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Abstract

Connotative meaning and associations of light may present a pathway to influence emotions and behavior. In this abstract, we will describe theoretical work on cross modal associations between light and aggression. We present findings on a first empirical test of explicit associations between two characteristics of dynamic light – brightness and the rate of change in brightness – with aggression. Furthermore, we give a detailed overview of an experiment to test the implicit association between dynamic light and aggression to be performed this month.

Introduction

Aggressive incidents around bars and clubs at night are a problem in Eindhoven, and lead to great personal and social costs. When aggression occurs, a common response of the police is to turn on bright illumination to enhance visibility. Intuitively, light is associated with positivity, whereas darkness is associated with negativity. Therefore, turning on the light could have positive effects on people's behavior. However, an important aspect of turning on the light is the dynamic increase in brightness. This sudden increase in light could be associated with activity and arousal. If an increase in light is associated with an increase in activity, turning on the lights when aggression occurs could potentially have undesirable behavioral consequences.

People have the tendency to associate stimuli in one dimension (e.g., brightness) with stimuli in a second dimension (e.g., valence). We believe that such cross modal associations could also occur between aggression and light. In their seminal work Osgood and colleagues (1957) examined cross modal associations between concrete and conceptual dimensions. They developed the affective meaning theory, which holds that people evaluate the meaning of concepts on three features: Evaluation (good-bad), Activity (active-passive) and Potency (strong-weak). Words have different factor loadings on these semantic scales (E, A, P). These features can vary in dominance: GOOD is for example E-dominant, but STRONG is P-dominant. Furthermore, Osgood et al. suggest parallel polarity: when connecting different concepts, the diverse dimensions are related in parallel, positive endpoint with positive endpoint, and negative endpoint with negative endpoint. The parallel polarity predicts that GOOD and STRONG are related because they are both associated with positive polar endpoints on their dominant dimension.

According to a parallel polarity account an association between aggression and brightness is not likely to emerge. Anger and White have opposite loadings on the Evaluation dimension, and we could therefore expect that people evaluate WHITE as CALM instead of AGGRESSIVE. Indeed, Adams and Osgood (1973) found that people, across 23 cultures, associate white with positivity, low potency and moderate activity. Black on the other hand is bad, strong and passive. Research has repeatedly confirmed the association of white with positivity and black with negativity (Meier, Robinson, Crawford, & Ahlvers, 2007; Meier, Robinson, & Clore, 2004; Lakens, Fockenberg, Lemmens, Ham, & Midden, 2013; Sherman & Clore, 2009).

However, it might be important to differentiate between achromatic brightness differences (white vs. black) and luminous brightness differences (bright vs. dark). Most studies have examined white-black difference. Dynamic luminous intensity differences have rarely, if ever, been used as stimuli in such cross-modal matching tasks. The dynamic nature of a light stimulus could

affect which dimension is salient. For example, Eitan, Schupak, and Gotler (2013) found that cross modal associations between pitch and size can change depending on whether the stimuli are dynamic or static. Counterintuitively, they found that whereas people associate a high static pitch with a small object, and a low static pitch with a large object, when pitch dynamically rises, the object grows rather than shrinks. Therefore, when light is turned on, it could be that the *increase* in light changes the salient dimension. Instead of associating an increasing light with the Evaluation dimension, the Activity dimension might become salient.

Based on this line of reasoning, we predict that, when stimuli are static, people are likely to associate white with positivity and black with negativity on the Evaluation dimension. Because of the salience of the Evaluation dimension, black is more likely to be associated with aggression, whereas white is associated with calmness. Furthermore, people will associate an increase or decrease in achromatic brightness with the Activity dimension, and perhaps more so as the rate of change increases. Depending on the relative salience of the features brightness and rate of change of brightness, dynamic brightness may be associated with a decrease or an increase in aggression.

To investigate this, we have planned 2 studies. The present paper reports the results of Study 1, examining the effects of dynamic achromatic brightness on explicit associations. In addition, we will describe the planned Study 2, exploring implicit associations. Furthermore, follow-up studies will use luminous intensity (light vs. dark) allowing us to compare different brightness manipulations.

Study 1 Method

In this first study, we explicitly asked participants how they perceived static and dynamically changing screen brightness. Twenty university students (14 males) volunteered to take part in this experiment, which followed a 2 (target color: white vs. black) x 5 (rate of change: static vs. changing in 2040 ms, vs. 1020 ms, vs. 510 ms, and 255 ms) within groups design. The experimental stimuli consisted of a set of 16 short animations in which the entire screen changed in brightness, and 3 static stimuli (white, perfect grey, and black). The increasing white stimuli increased in brightness from 0 to 255 (the maximal brightness), gradually over time. The decreasing black stimuli decreased in brightness from 255 (white) to 0 (black), the decreasing grey stimuli from 128 (grey) to 0, and the increasing grey stimuli from 128 to 255 in brightness. The animations varied in rate of change and in brightness starting points (i.e. black, white and grey). After each animation, participants answered on a 9-point Likert scale how negative/positive, passive/active, weak/powerful, and calm/aggressive they thought the animation was. In view of space considerations, we only report the black-white stimuli in this manuscript.

Procedure

Participants were approached in the lunch facility of the Eindhoven University of Technology. They completed the experiment in an Authorware questionnaire on the experimenter's laptop.

Results

To investigate the associations people have with static white, we conducted a paired samples *t*-test. Paired samples *t*-test showed that static white (M = 6.30, SD = 1.56) is perceived as more positive compared to black (M = 3.50, SD = 1.76), $t(19) = 4.35$, $p < .001$, and less aggressive compared to black, $t(19) = 1.94$, $p = .07$. Means and standard deviations of the scores on Aggression for the different speeds are shown in Figure 1. There were no significant differences between black and white for the scores on potency and activity.

