the third questionnaire. Meanwhile, the experimenter wrote down the temperature of the room. After the participant finished the questionnaire, the GSR sensors were disconnected and the participant was asked to go back to the neutral room so the committee could prepare the room for the presentation. In the neutral room, de participant filled in the fourth questionnaire. Upon completion, participants were debriefed by informing them that the oral presentation was not required, and that the true purpose of the experiment was to research the effect of environmental factors on human emotion. Following the debriefing, the fifth questionnaire was given verbally. Participants were then thanked and rewarded for their participation.

## Results

To check if the manipulations were successful, both sound and color were rated using the SAM scales (see appendix 4) after the experiment. Pleasure and arousal ratings on the sound and color manipulation were compared with an independent *t*-test. To check the stress manipulation, a paired-samples *t*-test was conducted to compare GSR levels, pleasure and arousal ratings before and during the manipulation.

The SAM ratings for color were indicating that the color manipulation did not achieve the required effect on pleasure and arousal ratings. Due to the unsuccessful color manipulation, the pleasure and arousal ratings for the congruent colors and sounds did not match in a paired-samples *t*-test. Although the GSR averages did not differ before ($M$ = 21802, $SD$ = 31246) and during ($M$ = 22255, $SD$ = 29911) the manipulation ($t(59) = -1.09$, $p > .05$), being in the manipulated room did cause a significant decrease in pleasure and increase in arousal (see table 1).

Table 1.

*t*-test results for the Sound, Color and Stress Manipulation checks on Pleasure and Arousal

| Type of manipulation check | | Pleasure | | *t*-test | Arousal | | n | *t*-test |
|---|---|---|---|---|---|---|---|---|
| | | Mean | *SD* | | Mean | *SD* | | |
| Sound | Stressful | 4.86 | 1.56 | -4.31* | 5.18 | 1.68 | 28 | 3.86* |
| | Relaxing | 6.58 | 1.36 | | 3.46 | 1.58 | 26 | |
| Color | Red | 5.10 | 1.63 | -0.87 | 5.13 | 1.43 | 30 | 1.96 |
| | Blue | 5.48 | 1.77 | | 4.34 | 1.65 | 29 | |
| Stress | Before manipulation | 6.68 | 1.16 | 4.76* | 3.73 | 1.78 | 60 | -3.97* |
| | During manipulation | 5.62 | 1.44 | | 4.83 | 1.89 | 60 | |

*Note. SD* = Standard Deviation. * = $p < .01$.

The reliability of the SAM scales was tested using Pearson's *r*, which show no significant correlations for pleasure on both arousal ($r(60)= -.26$, $p > .05$) and dominance ($r(60)= .23$, $p > .05$). Dominance and arousal were significantly correlated, $r(60)= -.33$, $p = .01$, raising doubt concerning the validity of these scales.

To answer the first hypothesis, whether there is an interaction between color and sound on physical arousal, pleasure, arousal and dominance, a repeated measures MANOVA was performed using color and sound as the between-subjects factors. The measurements before and during the manipulation were the within-subjects variable. No significant main effects were found for color on physical arousal, pleasure, arousal or dominance. There was only a significant main effect for sound on pleasure ($F(1,56) = 4.01$, $p = .05$) meaning that participants hearing a stressful sound felt more pleasure than the participants hearing the relaxing sound. There were no significant interactions between color and sound on physical arousal ($F(1,56) = 1.70$, $p > .05$), pleasure ($F(1,56) = 0$, $p > .05$) or arousal ($F(1,56) = 0.46$, $p > .05$). Dominance (i.e. amount of control) did interact with color and sound. Participants in the blue room reported feeling more dominance when the sound was stressful compared to the relaxing sound ($F(1,56) = 4.02$, $p = .05$), while there was no effect of sound type for the participants in the red room, as can be seen in figure 3.