To investigate our hypothesis that people associate dynamic brightness with the Activity dimension as well as the Evaluation dimension, we conducted a linear mixed model with participants as random intercept, and Target color (i.e., towards black or towards white) and Rate of change (i.e.,

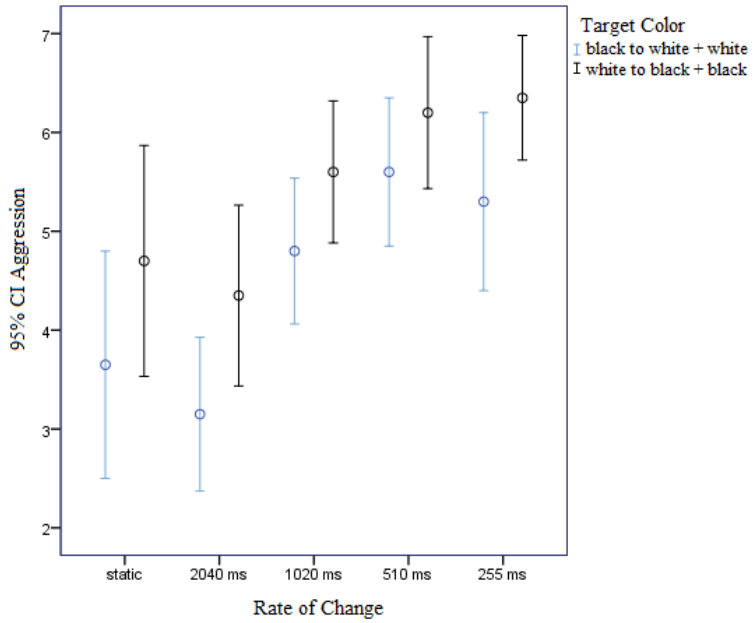

Fig. 1: means and standard deviations for Aggression scores for the Rate of change.

Tab. 1: Numerator df, Denominator df, and F value of the main effects of Target color and Rate of change on Aggression, Evaluation, Activity and Potency.

	Aggression		Evaluation		Activity		Potency	
	df	*F*	df	*F*	df	*F*	df	*F*
Target color	-1,18	14.44**	-1,2	93.01**	-1,18	0.525	-1,18	.99
Rate of change	-4,18	12.32**	-4,2	1.68	-4,18	33.33**	-4,18	3.91*

Note: *p<.01, **p<.001

static, 2040 ms, 1020 ms, 510 ms and 255 ms) as fixed factors.

First, in 4 separate models, we included aggression, evaluation, activity and potency as dependent measures (for results; see Table 1). The main effect of Target color was significant for Evaluation, and the main effect of Rate of change was significant for Activity and Potency. Both effects of Target color and Rate of change were significant for Aggression.

Second, we tested whether Activity and Evaluation mediated the main effects of Target Color and Rate of change on Aggression[1]. Specifically, we tested the model with Aggression as dependent measure, Rate of change and Target color as fixed factors, and Positivity and Activity as covariates. The results showed significant effects of both covariates: Activity (F (1, 200) = 84.18, p < .001) and Evaluation (F (1, 200) = 29, 37, p < .001). The main effect of Rate of change decreased, yet still remained significant (F (4, 200) = 6.24, p < .001). The main effect of Target color disappeared, F (1, 200) = .12, p= .73. Analyses[2] suggest that Evaluation fully mediates the effect of Target color, and Activity (partially) mediates the effect of Rate of change. Data for the grey stimuli revealed a similar pattern.[3]

Discussion

The results suggest that both the Evaluation and Activity dimension may become salient when people evaluate dynamic chromatic brightness, and therefore

[1] Due to large correlations between Potency and Activity, we excluded Potency from the model.

[2] Not fully reported for space considerations.

[3] Not fully reported for space considerations.

an association between brightness and aggression emerges for rapidly changing brightness, even if it becomes lighter. The main effects of Target color and Rate of change on Aggression are mediated by Positivity and Activity, with Activity being the strongest predictor. These results suggest that fast color transitions are not perceived as more negative, but mainly as more active and therefore as more aggressive. The target brightness (white vs. black), also contributes to the association, yet only modestly in comparison the stimulus' rate of change.

Study 2

In study 1, we explicitly asked people for their associations. In Study 2, we investigate implicit associations with brightness and the rate of change in brightness. Employing an implicit association test, we will test the hypothesis that a fast increase in achromatic brightness will affect the saliency of the dimension on which people evaluate the stimulus – activity becoming more salient than positivity - which will make the association with aggression more likely.

We will conduct two Implicit Association Tests. First we test, within subjects, whether people associate white and black stimuli with valence or activity. The stimuli will consist of words related to aggression and calmness and brightness stimuli (i.e. white and black filled squares). Participants will categorize the word stimuli and light stimuli into categories (i.e. aggressive, calm, brighter, and darker). In the second IAT we will use dynamic achromatic stimuli: participants will categorize increasing and decreasing brightness stimuli (i.e. squares which rapidly change from black to white, and from white to black). We expect that the response times will be the smallest when the stimuli are congruent (i.e. aggressive with black, calmness with white; aggressive with increasing white and calmness with decreasing white).

In a second series of studies we plan to replicate the studies with actual light (LED-based) stimuli instead of screen-based stimuli. This is relevant as pilot studies indicate brightness may be more explicitly associated with activity for light than for color. We also hope to be able to present these findings at the conference.

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