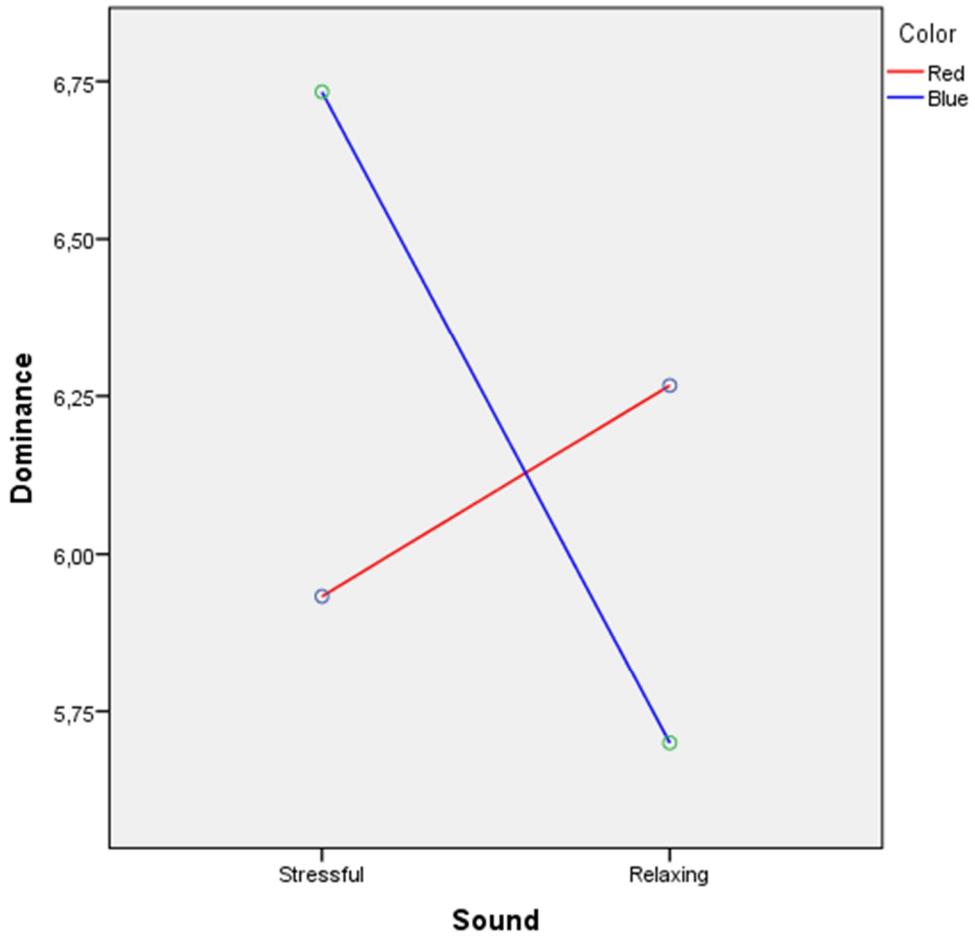


*Figure 3.* Interaction between sound and color on self-reported dominance on a 9-point scale.

To investigate whether the congruent conditions yielded a greater impact on pleasure, arousal, dominance and physical arousal than the incongruent conditions, the conditions have been coded into congruent condition (i.e. red color and stressful sound, blue color and relaxing sound) and incongruent condition (i.e. red color and relaxing sound, blue color and stressful sound). Performing a repeated measures MANOVA revealed that participants in the congruent conditions did not report feeling more pleasure than in the incongruent conditions, $F(1,58) = 0$, $p > .05$, nor did they feel more arousal than in the incongruent conditions, $F(1,58) = 0.48$, $p > .05$. Participants in the congruent conditions did report feeling less dominance than in the incongruent conditions, $F(1,58) = 4.07$, $p < .05$ (see figure 4). Physical arousal did not differ in between the congruent and incongruent conditions, $F(1,58) = 1.72$, $p > .05$.

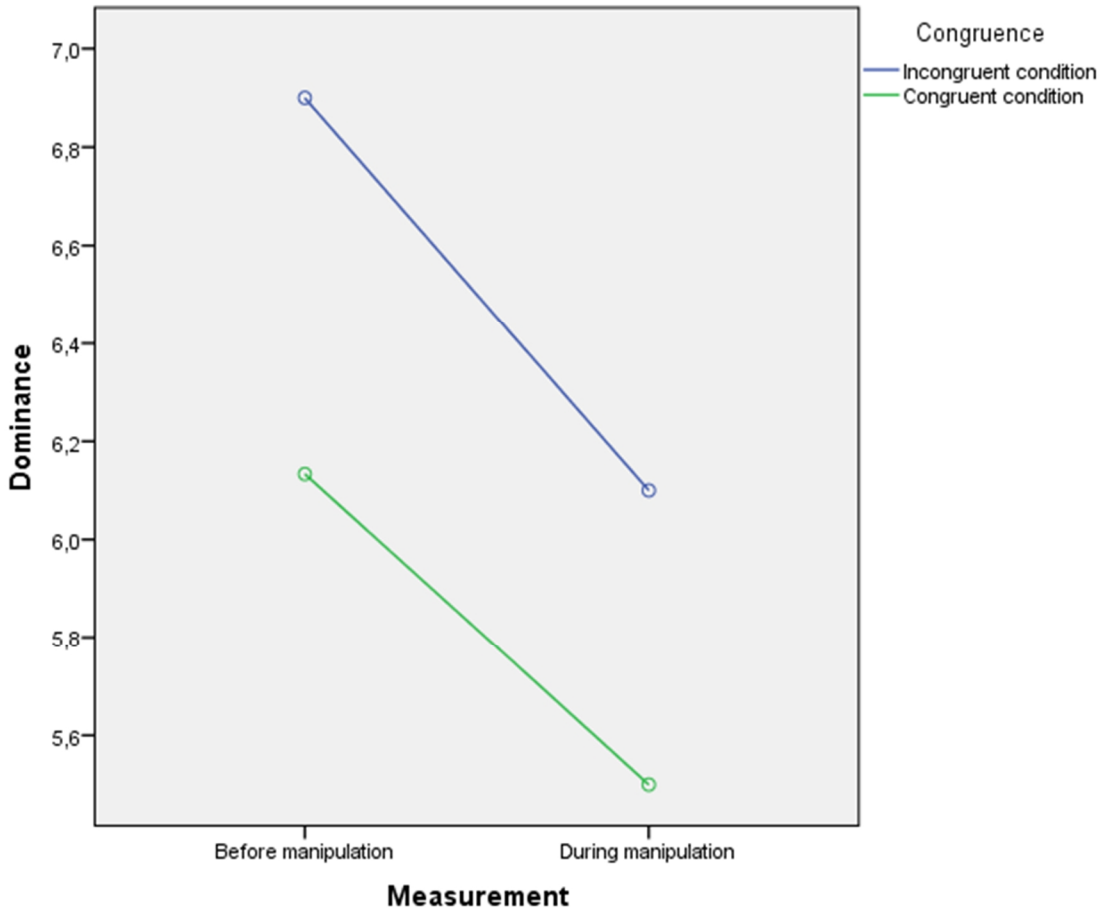


*Figure 4*. The effects of congruence between stimuli on self-reported dominance on a 9-point scale.

These findings can be explained by the lack of congruence between the affective ratings on color and sound. An analysis of these ratings in the congruent conditions showed no correspondence between ratings on pleasure ($r(26) = .14$, $p > .05$), arousal ($r(26) = .14$, $p > .05$) or dominance ($r(26) = .09$, $p > .05$) using Pearson's *r*.

Adding age, sex, room temperature, presentation confidence, believability of the presentation task as covariates to the analysis revealed that only age was significantly related to dominance ($F(1,55) = 10.68$, $p < .01$). Further analysis showed a direct correlation between age and dominance, $r(58) = .41$, $p < .01$, indicating a medium effect size. Controlling for age in a repeated measures MANCOVA resulted in a nonsignificant interaction between color and sound on dominance ($F(1,55) = 1.89$, $p > .05$). Age also cancelled out the interaction between congruence on dominance

($F(1,57) = 2.05$, $p > .05$). In the analysis only the main effect for sound on pleasure ($F(1,56) = 4.29$, $p < .05$) remained significant.

## Discussion

Referring back to the original research question, is there an interaction effect between color and sound on physical arousal, pleasure, arousal and dominance? Initially findings supported that participants in a blue setting felt more in control hearing the stressful sound than the relaxing sound, but this interaction was absent when controlling for age.

Congruent conditions yielded a greater impact on dominance than the incongruent conditions, but not for pleasure, arousal and physical arousal. This effect also disappeared when controlling for age. During the stressful task of preparing a for an oral presentation, a stressful sound was found to be more pleasurable than the relaxing sound. Congruence between stimuli was related to the amount of control, but the effect disappeared when controlling for age.

The following model (see figure 5) should pose as a guideline for future research on multisensory perception, highlighting the importance of intervening factors such as relative intensity of stimuli, individual differences and the moderating role of semantic congruence. The model is based on the principles of gestalt theory, where the sum of the environmental stimuli has an incremental effect on the perception of congruent stimuli, increasing the strength of the affective

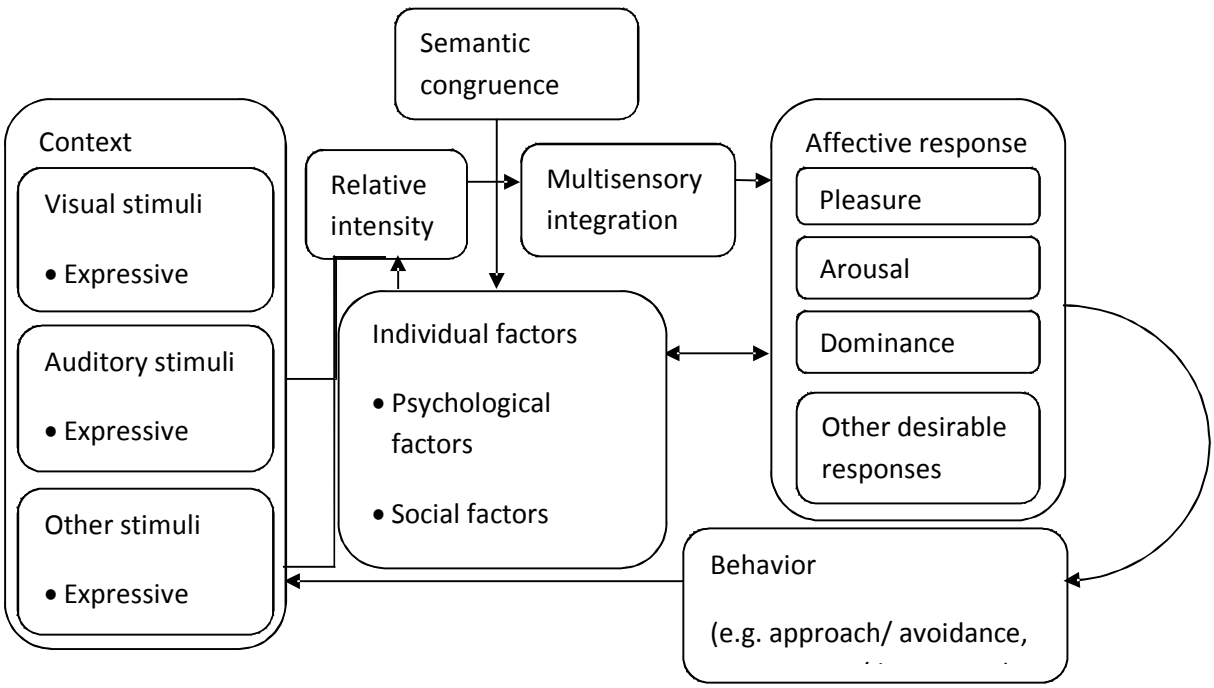


*Figure 5*. The proposed model for future research on the interaction of environmental stimuli on affective response and behavior.

state as a result of multisensory integration.

Due to the unsuccessful color manipulation, participants did not associate the colors with a distinct concept, as the sound fragments did. Although the relative intensity of the color manipulation was higher than the sound manipulation, the expressive quality was absent. As learned from the exit interview, some people associated red with “Moulin rouge” and the blue lighting setting with an anti-drugs measure used in public toilets instead of a relaxing or stressful color. Thus cues like twittering birds and merely the color blue will not necessarily lead people to associate with relaxing concepts as clear blue skies or being free as a bird, pointing at a lack of semantic congruence. In concordance with multisensory integration, it is likely that response depression occurred weakening the response of one modality by another incongruent modality (Calvert & Thesen, 2004), weakening the emotional response to the stimuli.

Based on the principles of gestalt theory, which state that the whole (expressive quality) is greater than the sum of the parts (e.g. hue, saturation and lightness), the expressive power of images of blue skies or birds would probably have been stronger than the color blue, just as well as the sound of twittering birds has more expressive power than a single tweet. Environmental stimuli should therefore possess enough expressive power to influence emotions.

Although personality has not been included in the present study, evidence does support its mediating role in environmental perception. Kwallek, Woodson, Lewis and Sales (1997) have stated that extraversion and neuroticism make people more susceptible to their environment in comparison to introversion and emotional stability. Mehrabian (1995b) defines it as the trait arousability where arousable individuals have stronger emotional reactions to environmental stimuli than less arousable individuals as they possess a better ability to automatically screen less important stimuli in various sensory modalities.

*Conclusion*

Color and sound did not interact with emotions, nor did congruent stimuli have a greater effect on emotions than incongruent stimuli. The limited emotional response to colors and the subjective perception thereof made it difficult to find support for these statements.

As stated in the literature review (see chapter 2.2 and 2.3), studies have shown that color and sound associations exists, but as this study points out that their effectiveness is very limited, especially for color. Putting the focus on the effects of basic sensory stimuli and their effect on emotions can lead to an oversimplification of the complex interaction of environmental stimuli on emotions and behavior. One has to take into consideration the expressive quality and congruence of

stimuli along with psychological, social and biological factors which influence the process of multisensory integration effecting the affective response. Each environment has to be studied separately, taking into consideration the desired purpose that the environment should fulfill. In a hospital environment, it may be desirable to express professional expertise to reassure patients waiting for an operation or in the intensive care unit, which could be accomplished by displaying framed diploma's on the wall or providing reassuring information concerning the operation. While being in a rehabilitation or office environment it may be more desirable to activate people using encouraging or motivational stimuli to achieve desired states or behavior.

Future research should focus on finding universal environmental stimuli that are known to improve people's moods, reduce tension or relieve depression. This can be done on the basis of the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), the IADS-2 (Bradley & Lang, 2007), or mimic environments which are known for their beneficial effects such as gardens or nature in a hospital setting (Ulrich, 1999). When such data is not available, extensive pilot testing of the stimuli is essential. These environmental stimuli can be incorporated into a healing environment which helps people cope with stressful situations during their job or being hospitalized. Equipping the environment with a projector, speakers and scent diffusers, for example, will allow researchers to customize sensory stimuli and set up testing environments relatively easy. Making it possible to adjust the environment in order to enhance the purpose it is trying to fulfill.

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Appendix 1 nr.

Hieronder volgen een aantal vragen die je kunt beantwoorden door het desbetreffende vakje aan te kruisen. Geef bij elke vraag het antwoord dat voor jou van toepassing is. Het is belangrijk dat je de instructies bij de vragen goed doorleest. Laat de proefleider weten wanneer je een vraag niet begrijpt of als deze onduidelijk is.

Wanneer je klaar bent, blijf dan rustig zitten en probeer te ontspannen. Het meten van je huidgeleiding duurt namelijk een aantal minuten. De proefleider geeft je een seintje wanneer deze meting klaar is.

Als alles duidelijk is, kan je nu de pagina omslaan en de vragen beantwoorden.

1. Wat is je sekse?

   ☐ man
   ☐ vrouw

2. Wat is je leeftijd?

   [ ] jaar

3. Heb je binnen 3 uur voor aanvang van het experiment gerookt?

   ☐ nee
   ☐ ja, _____ uur voor het begin van het experiment

4. Heb je binnen 3 uur voor aanvang van het experiment cafeïne houdende dranken (oa. thee, koffie of cola) geconsumeerd?

   ☐ nee
   ☐ ja, _____ uur voor het begin van het experiment

5. Heb je binnen 3 uur voor aanvang van het experiment psychoactieve drugs (oa. marihuana of cocaïne) gebruikt?

   ☐ nee
   ☐ ja, namelijk _____
   ____ uur voor het begin van het experiment

6. Beschouw je jezelf als een creatief persoon?

   ☐ nee
   ☐ ja

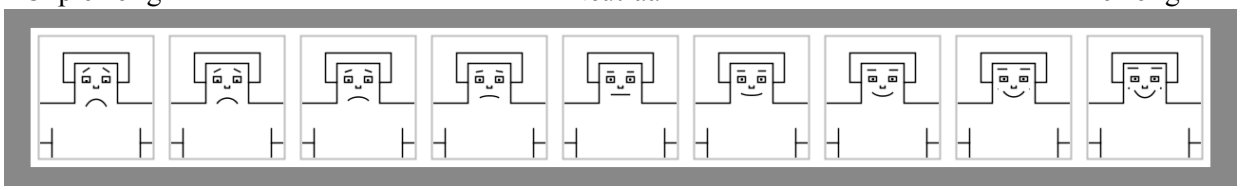
7. Heb je gedeelten van een dag waarop je het meest creatief bent?

   ☐ nee
   ☐ in de ochtend
   ☐ in de middag
   ☐ in de avond
   ☐ in de nacht

In de onderstaande schaal staan 9 vakjes onder de gezichten. De vakjes komen overeen met de mate van plezier die je op dit moment ervaart.

Kruis het vakje aan in hoeverre je je op dit moment onplezierig (links), neutraal (midden) of plezierig (rechts) voelt.

Onplezierig Neutraal Plezierig

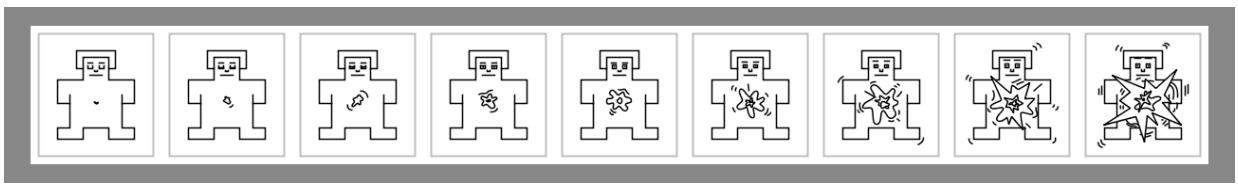


☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

In de onderstaande schaal staan 9 vakjes onder de poppetjes. De vakjes komen overeen met de mate van spanning die je op dit moment ervaart.

Kruis het vakje aan in hoeverre je je op dit moment ontspannen (links), neutraal (midden) of gespannen (rechts) voelt.

Ontspannen Neutraal Gespannen

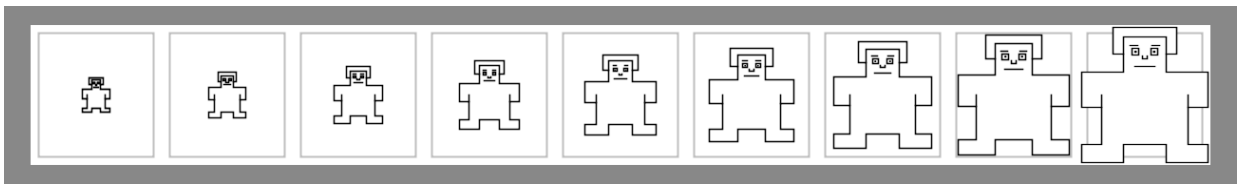


☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

In de onderstaande schaal staan 9 vakjes onder de poppetjes. De vakjes komen overeen met de mate van controle die je in deze situatie ervaart.

Kruis het vakje aan in hoeverre je op dit moment gebrek aan controle hebt (links), neutraal (midden) of in controle (rechts) bent.

Gebrek aan controle Neutraal In controle



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Dit is het einde van deze vragenlijst!

Appendix 2 Nr. 

Je gaat zometeen creatieve oplossingen bedenken voor mensen die last hebben van sociale fobie.

Sociale fobie is een veelvoorkomende angststoornis, ongeveer 5 tot 15% van de mensen heeft gedurende het leven last van een sociale fobie. Sociale fobie treedt op in contact met anderen. Iemand met sociale fobie blokkeert van angst tijdens bijvoorbeeld het toespreken van een groep, bij het ontmoeten van onbekenden, of in een gewoon gesprek. Zowel verlegenheid als sociale faalangst hebben raakvlakken met sociale fobie.

Om mensen beter te kunnen helpen, is er een commissie opgesteld om nieuwe methoden te ontwikkelen voor de behandeling van mensen met sociale fobie. Deze commissie bestaat uit persoonlijke coaches die graag gebruik maken van de kracht van jouw creatieve oplossingen.

Omdat mensen met sociale fobie vooral problemen hebben in sociale situaties, is het de bedoeling dat je zo veel mogelijk creatieve uitdagingen gaat verzinnen die hen helpt om hun sociale fobie te overwinnen. Een voorbeeld zou zijn “Ga een gesprek aan met een vreemde”.

Uiteraard is het de bedoeling om bij jouw uitdagingen creatiever te zijn dan in het voorbeeld. Je krijgt 15 minuten de tijd om zoveel mogelijk creatieve uitdagingen te verzinnen. Werk deze uitdagingen goed uit zodat je deze in een presentatie van 5 minuten in een goed lopend verhaal duidelijk kunt uitleggen. De presentatie wordt met de camera opgenomen in het bijzijn van de commissieleden. Zij zullen letten op de creativiteit, haalbaarheid, effectiviteit en toepassing op de literatuur.

De literatuur is te vinden in de multomap links voor je. Lees deze goed door!

Als alle instructies duidelijk zijn, kun je nu de pagina omslaan.

Nr. 

Gebruik de onderstaande ruimte om zoveel mogelijk creatieve uitdagingen op te schrijven en uit te werken. Je kunt gebruik maken van extra kladpapier in het postvakje.

Appendix 3 Nr. 

Hieronder volgen een aantal vragen over jouw ervaring met het geven van presentaties. Geef bij elke vraag het antwoord dat voor jou van toepassing is.

1. Hoeveel ervaring heb je met het geven van presentaties?

| Weinig | | Gemiddeld | | Veel |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

2. Hoe sta je tegenover het geven van presentaties?

| Negatief | | Neutraal | | Positief |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

3. Hoe goed denk je dat jouw creatieve uitdagingen zijn?

| Matig | | Redelijk | | Goed |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

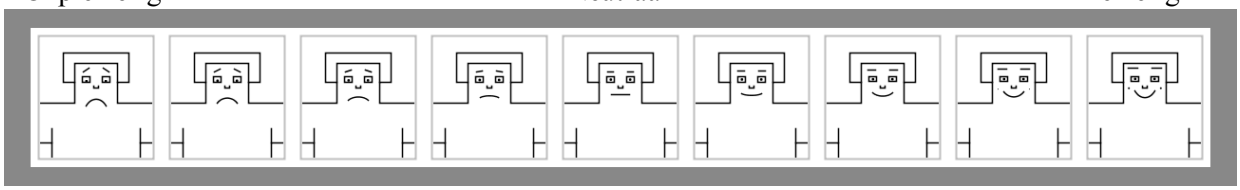
Ga verder naar de volgende pagina

Nr.

In de onderstaande schaal staan 9 vakjes onder de gezichten. De vakjes komen overeen met de mate van plezier die je op dit moment ervaart.

Kruis het vakje aan in hoeverre je je op dit moment onplezierig (links), neutraal (midden) of plezierig (rechts) voelt.

Onplezierig Neutraal Plezierig

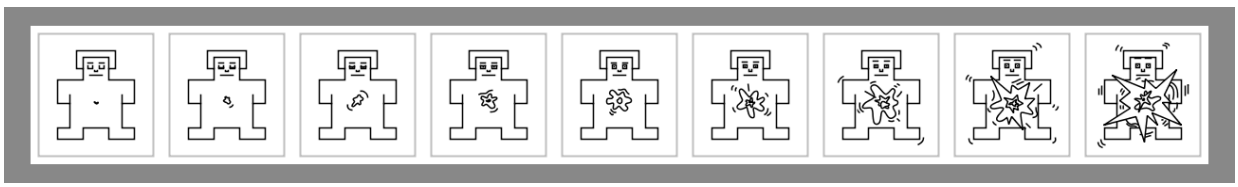


☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

In de onderstaande schaal staan 9 vakjes onder de poppetjes. De vakjes komen overeen met de mate van spanning die je op dit moment ervaart.

Kruis het vakje aan in hoeverre je je op dit moment ontspannen (links), neutraal (midden) of gespannen (rechts) voelt.

Ontspannen Neutraal Gespannen

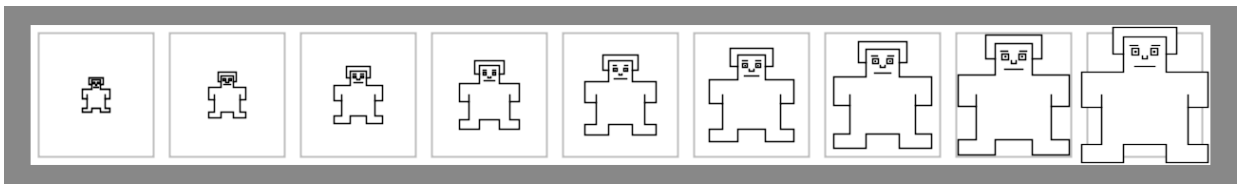


☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

In de onderstaande schaal staan 9 vakjes onder de poppetjes. De vakjes komen overeen met de mate van controle die je in deze situatie ervaart.

Kruis het vakje aan in hoeverre je op dit moment gebrek aan controle hebt (links), neutraal (midden) of in controle (rechts) bent.

Gebrek aan controle Neutraal In controle



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Appendix 4 Nr.

Is je nog iets opgevallen terwijl je in de andere kamer zat?

Nr. ☐

Was je je bewust van bepaalde geluiden terwijl je in de andere kamer zat?

☐ nee

☐ ja, namelijk:

Had je bepaalde positieve of negatieve associaties met de aard van het geluid?

☐ nee

☐ ja, namelijk:

Hoe intens heb je de geluiden ervaren?

| Zwak | | Gemiddeld | | Sterk |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

Had je het idee dat geluid iets met het onderzoek te maken had?

☐ nee

☐ ja, namelijk:

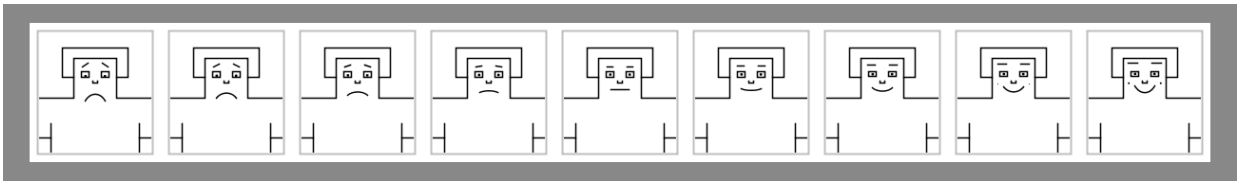
Had geluid invloed op het voorbereiden van de presentatie?

Nr. ☐

Indien je geen geluiden hoorde, kun je deze vragen overslaan en verder gaan op de volgende pagina.

Kruis het vakje aan in hoeverre het geluid in de andere kamer als onplezierig (links), neutraal (midden) of plezierig (rechts) aanvoelde.

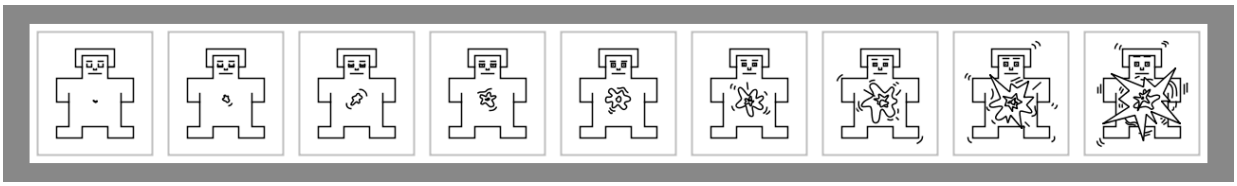
Onplezierig Neutraal Plezierig



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Kruis het vakje aan in hoeverre het geluid in de andere kamer als ontspannend (links), neutraal (midden) of gespannen (rechts) aanvoelde.

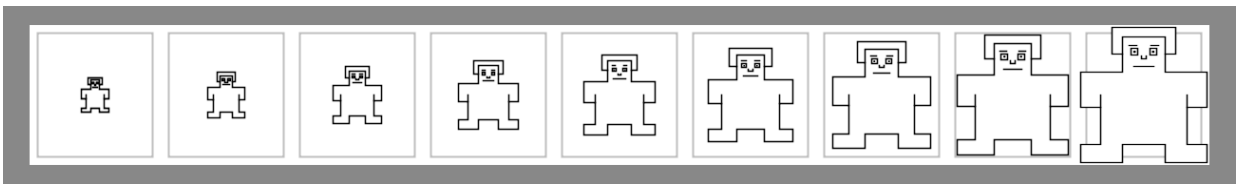
Ontspannend Neutraal Gespannen



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Kruis het vakje aan in hoeverre het geluid in de andere kamer je een gevoel van gebrek aan controle (links), neutraal (midden) of controle (rechts) in de situatie gaf.

Gebrek aan controle Neutraal In controle



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Nr.

Was je je bewust van bepaalde kleur(en) terwijl je in de andere kamer zat?

☐ nee

☐ ja, namelijk:

Hoe intens heb je kleur ervaren?

| Zwak | | Gemiddeld | | Sterk |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

Had je het idee dat kleur iets met het onderzoek te maken had?

☐ nee

☐ ja, namelijk:

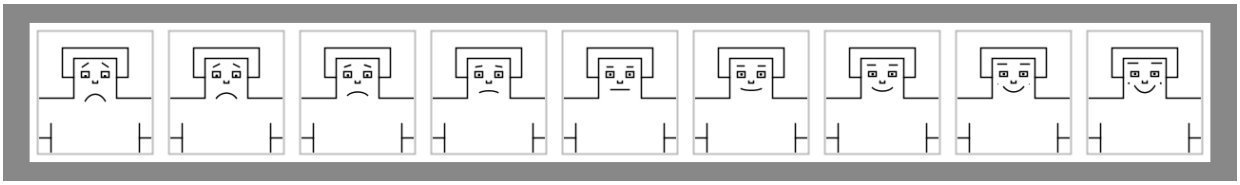
Had kleur invloed op het voorbereiden van de presentatie?

Nr. ☐

Indien je geen kleur zag, kun je deze vragen overslaan en verder gaan op de volgende pagina.

Kruis het vakje aan in hoeverre kleur in de kamer als onplezierig (links), neutraal (midden) of plezierig (rechts) aanvoelde.

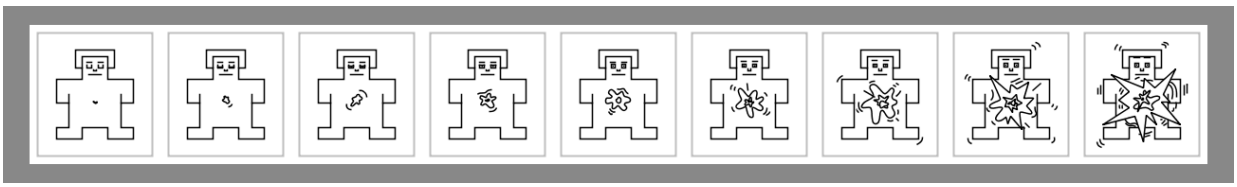
Onplezierig Neutraal Plezierig



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Kruis het vakje aan in hoeverre kleur in de kamer als ontspannend (links), neutraal (midden) of gespannen (rechts) aanvoelde.

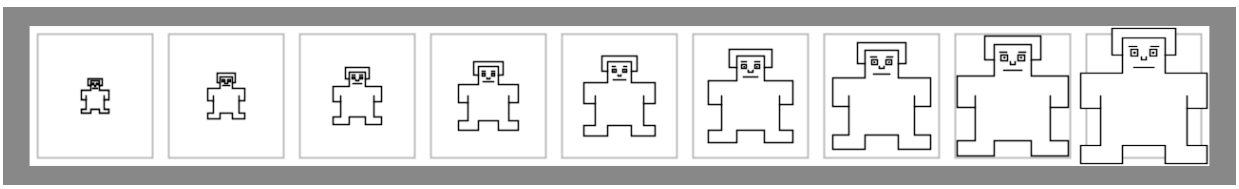
Ontspannend Neutraal Gespannen



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Kruis het vakje aan in hoeverre kleur in de andere kamer je een gevoel van gebrek aan controle (links), neutraal (midden) of controle (rechts) in de situatie gaf.

Gebrek aan controle Neutraal In controle



☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Nr. ☐

Hoe was de temperatuur terwijl je in de andere kamer zat?

| Zeer koud | | | Gemiddeld | | | Zeer warm |
|---|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Appendix 5 Nr.

Debriefing:
Je hoeft geen presentatie te geven. We hebben je dat alleen verteld om je onder stress te zetten. We onderzoeken namelijk wat het effect van rustgevende en stressvolle omgevingen is op bepaalde emoties en het stressniveau van de mens.

Had je tijdens het voorbereiden op de presentatie echt het idee dat je een presentatie moest geven?
☐ ja
☐ nee

Dacht je dat de commissieleden werkelijk tijdens de presentatie aanwezig zouden zijn?
☐ ja
☐ nee

Had je enig idee wat we probeerden te onderzoeken?
☐ ja
☐ nee

## Sociale fobie

Iedereen is wel eens verlegen of onzeker in bepaalde situaties, maar je spreekt pas van een sociale fobie als iemand door de angst niet meer goed kan functioneren in het dagelijks leven, privé en/of op het werk. Een sociale fobie is een psychische aandoening. Je ervaart vaak een angst voor een situatie die in werkelijkheid helemaal niet zo bedreigend is. Mensen met een sociale fobie zijn zich vaak bewust van hun angst.

Bij een sociale fobie ben je vooral angstig bij sociale situaties, zoals een praatje maken, spreken in het openbaar of telefoneren. Je bent meestal bang om af te gaan of bekeken te worden. Hierdoor ga je trillen, stotteren, word je rood of begin je te transpireren. Doordat je zweet of trilt kan de angst alleen maar erger worden. Vaak trekken deze symptomen weg als de situatie voorbij is.

Een sociale fobie lijkt veel op andere angstklachten, zoals een paniekstoornis. Deze twee stoornissen kunnen samengaan. Als je angstig wordt van een sociale situatie kun je bijvoorbeeld een paniekaanval krijgen.

## Depressie en eenzaamheid

Ook hebben mensen met een sociale fobie vaker dan gemiddeld last van eenzaamheid en depressies, omdat ze sociale situaties vermijden en zo langzaam steeds meer in een isolement terecht komen. Mensen met een sociale fobie hebben vaak weinig vrienden en kennissen en hebben vaak geen partner. Relatief vaak maken ze opleidingen niet af en hebben ze problemen om aan het werk te komen/blijven.

**Jeanette:**

*'Bij mij is het begonnen toen ik een jaar of 18 was. Ik was begonnen aan een opleiding tot verzorgende en ging stage lopen in een verzorgingshuis. Het omgaan met de dementerende bewoners ging nog wel, maar tussen mijn collega's wist ik me geen raad. Ik durfde geen vragen te stellen uit angst dom gevonden te worden en tijdens de lunch kwam er geen woord over mijn lippen. Ik concentreerde me vooral op mijn koffiekopje; mijn handen gingen al trillen bij de gedachte dat ik zou kunnen knoeien. Toen herkende ik de verschijnselen nog niet en ik dacht dat het vanzelf wel over zou gaan. Maar dat gebeurde niet, het werd eigenlijk alleen maar erger '*

De **sociale fobie**, ook wel **sociale angststoornis** genoemd, is een psychische aandoening. Iemand die aan deze stoornis lijdt, heeft angst, grote onzekerheid en verlegenheid voor alledaagse sociale interacties en gebeurtenissen, bijvoorbeeld feestjes, vergaderingen en soms telefoneren of boodschappen doen. Angst voor afwijzing, commentaar, kritiek, pesten en uitlachen.

Er zijn 2 subtypen van sociale fobie te onderscheiden. Ten eerste de specifieke sociale fobie. Hierbij heeft iemand vooral last van angst in één bepaalde sociale situatie, zoals bijvoorbeeld alleen bij spreken in het openbaar of optreden. Het tweede type is de gegeneraliseerde sociale fobie, waarbij mensen bang zijn in verschillende sociale situaties.

Iedereen is wel eens zenuwachtig voor een afspraakje of een feestje waarop hij of zij in de schijnwerpers komt te staan, maar dat is nog geen reden om er niet heen te gaan. Een echte sociale fobie is een overweldigende angst die in extreme gevallen zorgt dat de patiënt thuisblijft en gedurende lange periodes geïsoleerd leeft. Wie lijdt aan de sociale fobie, is overdreven bang voor beoordeling, voelt zich in de gaten gehouden en mogelijk vernederd door zijn/haar acties, gedrag of voorkomen. Mensen met de sociale fobie hebben soms ook een paniekaanval, maar ze zijn zich ervan bewust dat ze een irrationele angst ervaren. Slechts weinig mensen met de sociale fobie gaan vrijwillig naar een ziekenhuis, omdat ze bang zijn afgewezen of negatief beoordeeld te worden door gezaghebbende mensen (bijvoorbeeld de medische staf). De interactie met gezaghebbende personen is voor hen bijzonder moeilijk, net als telefoneren, afspraakjes, feestjes en sollicitatiegesprekken.

Appendix 8

Welkom bij het onderzoek “De kracht van creatieve oplossingen”

Doel van het onderzoek
In dit onderzoek zijn wij geïnteresseerd in creatief denken, en hoe creatief denken kan helpen bij sociale fobie.

Gedurende het onderzoek word je huidgeleiding gemeten dmv. twee sensoren om de wijs- en middelvinger van de niet-schrijfhand. Je zult vervolgens plaatsnemen in de onderzoekskamer waar je een aantal vragen beantwoordt en creatieve oplossingen gaat bedenken en opschrijven. Er is een camera aanwezig waarmee beeldmateriaal wordt opgenomen.

Duur en beloning
Het onderzoek zal ongeveer 30 minuten in beslag nemen waarvoor een beloning van €20,- of 1,5 research credit wordt toegekend.

Vrijwillige deelname
Deelname aan dit onderzoek is vrijwillig. Alle informatie zal strikt vertrouwelijk behandeld worden. Alle resultaten zullen anoniem verwerkt worden en enkel in het kader van het onderzoek gebruikt worden en zal niet worden verspreid aan derden. Je kunt op ieder moment om welke reden dan ook het onderzoek stopzetten en de toestemming alsnog intrekken zonder nadelige consequenties. Als je na het onderzoek nog vragen hebt kun je contact opnemen met M. Wolzak, matthijs.wolzak@tno.nl.

Ik verklaar hierbij de informatie over het onderzoek “De kracht van creatieve oplossingen” te hebben gelezen, en ga akkoord met de vrijwillige deelname.

Naam proefpersoon: _____

Handtekening: _____ Datum:

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Ik verklaar hierbij dat ik deze proefpersoon volledig heb geïnformeerd over het onderzoek.

Naam onderzoeker:_____

Handtekening: _____ Datum: