COLOR AND EMOTION

A Study on the Affective Judgment of Color

Across Media and in Relation to Visual Stimuli

Inauguraldissertation zur Erlangung des akademischen Grades eines Doktors der Sozialwissenschaften der Universität Mannheim

vorgelegt von

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To my parents and the Horpàcsy family

Ehrenwörtliche Erklärung

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ABSTRACT

Four experiments were carried out to describe emotional responses to color and to analyze the relationship between color attributes and emotional dimensions. Conceptualization and measurement systems of emotion were discussed and emotional responses to colors were assessed in terms of valence, arousal, and dominance dimensions (Mehrabian, 1978; Osgood, Suci, & Tannenbaum, 1957), using Self Assessment Manikin (SAM) (Lang, 1980). The patterns of affective judgment were presented according to hue, Chroma, and lightness. Chroma was positively correlated with each of the three emotional dimensions in all experiments. In order to account for the cognitive quantity of color, stimuli were selected following hue and tone categorizations and based on the CIELab Lch system. Empirical evidence indicates that emotional responses to color vary more strongly with regard to tone than to hue categories. Moreover, the influence of the presentation medium on emotional response to color was investigated by presenting colors either on DIN A5-size paper or on CRT monitors. Utilizing the empirical results, a practical application tool was suggested for marketing purposes.

In addition, emotional response to color was examined in a cross-modality stimulus context. Other than colors, modalities of visual stimulus, such as pictures selected from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2005), film-clips, and adjectives were employed as background stimuli. Context effect was investigated by comparison to prior results and the emotional response to colors in arousal shifted significantly toward less excited. Judgmental shifts of affectivity of background stimuli were also analyzed. Furthermore, the process of affective judgment of colors was debated and future studies were proposed.

Keywords: Color, Emotion, Affective judgment, Self-Assessment-Manikin (SAM), Hue and Tone Categorization, CIELab Lch system, Film-clips, Product-color scheme, Context effect

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감사의 마음을 전하며

결코 짧지 않았던 학위 연구 기간 동안 너무나 많은 분들의 도움을 받았습니다.

사랑하는 부모님, 여동생 상은이와 제부, 남동생 상도, 이어텔 지도교수님, 헤르만 교수님, 폴 교수님, 호르파치님 가족, 카울링님 가족, 로테르담의 최부장님 가족, 단짝 라리사, 친구 니나와 산드라, 연구실 후배 안나와 파트릭, 슐레겔 교수님, 이건표 교수님, 권은숙 교수님, 김유진 교수, 이경재 연구원, 로레알 연구소 와나타베님, 옛 직장 동료 크리스티앙과 회계사 볼프가튼 아주머니, 월간 디자인 편집팀, 경남과학고 동기들, 싸이월드 1 촌 친구들, MSN 메신저 친구들, 네로&비앙카 컬렉션의 거래처 사장님들과 제품을 구매해주신 분들, 그랑포레의 정사장님, 중국의 김사장님, 그리고 4+3 개의 색채 실험에 참가해 주신 분들께 감사의 마음을 전합니다.

더불어, 저의 창작에 대한 열정을 일깨워 주신 분들을 떠올려 봅니다.

…시인 고은님, 소설가 박완서님, 서예가 정도준님, 오페라 감독 호르파치, 작곡가 카를로, 친구 권재원, 어머니이신 교사 송진련님, 그리고 저의 글과 그림, 디자인을 사랑해 주신 분들…

이 논문 또한 제 안에서 일어나는 느낌과 생각, 논리를 표현한 창작물이되, 그저 표현 양식과 기법에 작은 차이가 있었던 것은 아닐런지요.

'감사의 마음을 전하며' 어떻게 하면 이 감사의 마음을 단지 마음 내는 것으로 그치지 않고 행동으로 옮길 수 있을지 생각해 보았습니다. 창작을 하면서 느낄 수 있는 기쁨을 많은 사람들과 공유하고 싶습니다. 이것이 많은 사람들에게 제가 드릴 수 있는 가장 큰 보답이 아닐까 생각합니다.

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1. INTRODUCTION

1.1 BACKGROUND

Color is considered to be the most salient, resonant, and meaningful visual feature of those seen in early vision (Arnheim, 1956; Albers, 1963; Hilbert, 1987). This makes color a compelling visual cue for persuasive communication purposes such as conferring identity, meaning, or novelty to an object or idea (Garber & Hyatt, 2003, p. 313). Color contributes to the appreciation of and preference for products and plays an essential communication role, improving the efficacy of messages and increasing the likelihood of purchase (Birren, 1945; Hine, 1995; Lee, 2002; Miller & Kahn, 2002).

Due to recent technological developments, the use of color has been relieved from prior technical limitations to be expressed on various types of medium. Therefore, growing interest has centered on whether color may or may not communicate the emotions as intended. In view of the foregoing, much concern has derived on research on color affectivity, not only in psychology, but also in design, marketing, and fine arts. Emotional response to color has indeed been investigated in multiple disciplines. Although researchers generally agree on the fact that color elicits human emotions two diverging conceptualizations of emotion have emerged: either discrete (e.g. Jacobs & Suess, 1975; Lüscher, 1971) or dimensional (e.g. Adams & Osgood, 1973; Valdez & Mehrabian, 1994). Many empirical studies employed colors as stimuli but the issue of color perception as such and its characteristics have seldom been addressed. Basic colors were frequently used as independent variables, and consensual results associated with primary emotions prevail in existing literature. However, this method has no straightforward application.

Recent studies on color affectivity characterize emotional profiles of color in terms of emotional dimensions, thus approaching the issue of emotional influence of color attributes (i.e. Simmons, 2006; Valdez et al., 1994). In addition, the significant influence of Chroma (or saturation) of a color onto human emotions has been consistently confirmed, thus criticizing the color synesthesia of hue-based color categorizations and primary emotions (Valdez et al., 1994).

On the other side, in empirical studies on color and emotion, the stimulus context has always been dedicated to color, which seems rather far from reality. Such limitations may weaken the relevance of the results of empirical studies on the impact of color on emotional reaction. Thus, it is necessary to investigate color affectivity not only within colors, but also in relation to other modalities of stimulus.

1.2 GOALS AND CONTENTS

The foremost purpose of this dissertation is to describe emotional responses to colors in terms of three dimensions of emotion and to analyze the relationship between color attributes and emotional dimensions. Experiments are conveyed in various media and stimulus contexts, whose effects are investigated accordingly. Based on those experiments, a method for the development of a product-color scheme is suggested as a practical application tool for marketing purposes.

The dissertation is comprised of five major steps:

• Chapter 2

Firstly, the literature on human emotion is reviewed. Cognitive as well as non cognitive processes of emotion are described and two approaches of emotional conceptualization are discussed: discrete (Ekman, 1984; Fehr & Russell, 1984; Russell, 1990) versus dimensional *(valence, arousal, and dominance)* approach (Mehrabian & Russell, 1974; ; Osgood, Suci, & Tannenbaum, 1957). Three emotion response systems are explained and the dimensional measurement of emotional responses is advocated. A pictorial construct to represent three-dimensional emotion is introduced: Self Assessment Manikins (SAM) (Lang, 1980). Applied studies on the assessment of emotions elicited from various stimuli are summarized (e.g. IAPS, Lang, Bradley, & Cuthbert, 2005). Affective equilibrium as motivated behavior driven by emotion is discussed.

• Chapter 3

Secondly, aspects of viewing color are described and studies on color in mediated presentation are reviewed. The conceptualization of affectivity of color is discussed from the two perspectives: synesthesia (discrete) and interaction between color and emotion (dimensional). Emotion response systems for the measurement of affective judgment of color are discussed. Issues of color and emotion in practice are raised and methodological problems of practice based color research are pointed out. An outline for the development of a product-color scheme is suggested.

• Chapter 4

Thirdly, based on theories about emotion and color, Experiment I is carried out. The empirical study employs 43 digital colors and shows that affectivity of color can be described by valence and arousal of multi-dimensional emotions. A set of stimuli, including colors, pictures, and adjectives, is assessed with SAM and the emotional responses thereof are analyzed. Simultaneously, an identical experiment is conducted in South Korea with 17 subjects and the results are compared with those obtained from the German subjects. As a practical application tool for marketing purposes, a methodology to develop a product-color scheme is suggested.

• Chapter 5 and Chapter 6

Fourthly, the media effect between surface color and digital color was investigated in Experiments II and III respectively. In both experiments, color attributes are categorized according to their cognitive quantity. Five hue categories and five tone categories were introduced. The relationship between color attributes and emotional responses is analyzed. In addition to valence and arousal, dominance is proven to describe emotional responses to colors. The affective judgments of color stimuli are measured using the SAM system. All color stimuli employed in the experiments are selected from the CIELab Lch system, in which color attributes are identified with hue, Chroma, and lightness.

• Chapter 7

Lastly, since context effect influences affective judgment, emotional responses to colors are examined in relation to more complex visual stimuli. Literature on context effect (Marks, 1992), such as anchor effect (Haubensak, 1985), adaptation level theory (Helson, 1964), and judgmental shift (Russell & Fehr, 1987) is reviewed.

A Preliminary Test is conducted with 19 film-clips and nine of them are selected for Experiment IV. During the Preliminary Test, a judgmental shift of a color stimulus is presumed. In Experiment IV, 17 colors are presented among other visual stimulus modalities: nine film-clips, four achromatic pictures, four chromatic pictures, and nine adjectives. The displacement of affective judgments of colors in cross-modality stimulus context is investigated by comparing with results from previous (baseline) experiments. The affective judgment of colors is analyzed both within the modality and between other visual modalities.

• Chapter 8

Finally, empirical evidence and analyses from the series of experiments are summarized. Some insights into current research topics are discussed and concepts for future research are suggested.

1.3 HYPOTHESES

Eleven hypotheses are formulated and they are grouped into three themes. Each hypothesis is tagged after the related statement.

● Hypothesis group I: color as elicitor of emotion

Color stimuli are assessed with SAM in four experiments. After each experiment is conveyed, alpha internal consistency-reliability coefficients provide evidence of levels of internal consistency for the three dependent measures of emotion: valence, arousal, and dominance; respectively [H. 1], [H. 3], and [H. 6]. Color stimuli are displayed on CRT monitors in Experiments I, III, and IV, and they are presented on DIN A5-size color sheets in Experiment II. Thus, the influence of differences in media is examined [H. 7].

● Hypothesis group II: color attributes and emotional responses

The relationship between color attributes and dimensions of emotion are analyzed. It is hypothesized that emotional responses to color vary more strongly with regard to Chroma and lightness than regard to hue [H. 2]. In order to address cognitive quantity of color perception, a tone categorization is adequate [H. 5]. Different gray nuances are examined to verify, whether they influence on affective judgments on grays [H. 6].

● Hypothesis group III: context effect on emotional responses to colors

In the series of experiments, various visual stimulus modalities such as colors, pictures, adjectives, and film-clips are employed to elicit emotions. Since each modality of stimulus is associated with a different intensity of semantic contents, anchor effect between stimulus modalities should be observed [H. 9]. Stimuli with higher intensity of semantic contents define the perceptive reference field of emotion and negative distance effect occurs to those with lower intensity of semantic contents. Accordingly, the reference field of affective judgment of color, the target stimulus, is hypothesized to shrink.

Nevertheless, the pattern of emotional responses within the stimulus type remains [H. 10]. On the other side, adjectives as verbal stimuli, distinguished from the other pictorial stimuli are little influenced by context effects [H. 11].

2. EMOTIONAL RESPONSE

2.1 TERMINOLOGICAL ISSUES OF EMOTION

2.1.1 Definitions of emotion

"Everyone knows what an emotion is, until asked to give a definition."

- Fehr et al. (1984, p. 464)

The role of moods, emotions, and related phenomena in human cognition and behavior has received more attention, since the early 1980s, every time more attention (Schwarz & Clore, 1996). Various terminological distinctions between feelings, affect, emotion, and mood have been offered, but nevertheless emotion is often easily confused with feeling in common speech.

Kleinginna and Kleinginna (1981) tried to arrange 100 definitions of emotion according to a systematic order and found that two thirds of these were developed after 1970. This development reflects an increasing interest in the subject of emotion, instead of a convergence of the concept. Kleinginna et al. concluded to define emotion as: "a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can, firstly, give rise to affective experiences such as feelings of arousal, pleasure/displeasure; secondly, generate cognitive processes such as emotionally relevant perceptual effects, appraisals, labeling processes; thirdly, activate widespread physiological adjustments to the arousing conditions; and lastly, lead to behavior that is often, but not always, expressive, goal-directed, and adaptive" (p. 355).

Clore, Ortony, and Foss (1987) analyzed a set of approximately 500 words taken from the literature on emotion and developed a taxonomy of the affective lexicon, with special attention to terms referring to emotions. Lazarus (1991b) conceptualized the topic of emotion appears differently from the point of view of each of four field perspectives. Those perspectives are: the individual, the observer, the society, and the biological species and all four viewpoints are essential to a thorough understanding of emotions.

Resuming this, emotions could be defined as the result of the cognitive judgment of transactions between individuals and the environment in general (Clore et al., 1987; Mehrabian et al., 1974). In fact the terminological issue of emotion deals not only with the definition of emotion, but also with the matter of distinguishing it from other synonyms, which are often used in common language. In the following section a hierarchical work by Clore (1992) that illustrates an apex over the terms is presented.

2.1.2 Feelings, moods, and emotions

Clore (1992) composed a hierarchy of human feelings, as shown in Figure 1. Three broad classes of feelings can be distinguished in terms of the information they provide: **bodily** feelings, such as hunger or pain; **affective** feelings, such as happiness, sadness or fear; and feelings associated with **knowledge** (**cognitive** feelings), such as feelings of familiarity, confusion, or amazement. Among those three, the affective feelings reflect appraisals of situations with respect to the individual's goal and concerns. Affect is sometimes used as a synonym for emotion but can also refer to valence: the positive and negative aspects of things (Schwarz et al., 1996). Clore's work, in fact, elaborates the definition of Arnold (1960) which considers emotions as consequences of ongoing, implicit appraisals of situations with respect to positive or negative implications for goals and concerns.

According to Figure 1, all emotions are affective, but not all affective things are emotions. Moreover, affective **state** differs from affective **trait**. Preferences and attitudes, for example, may be thought of as affective traits, while emotions are affective states.

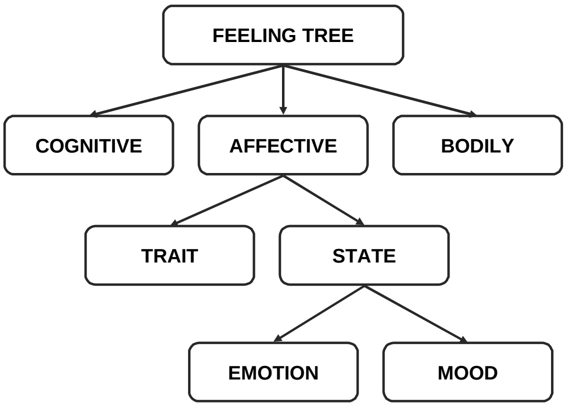


Figure 1. Feeling tree, Clore (1992) p. 159.

In the study of Clore et al. (1987), emotions are characterized as "internal mental states focused on affect", which is illustrated in the feeling tree, yet does not distinguish emotion from **mood**. Averill (1980: quoted in Schwarz et al, 1996) noted that emotions require an object while moods do not. Thus, mood generally refers to the state itself, while emotion refers to both the feelings and what those feelings are about. Schwarz et al.

(1996) added that the prototypical emotion, contrary to mood, is assumed to have an identifiable referent (what the emotion is "about"). Watson (2000) replicated this distinction. Compared to an emotion, a mood is a longer and slower moving state, which is less tied to specific objects or elicitors.

Although Clore (1992) distinguishes emotion from bodily feeling, studies have generally agreed that sensorial processes produce emotions, through feedback from muscular, visceral, and organic activities (Helson, 1964). Duffy (1948) saw emotion arising from changes in basic physiological patterns of response. It refers to emotion in terms of the way in which energy in the organism is mobilized toward action. Thus, feelings are interacting across cognition, affectivity, and physiology (bodily feeling). Nevertheless, Clore's hierarchical work provides an overview of feeling-related terms. The term emotion, is distinguished from other affective concepts in this dissertation.

2.2 EMOTIONAL PROCESS

Within the view discussed, cognitive causes may be seen as essential for emotion. Debate regarding whether or not cognitive appraisal is responsible for emotion is, however, still going on. Those two aspects are discussed:

2.2.1 Cognitive emotional process

The cognitive activity that leads to emotions results in a distinctive experiential state (Clore, 1992), thus containing emotion itself a process of perception. Variables from the surrounding provide input for emotional experience and the individual behavior is produced as output. Individuals differentiate the process based on their own way of interpretation of the input.

Ekman (1984) stated that in automatic appraisal an event is instantly matched with one of the **prototypic situations**. This assertion was later confirmed in Shaver, Schwartz, Kirson, & O'Connor (1987). It explained that conceptualization of **prototypical emotions** begins with the appraisals of the way emotions bear on a person's motives, goals, values, or desires. According to the authors, emotion implicates subjects' account of self and typical emotion episodes. More precisely, Fischer, Brauns, and Belschak (2002) illustrated an input-output system of emotional process, which consists of three steps: (a) input, (b) appraisal, and (c) output (Figure 2).

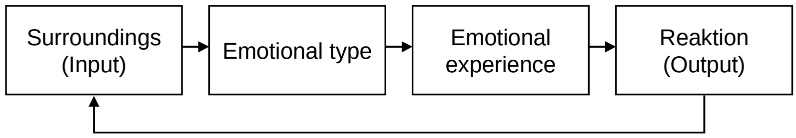


Figure 2. The input-output system of emotional process, Fischer et al. (2002) p. 43.

(a) Input: A person reacts within the context of his or her interest and size of stimuli. The type of the emotion is then defined. The system of the emotional process emphasizes the importance of immediate experience because it is a distinctive aspect of emotion that they are experienced (Fischer et al., 2002).

(b) Appraisal: Based on this assertion, one evaluates the emotional experience and a reaction is generated, which may affect context in return. Concerning the input of the emotional process, Schachter and Singer (1962) documented that cognitive appraisals are sufficient to determine the quality of an emotional experience. It showed that, although there are physiological bases to emotional experiences, attributions of a reason for the experience influence perceptions of the quality of the experience. Lazarus (1984) supported this notion with the argument of the primacy of cognition, claiming that it is cognitive assessment that produces emotional reactions. Cognitive appraisal of a situation, according to Lazarus, determines the intensity of emotional experiences.

(c) Output: Hamm & Vaitl (1993) suggested that there are three manifesting indications for the output of an emotional process: verbal expressions about subjective experiences; motor activity or expression such as mimic, gesture, or sounds; and vegetative changes controlled by the autonomous nerve system. Dealing with measurements of the output, emotion response systems are also categorized into those three in general: experience, behavior, and physiology. Once experienced, emotion returns to the cognitive process as input surroundings or to affect appraisal.

2.2.2 Non cognitive emotional process

Contrary to the appraisal theory during the cognitive process of emotion (Lazarus, 1984), Zajonc (1980) claimed that, 'preferences need no inferences'. It views emotion as being independent of cognition and as an immediate physiological and psychological response to stimuli. Zajonc maintained that one can come to like something, or even develop pleasant feelings, without the intervention of cognition.

There are, however, heated debates objecting to Zajonc's clear separation of emotion and cognition. A growing number of researchers believe that the appraisal perspective cannot account for all "emotion related" phenomena (Berkowitz, 2000). Moreover, recent studies agreed that the dispute here is largely about how one defines cognition and emotion. Berkowitz (2000) explained Zajonc's meaning of emotion is broad, encompassing affective preferences and general feelings of pleasure and displeasure. It added that the appraisal process is relevant only for those emotional states whose cause is salient to the people experiencing it.

Earlier, Helson (1964) argued that emotional states are primary and the perceptual states secondary, even if it basically accepted that the cognitive process is primarily responsible for emotional states. As a possible resolution, it is granted that affectivity and the cognitive process interact to generate emotional states (Berkowitz, 2000; Helson, 1964).

2.3 CONCEPTUALIZING EMOTION

In studies of emotion, there are two primary theoretical frameworks. One conceptualizes emotion discretely and the other regards emotion as a dimensional construct. Both are reviewed in the following.

2.3.1 Discrete approach

Many emotion theorists have claimed that there is a set of basic emotions. Although the term, 'basic' supposedly points to underlying biological substrates, the prototype theory suggests that it concerns the most salient and frequently used categories (Ekman, 1984). Thus, emotional terms used in the discrete approach occupy the basic level of categorization of emotion (Shaver et al. 1987). This approach thus deals with basic emotions and is considered as a qualitative approach by Russell et al. (1987).

In recent years, many studies using the discrete approach tried to suggest a framework for mapping out people's knowledge about emotions. They indicated that the emotion domain might fruitfully be analyzed from a prototype perspective. Shaver et al. (1987), for example, explored the hierarchical organization of emotion concepts and specified the prototypes of five basic emotions: fear, sadness, anger, joy, and love. Its cluster analysis of emotion-similarity-sorts produced a multilevel hierarchy. The top level distinguishes positive from negative emotions and the middle level distinguishes between love, joy, surprise, anger, sadness, and fear. An analysis of emotion based on the discrete approach may produce generalizations about the cognitive representation of emotion episodes, which is its major advantage.

In addition, Fehr et al. (1984) and Russell (1990) supported the discrete approach to conceptualize emotion, since the prototype theory provides insights into other concepts central to psychology, including behavioral act, personality trait, intelligence, social situation, and environmental setting. A prototyped emotion can easily predict how readily it comes to mind when one is asked about one's emotion.

The prototype analyses of emotions depict a hierarchy. At the topmost or super-ordinate level is the word emotion. The middle level, emotion is divided into fear, anger, sadness, happiness, disgust, and so on. Many of the categories at this level may be further divided, forming subordinate levels. Anger, for instance, is divided into rage, wrath, annoyance, etc. According to the classical view, there exist a set number of categories at each level of the hierarchy. Thus, on some versions the categories at a given level are mutually exclusive. Fear and anger could occur simultaneously, but no emotion is both fear and anger.

Nevertheless, the discrete approach has still unresolved issues. Lang (1980) criticized the way emotions are described with adjectives. It noted that the appropriate adjectives to describe emotion are myriad, and that the linguistic distinctions that between emotions are various and subtle. Russell (1990) pointed out that the classical approach has yet to yield commonly agreed-on definitions for the prototypes of emotion. Pertaining to the definitions of emotional terms, some studies demonstrated that the boundaries between prototypes of emotion are blurry (Russell & Fehr, 1989). Moreover, prototype analyses of emotion lexicons other than that of the English language should be carried out.

2.3.2 Dimensional approach

The approach of dimensional constructs of emotion provides a common frame of reference for the operation of outer and inner factors in perception. Major dimensions could summarize the connotative meaning of objects and concepts adequately. Thus, the variety of emotions that can be experienced by humans constitutes a challenge for psychologists who attempt to reveal their basic structure (Helson, 1964).

Dimensional views of emotion have been advocated and applied by a large number of researchers through the years (Bentler, 1996; Hamm et al., 1993; Mehrabian et al., 1974; Michotte, 1950; Sokolov & Bouscein, 2000). Russell et al. (1987) refers to the dimensional approach as qualitative approach, setting it apart from the quantitative (or discrete) approach.

One effort at organizing the semantic space of emotions was prompted by the work of Osgood et al. (1957). It proposed a three-dimensional approach, utilizing factor analyses to organize emotions through the semantic differential. A wide variety of verbal judgments indicated that variances in emotional assessments are accounted for by three major dimensions: The two primary dimensions are an affective **evaluation** factor (e.g. pleasant versus unpleasant) and an **activity** factor (e.g. active versus passive). A third, less strongly related dimension is called **potency** factor (e.g. strong versus weak).

Following Osgood's lead, Mehrabian (1972) suggested that these three judgment factors are related to three fundamental emotion responses, which he labeled as **pleasure, arousal,** and **dominance** (acronym: PAD theory; Mehrabian (1978)). It further suggested that most other feelings and connotative needs can be described as combinations of these basic factors. In addition, the same or similar factors are obtained from factor-analytic studies of social cues that include postures, body positions, facial and vocal expressions, gestures, and movements.
In a series of experiments using his own semantic differential scales, Mehrabian et al. (1974) studied subjects' responses to a variety of situations. In the study, subjects were asked to "define" emotion-denoting terms directly by means of semantic differential-type scales with regard to pleasure, arousal, and dominance. Factor analyses confirmed the relative independence of the three proposed dimensions. Other correlational investigations suggested that values obtained for this triad of factors provided stable descriptions.

Valdez et al. (1994) dichotomized each dimension of PAD: pleasure (+) versus displeasure (-), arousal (+) versus non-arousal (-), and dominance (+) versus submissiveness (-) (see Table 1). It presented emotional terms according to 2P × 2A × 2D categories (p. 395). Terms were originally derived from ratings of 240 emotions on the PAD scales (Mehrabian, 1978; Russell & Mehrabian, 1977).

The considerable evidence gathered with the semantic differential shows that these three dimensions adequately describe emotional responses to all types of stimuli. The three fundamental dimensions of emotion are defined by: **valence** (interchangeable with 'evaluation' (Osgood et al., 1957) or 'pleasure'

(Mehrabian, 1972)), **arousal** (interchangeable with ‘activity’ (Osgood et al., 1957)), and **dominance** (interchangeable with ‘potency’ (Osgood et al., 1957)) in this dissertation.

dichotomization of each dimension			terms of emotional states
pleasure	arousal	dominance	
+	+	+	admired, bold, creative, powerful, vigorous
+	+	–	amazed, awed, fascinated, impressed, infatuated
+	–	+	comfortable, leisurely, relaxed, satisfied, unperturbed
+	–	–	consoled, docile, protected, sleepy, tranquilized
–	+	+	antagonistic, belligerent, cruel, hateful, hostile
–	+	–	bewildered, distressed, humiliated, in pain, upset
–	–	+	disdainful, indifferent, selfish-uninterested, uncaring, unconcerned
–	–	–	bored, depressed, dull, lonely, sad

Table 1. Categorization of emotional terms (Valdez et al., 1994, p. 395).

2.3.2.1 Dimension 1: valence

The fundamental roles of **approach** and **avoidance** (or withdrawal) are discussed in widely different areas of psychology. Helson (1964) noted that approach versus avoidance responses were primitive forms of categorizing since they served to dichotomize objects into positive and negative classes (p.66). Bentler (1969) agreed to Helson’s view of the bipolarity of behavior. It described the positive and negative scale as a continuum ranging from extreme pain or unhappiness at one end to extreme happiness or ecstasy at the other. It added that approach and avoidance do not need to be all-or-none responses but could vary in degrees of acceptance or rejection. This implies the relevant utility of a valence dimension to conceptualize emotion.

Carver and Scheier (2003) found that the affective valences, which might potentially arise regarding any given action domain and the action, should fall along a bipolar dimension. That is, for any given action, emotion can be positive, neutral, or negative, depending on how well or poorly the action is carried out.

Mackintosh and Mathews (2003) manifested emotional valence by comparing it to the two dimensions, indicating valence as the single most important attribute of a stimulus event.

2.3.2.2 Dimension 2: arousal

Bentler (1969) described arousal as ranging from sleep through intermediate states of drowsiness and alertness, to frenzied excitement. So far, many empirical studies provided evidence that arousal must be defined as independently varying dimension from valence, emphasizing that arousal obviously describes other properties of emotion of a given action. (Hamm et al., 1993; Russell et al., 1977).
In fact, a crucial assumption of the semantic space used by Osgood and his colleagues is bipolar, which explains that each dimension is represented by polar oppositional terms, usually antonyms (Osgood et al, 1957).

Green and Goldfried (1965), however, criticized this assertion. Many adjectival dimensions could not reasonably be considered as bipolar. For example, the “loneliness” continuum is a uni-polar continuum possessing no reasonable opposite. The continuum may indicate the degree of activity from “not-activated” to “extremely-activated” Although it is agreeable to account for the arousal dimension as being uni-polar, arousal is, in general, considered as a bi-polar dimension in emotion studies (i.e. Bradley & Lang, 1999; Bradley & Lang, 2000; Hamm et al., 1993; Lang, 1980; Lang et al., 1999; Valdez et al., 1994)

2.3.2.3 Dimension 3: dominance

Dominance ranges from feelings of total lack of control of or influence on events and surroundings to the opposite extreme of feeling influential and in control (Bentler, 1969).
Some studies do not take the dimension of dominance into consideration (i.e. Bradley et al., 2000; Morris, 1995; Russell et al., 1987), even though they basically agree with the idea of a three dimensional structure of emotion suggested in the study of Osgood et al. (1957). It showed dominance appears much weaker than the other two dimensions, and is positively correlated with the valence dimension (Bradley & Lang, 1994; Hamm et al., 1993).

Nevertheless, Shaver et al. (1987) advocated using all three dimensions in research on emotion. It used multi-dimensional analyses to study 135 emotion terms, and its results corroborated the three-dimensional approach. The work obtained two-dimensional (evaluation and intensity) and three-dimensional (evaluation, activity, and potency) solutions. However, it claimed the three-dimensional representation of affect to be more informative than the two-dimensional one (Shaver et al., 1987)

On balance, the evidence shows that all **three dimensions** are necessary for an adequate description of emotions. Emotions profiled by dimension are then allocated to three bipolar continua according to their affective behavior.

2.3.3 Reconciling both approaches

Russell et al. (1977) insisted that an adequate description of emotions requires the identification of those dimensions that are both necessary and sufficient to define all emotional states. Emotional terms such as "anger" and "anxiety" can be defined readily as combinations of three independent and bipolar dimensions. Fundamentally "emotion" does not merely include occasional passionate states. Rather, a person is viewed as being in a certain emotional state at all times, a state that can be described as a region within a three-dimensional space.

Russell et al. (1987) replicated in a later study that categorical descriptors such as happy, sad, calm, and angry are at specific locations around the periphery of an emotion judgment defined by degree of valence and degree of arousal.

Recent studies on measuring emotion have often combined both approaches of conceptualization: discrete and dimensional. Russell et al. (1987), for instance, employed both in experiments on the judgment of facial expressions. It demonstrated that emotion categories are systematically interrelated, describing pleasure and arousal dimensions of emotion. Shaver et al. (1987) described that within the three dimensions, five basic-level emotion categories—fear, sadness, anger, joy, and love—could be seen to differ systematically from one another. This indicates that the dimensional approach might be able to explain the relationship or distance among discrete emotions.

The preceding insights into each dimension (valence, arousal, and dominance) illustrate the considerable generality and potential versatility as a descriptive system for emotion.

2.3.3.1 The emotion space

If emotional dimensions are independent of each other, one three-dimensional space or three two-dimensional spaces are possible.

In the model of “emotion space”, Russell et al. (1987) demonstrated that more extreme degrees of an emotion are positioned closer to the edge of the space, and milder emotions closer to the center. As shown in Figure 3, a two-dimensional emotion space is defined by valence and arousal. The horizontal axis is a continuum ranging from extreme displeasure through a neutral point to extreme pleasure. The vertical axis (degree of arousal) is a continuum ranging from sleep through a normal waking state to extreme arousal.

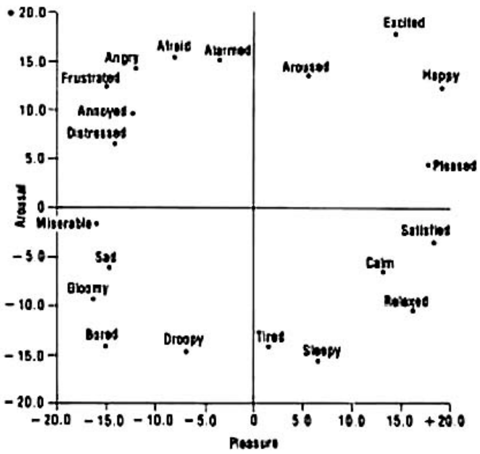


Figure 3. A two-dimensional map of emotion space, Russell et al., 1987, p. 224.

Emotional-related categories fall in an approximately circular order around the perimeter of the space. Some regions (e.g. toward the edge of the space) of the space are thus more emotional than others, just as some adjectives are more emotional than others. Therefore, the emotion space is a **geometric metaphor** for the internal scale on which stimuli are judged that reconciles both approaches: discrete (substance distributed in the emotion space) and dimensional (the structure of the emotion space).

2.4 MEASURING EMOTIONAL RESPONSE

An emotion eliciting procedure in laboratory experiments includes efforts to evoke a brief affective response via some type of stimulus. Rottenberg and his co-workers (Rottenberg, Ray, & Gross, in press) indicated several key features of the emotion-generative process as it unfolds during a laboratory elicitation procedure. Figure 4 depicts an emotion-generative process that explains any procedures related to emotional elicitation. The left of the figure draws attention to the fact that emotions elicited in the laboratory usually are not created *de novo* but rather arise from pre-existing affective states.

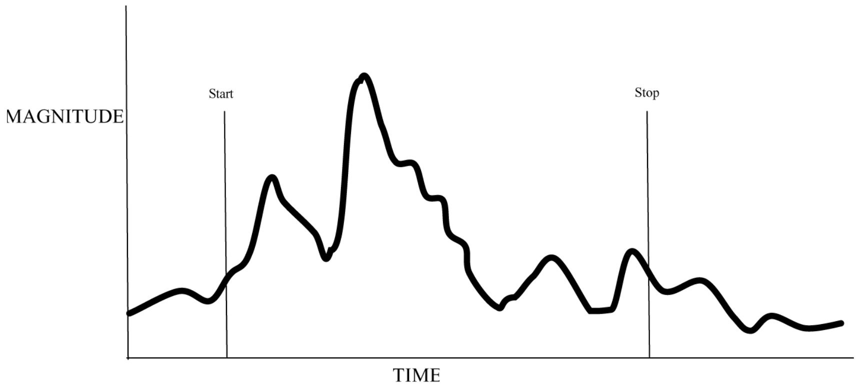


Figure 4. Emotion-generative process, Rottenberg et al. (in press).

Helson (1964) described this as residual. Indeed, Russell (2003) asserted that affect is understood as a stream with continuous output. An inspection of Figure 4 suggests that it is difficult to distinguish the waves of emotion from background affectivity in order to decide where one phenomenon ends and another begins. Finally, the different "peaks" within Figure 4 illustrate the related complexity of emotional impulses having no uniform signature and exhibiting instead a variable duration and morphology (Rottenberg et al., in press).

2.4.1 Emotion response systems

Despite the difficulties of measuring emotional responses mentioned above, a growing number of studies have used various representations, which assume that different emotion response elements exhibit synchrony during emotion activation: **physiology, behavior, and experience**. Many investigators do not conceptualize emotions as internal states, but as loosely integrated response constructs. Anxiety, for example, is a label applied to many different response events or response complexes, that fall into three general categories of emotion response systems (Lang, 1978; Lang, 1980).

If so, these emotion response systems should correlate with each other. Some studies advocate this theory (e.g. Bradley, Codispoti, Cuthbert, & Lang, 2001a; Elliot, Maier, Moller, Friedman, & Meinhardt, in press; Greenwald, Cook & Lang, 1989; Hamm et al., 1993; Lang, Greenwald, Bradley & Hamm, 1993; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), some support it partially or moderately (e.g. Mauss, Wilhelm, & Gross, 2004), while others are rather skeptical (e.g. Edelmann & Baker, 2002; Lacey, 1967). Mauss et al. (2005) asserted that weak emotions may provide little coordination of response systems, whereas strong emotions may provide greater coordination.

These debates are not concluded and focus on various independent variables, such as stimulus types, aspects of emotion, and individual differences. The three general categories of the emotion response system for viewing **colors** are discussed in greater extent in terms of physiology, behavior, and experience in section 3.4.

2.4.2 Harmonizing emotion response systems

Although the three general categories of the emotion response system—physiology, behavior, and emotion experience—are widely accepted and continuously researched, some investigators do not agree which of the three emotion systems controls the broad organization of an emotional state. As one explanation for this, Lang (1980, p. 121) noted that most theories of emotion are efforts at using inadequate, but available data, i.e. to explain feelings through physiology and behavior, or alternatively, to explain behavior as a product of physiology and feelings.

Since the multi-dimensional conceptualization of emotion was generally accepted (Osgood et al., 1957), studies have shown the coherence across the emotion response systems by using self-reporting affective judgment (or rating) on three dimensions. Lang (1980) noted that the concept of ratings on dimensions emphasizes the response of subjects to specific situations, rather than asking about generalized tendencies. It asserted that the method is consistent with the functional-analytic approach of behavior therapists.
Moreover, empirical studies have provided evidence that physiologically measured values often show positive correlations with affective judgments on dimensions. In the following, some studies dealing with *visual* stimuli will be reviewed. All of them support the three-dimensional evaluation of affective reports for use in emotional assessments.

• In the experiment in Greenwald et al. (1989), an unpleasant picture caused clear cardiac deceleration, and a large skin conductance response. Furthermore it increased a large scalp-recorded positivity, and potentiation of the startle reflex in corrugator electromyogram (EMG). This study demonstrated that when people look at affective pictures, reliable patterns of physiological changes can bee found in the somatic, visceral, and central system that vary significantly with ratings of valence and arousal dimensions of emotion.

• In a series of experiments with German subjects, Hamm et al. (1993) employed three systems to compare emotional responses to normative slide images: verbal reports (emotion experience), motor expression (behavior), and changes in effectors innervated by the autonomic nervous system (physiology). The verbal responses converged into three dimensions. Facial muscle activity and the corrugator EMG react significantly when the stimuli refer to the valence dimension. Skin conductance showed a straightforward covariation with judged arousal.

• Based on empirical studies employing normative pictures, Rottenberg et al. (in press) extended the study to higher semantic intensity of visual stimuli, such as film-clips and asserted the high emotional coherence across multiple response systems in film viewing. Furthermore, **self-reported measurement may be the most robust among emotion response systems.**

• Mauss et al. (2005) empirically examined within-subject associations among experiential, facial behavioral, and peripheral physiological responses during emotional responding to a film of 5 minutes. The scene was sequenced targeting to amusement, sadness, and amusement once again. The work showed that emotion experience and behavior are highly associated and that physiological responses are modestly associated with experience and behavior.

The foregoing considerations have prompted an effort to adapt this three-dimensional evaluation of affective reports to the application in emotional assessment for the entire aspects of the emotion system. In line with this, Lang (1980) devised the "Self- Assessment Mannequin" (p. 124), a series of pictograms to judge the affective quality of stimuli. It is later called **Self Assessment Manikin (SAM)**.

2.4.3 Graphical measurement system: SAM

The three basic emotional dimensions would describe verbal expression, regardless of how each of the verbal items has been scaled (Russell et al., 1977). If so, each of the three dimensions- *valence, arousal, and dominance*- can be visualized and stimuli might be assessed directly by the illustration. This should be, ideally, guaranteed in a numeric system, when the structure is reproduced (Fischer et al., 2002). The construction and applications of SAM are discussed, as follows.

2.4.3.1 The development of SAM

Originally derived from Osgood's semantic differential (Osgood et al., 1957), SAM is a nonverbal, culture-fair rating system based on a three-dimensional system of emotion consisting of valence, arousal, and dominance. The SAM rating scale is comprised of three sets of graphic figures, respectively representing the three dimensions.

Those graphic figures, which depict values along each of the three dimensions on a continuously varying scale, are used to indicate emotional reactions. As shown in Figure 5, SAM ranges from a frowning, unhappy figure to a smiling happy figure, when representing the valence dimension. For the arousal dimension, SAM ranges from a relaxed, sleepy figure to an excited, wide-eyed figure. For the dominance dimension, SAM ranges from a small figure (dominated) to a large figure (in control). The subject can select any of the five figures comprising each scale (Lang et al., 1999).

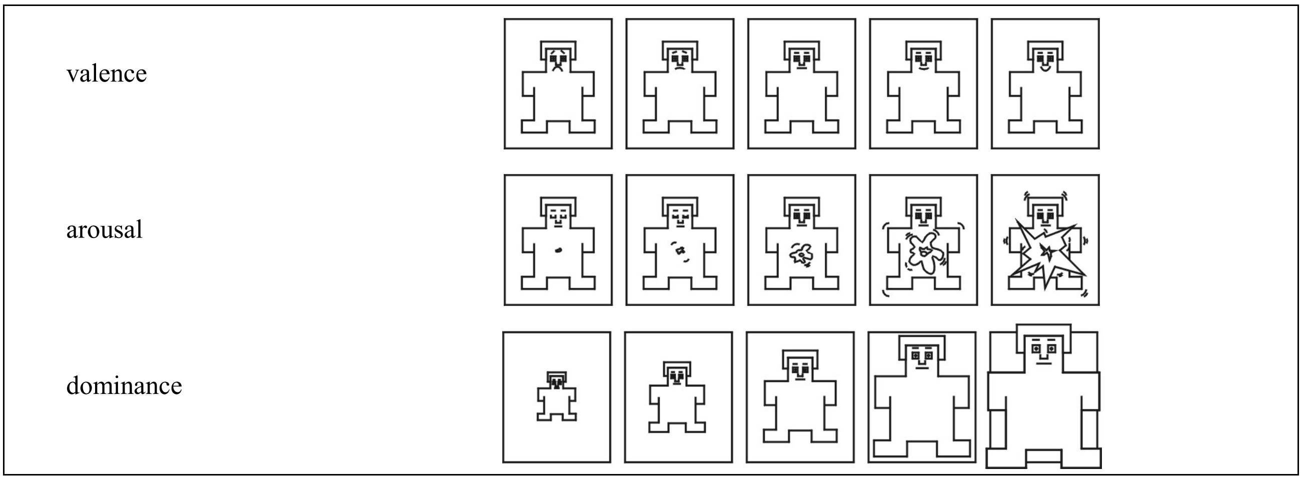


Figure 5. Self-Assessment Manikins (SAM), Lang (1980).

Although the measurement process avoids any verbal intervention that may evoke an influence on the affective judgment, it is inevitable to explain the usage of the pictograms to subjects. During the introduction of the experiment, sets of adjectives are employed to verbally describe SAM. Thus, subjects may capture the meaning of the dimension, instead of depending on a specific verbal expression. As presented in Table 2, different adjectives were used in several studies. In the study of Hamm (1989) bilingual experts provided 18 pairs of German adjectives, translated from English. The validity was confirmed through back- translation.

Fischer et al. (2002) advocated the acceptance of SAM for measuring emotion, since graphic representation of emotions implicates less ‘awareness’ than verbal expression. A non-verbal scale may activate already known affective and cognitive elements of emotion to a lesser extent (p. 127). Earlier, Hamm et al. (1993) described an increasing interest in questionnaires using SAM in comparison to the verbal survey form: SAM produces a lower rate of outliers and is also preferable from an economical point of view.

valence		arousal		dominance		source	Language
-	+	-	+	-	+		
unhappy frowning annoyed unsatisfied melancholic despaired bored --- (for children) unhappy scared angry bad sad	happy smiling pleased satisfied contended hopeful --- (for children) happy glad cheerful pleased good hopeful	calm relaxed sluggish dull sleepy unaroused --- (for children) calm relaxed bored sleepy	excited stimulated frenzied jittery wide-awake aroused --- (for children) excited nervous jittery active wide awake	controlled influenced cared-for awed submissive guided --- (for children) unimportant out of control bullied someone else is in charge	in-control controlling influential important dominant autonomous --- (for children) important big don’t need anyone’s help	Lang et al., 1999	English
frowning, unhappy	smiling happy	relaxed, sluggish, sleepy	wide-eyed, excited			Jennings, McGinnis, Lovejoy, & Stirling, 2000	English
frowning unhappy	smiling, happy			feeling of being controlled, submissive	in-control, powerful feeling	Morris, 1995	English
unzufrieden unglücklich genervt verzweifelt schwermütig gelangweilt	zufrieden glücklich erfreut hoffnungsvoll ausgeglichen entspannt	träge unerregt lahm schläfrig ruhig entspannt	rasend erregt zappelig hellwach aufgeregt stimuliert	submissiv kontrolliert beeinflusst geführt ehrfürchtig versorgt sein	dominant kontrollierend einflussreich autonom wichtig in der Hand haben	Hamm, 1989	German

Table 2. Emotional adjectives depicting SAM.

The universality of SAM was examined in several studies and some indications were postulated in aspects of demographic data. The willingness of using SAM as a tool to represent one’s emotional state was analyzed with regards to age, education, and gender.

• **age:** Vogelsang (1993) found out that there is significant age difference with regard to willingness of using SAM. Over 1200 travelers participated in the survey. Subjects were allowed to refuse to answer. It established that younger people are more likely to consider all dimensions, whereas older people often refuse to assess arousal or dominance. Fischer et al. (2002) asserted that older people are reluctant to learning “comic-experience” and that it is necessary for subjects to agree with the procedure of emotional expression through SAM.

• **education:** people with higher educational background, which is strongly positively correlated with income in general, are more willing to use SAM. The correlation analysis between the acceptance rate of SAM and educational levels yielded significant correlation coefficients for all dimensions (Vogelsang, 1993).

• **gender:** some empirical studies showed that women are more willing to utilize SAM than men (Fischer, Blumberg, Froese, & Riesenkönig, 1999; Riesenkönig, 2000). Vogelsang (1993), however, did not find any significant difference concerning gender. Summarizing previous studies, Fischer et al. (2002) noted that gender does not affect the acceptance of SAM in general.

Despite of some variables to be considered, SAM has been applied to various domains of research and proven to be adequate to measure not only a single modal stimulus but also complex life experience. Usage is facilitated due to its non-verbal aspect, particularly in the field of cross-cultural research.

2.4.3.2 Applied studies with SAM

Previous studies showed that SAM accurately measured emotional reaction to imagery as visual stimuli (Morris, 1995; Vrana, Cuthbert, and Lang, 1986). It has also been validated as an effective and easy method for assessing individuals’ emotions. Some case studies applying SAM are introduced in the following.

• **International Affective Picture System (IAPS)**

The International Affective Picture System (IAPS) was developed to provide a set of normative emotional stimuli for experimental investigations of emotion and attention. The goal was to develop a large set of standardized, emotionally evocative, internationally accessible, color photographs that includes contents across a wide range of semantic categories (Lang et al., 1999, updated in 2005). The database of pictures is continuously updated and there are 956 pictures available in the 2005 version. Pictures have been assessed for more than twelve years and more than 10,000 subjects joined to assess them. Figure 6 depicts plots of means, valence and arousal of the 956 pictures, based on the updated data of IAPS (Lang et al., 2005)

The selection of photos aimed at covering semantic contents of everyday life (Lang et al., 1999). Nevertheless, a boomerang-shaped distribution is observed in the emotion space (Bradley et al., 2000; Bradley et al., 2001a). This is consistent with a bi-motivational structure, involving two motivational systems of **appetitive** and **defensive** underlying all emotional experience.

These motivational systems are founded on simple reflexive responses to primary reinforcers that evolved to facilitate the survival of individuals and species. In this view, unpleasant affects ('–' valence) in humans are associated with an activation of the defensive system, while pleasant affects ('+' valence) are associated with the activation of the appetitive system (Bradley et al., 2001a, p. 281).

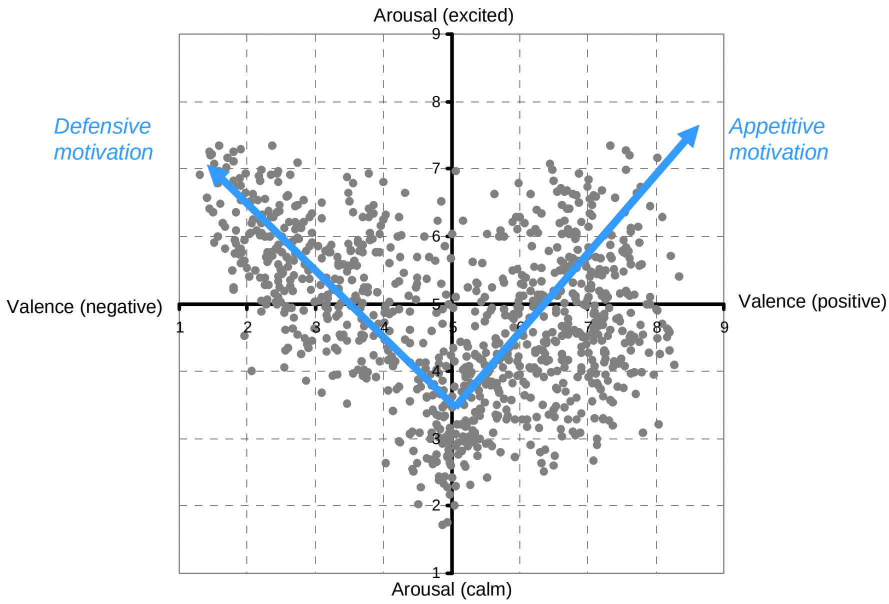


Figure 6. Mean valence and arousal of 956 IAPS pictures, based on IAPS (Lang et al., 2005).

This corresponds with evidences from previous studies that claimed the bipolarity of emotions. Michotte (1950) asserted the bipolarity of emotions by dividing them into two groups: segregative versus integrative. The former involves withdrawal (apartness, segregation); the latter involves approach, contact, clasp, embrace, sympathy, love, and friendship. Watson and Tellegen (1985) replicated the two affectivity tendencies, describing them in terms of valence and arousal.

Table 3 presents the percentages of 956 IAPS pictures and the selected adjectives (Valdez et al., 1994), which are categorized into eight groups of emotional profiles. Since a scale ranging from 1 to 9 was used, the mean values smaller than 5.00 were labeled '–' and those equal to or larger than 5.00 were labeled '+'.

In line with the assertion of Russell et al. (1987) that there are different degrees of emotional intensity, the IAPS pictures are not homogeneously distributed in emotion space. The category to which the largest proportion of pictures was assigned (331 pictures, 34.62%) belongs to the category profiled by '+' valence , (−) arousal, and '+' dominance.

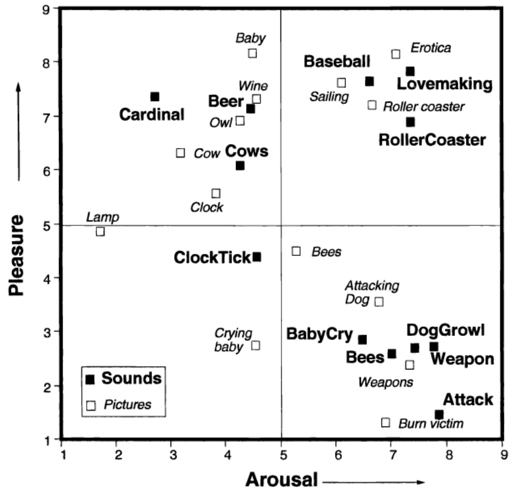
dichotomized dimensions			number of pictures in each category of emotional profile total number of picture stimuli: 956 (adjectives, Valdez et al., 1994)
valence	arousal	dominance	
+	+	+	16.95% (162) (admired, bold, creative, powerful, vigorous)
+	+	–	2.51% (24) (amazed, awed, fascinated, impressed, infatuated)
+	–	+	34.62% (331) (comfortable, leisurely, relaxed, satisfied, unperturbed)
+	–	–	.73% (7) (consoled, docile, protected, sleepy, tranquillized)
–	+	+	.73% (7) (antagonistic, belligerent, cruel, hateful, hostile)
–	+	–	25.73% (246) (bewildered, distressed, humiliated, in pain, upset)
–	–	+	10.67% (102) (disdainful, indifferent, selfish-uninterested, uncaring, unconcerned)
–	–	–	8.05% (77) (bored, depressed, dull, lonely, sad)

Table 3. Percentages of IAPS pictures and colors of eight categorized emotional profiles.

● International Affective Digitized Sound system (IADS)

Bradley et al. (1999) developed the International Affective Digitized Sound system (IADS), which was supposed to be comparable to the previously proposed set of picture stimuli, IAPS. The system provides a set of acoustic emotional stimuli for experimental investigations of emotion and attention. Based on IADS, Bradley et al. (2000) empirically showed that the pattern of reactivity while listening to 60 affective sounds is similar to that of looking at affective pictures. They provided evidence that emotional sounds produce patterns that co-vary with affect similar to those observed when people look at pictures. Figure 7 shows that items with similar semantic contents are located very close together in the affective space (e.g. roller coasters both in picture and sound stimuli).

Figure 7. Plots of selected sounds from experiment (filled square) and those of pictures from IAPS, (Lang et al., 1999; open squares), Bradley et al. (2000) p. 207.



Due to the results of the experiment, the authors explored the reliability of the affective measures across the sensory modality. Because similar patterns were obtained, the data supported the idea that a number of physiological systems are primarily sensitive to emotional activation, rather than to the specific mode of presentation.

Based on the standardized database of pictures (i.e. IAPS) and sounds (i.e. IADS), it would be desirable to have a database of valid film stimuli that rivals those of other normative emotional stimuli as well (Rottenberg, 2005).

● Other studies: life experiences as stimuli

/ Personality:

Geason (2003) investigated the viability of using the SAM as a nonverbal instrument for measuring the personality dimension of agreeableness, surgency, and emotional stability as they relate to brand personality. Results were significant and indicate that the SAM pictograms can be used to mark these three personality traits.

/ TV advertisements:

SAM could be applied not only for normative and standardized stimuli, but also for life experiences as such. Morris (1995) employed SAM in an experiment to evaluate advertisements in order to provide affective insights that were to be used in creative strategy and product positioning. It is useful to evaluate the advertiser's success in reaching the desired levels of response of goals. Scores of pleasure (corresponding to valence) and arousal reported by subjects viewing a commercial were positioned in emotion space defined by 'pleasure (valence) × arousal space', which was already occupied by 135 emotional terms of Russell et al. (1977). The adjectives obtained from the advertisement-adjective space might be used in a qualitative setting. This global study showed that emotional responses to “standardized global advertising” are generally the same in the United States and in Taiwan. The author advocated SAM as a tool for measuring affective responses with a wide range of applications in marketing communications, since it provides consistent results.

/ Financial investment:

Fischer, Koop, & Peters (1994, quoted in Fischer, 2002) applied SAM to support typology of four emotional types of investors: “the curious” (‘–’ valence, ‘+’ arousal), “the enthusiastic” (‘+’ valence , ‘+’ arousal), “the inactive” (‘–’ valence, ‘–’ arousal), and “the self-satisfied” (‘+’ valence , ‘–’ arousal). Investors were positioned into one of these four quadrants based on their life satisfaction. The study found inherent behavioral characteristics for each group to invest in different financial products. The largest category (39%, N=190) of subjects was the category of the self-satisfied. Investors in this category hold auctions and consider their investment as leisure activity. At the same time, they possess options or bonds but they mostly do not own saving accounts. The authors interpreted this as evidence for elaborative reasoning behavior.

On balance, SAM has been proven to be an adequate measurement not only in laboratory situations but also in real life situations. Moreover, previous studies provided evidence that SAM may motivate emotional responses across the entire emotional systems, such as physiology, behavior, and emotional experience. In a series of experiments in this dissertation, SAM is used to measure emotional responses to visual stimuli, such as colors.

2.5 EMOTION AS DETERMINANTS OF MOTIVATION

Rottenberg (2005) categorized empirical studies on the elicitation of emotions according to two major approaches. In the first approach, emotion is used as a **dependent** (or outcome) **variable**. This has illustrated emotion response systems mentioned in 2.4.1. The second approach considers emotion as an **independent variable**, since emotions are basically potent inciters or inhibitors of action (Clore et al., 1987). Empirical studies demonstrated the important contribution made by emotion to a diverse array of phenomena, ranging from aggressive (Zillman & Weaver, 1999) to helping behavior (Isen, Daubman, & Nowicki, 1987). Emotion is hence considered as a determinant of motivation.

Earlier, Helson (1964) asserted the importance of **affectivity** as a **motivating** factor. It noted that states of feeling initiate directly and terminate almost all types of behavior, thus playing a dominant role in individual modes of adjustment. It is generally recognized that motivation depends on affective states. There is little or no motivated behavior that is not affectively toned and aroused by emotion. Indeed emotions influence what one sees, tastes, hears, and smells. In addition, levels of learning and performance depend to a great extent on affective states, and the role of reinforcement in most learning theories attests the importance of emotion as determinant of motivation. (Helson, 1964; Schwarz et al., 1996).

2.5.1 Emotion congruent effect on cognitive processes

During the last decades, social psychologists showed much interest in emotion as a factor of information-processing. Simon (1967) suggested that emotions serve as cognitive interruptions. Said study states that it is important to interrupt an ongoing processing, if more urgent (more emotionally involved) situations arise, since processing resources are limited. Emphasizing the role of moods, emotions, and related phenomena in human cognition and behavior, Schwarz et al. (1996) distinguished between “hot” processes in contrast to “cold” cognitive processes, explaining that emotion provides ‘hot’ information with motivational implications. Researchers described the following motivational processes led by emotions: information serves as input to judgment (Schwarz & Clore, 1983), decision-making processes (Isen & Means, 1983), self-regulatory processes (Aspinwall, 1998), or influences processing priorities (Simon, 1967). To a certain extent, emotions facilitate behavior such as mobilization for action, attention, and social communication (Bradley et al., 2001a).

In addition, some studies specified **motivated behaviors**, as cognitively driven by emotion, i.e. defensive versus appetitive motivational systems (discussed in 2.4.3.2 referring to IAPS) or affective equilibrium.

● **Affective equilibrium**

Another discussion about the circuit of cognitive motivation is explainable by means of the law of affective equilibrium (Beebe-Center, 1929, quoted in Helson, 1964; Harris, 1929; Maslow & Mintz, 1956; Russell et al., 1987). According to this law, balance of opposed pleasant-unpleasant states or approach-withdrawal tendencies are expected when making affective judgment.

The experiment of Beeber-Center (1929, quoted in Helson, 1964) and Harris (1929) showed that the affective value of colors is changed in accordance to the law of affective equilibrium. They regarded results following a **compensatory mechanism**, in which shifts in affectivity are the result of a balancing process within the organism.

Moreover, there are two additional laws derived from a similar approach quoted by Helson (1964): "law of hedonic contrast" and "mass hedonic contrast". These laws are restatements, accounting for the motivational behavior that a stimulus following a series of unpleasant stimuli is experienced as pleasant. In concordance, Russell et al. (1987) conveyed a series of experiments with facial pictures based on the anchor effect caused by pre-dominant affectivity. Subjects judged a face more pleasant after they had seen a series of unpleasant facial pictures than when they assessed without having seen any facial pictures.

The motivated emotions will be investigated in Experiment IV.

2.6 CHAPTER REVIEW

● The literature on terminological issues on emotion was reviewed (3.1.1) and emotion was distinguished from feeling or mood. The hierarchy of Clore (1992) explains the relationship between emotion related terms (2.1.2).

● The cognitive process of emotion was described in terms of input, appraisal, and output (2.2.1). Parallelly, an aspect of emotion as immediate response was debated (2.2.2).

● Two approaches of emotional conceptualization were discussed: The first refers to a discrete, prototypical (Ekman, 1984), or qualitative (Russell, 1990) approach. Emotional terms occupy the basic level of a categorization of emotion (2.3.1). The second refers to a dimensional structure: *evaluation, activity, and potency factors*, prompted by Osgood, et al. (1957). Similarly a PAD theory (Mehrabian, 1978) was explained in terms of pleasure (interchangeable with valence), arousal, and dominance (2.3.2). Characteristics of each dimension were described respectively (2.3.2.1 ~ 3). Reconciling both approaches, an emotion space offers a geometric metaphor and profiles discrete emotions defined by dimensions (2.3.3).

● General issues of measuring emotional response were discussed (2.4.1). The concept of rating on emotional dimensions was advocated, to result coherence across the response systems. Accordingly, relevant studies were reviewed (2.4.2). Self Assessment Manikins (SAM) (Lang, 1980), a pictorial construct to represent emotions three dimensionally, was introduced (2.4.3, 2.4.3.1). Some applied database systems and studies of SAM were explained, for example, IAPS (Lang et al., 1999) (2.4.3.2).

● Studies on emotion as motivating factor were summarized and the affective equilibrium (Helson, 1964) was described as motivated behavior cognitively driven by emotion (2.5.1).

3. EMOTIONAL REPONSE TO COLOR

3.1 VIEWING COLOR

3.1.1 Color in human vision

The perception of color is essential to our visual experience and it is human's most powerful information channel (Albers, 1963; Arnheim, 1956). Goldstein (2002) distinguished viewing color from other visual experiences. It proclaimed that the connection between the central characteristic of the physical stimulus (the wavelength of light) and the experience of color is arbitrary, unlike some visual qualities such as shape, depth, location, and movement (p. 204). Color provides information that helps us to understand the physical world and carries symbolic and associative information. Garber et al. (2003) pointed out the duality of the color phenomenon: sensory and cognitive aspects. In line with this, much research has been written about the nature of color, the perception of it, and its aesthetic aspects.

Many disciplines, including physics, computer science, psychology, and visual arts, among other are involved in studying viewing of color. Accordingly, a great deal has been written about the nature of color focusing on different interests, which could be categorized into five domains of aspects: **(a)** color match, **(b)** color sensation, **(c)** color perception, **(d)** color aesthetics (McCann, 1990), and **(3.2.1)** color semantic. Each aspect builds on the previous and the techniques for measuring human performance in each aspect are different respectively. Moreover, each successive layer adds more and different disciplines, as shown in Figure 8.

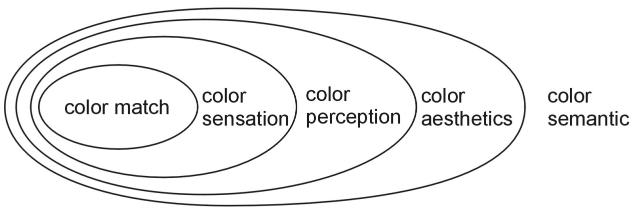


Figure 8. Different aspects of viewing color.

(a) Color match

Colors or a group of colors will match if they are placed side by side and if they send photons to the eye that generate the **same quantum catch** in the rod and cone cells of the retina. In terms of color match, numerous scientists have advanced colorimetry models and certified them as international standards

(McCann, 1990). The most used standard is CIE (Commission Internationale de l'Eclairage). Basically, colorimetry takes into account the spectral properties of the light source, the spectral reflectance properties of the objects, the pre-retinal absorbance of the eye, and the sensitivity of the rods and cones of the retina (Wyszecki & Stiles, p. 429). Studies in this domain deal with physical quantity.

(b), (c) Color sensation and Color perception

Color sensation and color perception are almost interchangeable in common usage, although they should be distinguished from each other. Color sensation concerns whether colors **appear** the same, if they have the same physical properties, i.e. wavelength. A successful sensation model, for instance, must **render** differences of color hue and visible gradients due to illumination, whereas a successful model of color perception must **report** the **recognition** thereof. Computational models of color sensation use the quanta catch physics of colorimetry as input to the color-appearance calculation. Color sensation is concerned with **psychophysical quantity,** while color perception deals with **cognitive quantity** (McCann, 1990), which is how a person **recognizes** a color. In this case, color is the product of the brain's interpretation of the visual sensory information that it receives (Garber et al., 2003). Mollon (1995) asserted that one advantage of viewing color is that it allows people to detect a spectrally distinct target (e.g. a ripe fruit) against a background that varies randomly in lightness and form. This is in concordance with the biological development of color perception.

A number of studies are concerned with the attempt to construct calculations of recognition in order to compute the reflectance of objects in a scene. Here, color is treated as one of the major visual attributes.

(d) Color aesthetics

Color aesthetics deal with **aesthetic quantity**. Visual artists assign colors to media images to generate physical, sensational, and perceptual values in order to contribute to the visual content of the image (McCann, 1990). The appropriate computer model for color aesthetics should calculate the color for an arbitrary image so as to activate a particular aesthetic message. As shown in Figure 8, viewing color in terms of aesthetics requires comprehensive understanding of different disciplines.

3.1.2 Color semantic: viewing color in social and cultural context

Although McCann's categorization of color vision provides a clear understanding, the aspect of color semantic needs to be added. Color carries information that explicitly or subtly links a color and a particular message, concept, or experience in a particular context (Garber et al., 2003; Elliot et al., in press). Color semantic positions outside the circles in Figure 8 refer to viewing color in social and cultural semantic context.

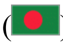
There is a widespread belief that the expression of color is based on **association**. For example, red is said to be exciting because it reminds people of the connotations of fire, blood, and revolution (Arnheim, 1956, p. 275). In line with the symbolic function of colors, Welsch and Liebmann (2003) addressed items to be associated with “red” in various themes (p. 56):

love	erotic	anger	rage	energy	blood
danger	fire	heat	warmth	lips	ambition
rose	poppy	mouth	cherry	wine	socialism
heart	communism	prohibition	seduction	fire truck	traffic light
Ferrari	Mars	Orion (α)	tomato sauce		

There have been attempts to describe some major influential artifacts that hold color semantic. Gage (1995) argued the *typical* responses to color, based on **archetypal** human experiences of black night, white bone, red blood and so on (p. 179).

Also, color is often perceived depending on the **social** context. Lüscher (1971) noted an example. 75% of 1600 school children answered “violet” as their favorite color, since violet implicates indifference among those children who reside in a slum area.

Moreover, concerning the **cultural** impact on color perception, Silvestrini and Fischer (2002) summarized meta-systems and analogies of color, which describe the understanding of color in certain cultural contexts. For example, colors indicate directions in traditional Chinese color analogy, based on the lecture of Confucius. This analogy has been applied to the exterior as well as the interior in traditional Chinese architecture: red for the South, black for the North, green for the East, white for the West, and yellow for the Southwest. Another usual example of difference in the symbolic meaning of color across cultures is that in Western societies, the color of death is black, whereas in many Asian countries, the color of death is white (Garber et al., 2003, p. 316).

Welsch et al. (2003) noted that colors have a **religious** aspect. Green is, for example, used in the national flags of many Islamic countries, such as Bangladesh (), Libya (), Mauritania (), Pakistan (), and Saudi Arabia (). In Islam, green is associated with luxurious green meadows and trees, and it symbolizes paradise for those who liven in barren land (p. 22).

Garber et al. (2003) pointed out a **situational factor**, which changes over time, as in fads and fashion, and which depends on the subject category in whose context it is considered. For example, Hine (1995, p. 221) demonstrated that residents of four American cities believed, in general, that the color red can symbolize love, safety, danger, strength, and warmth. However, when asked to think about red in relation to products, they stated that it stands for Coca-Cola.

Color carries different semantics in different contexts and arouses different associations. Therefore, various emotional and behavioral reactions are predicted accordingly. Insofar, color semantic embraces insights into various aspects of human life.

In line with the cultural aspect of viewing color, a cross-cultural study between German and Korean is conveyed in chapter 4. The module of Experiment I is also carried out with 17 Korean subjects in Seoul, South Korea. For further research, it is suggested to conduct the experiment modules with various subject groups in order to account for the social and cultural effect on color affectivity.

3.2 COLOR AS EMOTION ELICITOR

In studying color as emotional elicitor, there are two major perspectives: the first deals with the influence of color in mediated presentations (3.2.1); the other excludes semantic contents of color and sees color as direct elicitor of emotion (3.2.2).

3.2.1 Color in mediated presentation

In mass media research, color has often been the subject of investigations into learning and memory, persuasion, perception, and emotional impact (Detenber, Simons, Roedema, & Reiss, 2000). Studies have investigated how color presented in different media affects cognitive processing. One of the main streams in this field is to compare the effect of chromatic versus achromatic contents on different media, i.e. newspaper, still pictures, television, etc.

Besides Chroma quality of visual contents, two other attributes of color, namely hue and lightness, may be concerned as influential factors. Helson (1964) examined the correlation between pleasantness and appropriateness of color and indicated that discrepancy correlates with unpleasantness. His study, for instance, mainly dealt with color hue. However, little has been systematically investigated, regarding the influence of the entire color attributes on emotional reaction or cognitive processing.

Yet, the effect of Chroma on affectivity of media content has been intensively examined. The relevant studies on viewing pictures (3.2.1.1) and films (3.2.1.2) are reviewed and summarized with respect to cognitive processing (Table 4) and emotional reactions (Table 5).

3.2.1.1 The influence of color in viewing picture

Due to emergence of cost effective printing technology, it was generally accepted that chromatic presentation is richer and more informative. Thus, it has been expected that chromatic (i.e. colorful) pictures contribute to the effectiveness of cognitive processing and enhance the affectivity of the printed material.

Providing evidence, some empirical studies advocated that chromatic contents are recalled easier than achromatic ones (i.e. Shaps and Guest, 1968; Borges, Stepnowsky, & Holt, 1997: quoted in Detenber et al., 2000). Gilbert and Schleuder (1990) found out that image processing can be accelerated by chromatic still pictures; however, some researchers found no advantage of chromatic still pictures in terms of recognition accuracy. Kiphart, Sjogren, and Cross (1984, quoted in Detenber et al., 2000) and Garcia and Stark (1991) showed that there is no influence of color concerning the recognition of content in television and in newspaper. Scanlon (1967) even presented that achromatic contents arouse more attention.

Bradley et al. (2001a) investigated that affective responses, both self-reported emotion and physiological reactions, were essentially the same regardless of whether IAPS[1] pictures were presented in color or in grayscale. The Chroma of the picture presentation did not result in any significant main effects or interactions involving picture content in analyses of any dependent measure (valence and arousal).

[1] introduced in 2.4.3.2

In sum, the previous studies do not present a uniform set of findings or a consistent perspective on the influence of color on cognitive processing (Detenber et al. 2000).

3.2.1.2 The influence of color in viewing film

Scanlon (1970) found that achromatic television contents arouse more attention. In his study, he suggested that color positively influences the acceptance of the television presentation. Similarly, Donohue (1973) found that color increases perceptions of aesthetic quality in political TV advertisements and that women tended to be more influenced than men by them. Recently, Detenber et al. (2000) concluded the study: color can evoke potent emotional responses in viewers and thus color is a director's most important tool.

However, a study by Perse, Pavitt and Burggraf (1991: quoted in Deteber, 2000) failed to find any differences in emotional reactions between chromatic and achromatic film-clips. Thurman, Ball, Hammack and Walker (1983) pointed out that people spend more time watching achromatic contents, although they often stated that they prefer chromatic contents on TV.

Taken together, a universal effect of color (Chroma) in terms of either cognitive processing or emotional reaction in media has not yet been confirmed (Zettl, 1990; Detenber et al., 2000). Table 4 and Table 5 below summarize the effect of color on cognitive processing and emotional reaction in mediated presentations.

media	effect of color for cognitive processing		
	achromatic > chromatic	**indifferent**	achromatic < chromatic
newspaper		• Garcia et al. (1991): color does not influence reading	
still pictures		• Kiphart et al. (1984): picture recognition is not influenced by color • Gilbert et al. (1990): no advantage for recognition accuracy	• Borges et al. (1997): memory advantages • Gilbert et al. (1990): image processing was speeded up
moving images (film-clips or television programs)	• Scanlon (1967): more attention	• Kiphart et al. (1984): no effect on film recognition	• Shaps et al. (1968): more details were recalled

Table 4. Color in mediated presentations.

media	effect of color for emotional reactions		
	achromatic > chromatic	**indifferent**	achromatic < chromatic
newspaper			• Gardner et al. (1996): achromatic newspaper ads were less attractive
still pictures		• Bradley et al. (2001a): no significant difference of emotional reaction	
moving images (film-clips or television programs)	• Thurman et al. (1983): people spent more time watching black and white programming • Zettl (1990): desaturated colors, or black and white, can produce stronger emotional reactions	• Perse et al. (1991): no differences in emotional reactions to scenes from feature films. • Detenber et al. (2000): no effect on the physiological component of emotional experience	• Scanlon (1967): color positively influences liking of the television presentation • Donohue (1973): color increased perceptions of aesthetic quality in political TV ads. • Detenber et al. (2000): color film-clips were rated with greater arousal and more positive

Table 5. Color in mediated presentations affecting emotional reactions.

3.2.2 Color stimulus

It is widely believed that viewing color acts as internal or external stimulus, activating emotional reaction in a certain pattern. Physical properties as well as memory color (through cognitive process) interact to elicit emotional responses. Schachtel (1943) asserted that the connection between color and emotion arises from a similarity in subjective experience. Arnheim (1956) also emphasized the association on which expression of color is based. In line with this, the influence of memory color may not be completely excluded during emotional response to color. Memory color refers to past knowledge that can affect color perception through the operation of a phenomenon in which color is mediated with an object or situation (Goldstein, 2002, p.209).

Apart from the concept of color as a component in mediated presentation, based on its physical properties, color has been often dealt with as visual stimulus. A great body of empirical studies has focused on providing evidence that viewing color pools affectivity that could be predicted quantitatively (e.g. Valdez et al., 1994).

In this dissertation, it is intended that color stimuli are viewed excluding semantic contents. A set of color stimuli is displayed on a CRT monitor (Experiment I, III, and IV) or presented on a DIN A5-size sheet (Experiment II). Color attributes are characterized in terms of their physical properties: hue, Chroma, and lightness.

3.3 CONCEPTUALIZING COLOR AND EMOTION

Investigating emotional response to color as well as emotion conceptualization in general (in chapter 2), two approaches of conceptualization are discussed: a discrete approach versus a dimensional approach.

3.3.1 Discrete approach: synesthesia of color and emotion

Plutchik (2003) noted that an alternative approach to identify the language of emotions is to assume the existence of a small number of basic or primary emotions, just as there are primary colors. More specifically, Jameson and Alvarado (2003) indicated that linguistic representation and referents are linked through a cognitive process and thus color namings are assigned, as needed, to accomplish a performance-related goal, such as emotion. Numerous studies have been carried out both scientifically as well as in non-scientific ways. The approach in which categories of color and emotion are combined is called "synesthesia of color and emotion" in this dissertation.

Synesthesia explains a corresponding reaction to a stimulus that belongs to one sense modality with a sensation that belongs to another sense modality (Fröhlich, 2002; Welsch et al., 2003). The idea of synesthesia of color and emotion is based on the assumption that each color is tied to a specific emotion (Terwogt & Hoemksma, 2001). For example, 'red' is associated with excitement (Lüscher, 1971; Wexner, 1954), happiness (Terwogt et al., 2001), anxiety (Jacobs et al., 1975), and so on. Some empirical studies on synesthesia of 11 basic colors (Berlin & Kay, 1969) and primary emotions are presented in Table 6.

11 Basic color categories											Source	color stimuli	
black	white	red	blue	yellow	green	brown	purple/ violet	orange	pink	gray		verbal	pictorial
powerful strong masterful		exciting, stimulating	secure comfortable, tender, soothing					disturbing distressed upset			Wexner, 1954		✓
bad, strong, inactive	good, weak	strong, active	good	weak, bad	good					bad, weak, inactive	Adams et al., 1973	✓	
		higher anxiety		higher anxiety	lower anxiety	lower anxiety					Jacobs et al., 1975		✓
lost		active, exciting	relaxed, released	anxious	tensioned	passive	mystery-ous, erotic			calm, neutral	Lüscher, 1971		✓
positive		excitement, happiness									Boyatzis & Varghese, 1994 [children]		✓
aversion, anger	surprise, fear, sadness		happiness								Terwogt et al, 2001 [7-year-old children]		✓
anger, sadness, aversion, fear	surprise			anger	happiness						Terwogt et al., 2001		✓

Table 6. Examples of synesthesia between 11 basic color categories and emotional terms.

Gerard (1957) tried to explain some of the specific connections between colors and emotions by referring to **common physiological reaction patterns**. It maintained that the color red and the emotion of anger both have an energizing effect that calls for action and are therefore linked to each other. Elliot et al. (in press) replicated the physiological responses to the color red in their empirical study. Kreitler and Kreitler (1972) argued that such links between color and emotion root in **culture**. In the medieval heraldic system, for instance, the color white was related to purity and the color yellow to hatred.

Some researchers (e.g. Frank, 1976), however, claimed that it is not yet clear why specific colors are tied to specific emotions, since it is hard to trace the origin of synesthesia or how associations between emotions and sensual perceptions evolve.

The associations between color and emotion are highly dependent on target groups. Boyatzis et al (1994) showed, for instance, that children, in contrast to adults, do not associate the color red with anger or sadness but rather with excitement and happiness. It suggested that clinicians might need to revise their assertions about the emotional significance of the color red, especially because they report little empirical data on their subjects' color-emotion associations. Besides, it also found that black had evoked positive emotions in half of the children's responses. This finding refutes clinicians' claim about the predominantly negative significance of black.

Additionally, the synesthesia between basic colors and primary emotions exclusively refer to a "focus color" (Berlin et al., 1969) of each hue category that is a division on spectral location (Gage, 1995). The 'basic' set of colors used in the synesthesia offers a categorized structure but ignores the influence of both Chroma and lightness of colors.

Lastly, the discrete approach may overestimate the relationship between a color and an emotion, although it accounts for the weakness of synesthesia in general (Welsch et al., 2003).

In sum, concerning the conceptualization of synesthesia between basic colors and primary emotions, there still remain deficiencies to provide a thorough and general characterization of the relationship between color and affect. Valdez et al. (1994) characterized the discrete approach as insufficient to produce reliable, valid, or comprehensive measures of emotional responses to color stimuli.

3.3.2 Dimensional approach: interaction between color and emotional dimension

Some studies tried to describe color in terms of three dimensions of emotion. Guilford (1934) measured affectivity (pleasantness) of 40 Munsell colors in terms of color attributes: hue, Chroma, and value and found a periodic relationship between affectivity and hue. It also showed a linear relationship between affectivity and saturation on one side, and affectivity and value on the other[2].

In the study of Valdez et al. (1994), the affectivity of colors was measured with 24 pairs of items for pleasure (valence), eight for arousal, and 15 for dominance. Running multiple regression analyses, they provided constellations for pleasure, arousal, and dominance in terms of magnitudes of wavelength, value and saturation. 76 color stimuli were employed and subjects assessed seven or more of them with 47 bi-polar emotional items. However, the authors could not provide within-subject analysis and a systematic approach for variations of color stimuli in terms of Chroma and lightness is still expected.

As discussed in 2.3.2, the dimensional approach to conceptualize emotion has the advantage of generality and potential versatility as a descriptive system for emotion. It characterizes an emotional profile of the stimulus and it provides a base for geometric construction (i.e. emotion space), in order to explain the relationship among stimuli is explained. However, it has been taken into consideration by only few researchers and the selection of color stimuli has not yet been systemically approached.

3.4 MEASURING EMOTIONAL RESPONSE TO COLOR

In section 2.4, three categories of emotion response systems were discussed: physiology, behavior, and emotion experience. Based on those categories, previous studies concerning methodologies of measuring emotional response to color are reviewed.

3.4.1 Physiological measurement

It is believed that color is linked with emotion (Kaiser, 1984). Féré (1887, quoted in Gage, 1995), for example, found that red light has the most stimulating effect and violet the most calming. Gage (1995)

[2] The Munsell color system decomposes color into its constituent elements, such as hue, Chroma, and value, which correspond to hue, Chroma, and lightness in the CIELab Lch system. Fore more detailed information see section 4.2.2.1

added that an exposure to variously colored lights could have a direct and variable effect on human body functions.

Researchers have measured physiological responses to color by means of the galvanic skin response (GSR), electroencephalograms (EEG), heart rate, respiration rate, oxiometry, eyeblink frequency, blood pressure, etc (Kaiser, 1984). These studies have been largely motivated by the hypothesis that long-wavelength colors (warm colors: red, orange, yellow, etc.) are more arousing than short-wavelength colors (cool colors: green, blue, etc.) (Valdez et al., 1994). Empirical studies generally have shown that the colors red and yellow are indeed more arousing than blue and green.

The subjects in experiment of Wilson (1966) were exposed to five red and five green slides, in alternating order. Results with two measures supported the hypothesis that the color red is more arousing than green, with the effect being particularly apparent in the GSR data. Lüscher (1971) empirically presented that the color red resulted in the subjects' faster heart beat, increased pulse, increased blood pressure, and faster breathing frequency.

Reviewing studies on physiological responses to color, Kaiser (1984) basically agreed there is a certain effect of color on response but critically concluded that the evidences of various physiological tests are inconclusive and the results are not yet stringent enough to reveal a general tendency. Following this critical view, Detenber et al. (2000) asserted that color does not cause any effect on the physiological component of emotional experience.

3.4.2 Behavioral measurement

Studies on the measurement of behavioral patterns of emotional response to color were carried out both under laboratory conditions (e.g. facial expressions) and as field studies. The former is often conducted from a physiological perspective (Detenber et al., 2000), while the latter form is mostly related to life experience. The study of Garrett and Brook (1987) found that ballot color (green versus pink) affected voting behavior. Men generally preferred a green ballot and women preferred pink. However, ballot color had no effect when the candidate's gender was known. Accordingly, the authors failed to find any significant effect of ballot color on behavioral pattern in their study. Damhornst and Reed (1986) investigated the effects on male subjects (in perspective of juries) of female job applicants' dark versus light clothing and facial expressions. Male subjects rated models wearing dark jackets as more powerful and competent than models wearing light jackets. The behavioral difference may be observed even without consciousness of the color. In a recent cross-cultural study by Elliot et al. (in press), it was shown that the perception of red in prior to an achievement task impairs performance (e.g. anagram, analogy, and numeric tests) relative to the perception of green or achromatic color. However, subjects were unaware of the colors influencing performance ability.

As reviewed, the involvement of mediated objects (i.e. ballots, jackets, or test sheets) is inevitable, especially when behavioral patterns are observed in field studies. The color green of the green ballot in the study of Garrett et al (1987) does not implicate the same as the color green of the green jacket in the study of Damhornst et al. In those studies, certain situations are observed, which are highly dependent on the environmental context. Also, it is difficult to employ a large number of color stimuli, i.e. enough stimuli to observe emotional response varying in terms of the attributes—hue, Chroma, and lightness—of color.

3.4.3 Experiential measurement and SAM

Studies revealed that experiential measurements, such as self-reported results provide robust effects of color on emotion (Detenber et al., 2000; Rottenberg et al., in press). Detenber et al. for example, investigated the emotional effects of color in film and television clips. The study involved obtaining physiological measures (skin conductance, heart rate), behavioral measures (facial muscle movement), and self-reported measures of the participants' emotional reactions during the presentation of film-clips. Results established that the influence of color becomes evident in the self-report of emotional experience, but in none of the other two measures.

Self-reported measurements, rating on emotional terms (items), developed by Mehrabian (1974; 1978) is often employed. In fact, by employing numbers of items, working capacity of subjects may be consumed. Thus, in the study of Valdez et al. (1994), seven color stimuli were randomly allocated to each subject and every color was supposed to be assessed with 47 bi-polar scales: 24 pleasure (valence) items, eight arousal items, and 15 dominance items.

Therefore, SAM may contribute to relieve subjects from the time consuming work of rating items, because the subject may assess the emotional response to color directly. In other words, a larger set of color stimuli may be examined with the same number of subjects. A larger stimulus set refers to a sufficient number of color stimuli, which may be representative concerning all color attributes: hue, Chroma, and lightness. Moreover, it enables to test within-subject-variation (i.e. repeated measurements), when subjects are exposed to all stimuli.

As discussed in 2.4.3, SAM is broadly considered to be adequate and reliable to measure affectivity of various types of stimuli. Moreover, it is expected that SAM may provide reliable results to describe emotional characteristics of color.

In the following experiments, SAM will be used to assess emotional response to a color stimulus in the dimensions of valence, arousal, and dominance. SAM is implemented through PXLab© software in computer based experiments (Experiment I, III, and IV) and is printed out in questionnaire form in a paper-pencil experiment (Experiment II).

3.5 COLOR EMOTION AND PRACTICE

"Color sells."

– Birren, 1945; Gekeler, 2000

As discussed in 3.1, color may be viewed from the perspective of physics, computer science, psychology, fine arts, anthropology, design, marketing, etc. The individual disciplines have different approaches to problem definition: although many of them are concerned with color affectivity. There have been a great number of studies in emotional psychology, but only a few interdisciplinary studies link theory and practice.

In chapter 2 emotion was discussed according to psychological concerns, such as terminology, conceptualization, response system, and motivational aspects. On the other hand, designers and artists focus on a consensual result between color and emotion, based on which they may obtain creative ideas. In doing so, the terms feeling, emotion, and mood are often interchangeably used. When it comes to marketing, the main concern is which color appeals to whom, in a social rather than logical way (Garber et al., 2003). Designers often collaborate with marketing experts, since both are precisely looking for the color that sells.

In this dissertation, I provide empirical results for practical use and review how color emotion is communicated in practice. Furthermore point out, some current issues of color research that may offer insights and considerations to construct a practical color application tool. Therefore, I suggest a methodology for the development of a product-color scheme for marketing purposes as a theory based application.

3.5.1 Emotional communications of product color

Color is a salient and resonant visual feature of those seen in early vision (Garber et al, 2003). This makes color a compelling visual cue for persuasive communication purposes, such as conferring identity, meaning, or novelty to an object or idea. Thus, color contributes to the preference for and appreciation of products. Researchers asserted that color plays an essential role to improve the efficacy of message and to increase the likelihood of purchase (Birren, 1945; Hine, 1995; Lee, 2002; Miller et al., 2002). Hence, studies have investigated how color information of a product is communicated, including digital merchandizing platforms (i.e. the World Wide Web). Besides, studies are diversified across different categories of product: fashion (Nitse, Parker, Krumwiede, & Ottaway, 2004; Suk, 2000), home appliances (Suk, 2000), automobiles (Suk, 2000).

Pointing out the emotional communication of a product color, visible and invisible ways can be thought of: first of all, people perceive product color from its reflectance and are aware of it. Since every single product should be coherent to its brand or corporate identity[3], product color addresses different levels of concern: from a single product to corporate identity (3.5.1.1). Secondly, the invisible way refers to the affective usage of color terms on product color perception. It bases on the concept that color terms may contribute to the elaboration of the product image (3.5.1.2).

3.5.1.1 Product and corporate color

Color is one of several visual elements that the consumer must perceive and integrate in order to recognize and interpret an object in its visual field (Garber et al., 2003). Color issues in design and marketing practice reach from a single product design to the coordination of corporate design.

[3] A corporation may have several brands, for example, Coca, Fanta, Sprite, and Lift are brands of the Coca Cola company.

Garber et al. (2003) claimed that color can either enhance or diminish the brand equity by facilitating or inhibiting identification and the retrieval of positive associations. Thus, there are many companies that are identified with a certain color.

Vivid red for Coca Cola™ is an example. The vivid red illustrates the coherent utilization of color for both product and corporate identity (in this case, brand identity as well). Another example of using vivid red for corporate identity is Levi's™ jeans. The vivid red for the Levi's is understood as brand identity, which is not necessarily applied to the products. Thus, corporate color is applied for products in different degrees of involvement. Corporate design manuals of a company guide the usage of corporate color for the application of various items as well as for different media platforms (e.g. painted objects, prints, façades, textiles, digital content) and occasions (i.e. advertisements, store atmospherics, and point-of-purchase displays including products and packages, etc. Garber et al., 2003, p. 316). Accordingly, a growing number of studies are dealing with the effect of different media platforms in design and marketing domains (e.g. color branding on the WWW, Lee, 2002).

Figure 9 presents some examples of how the vivid red of The Coca Cola Company is applied to different items and media. It shows the advantage of consistent usage of color to win the awareness of the product and corporate identity. It is an example of how a good package can so powerfully convey the image and identity (the equity) of a brand (Garber et al., 2003).

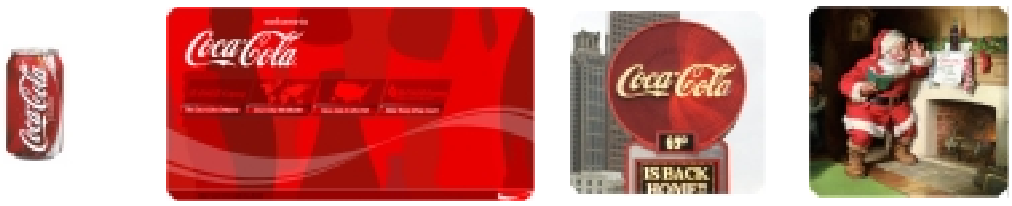


Figure 9. Applications of color of brand identity: i.e. Coca Cola company

(left to right): a can, homepage, a landmark, Santa, <http://www.cocacola.com>.

Winning awareness through color has been advocated not only by companies but also by non-profit organizations. What the respective color communicates, should be coherent with the message that the company or the organization intends to express.

BusinessWeek™ annually reports 100 of the most influential brands of the global market. Figure 10 presents logos of those companies. The logos are arranged alongside the color spectrum, according to the main color concept (Monthly Design, Feb. 2006, p.88). It is observed that 22 companies use the hue category of “red” and 29 use the hue category of “blue”. Another 30 companies apply achromatic colors.

Figure 10. The world 100 brands, Monthly Design, Feb. 2006 p. 88

Based on “The Best Global Brands”, BusinessWeek, 1st Aug. 2005.

Although some of the companies from Figure 10 run a multi-branding strategy[4], under which brands have their own identity concept (e.g. Braun of Gillette, Lancôme of L’Oreal); the companies generally pursue the color of corporate identity for various applications.

Also, it is noticeable that many of the logos are in highly saturated colors. For instance, there is a large number of companies supposed to be identified with ‘vivid red’ (i.e. Coca Cola, Kellogg, Heinz, etc). Concerning this trend, Garber et al. (2003) claimed that it is constructive marketing practice to divert and arouse the consumer. To this extent, those companies expect **similar emotional** impact on consumers.

3.5.1.2 Color terms

Color is perceivable not only through a visual sensor. Pitchford and Mullen (2005) tried to isomorph perceptual and linguistic color categories and found that constraints **driven by color naming** result from collective consensus among survey subjects rather than from constraints by visual perception with free and constrained numbers of categories.

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[4] Multi-branding strategy: a company runs brands, under their own identity. It is advocated, when a company takes over a brand and would maintains the brand image (i.e. Braun of Gillette) or when a company develops a brand and intends it to be distinguished from the corporate identity (i.e. Lancôme of L’Oreal).

Previously, Berlin et al. (1969) presented a convergence of experimental findings in the **universal recognition of 11 'basic' color categories**. It identified 11 'basic' terms in nearly 100 widely scattered languages, and even the far larger sample in the World Color Survey (WCS). It further suggested an evolution of basic color terms based on their extensive survey throughout different ethnic groups (Figure 11).

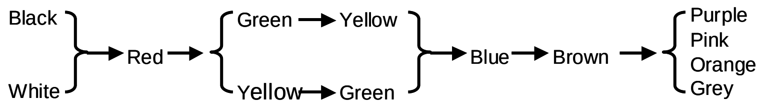


Figure 11. Evolution of basic color terms, Berlin et al. (1969).

The 11 basic color terms (Berlin et al., 1969) represent the color categorization. Further studies show that basic color terms are representative among contemporary and civilized cultures (e.g. Roberson, Davies, Corbett, & Vandervyver, 2005).

Jameson et al. (2003) explained the underlying circuit of the color naming function (Figure 12). It suggested a model of the basic naming function in order to apply a cognitive process for linking color terms (linguistic representation) and performance-related goals, such as color appearance and emotion (referent). The process is dynamic, rule-governed, and guided by information from the lexicon, category structure (concepts, theories), as well as other cognitive processes (p. 39). This may clarify the cognitive process of synesthesia between primary categories of color and emotion, as discussed in 3.3.1.

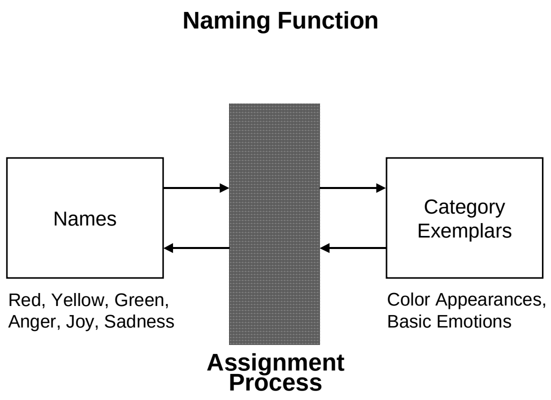


Figure 12. The basic naming function (Jameson et al., 2003, p.39).

Likewise, a discussion on the semantic threshold between color terms and their associated colors is not yet resolved, as Livingstone (2002) mentioned: "the question is of whether you see red like I see red" (p.30).

On the basis of knowing that life experiences have been different, individuals associate different experiences with the color red, although they do not show deficiency in viewing colors in general. If one says “red” and there are 50 people listening it can be expected that each of those 50 people will think of a different shade of the color red (Albers, 1963).

Empirical studies have revealed variables on which perception of color terms may depend: language (Alvarado & Jameson, 2002; Lucy, 1997; Stanlaw, 1997), gender (Bimler, Kirkland, & Jameson, 2004), or mediated products (Suk, 2000).

Recently, studies demonstrated that color terms may add emotional impact on product color. Miller et al. (2002) showed that consumers react favorably to unusual names because they are assuming that the marketing messages convey useful information. Specifically, since consumers cannot interpret the literal meaning of the ambiguous label, they focus on what they assume is the pragmatic or underlying meaning or reason for the communication effort. Since consumers believe that packaging or advertising would only provide positive information, they make positive assumptions about the brand based on ambiguous descriptions.

Such ambiguous descriptions are more individually perceived in comparison with basic color terms. Therefore, they provide less accurate information, referring to a specific color. On the other hand, those descriptions result in a rather positive association with the given products or a bigger likelihood to purchase them (Gekeler, 2000; Miller et al., 2002; Suk, Irtel, Kim, & Lee, 2003). In accordance with that, color terms in advertisements and promotions are expressed in shades. It is often observed that companies apply foreign language to describe colors of their products (see Figure 13).

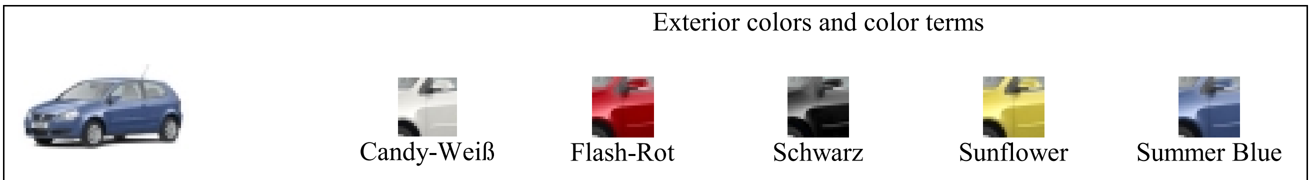


Figure 13. Color information: “Polo”. Volkswagen AG, <http://www.volkswagen.de>.

Suk et al. (2003) presented in a survey in which subjects expect color terms in a foreign language in order to express attractively the product color information. Two types of products were tested in the study: *passenger cars (Smart™ by DaimlerChrysler) and nail lacquers (Lancôme™ by L’Oreal)* and subjects were asked to create color terms for the products that may attract consumers' interest. The tendency of preferring foreign language for color naming of the product consistently appeared in different language contexts, such as Germany, South Korea, or the United States. Germans and Koreans tend to use English words and Americans tend to use French words.

3.5.2 Recent issues of color and emotion in practice

Two methodological issues of current studies on color and emotion are pointed out: limitations of color studies using terms are indicated (3.5.2.1) and the importance of color tone (Chroma and lightness) for investigating affectivity of color is discussed (3.5.2.2). After describing the process of creating a product-color scheme, a concept for an application tool is outlined (3.5.2.3).

3.5.2.1 Color studies by terms

As discussed in 3.5.1.2, color terms deserve potential usage in creating positive ambiguity with regard to product information. Nevertheless, color terms as used in the majority of empirical studies are supposed to be linked to referents (color categories) as any other linguistic representations. A number of studies elicited subjects' responses to verbal labels of color (e.g., "red" or "black").

Basic color terms research, initiated by Berlin et al. (1969), provides a universal recognition of 11 'basic' color categories. However, the basic color terms focus on **hue**, in particular on spectral location (Gage, 1995). This approach failed to specify the two additional characteristics of color necessary for a complete description of the color samples used: Chroma and lightness. The general problem of ignorance of Chroma and lightness in color studies is discussed in more detail in 3.5.2.2

Secondly, when it comes to vocabulary, it is obvious that **not all languages are isomorphic**. Lyons (1995) compared English basic color terms with French, with Hanunoo (the Malayo-Polynesian language of the Philippines), and with ancient Greek. He noted that many languages of the world do not have color-referring terms as such. They may, however, have words that are used to describe the appearance of things in terms of what people would identify as color. These words are often context-dependent, but they may be used, if required. Due to the definition of 'basic' by Berlin et al. (1969)[5], many of color terms would be excluded

[5] These are defined by having one morpheme (blood red), not being contained within another color (scarlet), restricted usage (blond), and not derived from the name of an object (saffron).

because of their context-dependence. Thus, Lyons's argument indicated the problem of transparent exchange of basic color terms throughout the languages. The issue can be extended to a multi-lingual context. Stanlaw (1997) demonstrated how differently bilinguals (Japanese-American) construct color perception depending on lingual context.
The exaggerated ambiguous color terms are used for marketing purpose, since they motivate consumers to make additional communication efforts. Consumers react favorably to such unusual color terms (Miller et al., 2002).

In addition, **emotional terms** are also often used in consensual studies. In most cases, studies used adjective checklists with dubious reliability and validity to access emotional reactions to color. An even more problematic technique had subjects match verbal emotion labels to basic color terms. Single-emotion terms such as "exciting" or "comfortable" refer vaguely to discrete emotion states and have doubtful reliability for assessing emotional reactions. Furthermore, in the absence of a theoretical system that interrelates discrete emotional states, single emotion terms do not provide a basis for characterizing similarities and differences in emotional reactions to various colors.

3.5.2.2 Color tone and emotion

Valdez et al. (1994) claimed that studies dealing with physiological reactions to color have failed to provide adequate specifications or controls for color stimuli. It criticizes the **absence of the control variables such as Chroma and lightness.** Therefore, in some recent studies, authors employed color stimuli, considering Chroma and lightness dimensions. Lee (2005), for instance, provided subjects with 216 digital color cells in a web-based survey, instead of a predefined limited number of color chips. It criticized current color preference research, arguing that the use of a limited number of pre-defined colors could result in a difficulty of predicting specific colors needed for diverse consumer groups.

There are few attempts to demonstrate that Chroma and lightness affect some aspects of emotion. Early work by Guilford (1934) established the dependence of pleasantness on hue, value, and saturation. In this study, five men and five women evaluated 40 Munsell colors for hue, value, and saturation. With value and saturation held constant, the functional relationship between pleasantness and hue appeared to be of a periodic type. With hue held constant, linear relationships were found to hold between pleasantness, value, and saturation. Later, Helson (1964) found that saturation is significantly associated with the pleasantness of colors. The study employed 125 Munsell colors and grouped them into three levels of saturation: least saturated colors, medium saturated colors, and most saturated colors. The most saturated colors turned out to have the highest mean pleasantness. This tendency was replicated with children in an empirical study conducted by Boyatzis et al. (1994). Further results showed a stronger pattern of emotional reaction in women than in men.

More systematically, Adams et al. (1973) dealt with color emotion based on the three dimensions. It proposed a general overview of relations between the three dimensions of emotion and color attributes (Munsell colors were employed): brightness correlated positively with evaluation (valence) and negatively with potency (dominance). Activity (arousal) was strongly associated with chromatic colors versus achromatic colors. With regard to color lightness, Hemphill (1996) replicated Adams et al., showing that bright colors elicited mainly positive emotional associations, while dark colors triggered negative associations.

In Valdez et al. (1994), the effect of hue was weaker than anticipated Especially the results relating hue to arousal and dominance were weak. Gekeler (2000) proposed the potential utilization of gray-modulation, indicating that gray nuances have not been investigated enough. It emphasizes that gray modulation might facilitate emotional communication by colors in domains of art and design.

3.5.2.3 Creating color solution

The challenge in practice is to “create color solution”. This is the process of choosing the ideal color or color combination from the available color palette or color space. From an analytical point of view, the color scheme of a product needs to express the emotion that may contribute to the image or the function a product. Thus, the mediated color must be coherent with the image or function of the product.

Averill (2005) explained that, while a product concept is activated, a creative process may take advantage of metaphor, as a direct conceptual link (p. 227). When a product concept is directly linked (associated) with a color, the product and the color are easily linked. (e.g. a color concept for the packaging design for orange juice).

The dilemma to develop a color scheme for a product takes place when the concept of the product is “new” or “abstract”, in other words it is lacking reference. For example, a soft drink (e.g. Coca Cola in Figure 13) became diversified according to different abstract concepts: ‘low calorie’, ‘zero calorie’, ‘decaffeinated’, etc. A mediating substance that links product concept with a color is required. Therefore, the basic concept for developing an application tool is to find out a systemic and practical approach to clarify the mediating substance.

Figure 14. Color scheme for a diversified product portfolio.

A new ‘emotional-experiential’ perspective on creative metaphors proposed in Getz and Lubart (2000) may provide clues to solve the problem. It proposed a model of metaphor formation mediated by resonating feeling tones. The model assumes that some associations between concepts are **mediated by emotional profiles** or feeling tones (Figure 14). “Feeling tones” in Getz et al.’s metaphor model indicate emotion in a mediational sense. Feeling tones refers to the broad matrix of experience in which all behavior is embedded (Averill, 2005).

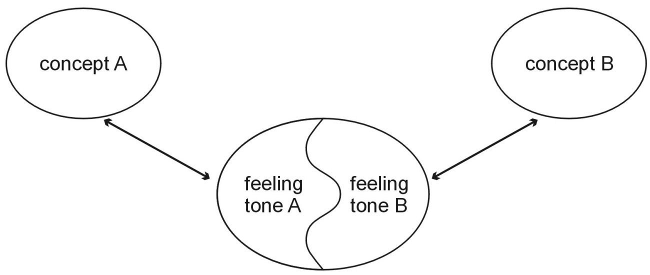


Figure 15. Emotional resonance model (ERM), (Getz et al., 2000; quoted in Averill, 2005, p. 227).

The ERM provides the base of communication between color concept and product concept in practice. An applied model of ERM is illustrated in Figure 15. It shows that the **emotional profile** of color concept (A) and that of product concept (B) should form a metaphor, which links the color concept with the product concept.

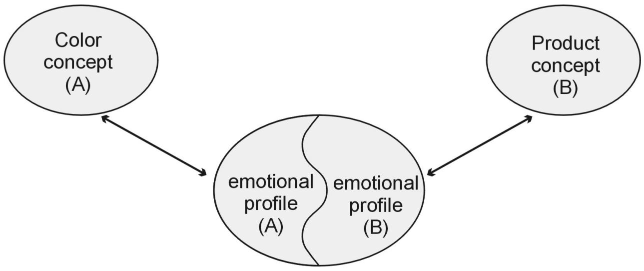


Figure 16. A concept of a color application tool based on ERM model.

In order to transfer the idea to an application tool, it is necessary to identify an emotional profile of substances (A) and (B) in a common parameter.

In a series of experiments in this dissertation, emotional profiles of color and product concept are characterized in terms of three dimensions of emotion: valence, arousal, and dominance, which are assessed with SAM. It is expected to show empirically the concept of an application tool and to propose a methodology for the development of a product-color scheme.

3.6 CHAPTER REVIEW

• Five different aspects of viewing color are described: color match (same quantum catch), color sensation (psychophysical quantity), color perception (cognitive quantity), color aesthetics (aesthetic quantity), and color semantic (social and cultural context). Each aspect builds on the previous and successively adds more and different disciplines to it (3.1).

• The aspect of affective color is discussed in two ways. One discusses that color may affect mediated presentations (3.2.1) such as pictures (3.2.1.1) and films (3.2.1.2). Previous studies on the influence of color on cognitive processing and emotional reactions are summarized. Nevertheless, it is not yet confirmed whether the effect of color is universal. The other claims that color itself may elicit emotion, which may vary depending on physical properties and individual memory of the color (3.2.2). In empirical studies, the color stimulus is used excluding semantic contents.

• Investigating emotional response to color, two approaches of conceptualization are discussed. The first corresponds to synesthesia of color and emotion, based on the assumption that each color is tied to a specific emotion. Some assert the reason for that association in terms of physiological reaction while others emphasize cultural roots. Examples of synesthesia are presented and also critique of the approach is put forward (3.3.1). In line with synesthesia of color and emotion, issues on color categorization by terms are discussed.

Secondly, color may be characterized in terms of three dimensions of emotion. Although it takes advantage of generality and potential versatility as a descriptive system for emotion, not much research has been done in this area (3.3.2).

• Previous studies about three measurement systems of emotional response to color—physiological (3.4.1), behavioral (3.4.2), and experiential (3.4.3)—are reviewed and experience based self-reports are revealed to be the most robust among the three measurement categories. Moreover it is discussed that SAM is indeed an adequate tool to generate reliable results to describe the emotional character of color.

• Given the lack of interdisciplinary research between theory (i.e. psychology) and practice (i.e. design), I try to link both domains by diagnosing current problems and interests. In doing so, visible and invisible channels of emotional communication of product color are discussed: product and corporate color (3.5.1.1) and color terms (3.5.1.2). Simultaneously, two methodological problems of studies on color and emotion are described: color studies carried out with terms (3.5.2.1) and those which do not controls for Chroma and lightness (3.5.2.2). In addition, an emotional resonate model (ERM) (Getz et al., 2000) is introduced as a basic structure, on which an application tool for the development of product-color schemes may be built (3.5.2.3).

4. EXPERIMENT I: PILOT STUDY

The purpose of the following four experiments is to investigate whether color elicits emotion as pictures do, and especially, whether color can be profiled in terms of the three dimensions of emotion: valence, arousal, and dominance. These empirical studies describe emotional responses to physical attributes of colors: hue, Chroma, and lightness, excluding semantic contents.

4.1 GOALS AND HYPOTHESES

Two hypotheses are tested in Experiment I. With regard to the first hypothesis, it is tested whether three dimensions of emotion are reliable to characterize an emotional profile of colors. For this purpose, 43 digital colors are employed and SAM is utilized to assess emotional response to a color stimulus. As discussed in section 2.4.3, SAM is a non-verbal self-reporting system proven to be adequate to judge the affectivity of pictures (e.g. IAPS in section 2.4.3.2). It is predicted that SAM assessments would also be adequate to describe an emotional response to a color stimulus.

[H. 1] Color stimuli elicit emotions as pictures do.

The second hypothesis tests if emotional responses are stronger with regard to Chroma and lightness than with regard to hue. As pointed out in section 3.5.2.2, it is of increased interest to study in what way these two attributes of color properties (Chroma and lightness) affect emotion. Previous studies on photoreceptors assumed that there is a relationship between highly saturated colors and the activation of emotion (Adams et al., 1973; Simmons, 2006; Valdez et al., 1994). Valdez et al. (1994) showed high robustness regarding correlations of brightness as well as saturation and emotional reactions, whereas hue and emotions were weakly correlated. The color stimuli in the study of Valdez et al. were based on Munsell, where the color attributes are defined by hue, value (corresponds to ‘lightness’ in the CIELab Lch system), and Chroma. Based on the review, a [H. 2] is formulated as follows:

[H. 2] An emotional response to a color stimulus is stronger with regard to Chroma and lightness than with regard to hue.

4.2 METHOD

4.2.1 Subjects

Forty-eight, including 10 male and 38 female, psychology students of the University of Mannheim served as subjects, in partial fulfillment of a course requirement (Table 7).

	number of survey subjects		age	
	male	female	M	SD
Mannheim, Germany	10	38	21.96	2.51

Table 7. Subjects of Experiment I.

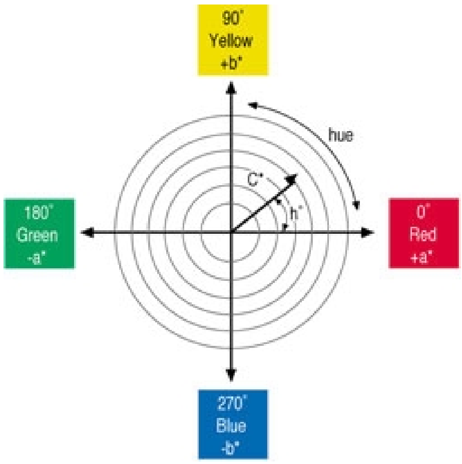
4.2.2 Stimuli

Three sets of stimuli, 43 digital colors (4.2.2.1), 19 adjectives (4.2.2.2), and eight IAPS pictures (4.2.2.3) were employed and assessed in separate sessions. Within a session, stimuli were presented in random order. Subjects were aware when a new session started. SAM was utilized as a measurement system.

4.2.2.1 Color stimuli: CIELab Lch

The color stimuli in all experiments of this dissertation are based on the CIELab Lch system, in which color attributes are defined by hue, Chroma, and lightness. Since the Munsell color system still prevails in color studies; hue, value, and Chroma (or saturation) are often used to describe the color attributes. The gamut of the Munsell system is included in the CIELab Lch system. Thus, all colors of the Munsell system can be represented in terms of the CIELab Lch system, but not the other way around. The fundamental representation concept of color attributes in the CIELab Lch system refers to the Munsell color system, namely lightness in the CIELab Lch refers to value in the Munsell system.

● **CIELab Lch** is a calculation derived from CIELab equations. It uses the basic CIELab information, but presents the graphical information with a focus on Chroma and hue, so that it may be **visually easier** to understand than typical CIELab graphical presentations. As shown in Figure 17, CIELch converts the CIELab linear coordinates into polar coordinates of C (Chroma) and h (hue). L remains as the lightness/darkness coordinate.



L – Absolute lightness or darkness on a scale of black to white

C – Chroma as a radial in polar coordinates

h – Hue as an angle originating from the +a (red) axis in polar coordinates (0 ~ 360°)

Figure 17. CIELab Lch, <http://www.gecolorxpress.com>.

In Experiment I, 43 color stimuli were selected based on CIELab Lch: five hue categories were set in terms of angles in Figure 17. They are hue categories of red (40°), yellow (85°), green (160°), blue (270°), and violet (320°). From each hue category seven to eight representative colors were chosen varying in Chroma and lightness. Moreover, five achromatic color stimuli including black and white were added, and two more colors, such as orange ($50_L\ 20_C\ 65_h$)[6] and brown ($30_L\ 20_C\ 80_h$) were included.

4.2.2.2 Semantic stimuli: Semantic network

In section 3.5.2.3, it was suggested to apply the Emotional Resonate Model (ERM) (Getz et al., 2000) in order to construct a methodology for the development of a product-color scheme. According to the revised ERM, shown in Figure 16, one side corresponds to the emotional profile of a product concept, while the other side corresponds to that of a color concept.

A semantic network is utilized to generate emotional terms (adjectives) to define the product image that a company desires. Berkowitz (2000) noted that a semantic network holds emotional states and semantically related ideas. If people experience a particular feeling, thoughts are likely to come to their minds. These activated ideas influence the interpretations of ambiguous situations. Mäder (2005) advocated it as an outstanding and realistic model among schema theories in describing characteristics of a product or a brand.

[6] The color orange employed in Experiment I is defined by lightness=50, Chroma=20, and hue=65°.

As a case study, a product concept of ‘low fat’ was applied. Four psychology students participated in the process and adjectives semantically related to the keyword ‘low fat’ were collected. Some adjectives were collected targeting a low fat dairy product, while some targeted a low calorie soft drink. Adjectives obtained from this semantic network were then assessed with SAM.

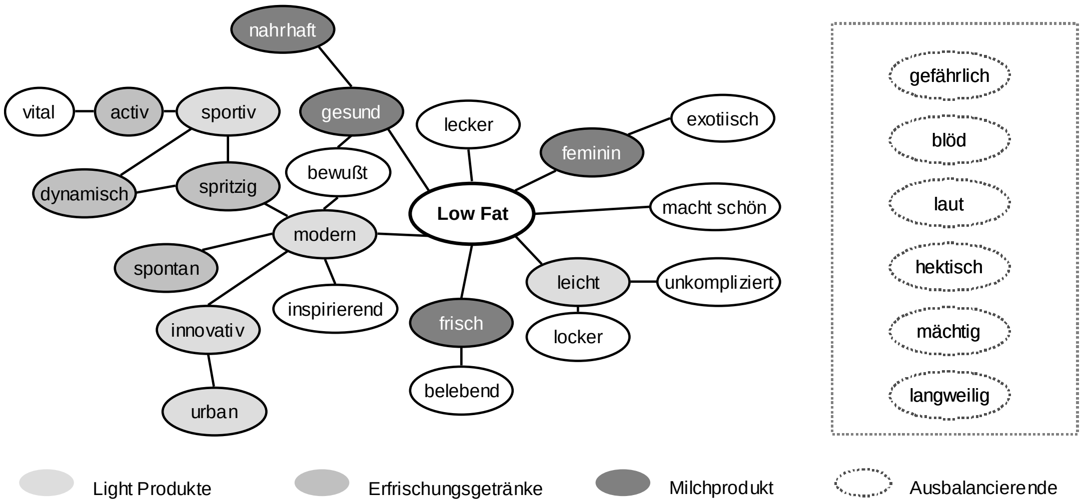


Figure 18. A semantic network for a “low fat” product and six adjectives for counterbalance.

In addition to 13 selected adjectives (ellipses filled with different grays), another six negative adjectives were added through a separate session of brainstorming. This was done in order to present a more complete range of adjectives, such that a positive bias of emotional responses is avoided. Thus, subjects may experience both positive and negative emotion of valence dimension while assessing 19 adjectives.

The procedure of creating a semantic network for the development of a new product can help companies to find items (i.e. emotional terms) to describe ideal images of their respective product.

4.2.2.3 Control stimuli (Baseline): IAPS pictures

Two sets of four pictures were selected from the IAPS (Lang et al., 2005), the pre-determined normative ratings of which were known. During Experiment I, the first set, which consisted of four achromatic pictures, was presented at the beginning of the experiment. The purpose of this procedure was that subjects would get acquainted with the SAM rating system.

The second set, composed of four chromatic pictures, was displayed at the end of the experiment. These pictures were employed to provide the baseline of the emotional state of each individual subject. The selected pictures of both sets occupy emotional profiles in the peripheral area of emotion space (see Figure 6) in some dimensions. Those pictures thus induce greater degrees of emotion (Russell et al., 1987). For instance, a picture with two bunnies (IAPS No. 1750) has a mean value of 8.28 (1~9 scale: SD=1.07) on the valence dimension judged by a large group of Americans in the United States[7]. This means that the majority of people would judge the valence dimension of this picture inclining closer toward the extreme '+' valence . On the other hand, if a subject evaluates the valence dimension of this picture closer to the extreme '–' valence, it could be interpreted that this person felt highly biased at the moment or did not understand how to use SAM.

Additionally, three more pictures (No. 6230, No. 7175, and No. 8030) were added as control stimuli, which had means closer toward the periphery: for '–' valence (No. 6250), for '–' arousal (No. 7175), and for '+' arousal (No. 8030). These four pictures are presented at the end of the experiment. Mean (μ_0) standard deviation (σ_0) values of IAPS (Lang et. al, 2005) are presented in Table 8.

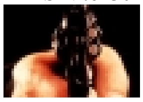
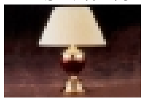
	IAPS Nr.1750	IAPS Nr.6230	IAPS Nr.7175	IAPS Nr.8030
				
valence μ_0 (σ_0)	8.28 (1.07)	2.37 (1.57)	4.87 (1.00)	7.33 (1.76)
arousal μ_0 (σ_0)	4.10 (2.31)	7.35 (2.01)	1.72 (1.26)	7.35 (2.02)
dominance μ_0 (σ_0)	6.15 (2.01)	2.15 (2.09)	6.47 (2.04)	4.70 (2.66)

Table 8. Mean μ_0 (standard deviation σ_0) of the four control stimuli selected from IAPS (Lang et al., 2005).

Therefore, the subjects, who assessed any of these four IAPS pictures in the way shown in Table 9, were considered outliers and their data was filtered out. Among the subjects who took part in Experiment I, there were no outliers. This baseline is applied to further experiments (II, III, and IV).

[7]The IAPS version of 1999 is comprised of data from more than 10,000 people. Each has evaluated 60 items of the whole database. The upgraded IAPS version of 2005 includes 956 items.

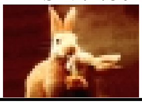
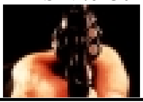
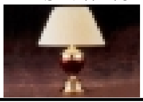
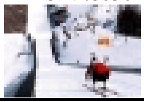
If a picture,	IAPS Nr.1750 	IAPS Nr.6230 	IAPS Nr.7175 	IAPS Nr.8030 
is assessed with an extreme,	'–' valence	'+' valence	'+' arousal	'–' arousal
which corresponds to SAM assessment in 5-scale,	1 (valence)	5 (valence)	5 (arousal)	1 (arousal)
Then	the all responses of the subject were filtered out.			

Table 9. Control stimuli to detect outliers.

4.2.3 Procedure

The experiment was conveyed in a laboratory of the Otto Selz Institut in Mannheim. The lighting of the closed room was dimmed. The stimulus presentation was implemented by PXLab© software. Subjects were first presented with four achromatic IAPS pictures, then followed 43 CIELab Lch colors, then 19 adjectives, and finally four chromatic IAPS pictures. Each stimulus was presented only once and displayed on 17-inch CRT monitors. Every person was subjected to all stimuli sets.

Chromatic as well as achromatic pictures were presented with the dimension of 21.1 cm width × 14.2 cm height, center aligned. Colors were displayed filling out the whole screen. An illustration of a color palette (a mosaic-color-spectrum) was inserted in the lower half of the screen, with the dimension of 25.3 cm width × 3.4 cm height. The underlying idea was color constancy, which works best when an object is surrounded by objects of many different colors (Goldstein, 2002). Adjectives were provided in "Arial" typeface in height of 3.5 cm in white against a black background.

Monitors were positioned approximately 50 cm from the subjects. A row of five SAM pictograms appeared in the bottom part of the screen and each of them was presented with the dimension of 5.8 cm width × 4.6 cm height. Subjects were to select one of the five by mouse-click and the input was submitted when subjects pressed the spacebar. Pictograms were exchanged with the next row of five pictograms in a periodic way (valence, arousal, dominance, valence,…). Each stimulus had to be assessed by three rows of SAM pictograms before the next stimulus was presented.

The introduction of the Experiment I can be found in Appendix A.

4.3 RESULTS

Considering cumulative data of IAPS (Lang et al., 2005) as a population, mean and standard deviation values of four chromatic pictures are compared. Since IAPS employs a scale ranging from 1 to 9, the ratings of Experiment I (scale ranging from 1 to 5) were multiplied by 2 and then subtracted 1. The modified inputs were,

$$\{1, 2, 3, 4, 5\} \times 2 - 1 = \{1, 3, 5, 7, 9\} \qquad \text{Equation 1}$$

Accordingly, the mean and standard deviation data in Table 10 were calculated from the modified data. Table 10 shows that the dominance dimension was explained incorrectly. Subjects interpreted it in terms of 'how dominant is the stimulus', instead of 'how dominant do I feel'. It may have been caused by insufficient explanation of SAM scales, and thus dominance ratings were excluded from the analyses of Experiment I. For the following series of experiments, an extended instruction of the SAM scale is provided in order to ensure accurate usage of SAM.

picture	IAPS nr.	valence		arousal		dominance	
		M (SD)	$\mu_0\,(\sigma_0)$	M (SD)	$\mu_0\,(\sigma_0)$	M (SD)	$\mu_0\,(\sigma_0)$
	1750	8.32 (1.13)	*8.28 (1.07)*	4.92 (2.51)	*4.10 (2.31)*	5.08 (2.33)	*6.15 (2.01)*
	6230	1.71 (1.46)	*2.37 (1.57)*	8.21 (1.35)	*7.35 (2.01)*	**8.08 (2.06)**	***2.15 (2.09)***
	7175	4.79 (1.52)	*4.87 (1.00)*	1.92 (1.54)	*1.72 (1.26)*	**2.46 (1.92)**	***6.47 (2.04)***
	8030	5.88 (2.64)	*7.33 (1.76)*	8.38 (0.98)	*7.35 (2.02)*	**7.33 (1.62)**	***4.70 (2.66)***

Table 10. Mean (M) and standard deviations (SD) values of four IAPS pictures, Experiment I

N= 48; Mean (μ_0) and standard deviations(σ_0) values from IAPS (Lang et al., 2005).

Based on SAM ratings on valence and arousal, alpha internal consistency-reliability coefficients provided evidence of satisfactory levels of internal consistency of the dependent variables of emotion: valence and arousal. Since dominance was excluded from the analysis, [H. 1] (color stimuli elicit emotions as pictures do) is hereby **partially confirmed.**

	valence	arousal
color stimuli (on 43 variables)	.806 (35 cases)	.962 (47 cases)
adjectives (on 19 variables)	.654 (39 cases)	.913 (47 cases)
color stimuli + adjectives + four IAPS pictures	.807 (26 cases)	.969 (46 cases)
(on 66 variables)	.957 (on 198 variables, 26 cases)	

Table 11. Reliability coefficients of Experiment I, Cronbach's alpha N=48

Missing data occurred due to double clicking the space bar.

A scatterplot of means of valence and arousal of colors and adjectives is depicted in the emotion space, defined by valence (abscissa) and arousal (ordinate), as illustrated in Figure 19.

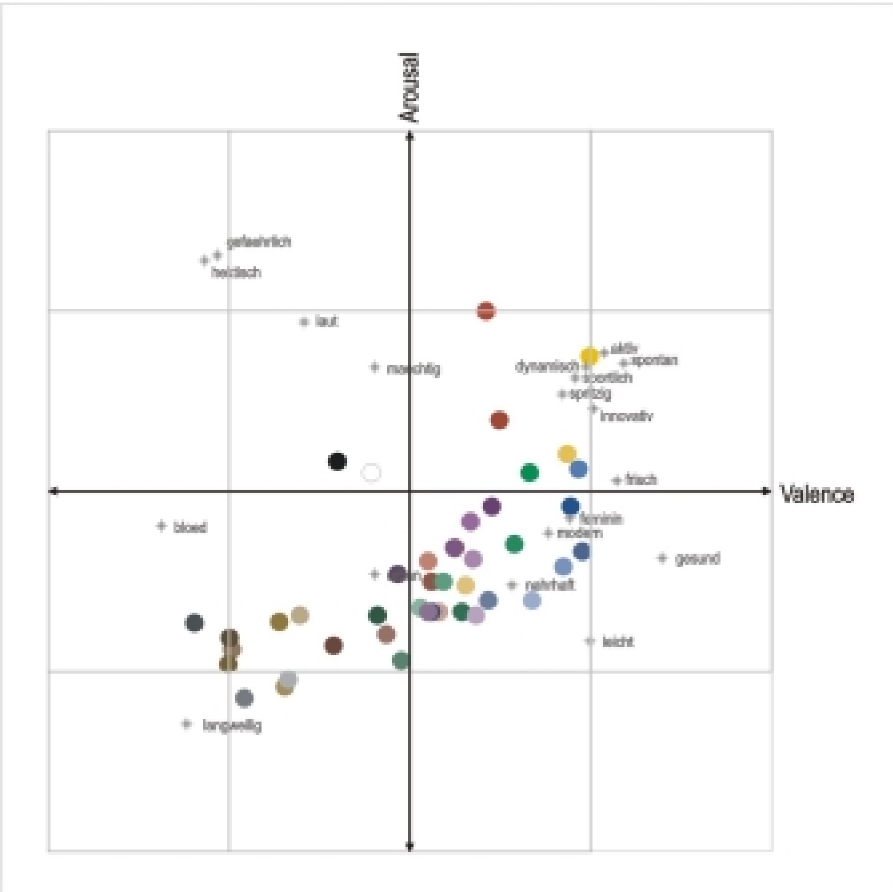


Figure 19. A scatterplot of means of valence and arousal of 43 colors and 19 adjectives, Experiment I

Emotion space defined by: valence (abscissa) × arousal (ordinate).

Within the emotion space, emotional profiles of both colors and adjectives are defined simultaneously. It provides a geometrical interpretation of the relationship **within** and **between** two kinds of stimulus types (colors and adjectives) in terms of valence and arousal. Moreover, it is observed that some are clustered. For instance, vivid yellow (080_L 85_C 085_h) is positioned close to adjectives, such as ‘dynamic (dynamisch)’, and ‘active (aktiv)’, whereas a dark gray (030_L 00_C 360_h) is located close to ‘boring (langweilig)’. This scatterplot supports the concept of an application tool, which will be outlined in section 4.6.

In addition, the six counterbalancing adjectives ‘laut (loud)’, ‘langweilig (boring)’, ‘hektisch (hectic)’, ‘mächtig (mighty)’, ‘blöd (stupid)’, and ‘gefährlich (dangerous)’ were assessed to be negative in the valence dimension, as expected. Also expectedly, the other 13 adjectives were evaluated rather positive. Mean and standard deviation values of all stimuli used in Experiment I can be found in Appendix C.

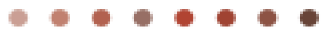
In Figure 19, a diagonal pattern runs roughly from the low-left to the upper-right can be observed. Within the pattern, colors of different hue are well distributed: each quadrant contains various categories of hue. The upper-right quadrant includes colors with the highest Chroma of the different hue categories. In the lower-right quadrant, there are color stimuli from various hue categories but colors that are little saturated. Accordingly, it is predicted that Chroma affect emotional responses differently. In particular:

- colors with higher Chroma are located mostly in the upper-right quadrant, ‘+’ valence and ‘+’ arousal, whereas
- colors with lower Chroma and achromatic colors are rather in the lower-left quadrant, (–) valence and (–) arousal.

The observed tendencies can be observed throughout all hue categories and are analyzed with regard to hue (4.3.1), Chroma (4.3.2), and lightness (4.3.3).

4.3.1 Emotional responses to differences in hue

Among the 43 color stimuli, there were five major hue categories, one achromatic category, and two additional colors, namely orange (50_L 20_C 65_h) and brown (30_L 20_C 80_h). For the analysis of emotional responses to differences in hue, colors of the five hue categories were taken into consideration.

h= 40°, the hue category of ‘red’, contained eight color stimuli : 

h=85°, the hue category of ‘yellow’, contained seven color stimuli : 

h=60°, the hue category of ‘green’, contained seven color stimuli : 

h=270°, the hue category of ‘blue’ contained seven color stimuli : 

h=320°, the hue category of ‘violet’ contained seven color stimuli : 

The charts in Figure 20 illustrate mean (dots) and standard deviations (range of error bar) of SAM ratings of the colors of each hue category regarding valence and arousal. Since the hue category ‘red (h=40°)’ included eight color stimuli, the number of ratings (frequency) is bigger than those of the other hue categories.

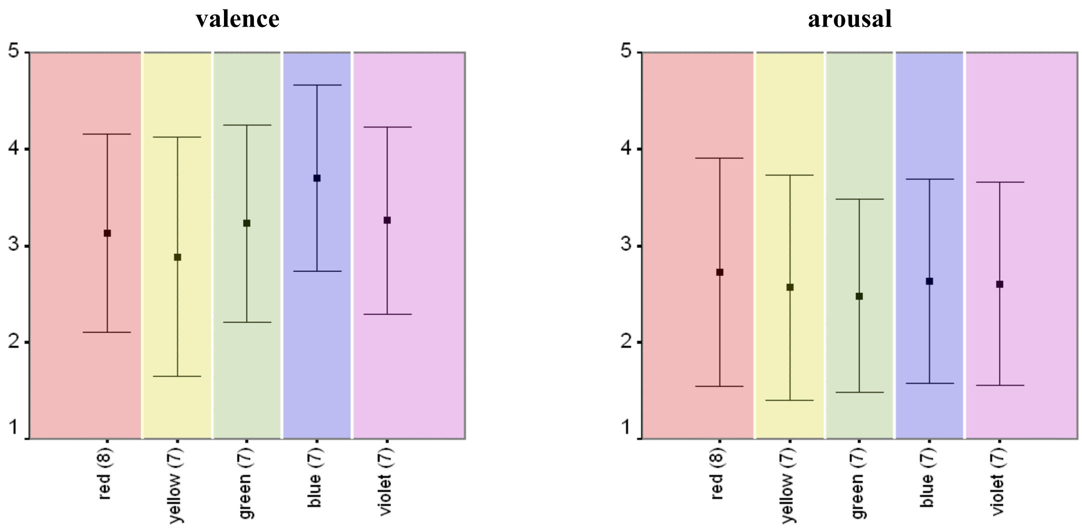


Figure 20. SAM ratings of hue, Experiment I

abscissa: hue category by the CIELab Lch system, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, numbers in parentheses: number of color stimuli, N of subjects=48.

The hue categories represent certain segmentations of a circle (0° ~ 360°, see Figure 17). Thus, the emotional response to hue segments is periodical**.** For instance, SAM ratings of each hue in valence dimension bound in yellow (85°) and rise up in blue (270°) **periodically**. The means for arousal of the entire hue categories are below 3 and there appears no characteristic tendency between hue categories and the arousal dimension.

4.3.2 Emotional responses to differences in Chroma

Additionally, the SAM ratings of color are observed in terms of Chroma. The mean values for valence and arousal in Figure 21 illustrate a **positive linear relationship between Chroma and emotional responses**: the higher the Chroma level is, the greater the SAM ratings are. Color stimuli belonging to Chroma ‘0’ are achromatic ones, such as different grays, black, and white.

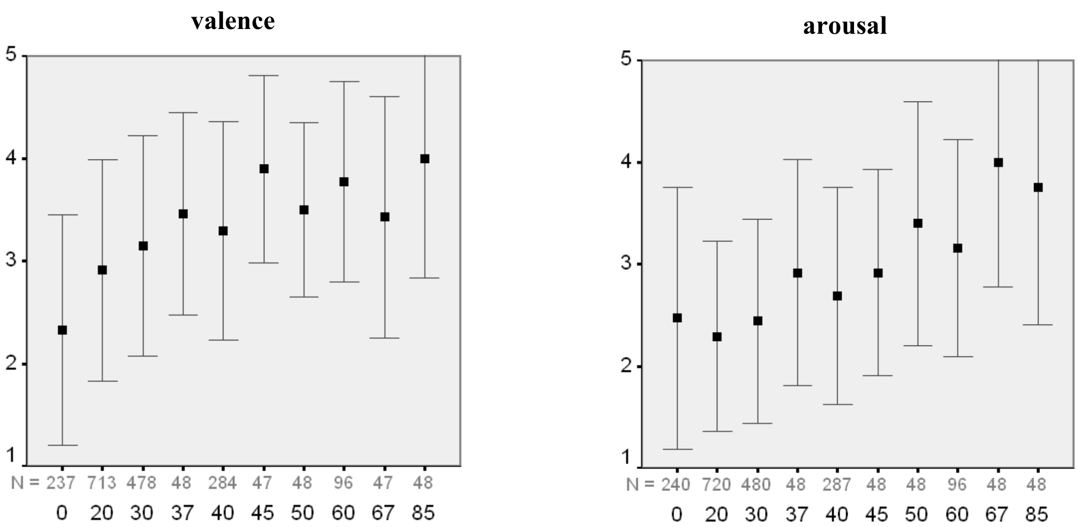


Figure 21. SAM ratings of Chroma, Experiment I

abscissa: Chroma by the CIELab Lch system, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N=48.

Correlation analysis yielded significantly positive correlation coefficients between Chroma and valence as well as between Chroma and arousal (Table 12). The results are in line with previous studies which revealed a positive relationship between Chroma (or saturation) and emotional reaction (Adams et al., 1973; Guilford, 1934; Helson, 1964; Valdez et al., 1994).

		Correlation coefficients	
		valence	arousal
Chroma	Pearson Correlation (*r*)	**.323*****	**.284*****
	N	2046	2063

Table 12. Correlation coefficients between Chroma and valence and arousal, Experiment I

*** Correlation is significant at the 0.001 level (two-tailed).

4.3.3 Emotional responses to differences in lightness

Since Chroma showed a positive linear correlation with valence and arousal, it is predictable that very dark colors or very light colors exhibit smaller mean values of valence and arousal, because these colors are characterized by low Chroma. Moreover, highly saturated colors, with the exception of yellow, are neither very dark nor very light. It can therefore be assumed that lightness shows a negative quadratic relationship (an inverted U-shape) to both valence and arousal.

As Chroma influences color affectivity, analysis is carried out first with **(a)** chromatic colors (Figure 22) and then with **(b)** achromatic colors (Figure 23).

(a) In Figure 22, the mean SAM ratings of chromatic colors are plotted against lightness level of the colors. However, the assumption of negative quadratic relationship can hardly be confirmed. Instead, three colors with a lightness of 80 received systematically higher mean SAM ratings than any other color regarding both dimensions (marked in yellow circle in charts). These three colors, in fact, belong to the hue category "yellow".

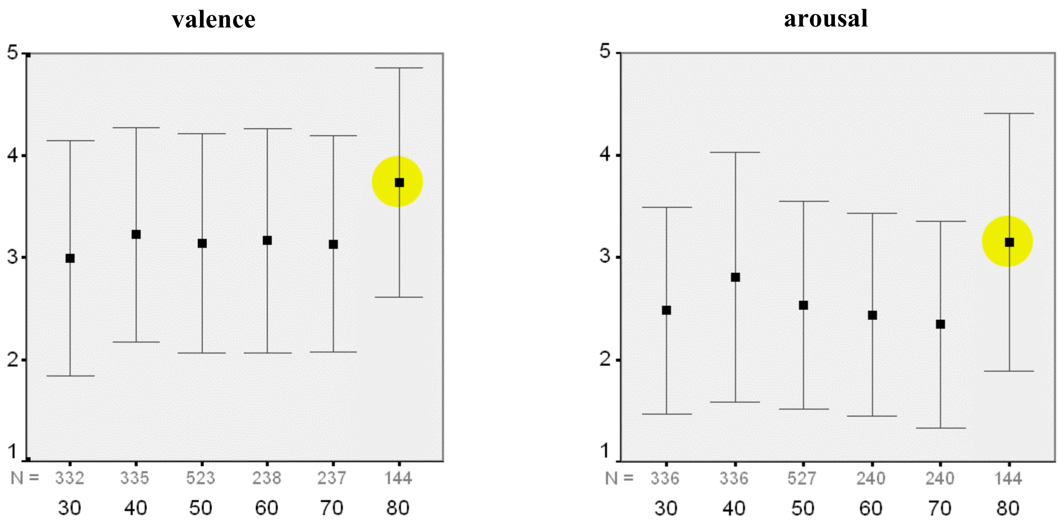


Figure 22. SAM ratings of lightness of chromatic color, Experiment I

abscissa: lightness by the CIELab Lch system, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N of subjects=48.

(b) Secondly, the mean SAM ratings of achromatic color stimuli, such as black, white, and grays, are analyzed. Colors are arranged 'black', 'dark gray', 'medium gray', 'light gray', and 'white' from left to right on the horizontal axis (abscissa).

It is found that black and white were assessed neutral, whereas the grays received mean SAM ratings in the lower half of the scale regarding both valence and arousal. A possible explanation is that the **discrepancy of lightness** between color stimulus and context might have increased the emotional responses to result in a U-shape. For future research, further studies that investigate the effect of **color contrast** in terms of discrepancy between color stimulus and background would be desirable.

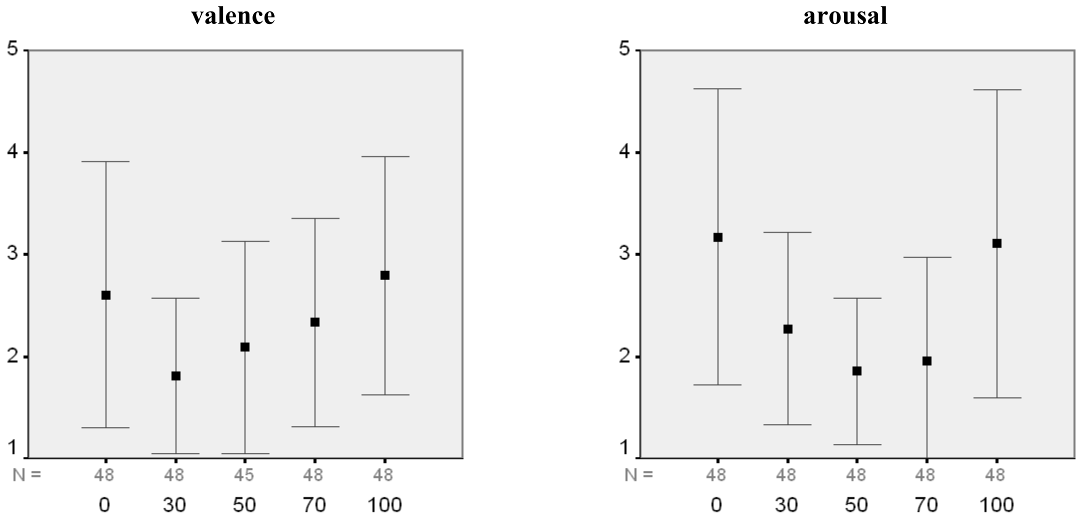


Figure 23. SAM ratings of lightness of achromatic color stimuli, Experiment I

abscissa: lightness by the CIELab Lch system, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N of subjects=48.

In addition, this implies that although lightness is the only common attribute between chromatic and achromatic color stimuli, lightness is not found to explain emotional responses to both stimuli in the same manner.

4.4 SUMMARY AND DISCUSSION OF EXPERIMENT I

Emotional responses to 43 color stimuli were assessed with SAM and the results showed that valence and arousal may characterize emotional profile of colors, supporting [H. 1] (Cronbach's α=.806: valence, α=.962: arousal). Emotional responses to color stimuli were analyzed in terms of hue, Chroma, and lightness which are based on the CIELab Lch system. Each subject was subjected to all stimuli.

As it is hypothesized [H. 2], SAM ratings vary only slightly with the five hue categories. On the other hand, Chroma is positively correlated with SAM ratings of valence (*r*=.323***) and arousal (*r*=.284***) dimension. The positive relationship between Chroma and affectivity confirms previous findings (Adams et al., 1973; Guilford, 1934; Simmons, 2006; Valdez et al, 1994).

With regard to lightness of achromatic colors, emotional responses were greater when the discrepancy of stimulus and context (e.g. color palette on display) was bigger (e.g. black or white). For chromatic colors, lightness influenced on affectivity much less than anticipated.

In order to construct a color application tool as a byproduct of the experiment, 13 adjectives were collected to describe a product concept (i.e. low fat) by means of a semantic network. Adding another six negative counterbalancing adjectives, the emotional responses to 19 adjectives were assessed with the SAM system. Then, SAM ratings of colors and adjectives were mapped on the same emotion space defined by valence and arousal. Colors and adjectives which were located adjacent to each other (qualitative setting: Morris, 1995) in emotion space, imply the similar emotional profile between both concepts. The empirical results support the concept for an application tool, based on the ERM by Getz et al. (2000). The expected advantages of the application tool for the development of a product-color scheme are discussed in section 4.6.

Although the two hypotheses could be partially confirmed, there remain some points to be improved for the next experiment. Firstly, due to insufficient information about the SAM pictograms of the dominance dimension, ratings to all the stimuli on dominance were excluded from the analyses. Thus, more intensive instruction about the usage of the SAM system is necessary.

Secondly, the analyses of Experiment I were relying on physical properties of colors. Therefore, not every hue category was analyzed equally in terms of Chroma and lightness. As shown in Figure 22, SAM ratings of lightness 80 (marked in yellow circle) refer, in fact, to three yellow colors. Due to subjective color perception, a hue and tone categorization is proposed in section 4.7, based on which color stimuli are selected for further experiments (II, III, and IV).

4.5 CROSS-CULTURAL STUDY: EXPERIMENT I IN SOUTH KOREA

The individual learning process and cultural influence diversify the emotions in terms of release and expression. The social and cultural influence during the viewing of color was discussed in section 3.1.1, as semantics of color.

As reviewed in section 2.4.3, SAM is a reliable and adequate measurement system for cross-cultural research. Morris (1995), for instance, demonstrated that affectivity of TV advertisements between US-Americans and Taiwanese.

Experiment I was conducted in South Korea aiming at **comparing tendencies of emotional responses to colors** between German and Korean subjects.

4.5.1 Method

The duplicated experiment was carried on at Paik-yang high school in Seoul, South Korea. Eighteen students, including one outlier, served as subjects (Table 13). Native speakers summarized the IAPS (Lang, 1999) introduction and translated it into Korean. Stimuli were provided on 17-inch CRT monitors and answers were given on paper.

	number of survey subjects		age	
	male	female	M	SD
Seoul, South Korea	7 (+ 1 outlier)	10	16.24	.55

Table 13. Subjects of Experiment I in South Korea

outlier: one Korean subject responded to the picture of two bunnies (IAPS nr. 1750) with extreme '–' valence.

The experiment took place in a computer laboratory, and thus the physical environment of the experiment was not identical with Experiment I in Mannheim, Germany.

The instruction and answering sheets of Experiment I in South Korea can be found in Appendix B.

4.5.2 Results

Firstly, the SAM ratings of the four IAPS pictures (baseline) were compared with regard to valence and arousal. Figure 24 compares the SAM ratings of four IAPS pictures between both cultural groups. Korean subjects evaluated 'bunnies' as very '+' valence , 'aimed gun' as very '–' valence, 'a lamp' as very '–' arousal, and 'skier' as very '+' arousal, similar to **German subjects**.

In order to investigate whether the nationality of subject groups (the first main factor) influenced affective judgment of the IAPS pictures, a two-way ANOVA with repeated measurement on the second main factor (stimulus: pictures) was run. The analysis yielded no significant effect of experiment ($p>.05$), implying that the SAM ratings of the four IAPS pictures were not significantly different between the two subject groups.

factor	valence	arousal
experiment (between)	**F (1, 63)=3.701, p=.059**	**F (1, 63)=1.063, p=.306**
stimulus: pictures (within)	F (2.472, 150.776)=107.262, p=.000***, ε=.824	F (2.445, 154.047)=121,911 p=.000***, ε=.815
exp.(between)*stimulus (within)	F (2.472, 150.776)=107.262, p=.055, ε=.824	F (2.445, 154.047)=121,911 p=.083, ε=.815

Table 14. Result of two-way ANOVA with repeated measurement on one factor: stimulus (pictures), Germans vs. Koreans, Experiment I.

Then the difference between the two cultural groups with regard to each picture was examined using a t-test (p=.05, two-tailed). It turned out that two pictures, one of each dimension, were significantly different. However, this difference cannot yet be considered as a systemic tendency.

aimed gun (IAPS nr. 6230)	in valence	[*t* (63)=-2.354	*p*=.022*]
skier (IAPS nr. 8030)	in arousal	[*t* (19.715)=-2.126	*p*=.046*]

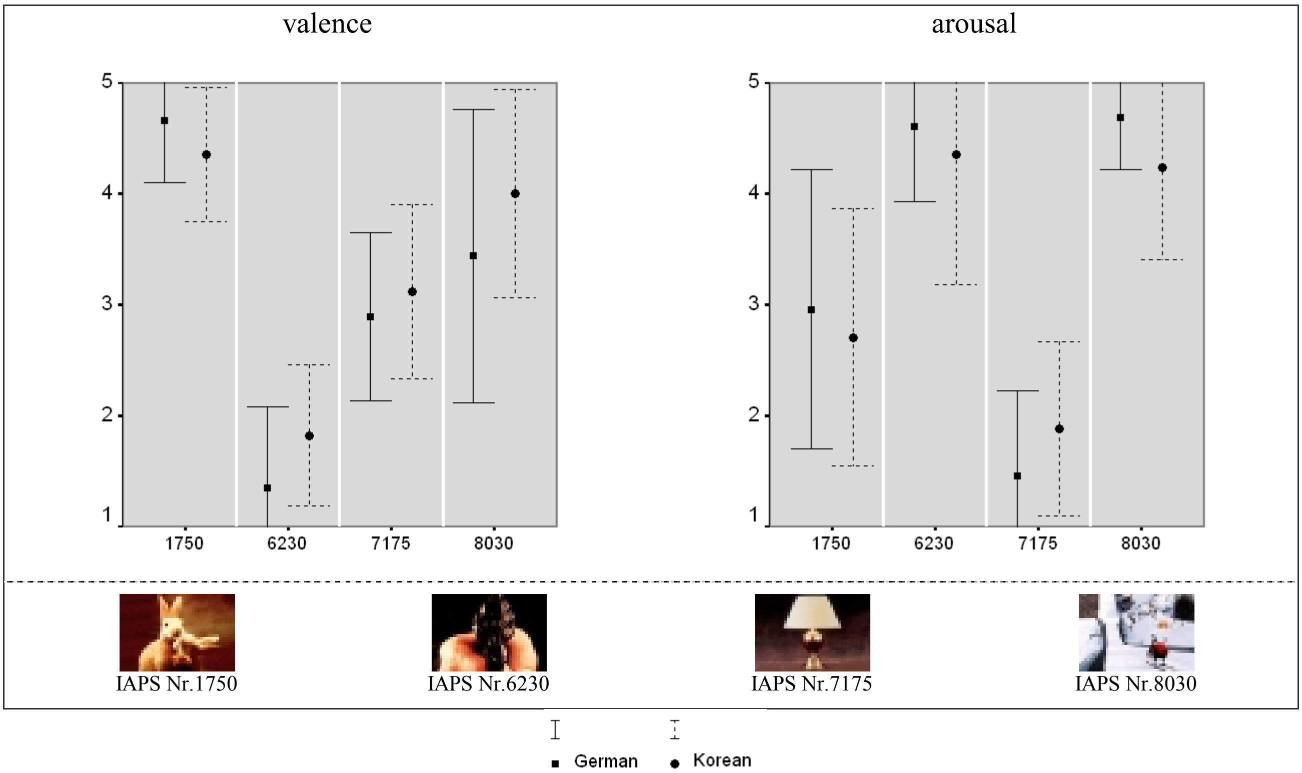


Figure 24. SAM ratings of four IAPS pictures of German (N=48) and Korean (N=17) subjects.

Secondly, SAM ratings of color were compared. In particular, it is investigated whether the major findings of Experiment I can be replicated. In the following, SAM ratings of (a) hue categories, (b) Chroma, and (c) lightness levels between the two groups are compared.

(a) **hue:** colors in the **blue** category were assessed as more pleasant (>3.0) than the color of the other hue categories. Regarding the arousal dimension, Koreans show a **stronger pattern** of emotional reaction. They assessed colors in the red category as exciting (>3.0), while Germans rated red colors rather less arousing (<3.0). Nevertheless, red was the hue category that induced the highest arousal in both subject groups. Table 14 illustrates SAM ratings of hue categories regarding valence and arousal by German (N=48) and Korean (N=17) subjects.

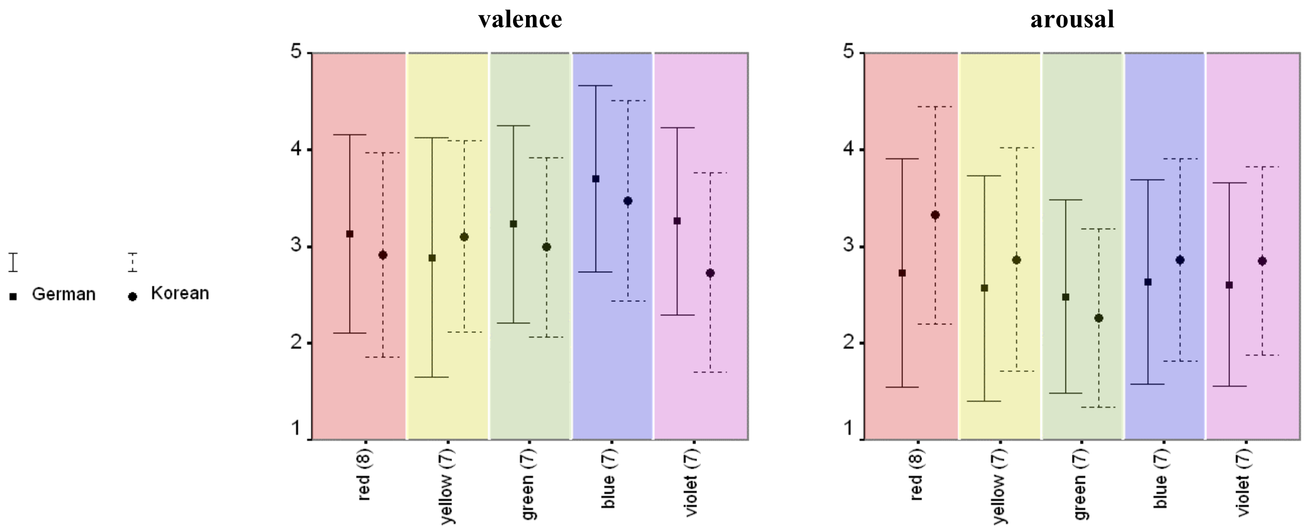


Figure 25. Comparison between German and Korean subjects: SAM ratings of hue

abscissa: hue categories, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N of subjects=48 (Germans), 17 (Koreans)

Numbers in parentheses indicate the number of colors in each hue category.

(b) **Chroma:** as in Experiment I, Chroma shows a **significantly positive correlation** (p<..001) with valence and arousal (see Table 15).

		correlation coefficients	
		valence	arousal
Chroma	Pearson Correlation (*r*)	**.277*****	**.306*****
	N	731	731

Table 15. Correlations coefficients between Chroma and valence and arousal, Experiment I in South Korea

*** Correlation is significant at the .001 level (two-tailed).

(c) **Lightness:** SAM ratings of achromatic colors are compared, as shown in Table 16. White (lightness=100) is evaluated neutral, whereas the other achromatic colors were assessed as negative ('–' valence) and calm ('–' arousal). With regard to the black (lightness=0), the difference between German and Korean subjects was examined by t-test and the analysis yielded significance in both valence and arousal dimension:

black	in	valence	[t (38.465)=2.625	p=.012*]
black	in	arousal	[t (63)=2.870	p=.006**]

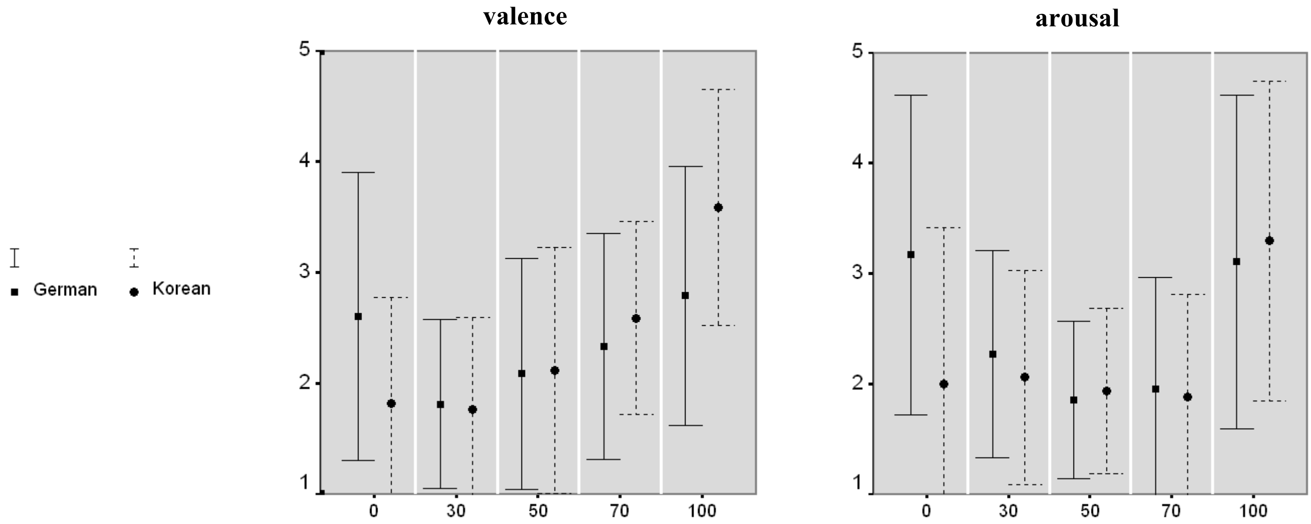


Figure 26. Comparison between German and Korean subjects: SAM ratings of lightness

abscissa: lightness level (CIELab Lch), ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N of subjects=48 (Germans), 17 (Koreans).

Mean and standard deviation values of SAM ratings of all the stimuli assessed by Korean subjects can be found in Appendix D. A discussion of the experiment conveyed in South Korea follows in section 4.5.3.

4.5.3 Summary and discussion of Experiment I in South Korea

Experiment I in South Korea had the identical structure and set of stimuli of Experiment I in Germany. The SAM assessments of Korean subjects were compared with those of German subjects, regarding variations in hue, Chroma, and lightness.

Koreans evaluated the category blue as more positive than the other hue categories and reacted slightly stronger with regard to hue categories on the arousal dimension. Particularly, the category red was assessed as ‘exciting’ (>3.0 on arousal), which differs from the results of German subjects. Similar to the results of Experiment I, SAM ratings and Chroma correlated positively with valence (r=.277***) and with arousal (r=.306***) dimensions. With regard to lightness, the contrast between stimulus and context was observed with white (lightness=100).

● Limitation of Experiment I in South Korea as a cross-cultural study

According to the aspect of color semantic in section 3.1.1, many of cross-cultural focus on the effect of contextual variables, which are obviously different: language, tradition, religion, politics, natural environment, etc. Such variables may influence the interpretation of color and motivate different emotional responses accordingly. With regard to the aspect of color semantics, the 17 Korean subjects differ from the 48 German subjects, for instance, in terms of contextual variables such as language and tradition. Besides, the German subjects were university students enrolled in psychology and the Korean subjects were high school students.

On the other hand, due to media effects and globalized markets, considerable aspects of lifestyle are similar between both groups. Subjects in both experiments were students and share analogous cultural interests in terms of entertainment, fashion, commercials, and communication technologies. Moreover, subjects belong to a similar age group ($M_{Germans}$=21.96 (SD= 2.51), $M_{Koreans}$=16.24 (SD=.55)).

Since each group is not representative for the German or Korean population, the comparisons conducted between the two cultural groups are inconclusive. Nevertheless, the results identify similarities and differences with regard to the specific demographic group in both countries and may be utilized as marketing resource for global brands, **which are targeting similar demographic groups in different cultural segments**. In order to obtain more reliable results, it is desirable to include a larger number of subjects.

4.6 A METHODOLOGY FOR THE DEVELOPMENT OF A PRODUCT-COLOR-SCHEME

In this dissertation it was tried to develop a method to create an individual color solution. Experiment I demonstrated how colors were found for a product concept (i.e. ‘low fat’ in the case study).

Interest in dietary products grows, creating the need for producers of low fat products to create their own corporate identity. The results of the experiment offer more answers (color solution) to a specific 'low fat' concept, depending on the specific profile of the target product image. For instance, one company might be considered to be feminine and light, whereas the competitor is seen as active and dynamic.

Three major advantages of this method for the development of a product-color scheme are indicated:

● First of all, the method follows a logical process with quantitative measurement. The method provides a systematic approach of finding out a color scheme that matches with the product concept. By examining correlation patterns, which is named as a 'qualitative setting' by Morris (1995), specific colors and adjectives (expressing a product concept) can be matched. Ideally, the results are coherent with intuitive and creative works of designers.

● Secondly, it is in fact, economical to use data. In this experiment, colors, terms, pictures were assessed in separate sessions, and results were overlapped in the emotion space later. Thus, repeated studies to collect data for a new topic could be avoided. Instead of 'low fat', a project could focus on other keywords. Relevant terms could be drawn from a semantic network.

● Lastly, each cluster can contain more than one color, and thus those pre-selected colors then admit further considerations for color selection. Frequently, a company might want to consider criteria due to managerial issues in choosing colors, such as taboos, competitors, techniques, etc. Otherwise, a company might want to choose particular colors that are considered to be "en vogue" in the current fashion season (Garber et al., 2003, p. 317).

4.7 COLOR STIMULI BASED ON COLOR PERCEPTION

Listed in Appendix C, five color stimuli of every hue category were the same with regard to Chroma and lightness of CIELab Lch. This takes advantage of the numeric order of the stimuli, nevertheless, it fails to provide cognitive quantity of color perception. For example, a color from the yellow hue category with a Chroma of 40 is not recognized to be as much saturated as the respective stimulus from the red hue category (see Table 16). More drastically, when the lightness of colors of the hue category yellow (yellowish colors) is lower than 70, the colors are perceived to be olive. In other words, the emotional responses to a yellowish color with low lightness must be interpreted as results of the olive hue category.

color	L	C	h
	50	40	85 (hue category: yellow)
			40 (hue category: red)

Table 16. Two colors having the same lightness and Chroma from different hue categories.

In line with this, Valdez et al. (1994) showed that yellow is a hue category which elicited negative valence (i.e. unpleasant), as shown in Figure 25. In fact, the average valence presented in Figure 20 confirms this tendency. It was caused by the inability of discriminatory perception of Chroma and lightness with respect to hue categories.

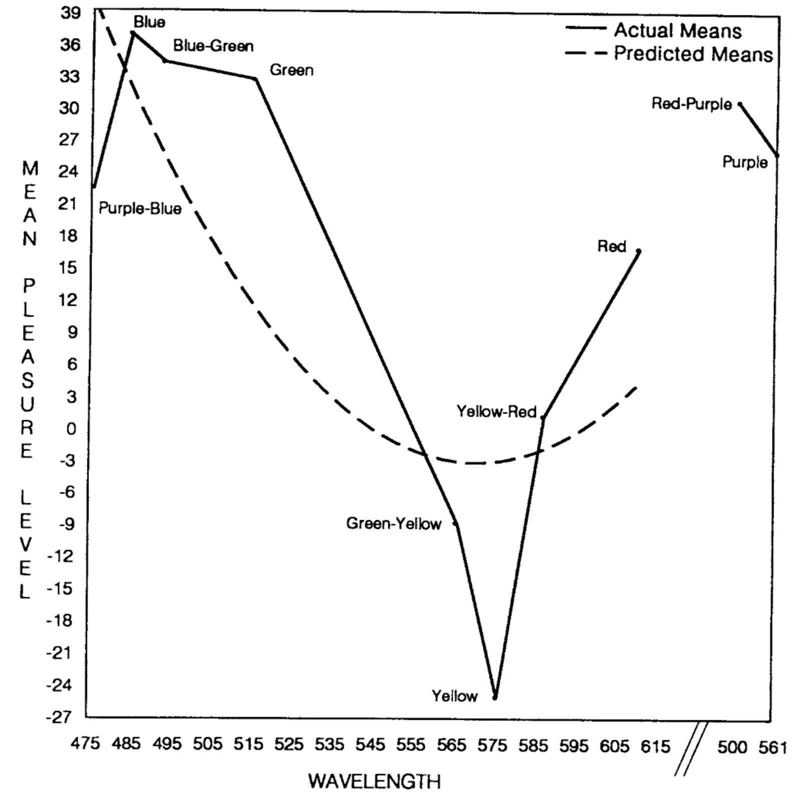


Figure 27. Averaged pleasure level as functions of color wavelength, Valdez et al., 1994, p. 402.

In order to apply the findings of Experiment I that emotional responses to color vary with Chroma throughout the different hue categories, it is necessary to choose a color which by itself is recognized to belong to the target hue category. Therefore, color selection for the next experiments was based on subjective color perception.

● **ISCC-NBS**

Between 1955 and 1976, Kelly and Judd (1976) attempted to segment colors into blocks, and then fill these blocks with terms for colors. Figure 28 shows the block separation for the color purple segment which is commissioned by the Inter-Society Color Council (ISCC) for the National Bureau of Standards (NBS).

The adjectives used in this particular example are the same as for all other colors: vivid, brilliant, strong, deep, light, dark, pale, and so on. It is apparent that the terms ‘pale’ and ‘dark’ are only used near the neutral black-white axis, and not in regions of high saturation.

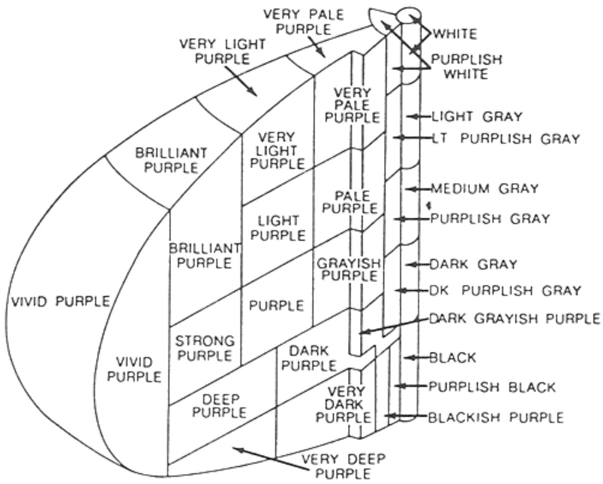


Figure 28. Block separation by ISCC-NBS: i.e. purple, <http://www.colorsystem.com>.

Kelly et al. (1976) used the three parameters hue, value, and Chroma to define the color blocks which subdivide each color.

The descriptive terms chosen for the various segments show the **subjective variables** of a color phenomenon which emerges when a color is held in front of the eye for an extended period. A vivid red (R4/14: hue=R, value=4, Chroma=14) by Munsell is identified as being just as "vivid" as the corresponding ultramarine-blue, although they were both of varying brightness (Silvestrini et al., 2002). Obviously, **vividness** is regarded as a significant parameter.

In the following experiments, color stimuli are employed according to cognitive quantity of color. A tone categorization is introduced to support a subdivision of recognized Chroma and lightness for each hue category. The categorization consists of five tone categories, namely **dark, deep, vivid, brilliant, and light**. Figure 29 depicts the categories in the color space. **Segmentations applied varied depending on hue categories**.

dark **deep** **vivid** **brilliant** **light**

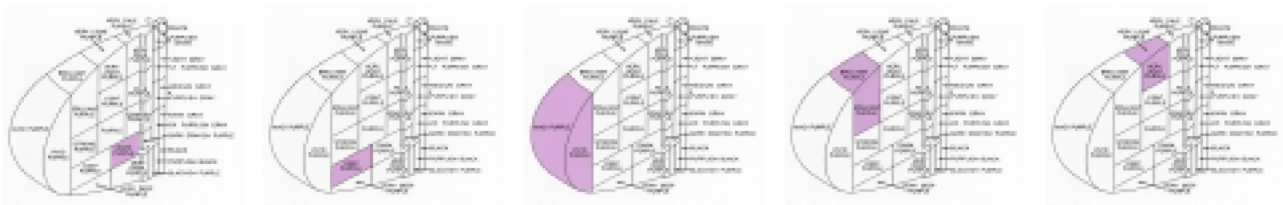


Figure 29. The five tone categories: i.e. purple (5PB).

Kobayashi (1987) described tone categories as the results of mixing black or white with a vivid chromatic color. In his book, he simplified chromatic colors into 12 and achromatic colors into ten blocks for practice purposes. Ten hue categories were set based on the Munsell system and he suggested a "hue and tone system" (Kobayashi, 1999, p.8). The system consists of 120 (12 tones × 10 hues) chromatic colors, which are divided vertically by hue and horizontally by tone. In addition, there are ten achromatic colors which makes a total of 130 colors all together. He distributed the 130 colors into a "Three Dimensional Image Scale" defined by warm/cool, soft/hard, and clear/grayish. The color distribution is adequate to represent the visual character (or style) of an observed color trend, e.g. a fashion fabric image (Choo & Kim, 2003)

4.8 CHAPTER REVIEW

● Two hypotheses were put forward: color stimuli elicit emotions as pictures do, and emotional response to color stimuli vary more strongly with regard to Chroma and lightness than regard to hue. Both were partially supported by empirical results of Experiment I (4.1).

● In Experiment I, four types of stimuli were employed and presented subsequently: four achromatic pictures, 43 colors, 19 adjectives, and four chromatic pictures. SAM was used to assess emotional responses to stimuli and subjects were submitted to all stimuli.

Forty-three colors were selected based on the CIELab Lch system, color attributes are defined as hue, Chroma, and lightness (4.2.2.1). By means of a semantic network, 13 adjectives to describe a product concept (low fat as a case study) were collected and another six counterbalancing negative adjectives were added (4.2.2.2).

The eight (four achromatic and four chromatic) IAPS (Lang et al., 2005) pictures formed the baseline of emotional state of the individual. It was found that the instruction about dominance dimension was insufficient. Thus, only SAM ratings on valence and arousal were taken into account for the analyses (4.2.2.3).

● SAM ratings of colors and adjectives were depicted in emotion space defined by valence and arousal (Figure 19). Emotional profiles of them were geometrically located and a diagonal pattern of colors was observed (4.3).

● Emotional responses to colors were analyzed according to the color attributes hue, Chroma, and lightness. Firstly, blue differs from the other hue categories and a periodic relationship is assumed on valence (4.3.1). Secondly, SAM ratings of Chroma appeared to be significantly and positively correlated concerning both valence and arousal (4.3.2). Lastly, achromatic colors, except for black and white, induced rather negative ('–' valence) and calm ('–' arousal) emotions compared to chromatic colors (4.3.3).

● A comparable experiment was conducted with 17 subjects in South Korea. In general, patterns of emotional response to colors were similar. However, these patterns are inconclusive, as they are specific to the demographic groups observed (4.5).

● Supported by empirical results of Experiment I, three major advantages of a new methodology for developing a product-color scheme are summarized. It is proposed as a practical application (4.6).

● Color selection based on color sensation remains a problematic issue. The ISCC-NBS (Kelly et al., 1976) color system was explained and hue and tone categorizations were suggested to select color stimuli in order to identify colors based on a subjective color perception (4.7).

5. EXPERIMENT II: EMOTIONAL RESPONSE TO SURFACE COLOR

In Experiment II and III, 36 CIELab Lch colors are employed and it is investigated if emotional responses are influenced by the media, in which color stimuli are presented: **surface color** in Experiment II versus **digital color** in Experiment III.

The surface color represents object-reflected color that was presented on DIN A5-size glossy paper. The digital color refers to self-illuminating color in digital media and was displayed on CRT monitors.

As discussed in section 4.7, color stimuli were selected according to hue and tone categorization accounting for the cognitive quantity of color and it was expected that emotional responses to color perception could be analyzed.

5.1 GOALS AND HYPOTHESES

The empirical results from Experiment I showed that color induces emotion that can be characterized by valence and arousal. After improving the instructions of how to use the SAM system, it is hypothesized that the dominance dimension will also contribute to describe an emotional color profile.

[H. 3] The three dimensions of emotion—valence, arousal, and dominance—can describe emotional profile of surface color.

After analyzing Experiment II and Experiment III separately, a comparison analysis between the results of the two experiments, i.e. between surface and digital color, will follow.

Secondly, it will be examined if hue and tone categorizations are appropriate to investigate emotional responses of color perception. By using tone categorizations, the Chroma and lightness of a color is recognized according to the **relative proportion of vividness**. The results can guide color researchers to refer to appropriate color systems for selecting color stimuli.

[H. 4] Tone categorization is more adequate to investigate emotional responses to perception of Chroma and lightness than physically measured Chroma and lightness.

Lastly, it will be examined if gray nuances, such as cool and warm grays, influence emotional response to colors. Arnheim (1956) discussed the characteristic meaning of color nuances. Color nuance refers to the deviation of a given color in the direction of another color. In accordance with his concept, the **nuance** of a color in this dissertation indicates the color of the **slight deviation** from the main color and determines the effect. Related with the nuance effect, Arnheim (1956) indicated that the deviation that contributes to the effect occurs not only in the hue dimension, but also in the lightness dimension.

Moreover, Hogg (1969) noted the growing interest of “warm” versus “cool” colors, indicating that artists and designers have often distinguished nuances of colors. For instance, he assumed that warmer colors induce greater activity.

The terms “warm” and “cold” have little reference to pure hues. Artists use these terms, and references to them are also found in studies on the theory of color. Nevertheless, unscientific remarks based on the subjective impressions of their authors offer no satisfactory material for a psychological theory (Arnheim, 1956). Despite of the increased interest in gray nuances in practice (Gekeler, 2000), the subtle difference, “nuance” has not yet been dealt with in empirical studies. A significant influence of the nuance effect may provide evidence for creative applications of different grays in practice.

[H. 5] Gray nuances influence emotional responses.

5.2 METHOD

5.2.1 Subjects

Thirty-seven students from the University of Mannheim served in exchange for extra credit. Participants were undergraduate students, 19 years of age or older (Table 17).

	number of survey subjects		age			
	male	female	min.	max.	M	SD
Mannheim, Germany	9	28	19	39	23,57	5,55

Table 17. Survey subjects for Experiment II.

5.2.2 Stimuli

5.2.2.1 Color stimuli: hue and tone categorizations

Five hue categories were fixed and the hue degrees of categories in CIELab Lch system are:

h=30°, the hue category of 'red', h=80°, the hue category of 'yellow'

h=160°, the hue category of 'green', h=260°, the hue category of 'blue'

h=320°, the hue category of 'violet'

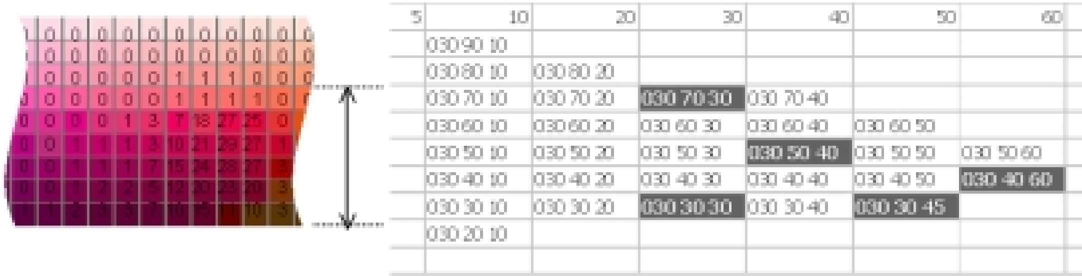
From each of them, representative colors of the following five tone segments were chosen:

dark deep vivid brilliant light

There are two basic reasons to employ tone categorization. Firstly, it was intended to let subjects recognize the same quality of tone (combination of Chroma and lightness) across hue categories. As indicated in section 4.7, the segmentation of tone categories varies with hue. Thus, it was necessary to consider different segments of Chroma and lightness that would be representative for the specific tone category of each hue. For instance, colors of the yellow category vary their tone segmentation with smaller change of Chroma and lightness than colors in red or in blue. Therefore, the discrepancies, defined with Chroma and lightness, differ between tone categories, depending on hue categories. In order to make suitable color choice for each hue category, ISCC-NBS categories for red (5R), yellow (5Y), green (5G), blue (5B), and violet (5P) were taken into account. A tone categorization of purple (5P) is illustrated in Figure 29.

The second intention was to include colors, which are identified by themselves as one of the five hue categories. For example, any of the five red tones should be perceived as "red". As a guideline, the results of an empirical study (Experimentalpsychologisches Praktikum supervised by Prof. H. Irtel during the Winter semester 2003/2004, University of Mannheim) were considered. The study investigated color categorization and focus color, perceived from basic color terms. During the experiment, subjects selected the color area in a color spectrum for the given color term. A chart on the left side in Figure 30 depicts the result for the color term ‘red’. The number in each color cell indicates the frequency of categorization as ‘red’ among the 30 subjects. Thus, those cells marked with ‘0’ represents that no subject categorized those colors to be red.

A chart on the right side in the same figure displays a section of the color space of RAL DESGIN System™ corresponding to hue degree 30º (red), the first three digits 030 in the chart. Each seven-digit-number indicates a color and it is available as color sheet produced by RAL DESIGN System. For hue degree 30º, the system offers, in intervals of 10, colors in six Chroma levels, from 10 to 60 and 8 lightness levels, from 20 to 90. Therefore, a color on the right edge (030 50 60 or 030 40 60) corresponds to ‘vivid red’.



5	10	20	30	40	50	60
	030 90 10					
	030 80 10	030 80 20				
	030 70 10	030 70 20	030 70 30	030 70 40		
	030 60 10	030 60 20	030 60 30	030 60 40	030 60 50	
	030 50 10	030 50 20	030 50 30	030 50 40	030 50 50	030 50 60
	030 40 10	030 40 20	030 40 30	030 40 40	030 40 50	030 40 60
	030 30 10	030 30 20	030 30 30	030 30 40	030 30 45	
	030 20 10					

Figure 30. Lightness boundary of color hue, ‘red’: left, the color selection for ‘red’: right.

• The RAL DESIGN System

Like HKS, Pantone, RAL is a color collection, frequently applied in various industrial fields, such as paint color of product design (Gekeler, 2000).

The RAL DESIGN System has been developed for professional color design. It contains 1688 colors arranged in a systematical order. All these seven-digit color shades are defined as individual RAL Colors. The color codes of the RAL DESIGN System indicate the technologically measured values of hue (h), lightness (L), and Chroma (C) by CIELab Lch. RAL 210 60 30, for instance, is a color shade with a hue of 210, a lightness of 60 and a Chroma of 30. RAL 210 70 30 is hence a color with higher lightness (70). Regarding the two other features, the two colors are identical.

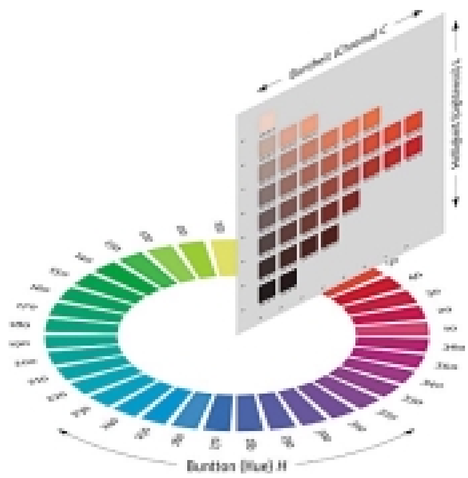


Figure 31. Concept of RAL DESIGN System, <http://www.ral.de>

The lightness area of 'red' is defined (left in Figure 30) and colors for five tone categories of hue degree 30º(red) are chosen (right in Figure 30). The selected five reds are shaded in dark gray in Figure 30: dark red (030 30 30), deep red (030 30 45), vivid red (030 40 60), brilliant red (030 50 40), and light red (030 70 30).

Accordingly, five colors for each hue category were selected. Table 18 presents CIELab Lch data of chromatic color stimuli used in Experiment II.

	tone categories				
hue (°)	dark	deep	vivid	brilliant	light
30 (red)	L: 30, C: 30	L: 30, C: 45	L: 40, C: 60	L: 50, C: 40	L: 70, C: 30
80 (yellow)	L: 60, C: 40	L: 60, C: 70	L: 80, C: 90	L: 80, C: 60	L: 80, C: 40
160 (green)	L: 30, C: 30	L: 40, C: 45	L: 50, C: 60	L: 40, C: 40	L: 70, C: 20
260 (blue)	L: 30, C: 20	L: 40, C: 30	L: 40, C: 45	L: 60, C: 35	L: 70, C: 25
320 (violet)	L: 20, C: 25	L: 30, C: 35	L: 40, C: 40	L: 50, C: 30	L: 70, C: 20

Table 18. chromatic color stimuli, Experiments II and III.

In addition, five achromatic colors were included: black, dark gray, medium gray, light gray, and white. Medium gray corresponds to the lightness of a vivid tone. Moreover, warm grays and cool grays from dark, medium, and light tone categories were added (Table 19).

	tone categories				
	black	dark	medium	light	white
achromatic color stimuli	L:0, C:0	L: 30, C: 0	L: 50, C: 0	L: 70, C: 0	L:100, C:0
warm grays hue (80°)		L: 30, C: 10	L: 50, C: 10	L: 70, C: 10	
cool grays hue (260°)		L: 30, C: 10	L: 50, C: 10	L: 70, C: 10	

Table 19. AChromatic color stimuli, including warm and cool grays, Experiments II and III.

Lastly, two more metallic colors were added for Experiment II, namely 'gold' and 'silver'. All color stimuli were presented in DIN A5-size glossy sheets.

5.2.2.2 Other stimuli for paper-and-pencil experiment

Three sets of stimuli were added: four IAPS achromatic pictures (set 1) were employed in order to practice the SAM scale and four IAPS chromatic pictures were included for the baseline (set 4). Besides, 19 adjectives (set 3) were also used. Stimulus sets were provided in numerical order. Stimuli within a set were ordered randomly. Subjects were subjected to all the stimuli sets.

The pictorial stimuli were provided on DIN A5-size sheets and adjectives were presented in height of 1.6 cm in white on DIN A5-size black background. A two-digit-ID number was marked (approximately 0.8 cm × 0.5 cm) on a corner of each stimulus sheet. The experiment was conducted as pencil-and-paper base and subjects were asked to write down the ID number of the stimulus, before ticking off SAM.

5.2.3 Procedure

Printed versions of the instruction and sets of SAM pictograms were provided along with black carbon pencils to tick off SAM pictograms (see Appendix E).

The experiment took place in an approximately 9m^2 (3m × 3m) size room at the Otto Selz Institute in Mannheim and was conveyed in daylight. Subjects freely communicated with the experimenter. All the answering sheets were gathered and checked immediately after the survey was finished and no missing inputs were found.

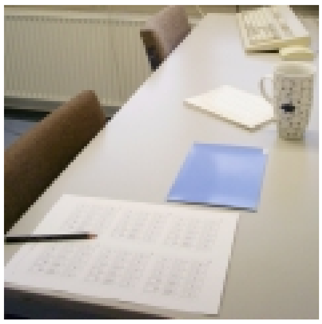


Figure 32. Surroundings, Experiment II.

5.3 RESULTS

According to the baseline (see Table 9), one subject was filtered out since he assessed one of the four IAPS control pictures (no. 7175, lamp) as extremely exciting.

Mean and standard deviation values of four IAPS control pictures were compared with IAPS data (Lang et al, 2005) and it was found that SAM ratings of the dominance dimension were much closer to the population than in Experiment I. The extended instruction was proven to be more adequate to explain the usage of SAM scales.

Based on SAM ratings of 36 subjects, Cronbach's alphas were calculated and yielded satisfactory level of internal consistency. Thus, the emotional profiles of surface colors are describable in terms of valence, arousal, and dominance, supporting [H. 3].

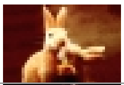
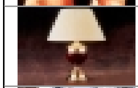
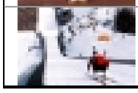
picture	IAPS nr.	valence		arousal		dominance	
		M (SD)	*μ_0 (σ_0)*	M (SD)	*μ_0 (σ_0)*	M (SD)	*μ_0 (σ_0)*
	1750	7.81 (1.60)	*8.28 (1.07)*	4.73 (2.46)	*4.10 (2.31)*	5.84 (1.86)	*6.15 (2.01)*
	6230	2.35 (1.89)	*2.37 (1.57)*	7.86 (1.97)	*7.35 (2.01)*	2.51 (2.18)	*2.15 (2.09)*
	7175	5.05 (2.52)	*4.87 (1.00)*	2.78 (2.15)	*1.72 (1.26)*	5.22 (2.25)	*6.47 (2.04)*
	8030	5.49 (2.56)	*7.33 (1.76)*	7.49 (1.90)	*7.35 (2.02)*	4.40 (2.90)	*4.70 (2.66)*

Table 20. Mean (M) and standard deviation (SD) values of Experiment II

Mean (μ_0) and standard deviation(σ_0) values of IAPS (Lang, 2005)

Scales were chosen among 1, 3, 5, 7, and 9 according to Equation 1, N=36.

	valence	arousal	dominance
color stimuli (on 38 variables)	**.767 (36 cases)**	**.886 (36 cases)**	**.691 (36 cases)**
adjectives (on 19 variables)	.512 (36 cases)	.827 (36 cases)	.490 (36 cases)
38 color stimuli + 19 adjectives + four IAPS pictures (on 61 variables)	.798 (36 cases)	.923 (36 cases)	.762 (36 cases)
	.905 (36 cases on 183 variables)		

Table 21. Reliability coefficients of Experiment II, N=36.

In Figure 33, means values of valence, arousal, and dominance concerning 38 colors and 19 adjectives from Experiment II are depicted in two emotion spaces, defined by valence (abscissa) × arousal (ordinate) on the left and valence (abscissa) × dominance (ordinate) on the right. Mean and standard deviation values of all the stimuli used in Experiment II can be found in Appendix F.

Figure 33 shows that emotional response to color varies strongly with Chroma. Although most of the color stimuli were not identical, the pattern of distribution seems to replicate [H. 2] in Experiment I.

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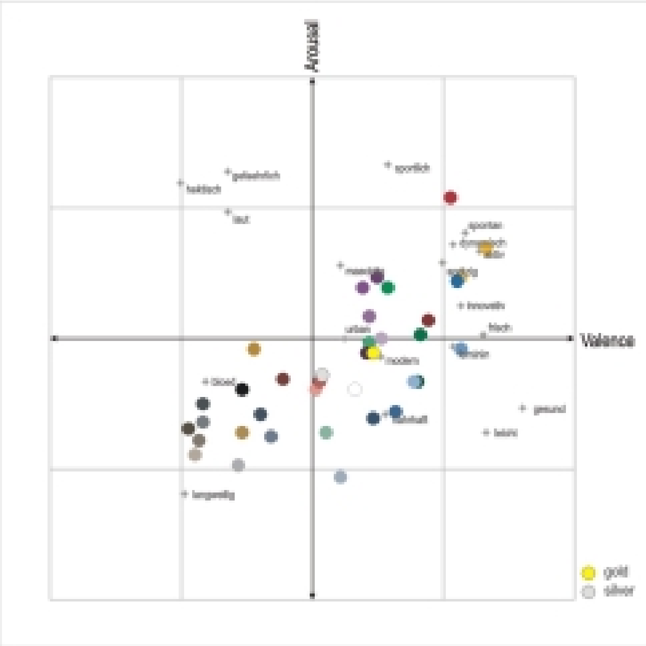


Figure 33. Plots of means of 38 colors and 19 adjectives in emotion spaces, Experiment II

defined by valence (abscissa) × arousal (ordinate): left, valence (abscissa) × dominance (ordinate): right.

Moreover, a diagonal pattern from lower-left to upper-right can be observed in both charts. This positive and linear trend between valence and dominance for both colors and adjectives confirms the results of previous studies (Bradley et al., 1994; Hamm et al., 1993).

The SAM ratings were averaged over subjects, thus 38 (equal to the number of color stimuli) mean values of valence, arousal, and dominance resulted. Based on them, the correlation analysis between dimensions was run and yielded significantly positive coefficients (p<.001, two-tailed, see Table 22). Therefore, a single dimension of color affectivity was assumed, in which any ratings of one dimension is known and the other two dimensions can be forecasted. A further discussion will follow in section 5.4.2.

color stimuli	correlation coefficients (Pearson *r*)		
	valence × arousal	valence × dominance	arousal × dominance
All, averaged (N of stimuli=38)	.700***	.879***	.659***

Table 22. Correlations coefficients between dimensions of emotion of color stimuli, Experiment II

*** p<.001 (two-tailed). N of subjects=36.

5.3.1 Emotional responses to hue categories

It was analyzed whether hue categories affect emotional responses. For this purpose, the SAM ratings of colors within a hue category were averaged. The SAM ratings of colors in different tones in a same hue category were averaged for each individual subject, which resulted into a representative mean of each hue category **per subject**. For example:

$$\frac{SAM\ rating\ of\ \left\{\frac{dark}{red}+\frac{deep}{red}+\frac{vivid}{red}+\frac{brillian}{red}+\frac{light}{red}\right\}}{5} = averaged\ SAM\ rating\ \ for\ red \qquad \text{Equation 2}$$

Therefore each subject was characterized by averaged SAM ratings for five hue categories: red, yellow, green, blue, and violet. In doing so, the variance among tone categories within each hue category was eliminated. The three charts in Figure 34 illustrate the averaged SAM ratings of 36 subjects alongside the hue categories.

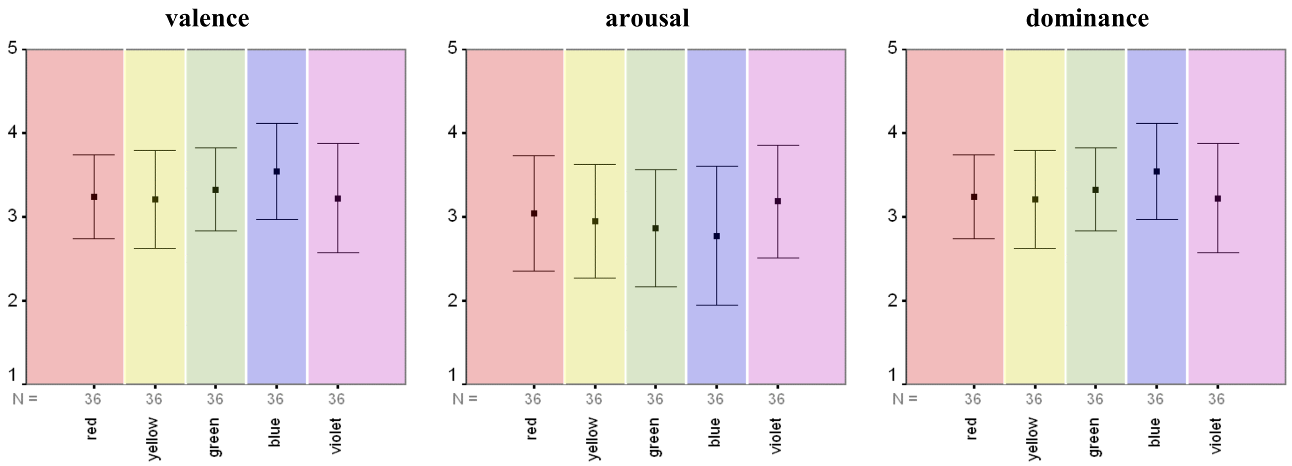


Figure 34. Result of averaged SAM ratings of five hue categories, Experiment II

dot: mean, range of error bar: standard deviation, N=36.

Based on these data, one-way repeated measurements ANOVA was run (factor: five hue categories). The results in Table 23 show that the influence of hue categories on affective judgment on three dimensions of emotion was significant (p<.05).

valence	arousal	dominance
F (2.930, 102.537)=3.351, ε=.732, p=.023*	F (4,140)=3.409, p=.016*	F (4,140)=2.759, p=.040*

Table 23. Result of one-way repeated measurements ANOVA, factor: hue categories, Experiment II

factor: five hue categories, ε : corrected by Greenhouse-Geisser, *p<.05

As observed in Experiment I, the averaged SAM ratings of the blue category are more positive, rated as less exciting, and more dominant than those of the other hue categories. This tendency confirms the results of Guilford & Smith (1959). Accordingly, a pair-wise multiple comparison, LSD (least significant difference), was run. As shown in Table 24, the mean differences (MD) between 'blue' and the other hue categories were often significant at an α-level of .05 (two-tailed).

(I) hue	(J) hue	valence		arousal		dominance	
		MD	SE	MD	SE	MD	SE
red	yellow	– .033	.094	.089	.103	.028	.114
	green	– .194	.133	.172	.105	– .089	.104
	blue	– .467 (*)	.131	.267 (*)	.114	– .306 (*)	.107
	violet	– .094	.176	– .144	.135	.017	.111
yellow	red	.033	.094	– .089	.103	– .028	.114
	green	– .161	.134	.083	.105	– .117	.121
	blue	– .433 (*)	.154	.178	.139	– .333 (*)	.149
	violet	.061	.183	– .233	.130	– .011	.129
green	red	.194	.133	– .172	.105	.089	.104
	yellow	.161	.134	– .083	.105	.117	.121
	blue	– .272 (*)	.111	.094	.096	– .217 (*)	.103
	violet	.100	.148	– .317 (*)	.136	.016	.102
blue	red	**.467 (*)**	.131	**– .267 (*)**	.025	**.306 (*)**	.107
	yellow	**.433 (*)**	.154	– .178	.210	**.333 (*)**	.149
	green	**.272 (*)**	.111	– .094	.333	**.217 (*)**	.103
	violet	**.372 (*)**	.164	**– .411 (*)**	.005	**.322 (*)**	.138
violet	red	.094	.176	.144	.292	– .017	.111
	yellow	.061	.183	.233	.082	.011	.129
	green	– .100	.148	.317 (*)	.025	– .106	.102
	blue	– .372 (*)	.164	.411 (*)	.005	– .322 (*)	.138

Table 24. Result of pair-wise comparison, LSD, between hue categories, Experiment II

MD: mean difference, SE: standard error, (*): Mean difference is significant at the 0.05 level (two-tailed).

Blue is, in fact, often found to be the Germans' favorite color (see Burda Advertisement Center, 1998). In the beginning of the Experiment II, subjects were asked to name and write down the term for their favorite color. More than 38% of subjects answered blue ('Blau' in German), as illustrated in Figure 35.

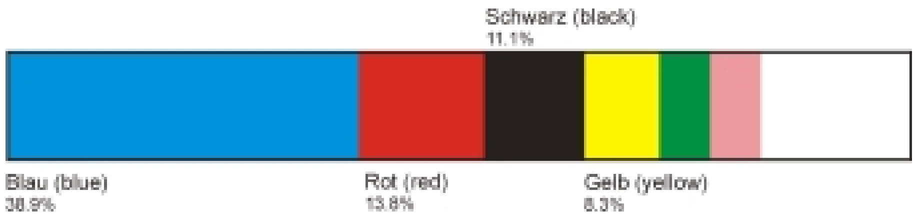


Figure 35. Percentage of favorite color (color term), Experiment II.

Therefore, **more positive and dominant affective judgment on blue colors corresponds to the consensus result** that blue is preferred by the majority of Germans. The relationship between favorite color and emotion is discussed in section 8.3.2.

5.4 Emotional responses to tone categories

In the following analyses of emotional responses to tone categories are approached in terms of Chroma levels (5.3.2.1) and lightness levels (5.3.2.2).

5.4.1.1 Effect of Chroma levels on emotional responses

Four Chroma levels are of interest. Starting from a group composed of achromatic color stimuli (first level), the five tone categories are grouped into three, according to their Chroma level:

‘dark’ and ‘light’→ second level, ‘deep’ and ‘brilliant’→ third level, and ‘vivid’→ fourth level.

Thus, there are one achromatic and three chromatic levels in sum (Figure 36).

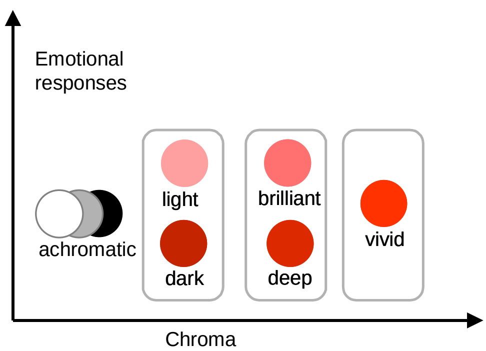


Figure 36. Four Chroma levels.

The first Chroma level included black, dark gray, medium gray, light gray, and white (cool and warm grays were excluded). Therefore, the frequency of each Chroma level was not identical among Chroma levels.

In addition, individual SAM ratings for colors that belong to the same Chroma level were **averaged**. For example, SAM ratings of vivid colors were averaged and each subject obtained an averaged SAM rating for each Chroma level. In this way, four averaged SAM ratings for Chroma levels were generated for each subject.

$$\frac{SAM\ rating\ of\ \left\{\substack{vivid\\ red} + \substack{vivid\\ yellow} + \substack{vivid\\ green} + \substack{vivid\\ blue} + \substack{vivid\\ violet}\right\}}{5} = averaged\ SAM\ rating\ \ for\ vivid \qquad \text{Equation 3}$$

The averaged SAM ratings of each Chroma level were calculated for 36 subjects and are depicted in Figure 37. A positive linear relationship between Chroma and the entire dimensions can be observed. Accordingly, correlation analysis was conducted.

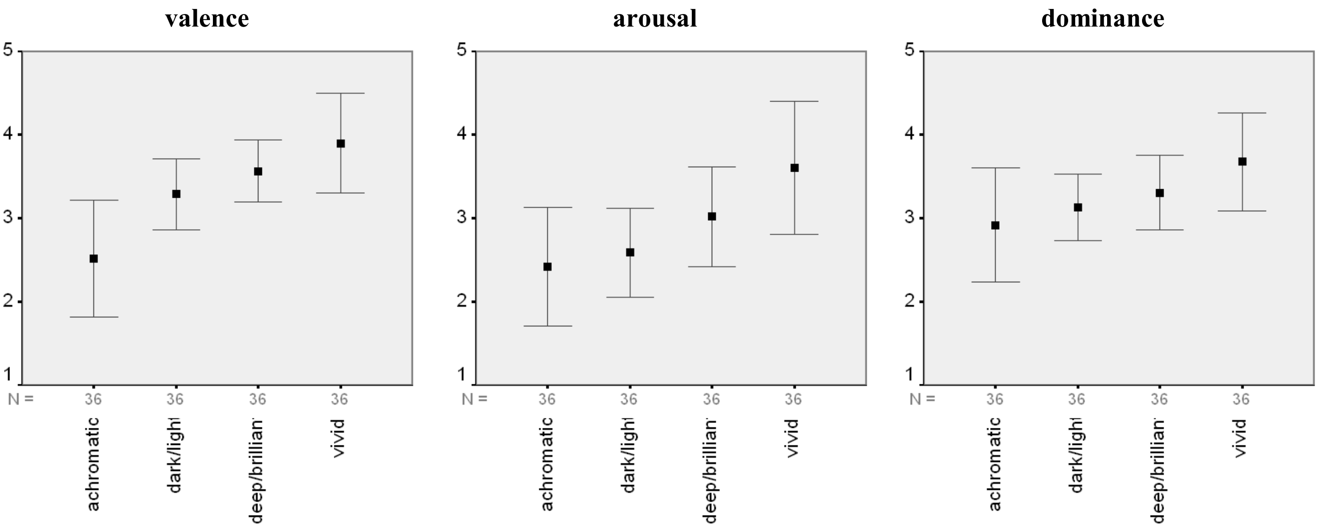


Figure 37. Averaged SAM ratings of four Chroma levels, Experiment II

dot: mean, range of error bar: standard deviation, N=36; ‘N’ in charts represents the frequency.

Chroma and emotional responses are correlated significantly and positively (Table 25). Furthermore, a correlation analysis with Spearman’s rho was run, since the distances between Chroma categories are, in fact, not identical. Nevertheless, the analysis yielded similar size of positive correlation and significance.

		valence	arousal	dominance
Chroma levels	Pearson's correlation	**.670****	**.554****	**.455****
	Spearman's rho	***.673*****	***.554*****	***.497*****
	N	144	144	144

Table 25. Correlation coefficients between Chroma and averaged SAM ratings

**Correlation is significant at α level of 0.01 (two-tailed).

The three charts in Figure 38 illustrate SAM responses to Chroma, based on CIELab Lch values (results from Experiment II). There are regular outliers, which are marked with yellow circles. The results indicate the problem of emotional response to the physical quantity of color, as discussed in relation to Experiment I (in section 4.7). Concerning chorma in physical quantities, colors of the yellow category do not follow the general trend of the other hue categories. A yellow with Chroma 70 marked in yellow circles is not vivid enough to be perceived as vivid yellow, whereas blue is perceived to be 'vivid' with a Chroma of 45. Hence, the results shown in Figure 38 cannot explain the general trend of Chroma versus emotion throughout the hue categories, since each hue category covers only a segment of the Chroma scale (abscissa).

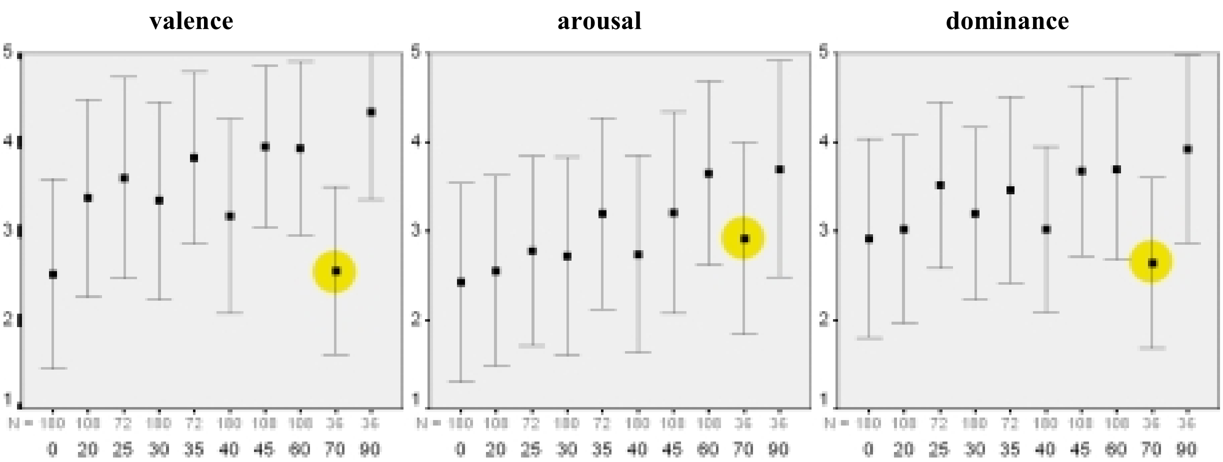


Figure 38. SAM ratings of Chroma based on the CIELab Lch system, Experiment II

dot: mean, range of error bar: standard deviation, N=36.

In Experiment I, this pattern was observed with lightness (see Figure 22). Such results occur because color attributes are dealt with in terms of their physical quantity. Therefore, a tone categorization in which color perception matters is proposed for color research, supporting [H. 4].

5.4.1.2 Effect of lightness levels on emotional responses

Lightness is a further aspect of tone categorization. Starting with black (lightness=0) as lightness level 1, five tone categories were ordered from dark, and going through deep, vivid, brilliant, and light in accordance with the increase of lightness (Figure 39). Additionally, white was added as the seventh lightness level. Thus, seven ($1_{black}+ 5_{tone\ categories} + 1_{white}$) levels in lightness scale are defined. Moreover, achromatic color stimuli including warm and cool grays were integrated into this lightness scale. Thus, for instance, the second level of lightness included 'dark gray', 'dark warm gray', 'dark cool gray', 'dark red', 'dark yellow', 'dark green', 'dark blue', and 'dark violet'.

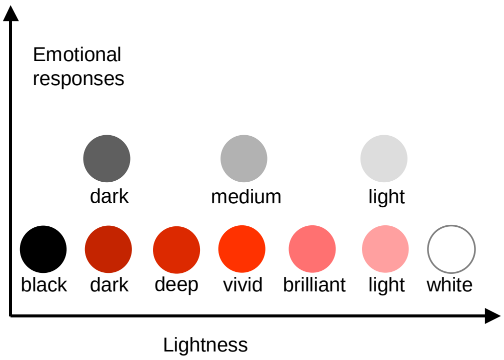


Figure 39. The seven lightness levels.

Based on positive correlation coefficients between Chroma and emotional dimensions (r=.670**: valence; r=.554**: arousal; r=.455**, Table 25), it is expected that SAM ratings of lightness categories would appear in a negative quadratic pattern, i.e. an inverted U-shape ($\cap$).

Because each lightness level included different numbers of achromatic colors, lightness levels were grouped into one set of **(a)** chromatic colors and one set of **(b)** achromatic colors, in order to investigate the tendency more precisely.

(a) Among chromatic colors, the lightness levels corresponded to tone categories. The **averaged** SAM ratings to each lightness level (or tone categories in this case) of each subject were calculated (see Equation 3) and are illustrated in Figure 40.

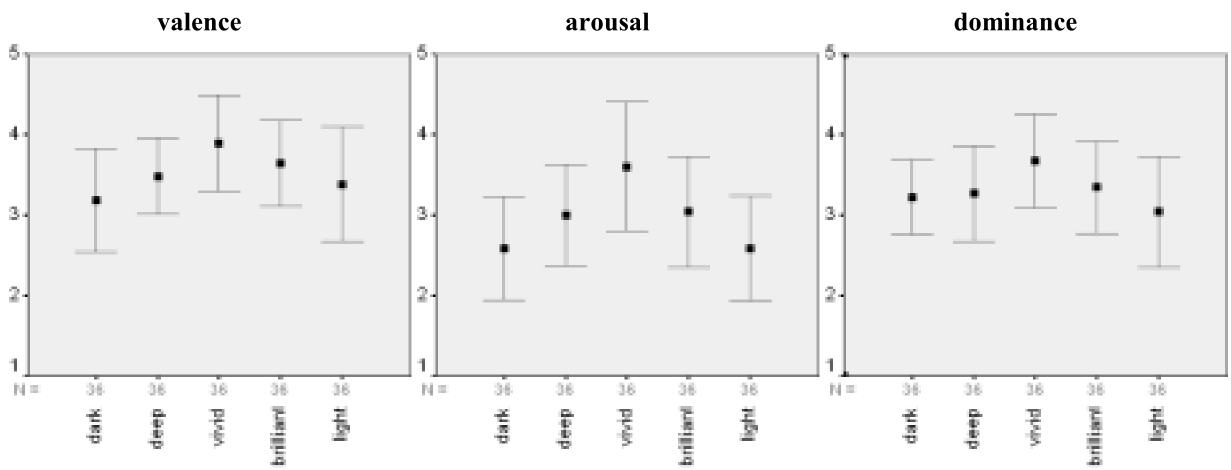


Figure 40. Averaged SAM ratings of lightness levels: chromatic color stimuli

dot: mean, range of error bar: standard deviation, N=36, 'N' in charts represents the frequency.

With the increase of the lightness level, SAM ratings appeared in an inverted U-shape, as predicted. Accordingly, a quadratic regression was run and variables for x^2 were negative. Because variations in lightness levels are able to explain only 12.6% (valence), 20.0% (arousal), and 8.3% (dominance) of the total variation (Table 26), it is not yet possible to conclude any generalization.

		dimensions		
estimation		valence	arousal	dominance
quadratic	R^2	.126	.200	.083
	variables in equation: constant	2.468***	1.500***	2.679***
	variables in equation: x, (Beta)	.815***	1.246***	.585***
	variables in equation: x^2, (Beta)	−.127***	−.208***	−.102***

Table 26. Result of regression analyses between lightness level of chromatic colors and averaged SAM ratings

*** p<.001.

In addition, Figure 41 splits the results in Figure 38 into hue categories and presents SAM ratings of tone categories over five hue categories. The color of the linear graphs corresponds to the target hue category.

It can be seen that colors in vivid tones elicited the greatest affectivity, similar to the results in section 5.3.2.1. There are, however, some exceptions. Especially the emotional responses to **violet** appear to diverge strongly from the other hue categories. Further research may deal with such specific cases.

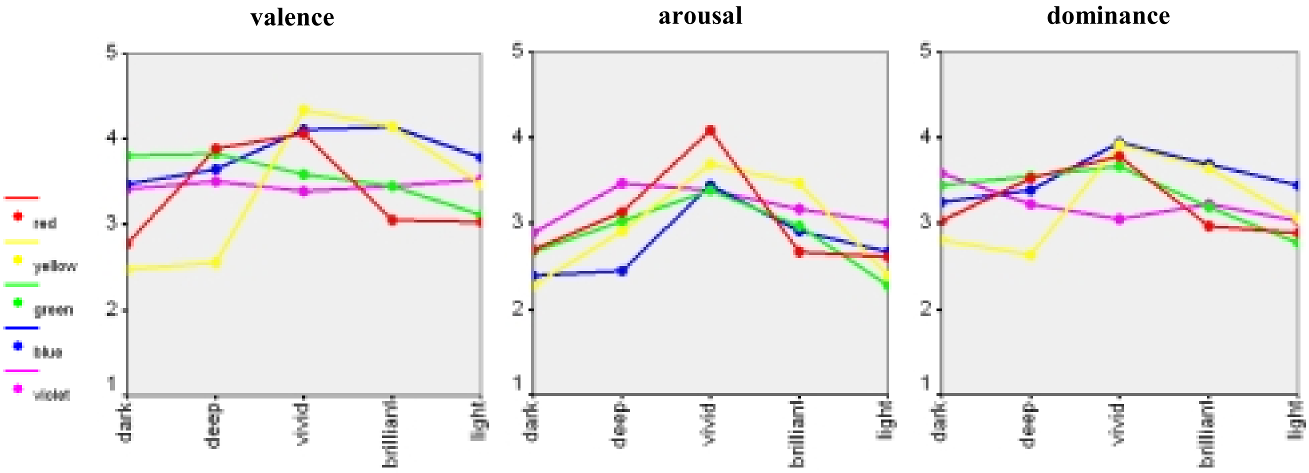


Figure 41. SAM ratings of lightness levels, Experiment II.

(b) Secondly, SAM ratings of lightness levels of achromatic color stimuli, such as black, dark gray, medium gray, light gray, and white were analyzed (Figure 42).

As it was demonstrated in Experiment I, the results appear in a U-shape, indicating that black and white were assessed rather as neutral (3.0), whereas the other achromatic colors (gray) were evaluated to be rather negative, calm, or submissive (<3.0). Possibly, the contrast of lightness between stimulus and context would have driven this tendency. However, the regression analysis (quadratic estimation) yielded significant effects on valence ($p<.001$) and dominance ($p<.001$), respectively explaining 14.9% and 7.4% of the total variation (Table 27).

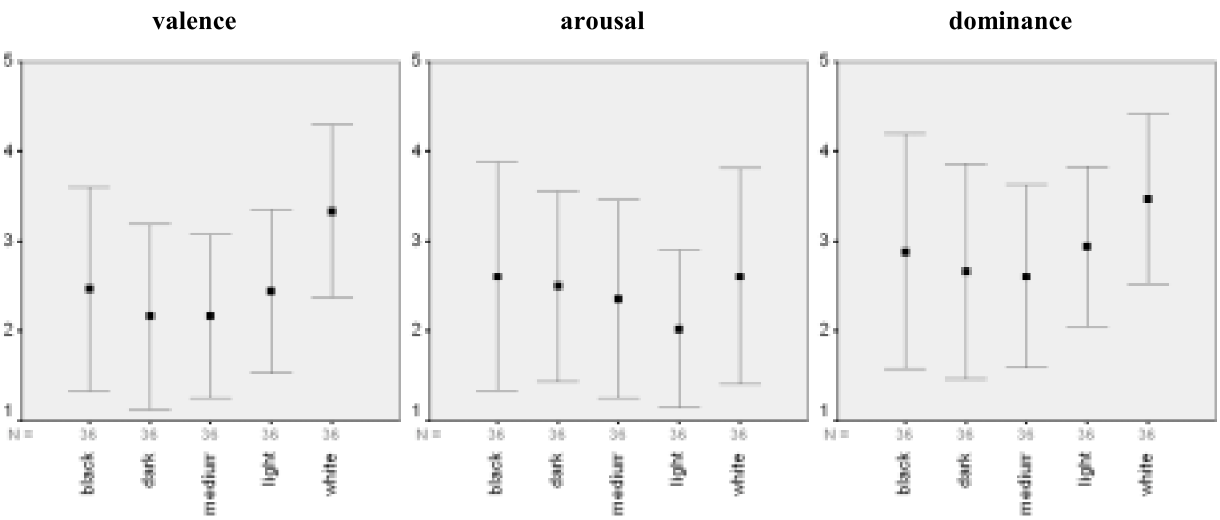


Figure 42. SAM ratings of valence, arousal, and dominance to lightness of achromatic color stimuli

abscissa: lightness level, ordinate: SAM ratings

dot: mean, range of error bar: standard deviation, N=36, 'N' in charts represents the frequency.

estimation		dimensions valence	arousal	dominance
quadratic	R^2	.149***	.018	.074***
	variables in equation: constant	3.000	2.959	3.271
	variables in equation: x, (Beta)	-.595	-.326	-.437
	variables in equation: x^2, (Beta)	.090	.036	.066

Table 27. Result of regression analyses between lightness level and SAM ratings

*** p<.001.

On balance, the two analyses (a), illustrated in Figure 40, and (b), illustrated in Figure 42, show that there is no general trend between lightness and emotional responses. Instead, either an inverted U-shaped influence (chromatic colors) or a U-shaped influence (achromatic colors) can be found.

5.4.2 Insight into color nuance: various grays

As indicated at the beginning of this chapter, different nuances of gray have been increasingly applied in product design, since gray neutralizes the background and supports the focus contents. Experiment II investigates whether different nuances of gray influence emotional responses. Three different gray nuances were taken into account: cool, neutral, and warm. Each of the nuances included three lightness levels: dark, medium, and light.

The SAM ratings of three nuances × three lightness levels are illustrated in Figure 43.

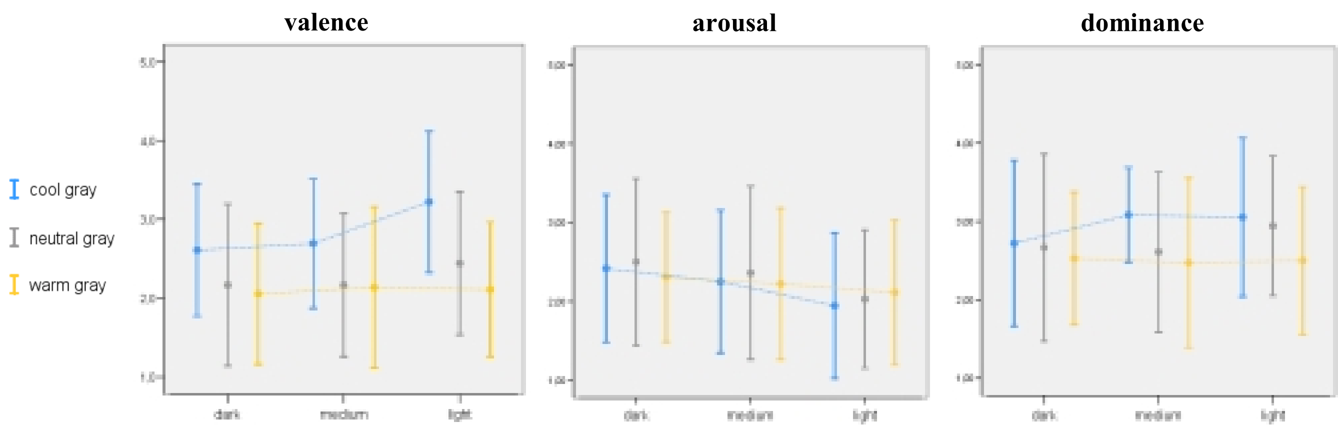


Figure 43. SAM ratings of cool, neutral, and warm grays, Experiment II.

Then, two-way repeated measurements ANOVA was run to test for a significant influence of nuance, lightness, or an interaction term on SAM ratings to valence, arousal, and dominance dimensions (Table 28).

factor	valence	arousal	dominance
gray nuance (cool, neutral, warm)	**F (2, 70)=23.553, p<.001*** **	F (2, 70)=.269 p=.765	**F (2, 70)=5.010, p=.009** **
lightness (dark, medium, light)	**F (1. 684, 58.957)=4.240, ε=.842 , p=.025***	**F (2, 70)=5.843, p=.005** **	F (2, 70)=.920 p=.403
gray nuances & lightness	**F (4, 140)=2.857, p=.026***	F (4, 140)=.454 p=.770	F (4, 140)=2.006 p=.097

Table 28. Result of two-way repeated measurements ANOVA, factor: gray nuances, lightness levels, Experiment II

ε: corrected by Greenhouse-Geisser, *p<.05, **p<.01, ***p<.001.

Nuances influenced emotional responses to grays with regard to **valence** and **dominance**, especially cool grays induced more positive and more dominating responses than warm grays did. Neutral grays elicited emotion between two nuances, in valence and dominance dimensions.

Therefore, the ‘nuance effect’ may open up another dimension of research on color affectivity. Further research may deal with other hue directions or focus on nuance effect on other cognitive performance.

5.5 SUMMARY AND DISCUSSION OF EXPERIMENT II

In Experiment II, a variation of hypothesis I was examined focusing on **surface color** [H.3]. Cronbach’s alpha provided evidence that valence (α=.767), arousal (α=.886), and dominance (α=.691) describe an emotional profile of surface colors. The 36 CIELab Lch colors were selected based on five hue and five tone categorizations, and 11 achromatic as well as two metallic (gold and silver) colors were included and presented on DIN A5-size glossy paper (RAL DESIGN™).

A tone categorization was used in order to measure emotional responses to **perceived color.** The five tones, such as dark, deep, vivid, brilliant, and light were segmented with regard to different patterns of color perception of each hue category. In doing so, empirical results of color categorization through color terms (Irtel, Experimentalpsychologisches Praktikum, Winter semester 2003/2004) and ISCC-NBS (Kelly et al.,

1976) were considered. Therefore, the analyses of emotional responses to Chroma and lightness resulted in more systemic explanations, since both color attributes were equally observed throughout the hue categories, regardless of the physical properties. Tone categorization is thus more adequate in order to detect trends of emotional responses to color (i.e. [H 4.]). For future color studies, it is recommended to use such tone categorizations, when they deal cognitive quantity of color.

The SAM ratings of hue, Chroma, and lightness were analyzed and **similar patterns** from Experiment I were observed. Blue was distinguished from the other hue categories and Chroma correlates with dimensions of emotion (r=.670**: valence, r=.554**: arousal, r=.455**: dominance). The lightness contrast between stimulus and background is predicted but yet inconclusive (R^2=.149: valence, R^2=.018: arousal, R^2=.074: dominance; regression analysis with quadratic estimation).

The analysis of the **nuance effect on emotional responses** to grays yielded significant results in valence (F (2,70)=23.553, p<.001***) and dominance (F (2,70)=5.010, p=.009**) dimensions. It implies a possible further research on such subtle differences, which may influence affectivity of color. In other disciplines, such as in design, it has been frequently argued whether there is an emotional distance cased by subtle displacement in color space. Kobayashi (1998) emphasize changes of nuances, taking the example of a yellow banana and that of a yellow lemon. Both colors communicate completely different objects, even if both are located closely to each other in the color system. It is expected that emotion studies on **color nuances** may postulate new pattern of emotional responses concerning specific colors.

5.5.1 What affects color emotion, hue or tone?

As shown in Figure 44, the averaged SAM ratings of 25 chromatic colors are illustrated in terms of the hue category (the three charts in the upper row: see Equation 2) and the tone category (the other three charts in lower row: see Equation 3).

Since one-way repeated measurements ANOVA yielded significant results (p<.05) for hue as well as tone categorizations, basically both influence emotional responses with regard to all dimensions. Nevertheless, the results emphasize the importance of variations of Chroma and lightness concerning emotional responses to colors.

In each chart, the mean difference is drawn, subtracting the minimum mean from the maximum one. The subtraction areas are marked in **light red**, as the **averaged SAM ratings** varied with hue categories and those are marked in **light green**, as the **averaged SAM ratings** varied with tone categories. Across the entire dimensions, **the subtracted amounts by tone categories (light green) are bigger than those by hue categories (light red).**

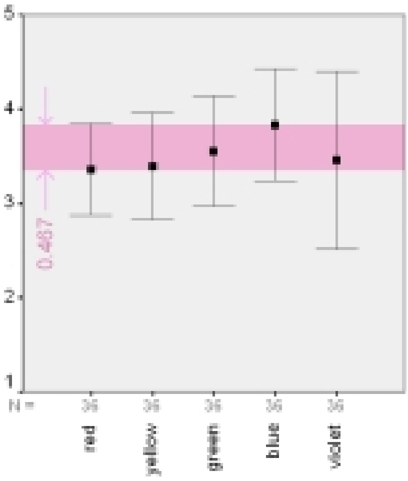
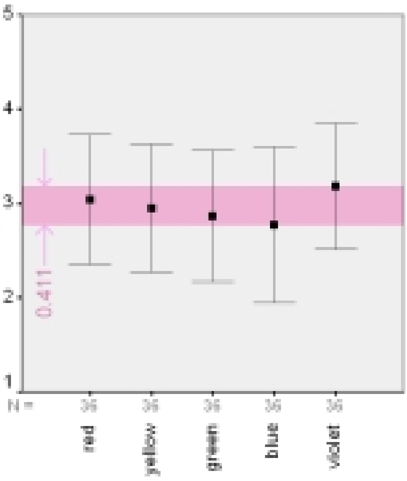
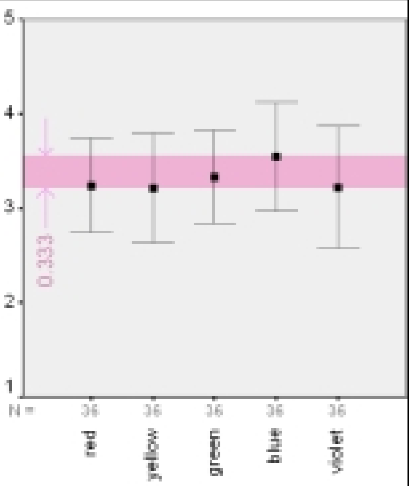
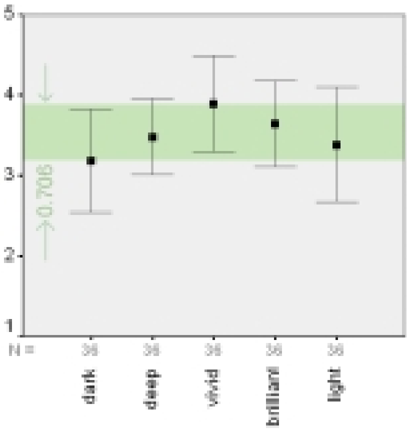
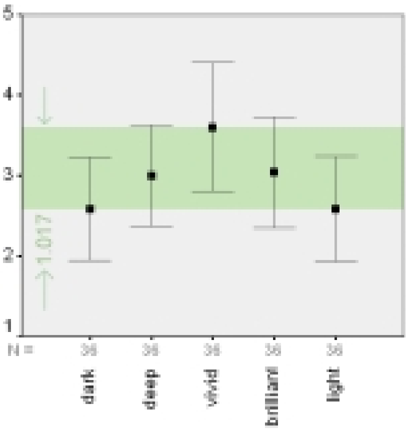
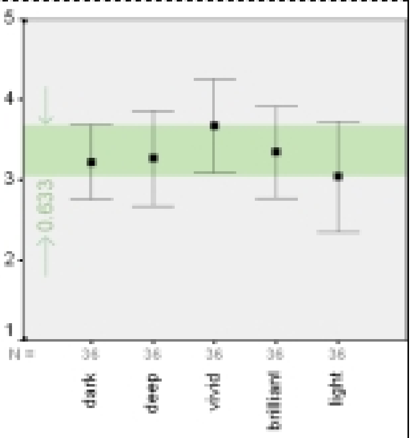
factor	**valence**	**arousal**	**dominance**
hue categories	 F (2.930, 102.537)=3.351 ε=.732, p=.023*	 F (4, 140)=3.409 p=.016*	 F (4, 140)=2.759 p=.040*
tone categories	 F (2.245, 78.574)=8.907 ε=.561, p<.001***	 F (3.077, 107.698)=28.954 ε=.769, p<.001***	 F (2.430, 85.064)=6.784 ε=.608, p<.001***

Figure 44. Mean differences of predicted by hue (colored reddish) and by Chroma (colored greenish)

ε: corrected by Greenhouse-Geisser, * p<.05, *** p<.001.

Therefore, [H. 2] is repeatedly confirmed: emotional responses to color vary stronger with tone, the combination of Chroma and lightness, than with hue. Moreover, the **tone categorization** provides the evidence in a systemic way, supporting [H. 4].

In addition, it should be noted that those five categories of hue and tone shall be representative of the visible wavelength spectrum and the entire tone variations of chromatic colors.

5.5.2 Emotional responses to colors on a single dimension

In Figure 33, a diagonal pattern of colors can be observed, from lower-left to upper-right. Accordingly, correlation analysis between dimensions resulted in positive and significant coefficients (Table 29); *r*=.700***: valence vs. arousal; *r*=.879***: valence vs. dominance; *r*=.659***: arousal vs. dominance.

Based on this, it was asked whether there may exist **a single dimension** of color emotions. If it is so, the other two dimensions can be forecast when the value of one dimension is known. At the same time, it suggests a single bi-polar scale, which drives emotional responses to color.

Since the plots depicted in Figure 33 represent the averaged SAM ratings through 36 subjects, another analysis of correlation was run based on the raw inputs, as shown in Table 30. Although significant, the correlation coefficients between dimensions decreased in size (*r*=.267***: valence vs. arousal; *r*=.526***: valence vs. dominance; *r*=.265***: arousal vs. dominance). Respectively, only 7.1%, 27.7%, and 7.0% of the total variation could be explained. It indicates that emotional responses within colors should be more homogeneous, in order to address a single dimension of color emotion with statistical approval.

color stimuli		correlation coefficients *r* (Pearson)		
		v × a	v × d	a × d
All	**averaged SAM ratings (38 cases, seeTable 22)**	**.700*** **	**.879*** **	**.659*** **
	Original inputs (36 subjects for 38 colors ⇒ 1368 ratings)	.267***	.526***	.265***

Table 29. Correlations coefficients between dimensions: SAM ratings of chromatic colors

v × a: valence vs. arousal, v × d: valence vs. dominance, a × d: arousal vs. dominance, *** p<.001 (two-tailed). N of subjects=36.

Furthermore, the correlation analysis was run divided by hue categories: on the one hand, the correlation accounts for the averaged SAM ratings (upper rows of each hue category, Table 30). On the other hand, the raw SAM ratings were admitted for correlation analysis (the second rows of each hue category, Table 30). Hue categories in the shorter wavelength segment, such as green, blue, violet do not seem to be correlated with valence and arousal dimensions. Thus the assumption of a single dimension of color emotion is plausible depending on specific hue categories, i.e. red or yellow.

Another point to be addressed is the fact that the correlation coefficients between **valence** and **dominance** are greater than the other pairs. This tendency is in line with previous empirical studies: Hamm et al. (1993) employed normative pictures and semantic items and both were assessed with SAM. It provided evidence for a highly positive correlation between valence and dominance dimensions. Moreover, Bradley et al. (1994) found SAM measurements of pictures on valence and dominance to be highly correlated. The authors investigated two forms of SAM administration, such as pencil-and-paper and computer controlled, and high positive correlation coefficients within and between administrations were found. Therefore, there is ample evidence that responses on dominance are positively correlated with responses on valence, also with regard to colors.

color stimuli		correlation coefficients *r* (Pearson)		
		v × a	v × d	a × d
red	averaged (five cases)	.873	.948*	.941*
	original inputs (36 subjects for five colors ⇒ 180 ratings)	.322***	.505***	.357***
yellow	averaged (five cases)	.774	.962*	.813
	original inputs (36 subjects for five colors ⇒ 180 ratings)	.342***	.650***	.388***
green	averaged (five cases)	.520	.877	.854
	original inputs (36 subjects for five colors ⇒ 180 ratings)	.116	.558***	.237**
blue	averaged (five cases)	.874	.926*	.982**
	original inputs (36 subjects for five colors ⇒ 180 ratings)	.042	.505***	.185*
violet	averaged (five cases)	-.067	-.326	-.480
	original inputs (36 subjects for five colors ⇒ 180 ratings)	.077	.378***	.264***

Table 30. Correlations coefficients between dimensions: SAM ratings of chromatic colors, divided by hue categories

* p<.05, ** p<.01, *** p<.001 (two-tailed). N of subjects=36).

5.6 CHAPTER REVIEW

• Three hypotheses were formulated, with regards to emotional response to surface color, hue and tone categorization based on color perception, and nuance effects of grays (5.1).

• Thirty-seven psychology students, including one outlier served as subjects in Experiment II (5.2.1). As discussed in section 4.7, colors were chosen based on five hue and five tone categorizations. The process of color selection is described, referring to an empirical study (Experimentalpsychologisches Praktikum, supervised by Prof. Dr. Irtel, Winter semester 2003/2004)(5.2.2). Thirty.six CIELab Lch colors and two metallic colors (gold and silver) were employed and presented on DIN A5-size glossy paper from RAL DESIGN System™. CIELab Lch values of color stimuli are presented.

• Cronbach's alpha supported reliable internal consistency, supporting [H. 3]; α=.767: valence, α=.886: arousal, and α=.691: dominance. Improved instruction regarding the dominance dimension was adequate to inform subjects to simplified SAM pictograms as bi-polar scale for dominance dimension. SAM ratings of all stimuli on three dimensions are analyzed accordingly. Based on mean plots of colors (see Figure 31), positive correlations between dimensions were detected (5.3).

• SAM ratings of hue and tone categories were analyzed. The significant influence of hue categories on SAM ratings was shown in one-way repeated measurements ANOVA. In particular, the color blue induced more positive, less excited, and more dominant emotions than the other hue categories (significant mean differences yielded by pair-wise multiple comparison; LSD)(5.3.1).

• According to tone categorization, four Chroma levels and seven lightness levels were taken into account. A positive linear relationship between Chroma levels and averaged SAM ratings on dimensions of emotion was observed and significant correlation coefficients were yielded: r=.670**: valence, r=.554**: arousal, and r=.455**: dominance. The advantage of tone categorization is addressed in comparison with emotional response to physical attributes of Chroma (5.3.2.1).

Secondly, SAM ratings of lightness levels were analyzed separately with achromatic and with chromatic colors. Respectively, an inverted U-shape and a U-shape were observed (5.3.2.2).

Moreover, according to tone categories, analysis of emotional responses to Chroma and lightness levels served to describe findings across five hue categories and thus **tone categorization based on color perception** is recommended for studies concerning the **cognitive quantity of color** [H. 4].

• As implicated in [H. 5], SAM ratings depending on three nuances of gray were analyzed with two-way repeated measurements ANOVA. It was found that temperature nuances of grays, such as cool, warm, and neutral may influence on emotional response in terms of the valence and the dominance dimension (5.3.3).

• Based on the empirical results of Experiment II, SAM ratings of hue categories were compared with those of tone categories. As shown in Figure 42, emotional responses varied stronger with tone categories than with hue categories in all three dimensions of emotion (5.4.1).

• In accordance with positive correlations between dimensions accounting for averaged SAM ratings of colors, a single dimension for color emotion was proposed. Including raw inputs of 36 subjects, correlation analyses were run. The results thereof are not yet conclusive, especially when emotional responses are induced by short wavelength hues, such as green, blue, and violet. On the other hand, the positive correlations between valence and dominance are in line with previous empirical studies (5.4.2).

6. EXPERIMENT III: EMOTIONAL RESPONSE TO DIGITAL COLOR

6.1 GOALS AND HYPOTHESES

As the technology of digital media became dominant in human communication, the domain of color research has obviously extended to it. There are two main aspects of interest. Firstly, studies focus on color stimuli presented in various digital media to investigate **media influence on color perception**. As initiated by McLuhan (1964), media research concerns the recognition of the influence of media stems. Thus, the characteristics of the respective medium including its physical properties were often taken into account as variables for cognitive patterns. For instance, it is often discussed whether color (e.g. Chroma) appearance influences the cognitive quality of semantic contents, as discussed in 4.2.1.
In parallel, every emergence of a new digital medium has offered physicians and computer scientists a new research domain, such as color systems, algorithms of color conversion, and calibration.

Secondly, digital media may provide **versatility** to color research. As psychologists set to use computers, Lang (1980) advocated the usage of computers, as they can help the researcher to reveal organizing structures in the data. This could condense the time taken in diagnosis and assessment. Moreover, since the WWW (World Wide Web) was introduced, it has been much easier to exchange visual information across geographical boarders. Thus, many studies benefited from inexpensive and flexible aspects of the digital media, expecting the result would be representative to explain the phenomenon, regardless of the media involvement.

Therefore it is necessary to provide evidence whether perception of colors presented on digital media is comparable to perception of surface color. In order to distinguish color presented on digital media from surface color, it will be called “digital color” in this dissertation. This refers to the self-illuminating color in digital media. In Experiment III, CRT computer monitors were used to provide the digital color stimuli.

The purpose of Experiment III is to investigate whether digital color induces emotional response in a similar fashion as surface color does (as shown in Experiment II). The identical color stimuli of CIELab Lch data that were used in Experiment II were implemented with the PXLab© software. Hypotheses 6 and 7 are thus formulated as follows:

[H. 6] Emotional profiles of digital color can be characterized by valence, arousal, and dominance.

[H. 7] Digital colors elicit emotion in the same way surface colors do. Within the medium, emotional responses to colors are consistent.

6.2 METHODS

6.2.1 Subject

Forty-six people served as subject in Experiment III. They were recruited through advertisements in the University of Mannheim. As reward, € 4.00 were offered for the approximately 20-minute experiment.

	number of survey subjects		age			
	male	female	min.	max.	M	SD
Mannheim, Germany	19	27	15	69	24.430	8.988

Table 31. Subjects of Experiment III.

6.2.2 Stimuli

Two sets of stimuli were employed: a color set and a picture set.

Excluding the two metallic colors (gold and silver), the remaining 36 colors in Experiment II, were implemented with the Java-based PXLab© software.

At the beginning of the experiment, a gray stimulus (L=30) was shown, in order to get acquainted with the SAM interface. Color stimuli were displayed centered on CRT monitors, in a size of 25.1 cm width × 15.2 cm height. Stimuli were presented in a random order and every subject went through all stimuli.

After assessing 36 color stimuli, the four IAPS baseline pictures were presented in the same size and position as the color stimuli. However, subjects were **not** told that pictures would be shown. In addition to the baseline function, it is intended to observe, whether pictures induce emotions in a stronger pattern than colors, because pictures contain a higher intensity of semantic contents.

Five SAM pictograms of each dimension were arranged below the stimuli and subjects moved on to the next page by pressing any key. The background color was gray with a lightness of 30.

6.2.3 Revised SAM

In Experiment III, SAM pictograms for the valence dimension were modified. The faces of the pictograms were enlarged, because the body parts of the manikin do not show any change and are therefore redundant. Zooming into the facial part, the continuum of changes from sadness to happyness was more clearly identifiable (Figure 45).

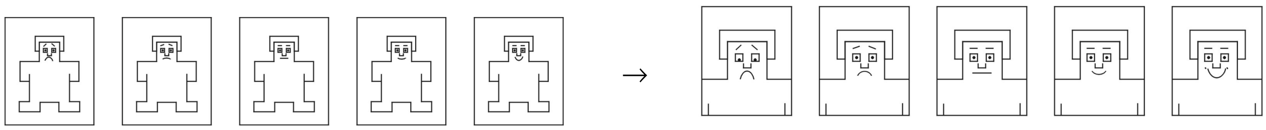


Figure 45. Modified SAM pictograms for the valence dimension
left=original (Lang, 1980), right=modified.

A row of SAM pictograms was presented, in the order of valence, arousal, and dominance. Subjects could select a pictogram by mouse click, until they pressed a key to go on to the next page. All subjects went through all sets of stimuli. As a pictogram was selected, the background darkened, as illustrated in Figure 46.

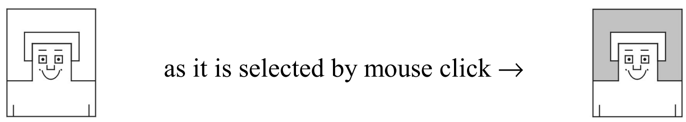


Figure 46. Interface design for unselected /selected SAM pictogram.

6.2.4 Procedure

After filling out the demographic information and reading through the introduction, which can be found in Appendix G, subjects started the experiment in front of the computer monitor. Two computers were set in a seminar room of the library of social science of the University of Mannheim (Room 015, A3, Mannheim) and the experiment was carried out in daylight.

Figure 47. Procedure of Experiment III.

Subjects were seated approximately 40cm from the CRT monitor. Monitors were calibrated by Gretag MacBeth Eye One Spectral Photometer, before the experiment started.

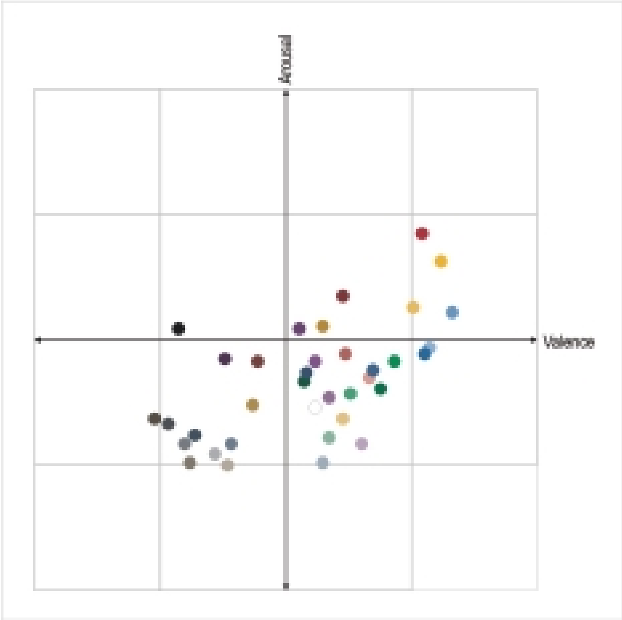
6.3 RESULTS

From the 48 subjects, two were filtered out, because they evaluated the aimed gun as very positive, rating it with the maximum for the valence dimension. Based on SAM ratings of 46 subjects, reliability of internal consistency was tested. Cronbach's alpha yielded significant values to support [H.6]. Valence, arousal, and dominance are thus adequate to describe emotional responses to digital colors (Table 32).

	valence	arousal	dominance
color stimuli (on 36 variables)	.793 (46 cases)	.880 (46 cases)	.904 (46 cases)
color stimuli (on 108 variables)		.869 (46 cases)	

Table 32. Reliability coefficients of Experiment III, Cronbach's alpha N=46.

In Figure 48, plots of averaged SAM ratings of 36 color stimuli shows a diagonal pattern from lower-left to upper-right. This can be observed in both emotion spaces. The trend is stronger in the emotion space defined by valence (abscissa) and dominance (ordinate), replicating the tendency found in Experiment II with surface colors.



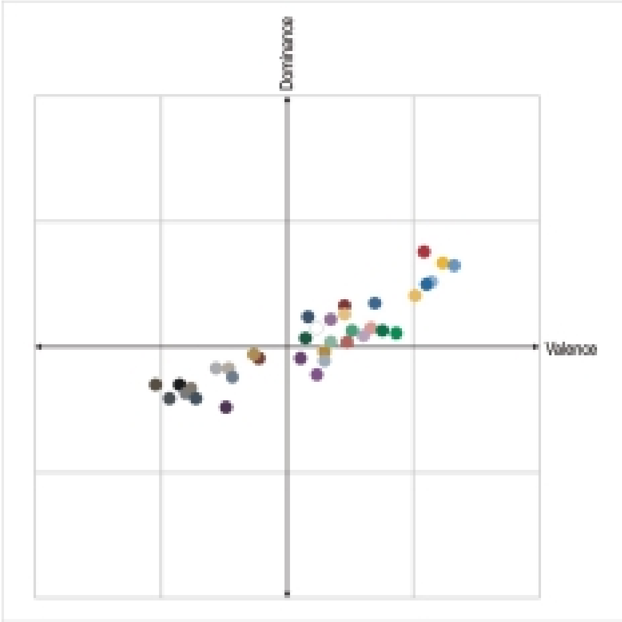


Figure 48. Plots of means of 36 colors in emotion space, Experiment III

defined by: valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right.

6.3.1 Comparison of emotional responses to color stimuli on different media

A two-way ANOVA was run in order to examine the influence of the medium effect. Since every subject of each experiment went through all stimuli, ANOVA was set with repeated measurement within colors.

As Table 33 shows, there was **no significant difference** between the two experiments. Therefore, the emotional responses to color in both media, namely surface color and digital color did not differ significantly (p>.05). This result supports the compatibility of digital color for research on color and emotion [H. 7].

factor	valence	arousal	dominance
experiment (between)	**F (1, 80)=.008, p=.929**	**F (1, 80)=.694, p=.407**	**F (1, 80)=(.989), p=.323**
stimulus: color (within)	F (13.877, 1110.180)=39.819 ε=.396, p=.000***	F (16.003, 1280.280)=18.260 ε=.457, p=.000***	F (13.980, 1118.367)=9.640 ε=.399, p=.000***
exp.(between)*stimulus (within)	F (13.877, 1110.180)=2.464 ε=.396, p=.002**	F (16.003, 1280.280)=2.056 ε=.457, p=.008**	F (13.980, 1118.367)=1.567 ε=.399, p=.082

Table 33. Result of two-way ANOVA with repeated measurement on colors, Experiments II vs. III

N of Experiment II=36, N of Experiment III=46. ε: corrected by Greenhouse-Geisser, *p<.05, **p<.01, ***p<.001

F value in parenthesis: variances of dependent variables are not homogeneous.

Furthermore, it was investigated whether the emotional responses to **each color** were different between the two experiments. The SAM ratings of the subjects of Experiment II and those of the subjects of Experiment III were compared with a t-test. P-values lower than .05 (Table 34) indicate that SAM ratings of the color stimuli in the two experiments are **significantly different**.

colors	mean comparison (p values yielded by t-test, two-tailed, df=80)								
	valence			arousal			dominance		
	M exp.II	M exp. III	p	M exp.II	M exp. III	p	M exp.II	M exp. III	p
dark red	2.778	2.783	(.983)	2.694	2.826	.575	3.028	2.913	.618
deep red	3.889	3.457	**(.035*)**	3.139	3.348	.359	3.528	3.326	.346
vivid red	4.056	4.087	.883	4.083	3.848	.264	3.778	3.761	.944
brilliant red	3.056	3.478	**.020***	2.667	2.891	.323	2.972	3.044	.745
light red	3.028	3.674	**.009****	2.611	2.696	.733	2.889	3.152	.306
dark yellow	2.472	2.739	.256	2.278	2.478	.341	2.806	2.935	.569
deep yellow	2.556	3.304	**.003***	2.917	3.109	.445	2.639	2.957	.178
vivid yellow	4.333	4.239	.662	3.694	3.630	.812	3.917	3.674	.365
brilliant yellow	4.139	4.022	.584	3.472	3.261	.388	3.639	3.413	.375
light yellow	3.472	3.457	.943	2.389	2.370	.935	3.056	3.261	(.394)
dark green	3.806	3.152	**.003****	2.667	2.674	.974	3.444	3.065	.096
deep green	3.833	3.761	.727	3.028	2.609	.089	3.556	3.130	.088
vivid green	3.583	3.870	.207	3.389	2.826	**.023***	3.667	3.109	**.014***
brilliant green	3.444	3.522	.733	2.972	2.565	.092	3.194	3.130	.770
light green	3.111	3.348	.291	2.278	2.217	.798	2.778	3.044	.294
dark blue	3.472	3.174	.183	2.389	2.739	.127	3.250	3.239	.968
deep blue	3.639	3.696	.783	2.444	2.761	.172	3.389	3.348	.853
vivid blue	4.111	4.109	.990	3.444	2.891	**.043***	3.944	3.500	(.048)
brilliant blue	4.139	4.326	.292	2.917	3.217	.262	3.694	3.652	.867
light blue	3.778	4.152	.084	2.667	2.935	.300	3.444	3.522	.736
dark violet	3.417	2.522	**.001****	2.889	2.848	.863	3.583	2.522	**.000*****
deep violet	3.500	3.109	.081	3.472	3.087	.069	3.222	2.913	.194
vivid violet	3.389	3.239	(.576)	3.389	2.826	**.019***	3.056	2.783	.250
brilliant violet	3.444	3.348	.679	3.167	2.544	**.011***	3.222	3.217	.982

light violet	3.528	3.609	(.739)	3.000	2.174	**.000*****	3.028	3.087	.809
dark gray	2.167	2.065	.653	2.500	2.326	.480	2.667	2.587	.777
medium gray	2.167	2.196	.887	2.361	2.174	.452	2.611	2.630	.935
light gray	2.444	2.435	.961	2.028	2.087	.787	2.944	2.826	.588
dark warm gray	2.056	1.957	.640	2.306	2.370	(.773)	2.528	2.696	.471
medium warm gray	2.139	2.239	.633	2.222	2.022	.314	2.472	2.674	.422
light warm gray	2.111	2.544	**.048***	2.111	2.000	.583	2.500	2.826	.160
dark cool gray	2.611	2.283	.086	2.417	2.239	.419	2.722	2.587	.589
medium cool gray	2.694	2.565	.485	2.250	2.174	.714	3.083	2.761	(.104)
light cool gray	3.222	3.304	.676	1.944	2.022	.709	3.056	2.891	(.526)
white	3.333	3.239	.701	2.611	2.457	.578	3.472	3.152	(.214)
black	2.472	2.152	.208	2.611	3.087	.115	2.889	2.696	(.560)

Table 34. Mean comparisons of SAM ratings between Experiments II and III

N of subjects of Experiment II: 36, N of subjects of Experiment III: 46

p values in parentheses: equal variances not assumed by Levene's F test.

This significant difference was found for seven colors in valence, five colors in arousal, and two colors in dominance dimensions. Violet colors in vivid, brilliant, and light tones induced significantly less excited emotions ('–' arousal) as digital colors than as surface colors. However, there is yet no systemic explanation for this. In general, the results tend to support the similarity in affective judgments of color stimuli in both media, supporting [H. 7].

Based on individual comparisons as presented in Table 34 it can be asserted that patterns of emotional responses to color attributes would have appeared in the similar way in Experiment II. Nevertheless, SAM ratings of hue (6.3.1.1) and tone categories (6.3.1.2) will be analyzed in the following sections.

6.3.1.1 Emotional responses to hue categories

Although there is no statistical evidence to indicate any difference between surface and digital colors, some findings based on the illustrated results could be pointed out.

The three charts in Figure 49 present averaged SAM ratings of individual subjects within hue categories (see Equation 2). Pairs of bars in each colored column compare the SAM ratings of the 36 subjects on the left (Experiment II: surface color) with the 46 subjects on the right (Experiment III: digital color, dotted bars).

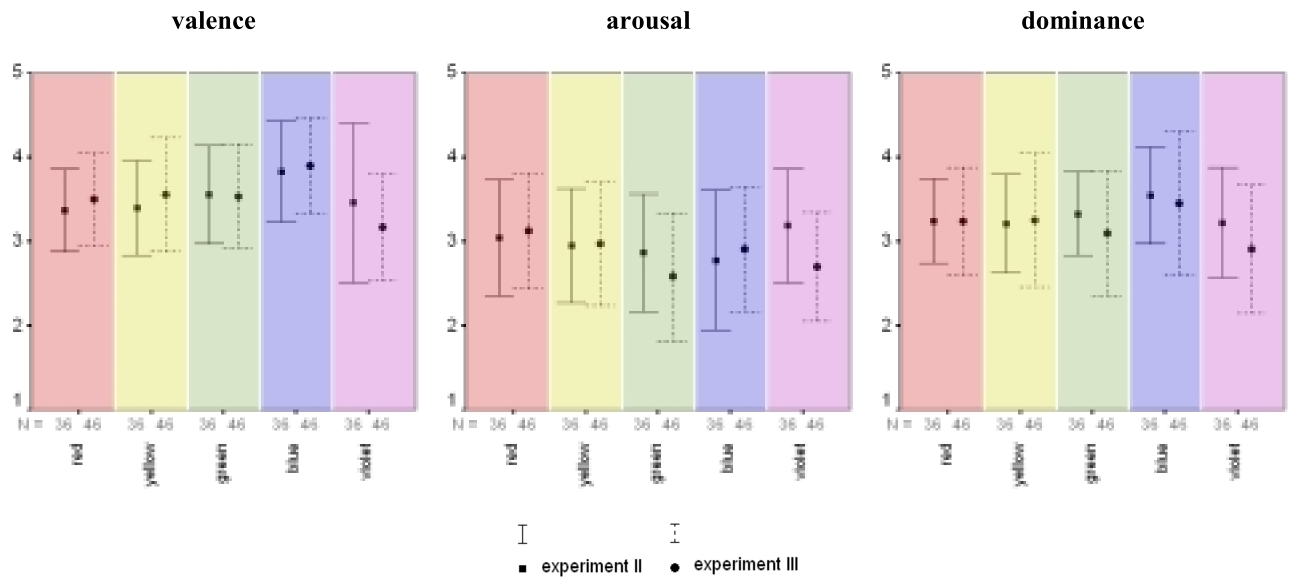


Figure 49. Averaged SAM ratings of hue categories, Experiment II (N=36) versus III (N=46)

Across the three dimensions, digital colors in the **violet** category were assessed less positive, less excited, and less dominant than surface colors. Besides, digital colors in the **green** category were assessed more calm than those in the blue category.

6.3.1.2 *Emotional responses to tone categories*

The SAM ratings of tone categories are analyzed under two aspects: **(a)** Chroma level and **(b)** lightness level.

(a) Chroma level

In Figure 50, averaged SAM ratings (see Equation 3) of Chroma levels are depicted, comparing the results of Experiments II and III. Basically, Chroma levels correlate positively with all dimensions of emotion, as observed in previous experiments.

However, digital colors (marked with red line) of the vivid tone category induce a weaker pattern of emotion regarding arousal and dominance dimensions than surface colors do.

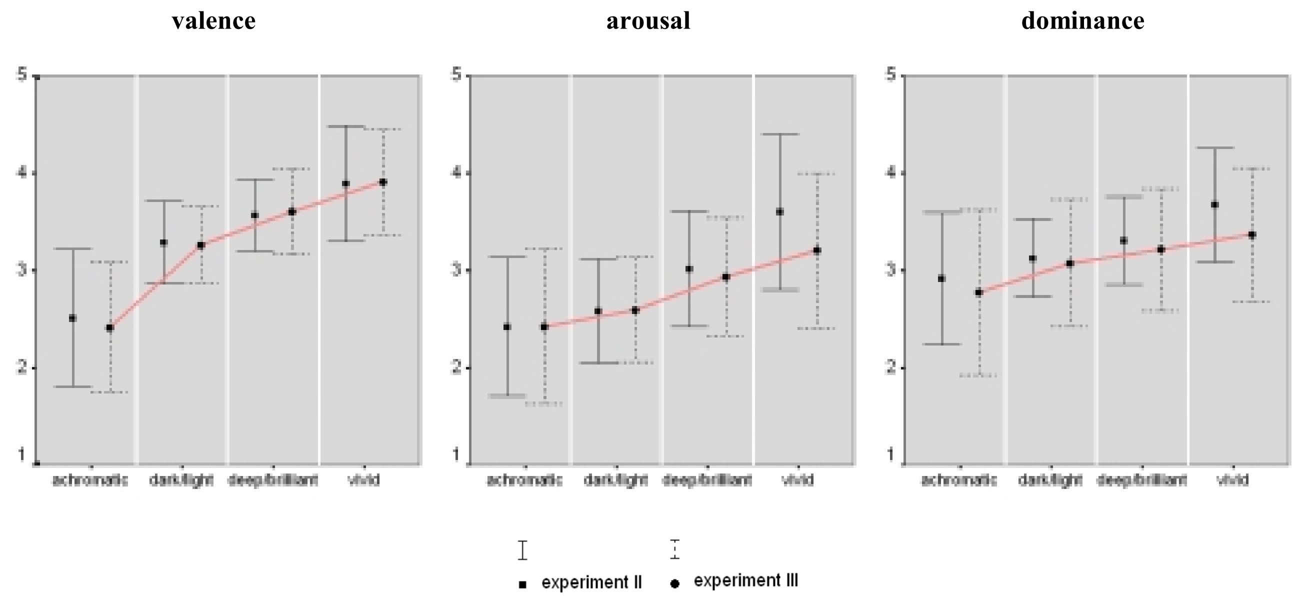


Figure 50. Averaged SAM ratings of Chroma levels, Experiment II (N=36) versus III (N=46).

The digital colors employed in this experiment correspond to surface colors in terms of the CIELab Lch system. It was intended to provide subjects with the same quality of hue, Chroma and lightness on the CRT monitor as on DIN A5-size paper. However, since the RGB projection on CRT monitors can produce in some hue domains even higher Chroma than can be printed in surface color (i.e. RAL Design color sheets), it is predictable that the reddish lines in Figure 48 will rise increasing Chroma level.

In addition, the perceived Chroma may be greater depending on the surrounding color. **An interaction with adjacent colors** may thus influence the perception of the target color and a complimentary color can increase the vividness of the target color.

(b) lightness level

As analyzed in (a), the digital colors in the vivid tone category induce weaker emotional responses regarding the arousal and dominance dimensions. Thus, an inverted U-shape appears less evidently in those dimensions. Among vivid colors across five hue categories, the t-test in Table 34 yielded significance for vivid green and vivid blue. This may have influenced the relatively flat curve in Figure 51.

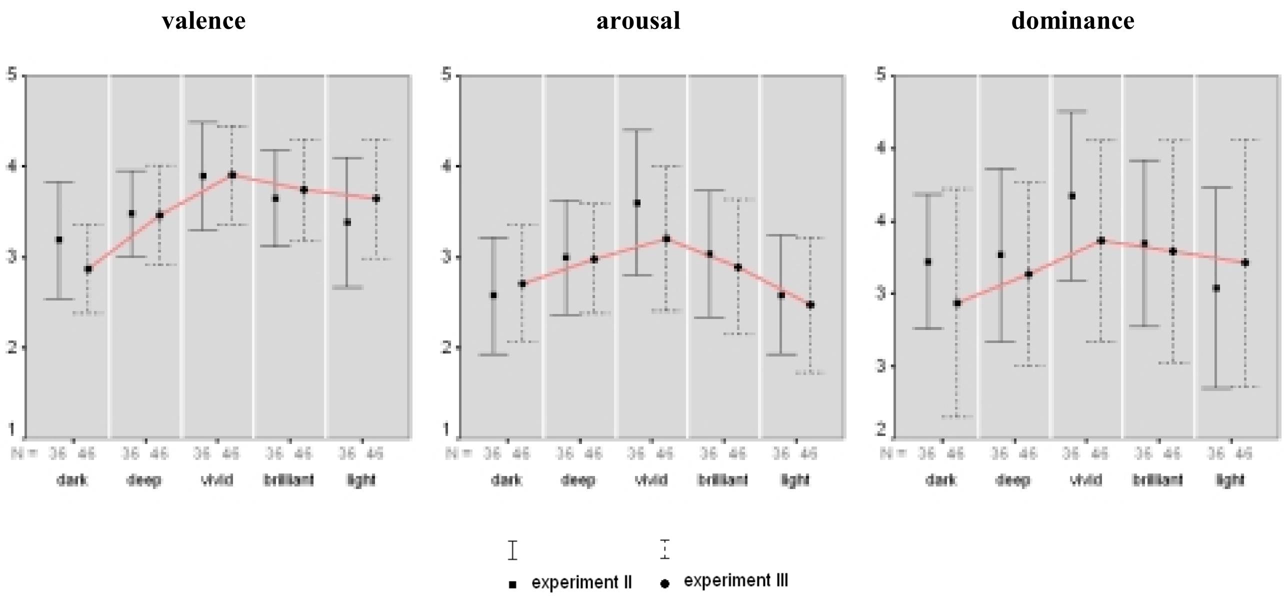


Figure 51. Averaged SAM ratings of lightness levels (chromatic colors), Experiment II (N=36) versus III (N=46).

In addition, the t-test did not yield significant differences for any achromatic color (Table 34). The U-shaped trend is thus consistently observed in both Experiments II and III (Figure 52).

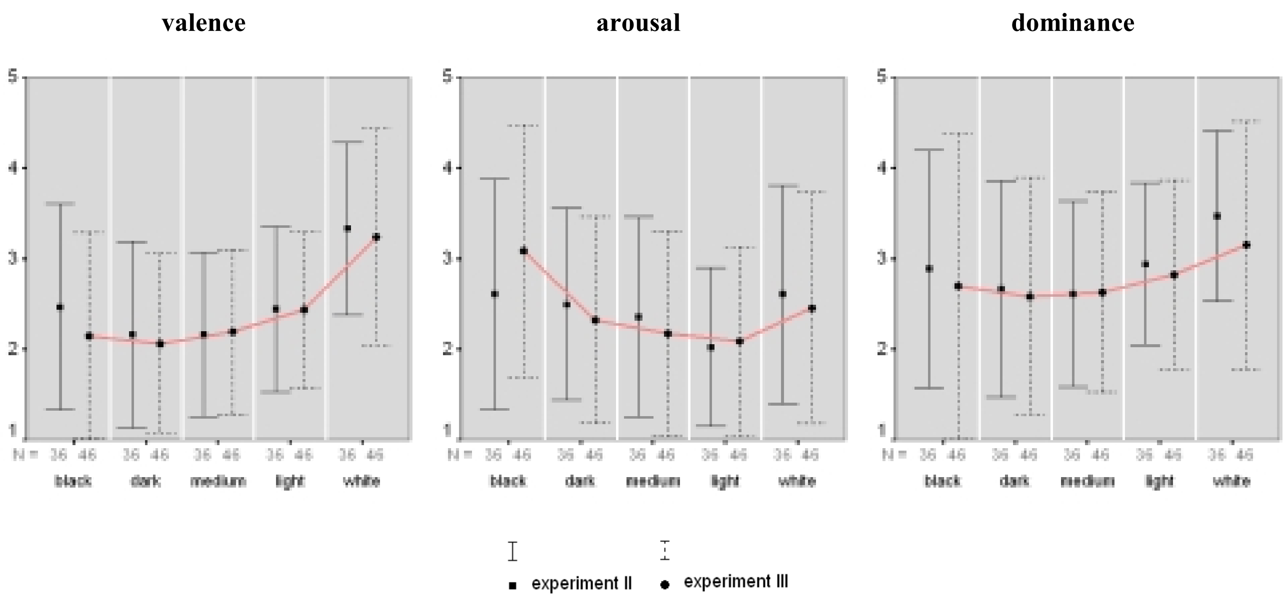


Figure 52. SAM ratings of lightness levels (achromatic colors), Experiment II (N=36) versus III (N=46).

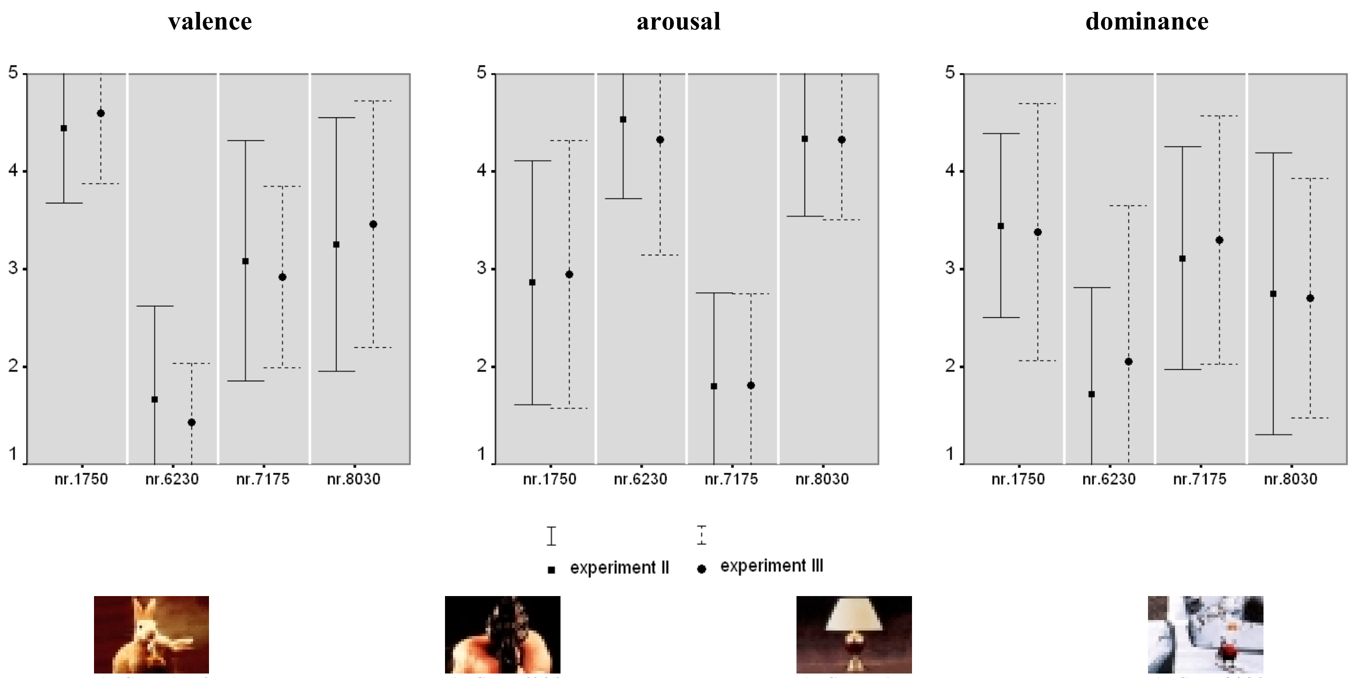
6.3.2 Emotional responses to pictures after colors

As described in 6.2.2, there were two objectives in employing four IAPS pictures. Firstly, as **baseline**, they were supposed to filter out outliers, as in Experiments I and II. Two subjects were excluded accordingly.

Secondly, it was intended to observe the contrast effect in terms of SAM ratings on dimensions. During Experiment II (as well as Experiment I), subjects were informed about the type of stimulus modality (i.e. colors, pictures or adjectives), before they assessed a new stimulus set. However, subjects in Experiment III were confronted with the four IAPS pictures at the end of the experiment without any notice. It was assumed that emotional responses to these pictures might exhibit a **stronger pattern of emotion caused by a higher degree of semantic intensity** in comparison with previous experiments.

In Figure 53, SAM ratings of four IAPS pictures on valence, arousal, and dominance are illustrated. It is observed that emotional responses to pictures are not stronger in Experiment III than in Experiment II. A t-test for each pair of bars **yielded no significant difference** (α=.05, two-tailed).

On the other hand, the result suggested reliability of the control stimuli since SAM ratings of IAPS pictures were consistent.



IAPS Nr.1750 IAPS Nr.6230 IAPS Nr.7175 IAPS Nr.8030

Figure 53. SAM ratings of four IAPS pictures in Experiments II, and III

N of Experiment II=36, N of Experiment III=46.

Nevertheless, there still remained an issue: what if stimuli with higher semantic intensity (i.e. pictures) had been shown in a mixed order with colors? The “range frequency model” of Parducci (1965) claimed that subjects adjust their reference scales to the endpoints of the subjective range. In this way, it is predicted that while subjects were assessing affection of color stimuli, they might have adjusted the 1-5 rating scale to refer to emotional responses to colors. Consequently, as subjects confronted pictures, there was no room to extend the scales, although picture stimuli could have evoked more extreme emotions in comparison with color stimuli. In other words, it might be possible that, when a color stimulus was presented after a picture, SAM ratings of the color stimulus would be influenced by the contrast effect. Affective judgment on color stimuli in different stimulus context was carried out in Experiment IV.

6.4 SUMMARY AND DISCUSSION OF EXPERIMENT III

As media continue to change, their impact on the cognitive performance of people has increasingly interested researchers in various disciplines. Investigating the psychological significance of formal properties and their interaction with message content is essential to a complete understanding of how media effects occur (Detenber et al., 2000). The comparison of Experiments II and III was an attempt at such an investigation in terms of the presentation medium: surface color and digital color.

The study of digital color deserves attention with regard to two different aspects: Firstly, it deals with color on a medium and the characteristics of the medium that may influence color perception. Secondly, computer based color research takes advantages of technical support and innovations (e.g. internet and WWW).

However, it had not been yet examined whether digital colors are comparable to surface colors. This is necessary to show before employing digital colors in color research. Therefore, the two hypotheses [H. 6] and [H. 7] examined the commonality between emotional responses to surface colors and to digital colors.

Thirty-six CIELab Lch colors were employed and 48 students (including two outliers) served as subjects for Experiment III. Based on the SAM ratings of 46 subjects, internal consistency was confirmed in the three dimensions of emotion, supporting [H. 6] (α=.793: valence; α=.880: arousal; α=.904: dominance).

The SAM ratings of the 36 colors were compared by running two-way ANOVA with repeated measurement on one factor, yielding no significant difference (α=.05) in all three dimensions of emotion. The results thus support [H. 7]: color affectivity is consistent within both media.

Then, a mean comparison was conducted for single color stimuli. Based on 108 t-tests (36 colors by three dimensions), 30 colors (83.3%) in valence, 31 colors (86.1%) in arousal, and 33 colors (91.7%) in dominance were not affected by medium change. Although there were a few pairs of colors that showed significant differences, no systemic pattern of such cases could be observed. Respectively, emotional responses to hue and tone categorizations exhibited similar trends as with surface colors in Experiment II, confirming [H. 7].

In addition, the four IAPS baseline pictures were implemented as stimuli at the end of the experiment. Subjects were not informed about the pictures and a contrast effect was expected, caused by the sudden discrepancy of semantic intensity. However, no statistical support for this was found.

6.5 GENDER AS VARIABLE: EXPERIMENTS II and III

It was shown that emotional responses to color stimuli were basically consistent in Experiments II and III. Combining the results from both experiments, a greater number of subjects, 36 + 46=82, was obtained. In the following, gender difference is discussed based on the empirical results of Experiments II and III.

Among the subjects of Experiments II and III, 28 men (34.1%) were men and 54 (65.9%) were women. Ages ranged from 15 to 69 years (M=24.06, SD=7.665)

As one of the major demographic characteristics is gender, affective judgments from male and female subjects have been often compared. Previous studies revealed that women, relative to men, exhibit **stronger** reports of emotional experience (Hagemann et al., 1999; Hemphill, 1996; Gross & Levenson, 1995; Rottenberg 2005).

On the other hand, Bradely, Codispoti, Sabatinelli and Lang (2001b) suggested that a subdivided sample would not have sufficient power for reliably assessing sex differences. Consistent with the assumption, the primary analyses including gender as a factor did not yield significant interaction or main effects. In all cases, the general direction of effects was similar for males and females (Schupp, Cuthbert, Bradley, Hilman, Hamm, & Lang, 2004).

Concerning emotional responses to color, Valdez et al. (1994) suggested that women, compared to men, were slightly more sensitive in terms of their emotional reactions to brightness and saturation levels of colors. However, the authors noted that male and female subjects reacted highly similarly. Nevertheless, it was indicated that females consistently show a slightly stronger pattern of reactions.

Based on the SAM ratings of 36 color stimuli in Experiments II and III, a two-way ANOVA with repeated measurement on one factor: colors, was run. Gender as main effect was not significant (p>.05, Table 35) for all three dimensions, which confirms previous studies (Valdez et al., 1994).

factor	valence	arousal	dominance
gender (between)	**F (1, 80)=.495, p=.484**	**F (1, 80)=.007, p=.935**	**F (1, 80)=.138, p=.711**
stimulus: color (within)	F (13.609, 1088.757)=33.768 ε=.389, p=.000***	F (16.085, 1286.818)=14.790 ε=.460, p=.000***	F (13.923, 1113.855)=8.223 ε=.398, p=.000***
gender (between)* stimulus (within)	F (13.609, 1088.757)=33.768 ε=.389, p=.038*	F (16.085, 1286.818)=14.790 ε=.460, p=.011*	F (13.923, 1113.855)=8.223 ε=.398, p=.517

Table 35. Result of two-way ANOVA with repeated measurement on one factor (colors), Experiments II vs. III

N of male subjects=28, N of female subjects=54. ε: corrected by Greenhouse-Geisser, *p <.05, **p<.01, ***p<.001

F value in parenthesis: variances of dependent variables are not homogeneous.

The SAM ratings of each color were compared, divided by gender, as presented in Table 36.

colors	mean comparison (p values yielded by t-test, two-tailed, df=80)								
	valence			arousal			dominance		
	M male	M female	p	M male	M female	p	M male	M female	p
dark red	3.036	2.648	.090	2.750	2.778	.910	2.929	2.981	.826
deep red	3.464	3.741	.212	3.321	3.222	.678	3.429	3.407	.925
vivid red	4.000	4.111	.620	3.929	3.963	.877	3.964	3.667	.239
brilliant red	3.179	3.352	.370	2.679	2.852	.467	2.929	3.056	.579
light red	3.500	3.333	.530	2.643	2.667	.927	2.964	3.074	.684
dark yellow	3.179	2.333	**.000*** **	2.714	2.222	**.024***	3.107	2.759	.140
deep yellow	3.500	2.704	**.003****	2.893	3.093	.448	3.143	2.648	**.043***
vivid yellow	4.107	4.370	.241	3.607	3.685	.782	3.857	3.741	.679

brilliant yellow	3.786	4.222	**.049***	3.214	3.426	.409	3.214	3.667	.087
light yellow	3.250	3.574	.153	2.500	2.315	.452	3.036	3.241	.416
dark green	3.536	3.389	.530	2.357	2.833	**.036***	3.071	3.315	.309
deep green	4.036	3.667	.087	2.821	2.778	.867	3.357	3.296	.817
vivid green	3.750	3.741	.969	2.821	3.204	.144	3.500	3.278	.360
brilliant green	3.393	3.537	.543	2.571	2.833	.304	3.071	3.204	.563
light green	3.214	3.259	.848	2.429	2.148	.253	2.821	2.981	.547
dark blue	3.393	3.259	.570	2.393	2.685	.225	3.250	3.241	.974
deep blue	3.714	3.648	.759	2.679	2.593	.724	3.143	3.481	.142
vivid blue	4.286	4.019	.184	3.143	3.130	.964	3.607	3.741	.592
brilliant blue	4.071	4.333	.158	3.000	3.130	.645	3.571	3.722	.567
light blue	3.857	4.056	.385	3.321	2.556	**.004****	3.607	3.426	.450
dark violet	2.857	2.944	.759	2.679	2.963	.253	2.786	3.093	.271
deep violet	3.143	3.352	.377	3.036	3.370	.133	2.964	3.093	.608
vivid violet	3.250	3.333	.758	2.786	3.222	.084	2.786	2.963	.477
brilliant violet	3.321	3.426	.669	2.464	3.000	**.038***	3.000	3.333	.124
light violet	3.429	3.648	.369	2.571	2.519	.831	2.893	3.148	.319
dark gray	2.357	1.981	.109	2.429	2.389	.878	2.714	2.574	.634
medium gray	2.464	2.037	(.053)	2.607	2.074	**.038***	2.643	2.611	.899
light gray	2.429	2.444	.939	2.536	1.815	**.001****	3.036	2.796	.294
dark warm gray	2.036	1.981	.807	2.393	2.315	.748	2.536	2.667	.591
medium warm gray	2.357	2.111	.261	2.357	1.981	.069	2.679	2.537	.591
light warm gray	2.607	2.222	.094	2.286	1.926	.087	2.893	2.574	.190
dark cool gray	2.500	2.389	.583	2.321	2.315	.977	2.679	2.630	.852
medium cool gray	2.679	2.593	.658	2.179	2.222	.841	2.714	3.000	.199
light cool gray	3.357	3.222	.512	2.214	1.870	.110	2.964	2.963	.996
white	3.214	3.315	.695	2.536	2.519	.953	3.036	3.426	.165
black	2.286	2.296	.968	2.714	2.963	.434	2.786	2.778	.982

Table 36. Mean comparisons of SAM ratings of color stimuli between gender

* t-test yielded significance ($p < .05$), p value in parentheses: homogeneous variances are not assumed.

N male subjects=28, N of female subjects=54.

Table 36 presents some significant cases: three cases in valence, six cases in arousal, and one case in dominance, no systemic explanation is yet concluded. In sum, the results confirm the previous studies, namely that the two gender groups do not respond differently to color stimuli (Bradley et al., 2001b; Schupp et al., 2004; Valdez et al., 1994).

6.6 CHAPTER REVIEW

• Studies on digital color are viewed under two aspects: media influence and versatility through technical support. Experiment III was intended to compare emotional responses to digital colors with emotional responses to surface colors, in order to support the compatibility of digital colors. Two hypotheses were put forward in this respect (6.1).

• The 48 subjects, including two outliers, served as subjects in Experiment III and 36 colors and four IAPS pictures were employed as stimuli (6.1.1 & 6.1.2). Some improvements of SAM pictograms and interface are illustrated (6.2.3).

• Based on SAM ratings of 46 subjects, the reliability coefficients of internal consistency provided evidence that three dimensions of emotion may describe an emotional profile of digital colors, supporting [H. 6] (6. 3).

• By running a two-way ANOVA with repeated measurement on one factor, colors, the effect of media, surface color versus digital color, was examined regarding the means of valence, arousal, and dominance. The distribution of mean values of colors did not differ from each other (α=.05).
Then a t- test was run for each color in both experiments and it was presented that 30 colors (83.3%) in valence, 31 colors (86.1%) in arousal, and 33 colors (91.7%) were assessed similarly to surface colors. There found no systemic explanation of a few cases, which yielded significance ($p<.05$, two tailed). (6.3.1).

• Based on the results of comparison analysis, it was assumed that characteristic patterns of emotional responses to digital color might appear in a similar way regarding to surface color. SAM ratings were analyzed in terms of hue and tone categories (6.3.1.1) & (6.3.1.2). The main tendencies appeared consistently, supporting [H. 7].

• The four IAPS baseline pictures were expected to provide evidence for the contrast effect caused by the different intensity of semantic contents. This could not yet be confirmed statistically (6.3.2).

• With a larger pool of subjects, it was investigated, if gender affects emotional responses to colors. The analyses were conveyed in terms of hue and tone categorizations and no significant differences were found, confirming previous studies (6.5.1).

7. EXPERIMENT IV: COLORS IN CROSS-MODALITY STIMULUS CONTEXT

In the previous three experiments, emotional responses to colors were analyzed and certain patterns of affectivity in terms of color attributes were found. The measurement with the 5-scale SAM system provided evidence for explaining the relationship between color and emotion. However, the measured values still represent the affective relativity **within colors** and indicate the emotional characteristics of plain colored surfaces. In the experiments, it was intended to exclude any semantic contents to avoid any obvious association with color stimuli. Thus, subjects were supposed to judge emotions according to physical attributes, such as hue, Chroma, and lightness on three dimensions: valence, arousal, and dominance.

The range-frequency model by Parducci (1965) showed that when subjects judge stimuli on rating scales, subjects tend to use the available response categories. Therefore, the empirical results provided in the previous three experiments corresponded to a situation in which a person views a series of plain-colored surface, which is rather seldom in everyday events.

Although hypotheses, [H. 1], [H. 3], and [H. 6] were statistically supported, it does not seem safe to say whether color would induce emotion in a similar way in the context of other categories of visual stimuli, in particular, when other modalities of stimuli exhibit a higher intensity of semantic content. In reality, people may perceive colored surface as a sequence, while they are experiencing pictures or moving images (e.g. reading a magazine or watching TV).

This issue converges into stimulus context effects, and their influences on target stimuli. The judgment of the **target stimulus is affected by the given context.** Thus, by viewing color in a cross-modality stimulus context, the affectivity of color, as target stimulus, may be influenced by other stimulus modalities. Simultaneously, it is expected that emotional responses to color would be profiled not only within colors but also in relation with other types of stimulus. In the following, theories on context effects are discussed and related empirical studies are reviewed.

7.1 CONTEXT EFFECT

Previous studies have provided evidence of the existence of context effects in terms of adaptation with spatial and sensorial stimulation. In general, the phenomena of context effect are similar to successive contrast effect (or sequential effect), afterimages of movement, and adaptation with negative after-effect (Gibson 1937; Russell et al., 1987). The response to the **current stimulus depends on previous stimuli and responses on the previous trials** (Jesteadt, Luce, & Green, 1997). More precisely, when a series of stimuli varying on one dimension is presented and subjects have to judge the stimuli by category ratings, responses depend not only on the current stimulus, but also on previous stimuli and responses (Petzold & Haubensak, 2004). Thus, judgments reveal **sequential dependencies**. Marks (1992) asserted that such context effects are virtually universal, appearing in a wide variety of procedures (bounded rating scales, magnitude estimation, absolute identification) and perceptual continua.

In the following, empirical studies on context effects of stimuli are reviewed, which are operative in recognition (7.1.1) and in affective judgment (7.1.2).

7.1.1 Stimulus context effect on recognition

The existence of context effects has been supported by several empirical studies. Various studies were related to recognition and some cases studies are described across the senses:

● **visual stimuli**: Helson (1964) revealed figural after-effects (FAE): a test (*T*) figure is repelled away from the inspection (*I*) figure when the eye is adapted to *I* figure. *T* figures within *I* figures appear smaller while *T* figures outside *I* figures appear larger.

● **acoustic stimuli**: Marks (1988) introduced the slippery context effect: changes in stimulus context can strongly affect which stimuli are judged to be equally intense. The empirical studies dealing with sound-pressure-level (SPL) show that loudness matches derived from the judgments changed with changing context (Marks, 1988; Marks, 1992; Marks & Warner, 1991). In one of the studies, subjects judged the loudness of tones that differed in sound frequency as well as intensity. It demonstrated that the stimulus context strongly influences the levels that are judged to be equally loud (Marks et al., 1991).

● **conceptual stimuli:** Haubensak (1985) took up the example of the “big mouse and small elephant” in order to explain the context effect of conceptual stimuli. He noted that judgment within a stimulus context depends on operationally and nominally available stimulus contexts. The difference is that the operationally available stimulus context could be manipulated, whereas the nominal stimuli would not always be required. Haubensak showed further examples in order to explain the context effect of conceptual stimuli: summer and winter temperature, age of sportsmen, tones of various musical instruments.

Moreover, recent research tried to examine context effects across different modalities, e.g. effects of acoustic stimuli on the perception of visual stimuli.

7.1.2 Stimulus context effects on affective judgment

Hunt and Volkmann (1937) and their co-authors showed in several experiments that **affective judgments are subject to the effects of anchors** in the same way that psychophysical judgments are influenced by predominant stimuli.
In line with this, Helson (1964) asserted that **identical stimuli may produce different responses** when they appear in different contexts. Especially in the field of affectivity, pre-exposure to stimulation leaves **residuals that modify responses to incoming stimuli**. Moreover, **affective adaptation resembles sensory adaptation,** e.g. repeated or prolonged stimulation causes pleasantness and unpleasantness to pass over into indifference. At the same time, emotion could be recovered as a result of affective contrast.

More recently, Russell et al. (1987) investigated **judgmental shifts of emotion** quantitatively, in terms of magnitude and angle in an emotion space defined by pleasure (valence) and arousal. The displacement of one of their experiments was measured: one anchor expression displaces the judgment of the next by an amount roughly equal to 40% of the magnitude of the anchor and at an angle roughly equal to the angular coordinate of the anchor plus 180°. One main finding is that a relatively neutral face (the target) is perceived as sad when presented alongside a happier face (an anchor), while perceived happy alongside a sadder face. Therefore, viewing one additional facial expression (an anchor) shifts the entire scale of judgment, displacing the emotion seen in a subsequent expression (the target) into the opposite direction. **The anchor "pulls" the emotion space toward itself, which corresponds to "pushing" the target in precisely the opposite direction**.

This study empirically replicated what Helson (1964, p. 341) had previously asserted. According to his argument, the intensity of affect and motivating power of stimulation are functions of magnitude (distance or discrepancy) of affective levels: the greater the discrepancy from level, the more pleasant or unpleasant and the more desired or rejected objects, goals, and values are.

In parallel, some investigated the the effect of the **context in terms of the physical environment** on affective judgment. For example, Maslow et al. (1956) showed that judgments of affectivity related with energy versus fatigue and well-being versus displeasure of individuals in photographs were greatly influenced by the aesthetic characteristics of the rooms in which the judgments were made. The difference of affective responses in a 'beautiful room' was significantly different from 'average room'. Examining a matter of everyday experience, they showed that individuals are influenced by the surroundings in which they live, work, and play. Therefore, the affectivity is influenced by the context and the resource may be extended to unconscious surroundings.

In Experiment IV, the context effect will be investigated focusing on **stimulus contexts in terms of the intensity of semantic contents**.

7.1.2.1 Stimulus context effects in emotional responses to colors

Some early studies employed colors to investigate context effects on affective judgment. For example, Beeber-Center (1929, quoted in Helson, 1964) presented three subjects with 21 colors after showing either the ten most pleasant or the ten most unpleasant stimuli (pictures). The percentage of pleasantness was higher following the ten unpleasant stimuli than following the ten pleasant stimuli. An empirical study by Harris (1929) confirmed this result. In both studies, the affectivity of colors was summarized and the effect of individual stimuli was thus ignored.

Hunt et al. (1937) dealt with colors more individually. In the empirical study, the same set of colors was judged under two sets of instruction. At the first session, subjects were asked to judge the pleasantness of ten colors on a 7-point scale (7 representing the most pleasant). In a second session, subjects were to think of the most pleasant color they could imagine and to define this "mental color". The results showed the strong influence of anchors on the pleasantness in a series of colors. The colors at the upper end of the series during the first session shifted down more than did the colors at the lower end of the series.

These changes in the level of affective responses under laboratory conditions are driven by residuals. Therefore, the studies show the existence of **anchor stimuli effects on affective judgment of colors**. This is usually the case with anchors when sensory dimensions of stimuli are judged (i.e. temperature, weight, noise, size, etc.).

However, little color research has taken up this result and there exists no empirical investigation regarding the affectivity of color in cross-modalities of visual stimuli.

7.1.3 Cross-modality stimulus context

It seems intuitively clear that there is no absolute single stimulus, and that all stimuli exhibit some degree of relativity. Moreover, changes in affectivity arise because new dimensions or aspects of the stimuli are perceived, acting as new sources of stimulation (Helson, p.373).

Nevertheless, much research has dealt with more than one modality stimulus and manifested that **higher levels of performance were observed when the modalities of the test are identical** rather than when they differ (Gibson & Bahrey, 2005; Haubensak, 1985 ; Park & Gabrieli, 1995; Petzold et al., 2004; Sarris, 1971). Consequently, the influence of the range of stimuli and sequential effects should be governed by the **same regularities** (Petzold et al., 2004, p. 665). The ranges of reference are thus category-specific (type of stimulus). In other words, it indicates the influence of **category membership** of stimuli on sequential effects. The magnitude of such sequential effects should be greater when the current stimulus and the preceding stimulus belong to the same category (Petzold et al., 2004). Shown by Sarris (1971, p. 113), an extreme stimulus also weakens the stimulus context effect (or anchor effect). Such 'beyond classification' or sufficient difference from the frame of reference (Pimentel & Heckler, 2003, p. 112) may operate as if the stimulus belonged to another category of stimulus modality. Sarris (1971) tested perception of weight and Pimentel et al. (2003) examined preference for new logo designs.

Modality can also refer to changes of typography or form, as in pictures versus words. The majority of studies manipulated the encoding modality and used a visual implicit-memory test. Recent cross-modality studies have extended to the manipulations of sensory stimuli, i.e. auditory and visual information during encoding and testing (i.e. Gibson et al., 2005; Petzold et al., 2004).

In this chapter, pictorial stimulus modalities (colors, pictures, and film-clips) are distinguished from verbal stimulus modalities (adjectives). The pictorial modalities are discriminated according to the intensity of semantic contents. All stimuli are visually presented and properties of stimulus modalities are described in section 8.3.1 and 8.3.2.

7.2 PRELIMINARY TEST FOR EXPERIMENT IV

The Preliminary Test examines film-clips, which are to be employed later in Experiment IV. The film-clips can be seen as 'background stimuli' or 'anchor stimuli' (Helson, 1964) that may modify the affective impact of focal (Helson, 1964) or target stimuli, i.e. the colors.

7.2.1 Film clip as emotional elicitor and its emotional response

The development of films as emotion elicitors has contributed to the research on emotion. The study of Lazarus, Speisman, Mordkoff, and Davison (1962) was one of the initiators. The authors selected individual film-clips using relatively informal criteria to elicit a diffuse state of anxiety or stress.

Recent studies tried to suggest reliable procedures of film-based emotion induction. There are two notable efforts by Phillippot (1993) and Gross et al. (1995) to build a scientific database concerning films by formalizing film selection criteria and assembling a standardized library of emotion stimuli capable of eliciting specific emotional states. Phillippot (1993) presented normative viewing data from a set of 12 film-clips that elicited six emotional categories, and reported success for stimuli that elicited amusement, sadness, and neutral state. From a discrete emotions perspective, Gross et al. (1995) presented normative viewing data from 16 films targeting eight discrete emotions, and reported success for stimuli that elicited amusement, anger, contentment, disgust, sadness, surprise, a neutral state, and fear.

Rottenberg et al. (in press) noted that emotional response to a **film-clip generally appears to be real and robust.** Advocating the utilization of film-clip as emotion elicitor, the authors noted seven key dimensions that are salient to the selection of film-clip stimuli: intensity, complexity, attentional capture, demand characteristics, standardization, temporal considerations, and ecological validity.

7.2.2 Goals and Hypothesis

The purpose of the Preliminary Test was to select film-clips that induce target emotions, inclining toward one or more dimensions of valence, arousal, and dominance. This was equivalent to the employment of IAPS pictures as a baseline in previous experiments. The selected film-clips will be employed in Experiment IV.

[H. 8] Moving and static images activate similar emotional circuits described by dimensions of valence, arousal, and dominance, when both communicate similar semantic contents.

7.2.3 Method

7.2.3.1 Subjects

Twenty-four students volunteered and served as subjects for Primary test.

	number of survey subjects		age			
	male	female	min.	max.	M	SD
Mannheim, Germany	11	13	22	34	26.38	3.048

Table 37. Survey participants for Preliminary Test, N=24.

7.2.3.2 Stimuli

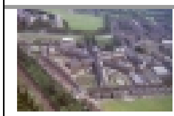
As Bradley et al. (2000) investigated emotional responses to sound stimuli, he let them appear with similar semantic contents of IAPS pictures. Thus, the corresponding scenes were looked up in several commercial films, referring to semantic contents of IAPS pictures, such as little girl (bunnies, see Table 39), violence or murder (aimed gun), and static object or view (lamp). The 19 chosen film-clips were obtained from commercial DVDs, as presented in Table 39.

Researchers have relied upon overall period averages to measure experiential, behavioral, and physiological reactivity during film-clips. Overall average response is a useful summary statistic, and provides an important starting point for analysis.

In this study, however, the main concern was to express **moving images by film-clips**, which distinguishes film-clips from static pictures (still images) during the experiment. Hence, the role of film-clips differs from story-telling. Similarly, Rottenberg et al. (in press) edited film stimuli typically between one and three minutes in length in his experiment, so that contents of the film-clips were **as homogenous as possible**. He emphasized the importance of the continuous emotion experience not to be disturbed during and after the film periods.

The length of the film-clips for this Preliminary Test was even shorter in order to increase the homogeneity of semantic contents of film-clips. Each film clip was edited to be 13 to 14 seconds in length, so that it showed only a part of a movie scene. Film-clips were played repeatedly without break. Moreover, the sound was switched off in order to focus on the effect of visual contents. Future research may extend to moving images with parallel acoustic stimuli. When sounds are matched with the respective visual contents, the effects of emotion remain strong (Bradley et al., 2000).

Among 19 film-clips, a screen filled with vivid red, was edited from 'Clockwork Orange (Kubrick, 1971)' and included. This clip was played until subjects proceeded to the next stimulus. Although the red screen did not contain any semantic contents, it was distinguishable from a still image. Thus, subjects perceived this stimulus as a film clip, which displaying only the color vivid red. It was intended to show that the plain red would elicit weaker patterns of emotion than the other 18 movie clips. Therefore, it was expected to observe a **contrast effect**, since it would be judged in relation to the other film-clips, which contained higher intensity of semantic contents.

resource		acronym	duration (seconds)	scene description	target emotion(s)
	A Clockwork Orange, S. Kubrick (1971)	top view	14	viewing some buildings from flying vehicle	0 valence – arousal + dominance
	Le Papillon, P. Muyl (2003)	hill	14	big tree on the hill. Leaves fanning in the breeze	+ valence – arousal
	A Clockwork Orange, S. Kubrick (1971)	gangsters	14	four men assaulting on a homeless old man	+ valence – arousal – dominance
	A Clockwork Orange, S. Kubrick (1971)	Jesus	13	Jesus Christ walking with the cross, tortured	– valence + arousal – dominance

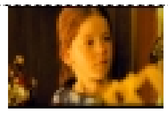
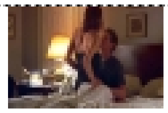
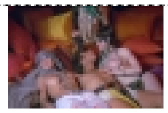
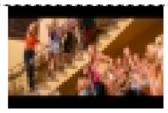
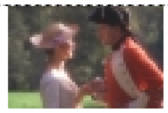
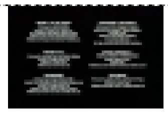
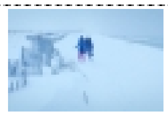
	Amélie, J.P. Jeunet (2001)	bunny	13	a little girl photographing bunny-shaped clouds	+ valence
	Le Papillon, P. Muyl (2003)	butterfly	14	a young girl calmly opens a door to butterfly garden	+ valence – arousal
	Unfaithful, A. Lyne (2002)	bed	14	husband and wife caressing each other	+ valence + arousal
	A Clockwork Orange, S. Kubrick (1971)	harem	14	a man surrounded by three semi naked women	– valence (female) + valence (male) + arousal
	Legally blond, R. Luketic (2001)	applause	14	many girls celebrating	+ valence + arousal – dominance
	Barry Lyndon, S. Kubrick (1975)	date	13	a dating couple holding hands in nature	+ valence
	Legally blond, R. Luketic (2001)	Chihuahua	14	a Chihuahua dressed in pink carries a pink letter	+ valence
	Barry Lyndon, S. Kubrick (1975)	sailing	14	a sailing ship on the ocean	– dominance
	Eyes wide shut, S.Kubrick (1999)	subtitle	14	credits, pages changing three times	0 valence – arousal
	A Clockwork Orange, S. Kubrick (1971)	corridor	14	a perspective view into a corridor and some persons are slightly moving	0 valence – arousal + dominance
	Barry Lyndon, S. Kubrick (1975)	riding	14	a man riding on a horse, disappearing in landscape	0 valence – arousal
	Barry Lyndon, S. Kubrick (1975)	poison	14	a poisoned woman screaming, letting furniture drop	– valence + arousal
	A Clockwork Orange, S. Kubrick (1971)	fighting	13	a soldier cutting the neck of the other	– valence + arousal – dominance
	Eternal Sunshine of the Spotless Mind, M. Gondry (2004)	couple	14	a couple playing tag in the snowy landscape	+ valence + arousal
	A Clockwork Orange, S. Kubrick (1971)	red	14	a red rectangular during the introduction of the movie	0 valence 0 arousal 0 dominance

Table 38. The 19 Film-clips investigated in Preliminary Test.

7.2.3.3 *Procedure*

The 19 film-clips were presented in random order and subjects assessed emotional responses with SAM ratings by pencil-and-paper method. The SAM pictograms as well as the usage instruction were modified from those used in Experiment III. An identification code was displayed above the respective film clip in the display and subjects were supposed to write it down along with SAM ratings. The experiment was carried out with several notebook computers in cafeteria restaurants at the University of Mannheim during daytime.

When subjects were already acquainted with the presented films, they were asked to note that in the survey form. There were, however, only few such cases and thus the effect was not analyzed in results. Film-clips were presented in height of 14.50 cm, while the width varied depending on the film formats.

7.2.4 **Results**

The reliability coefficients were rather small. This might have been caused by an insufficient number of subjects.

	valence	arousal	dominance
19 film-clips	.537	.683	.380
	.547 (on 57 variables)		

Table 39. Reliability coefficients for Preliminary Test. Cronbach's alpha, N=24.

Plots of mean values of valence, arousal, and dominance ratings of the 19 film-clips ( ) are depicted in two emotion spaces defined by valence × arousal (left) and valence × dominance (right) in Figure 54. The mean values of IAPS pictures from Experiment III are also displayed in the emotion spaces. This shows that, for many stimuli, film-clips and pictures with similar semantic contents are located close to each other in affective space.

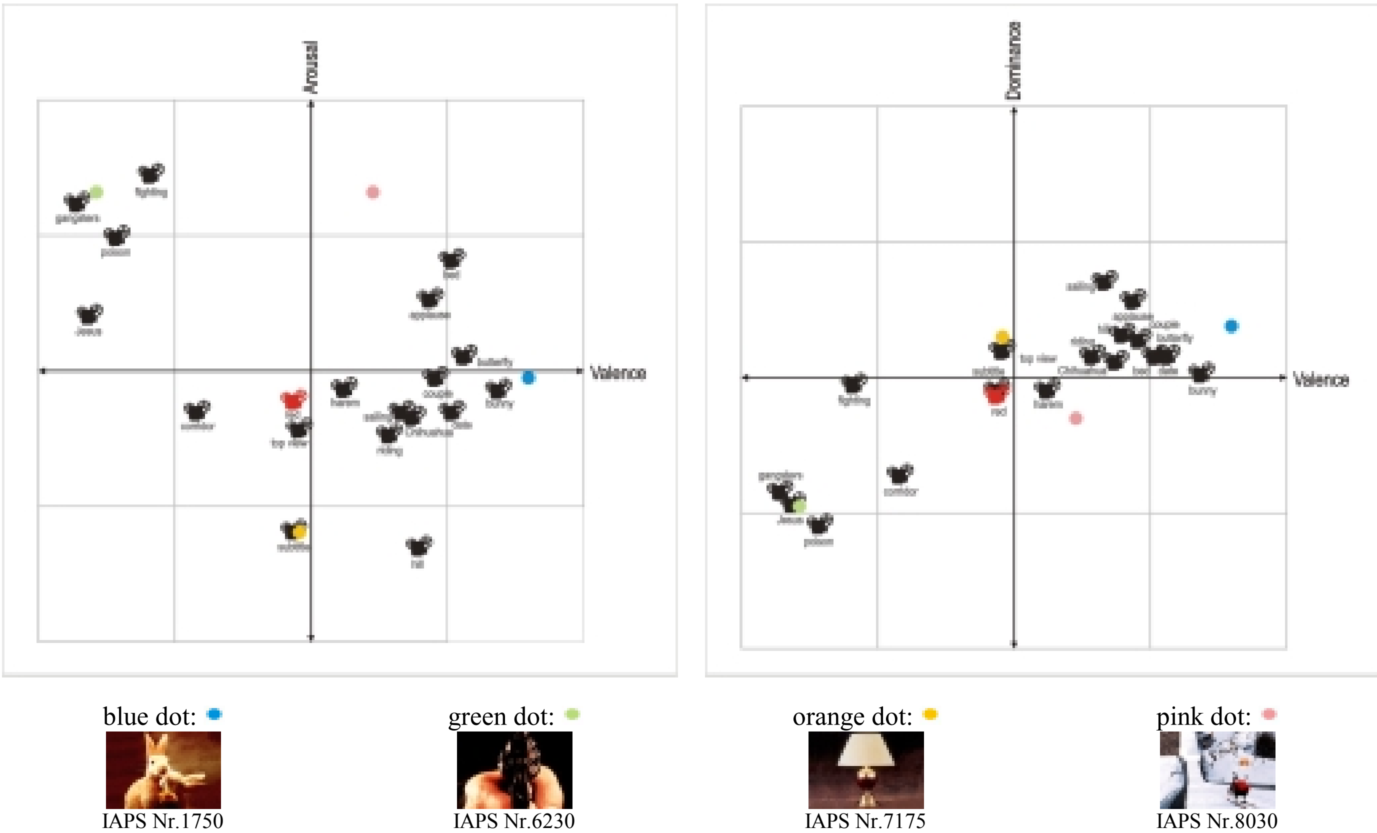


Figure 54. Plots of means of 19 film-clips and four IAPS pictures in two-dimensional affective space, Preliminary Test defined by: valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right.

For instance, a blue dot (), which represents the IAPS picture with two bunnies is positioned closely to film-clips, such as 'bunny' ('Amélie', Jeunet 2001) and 'butterfly' ('Le Papillon', Myul 2003). The plot marked in red (), indicates the film clip merely showing vivid red. Mean and standard deviation values of SAM ratings of each film clip can be found in Appendix I.

7.2.4.1 *Color stimulus as emotion elicitor among moving images*

The mean SAM ratings of 'vivid red' obtained in Preliminary Test was 2.875 in valence, 2.792 in arousal, and 2.875 in dominance (film-clips in Figure 56). In Figure 55, averaged SAM ratings of 'vivid red' from two different experiments are presented. It was found that the 18 film-clips anchored extreme emotional profiles **due to their intensive semantic contents** and pushed the red film clip toward a neutral emotional position.

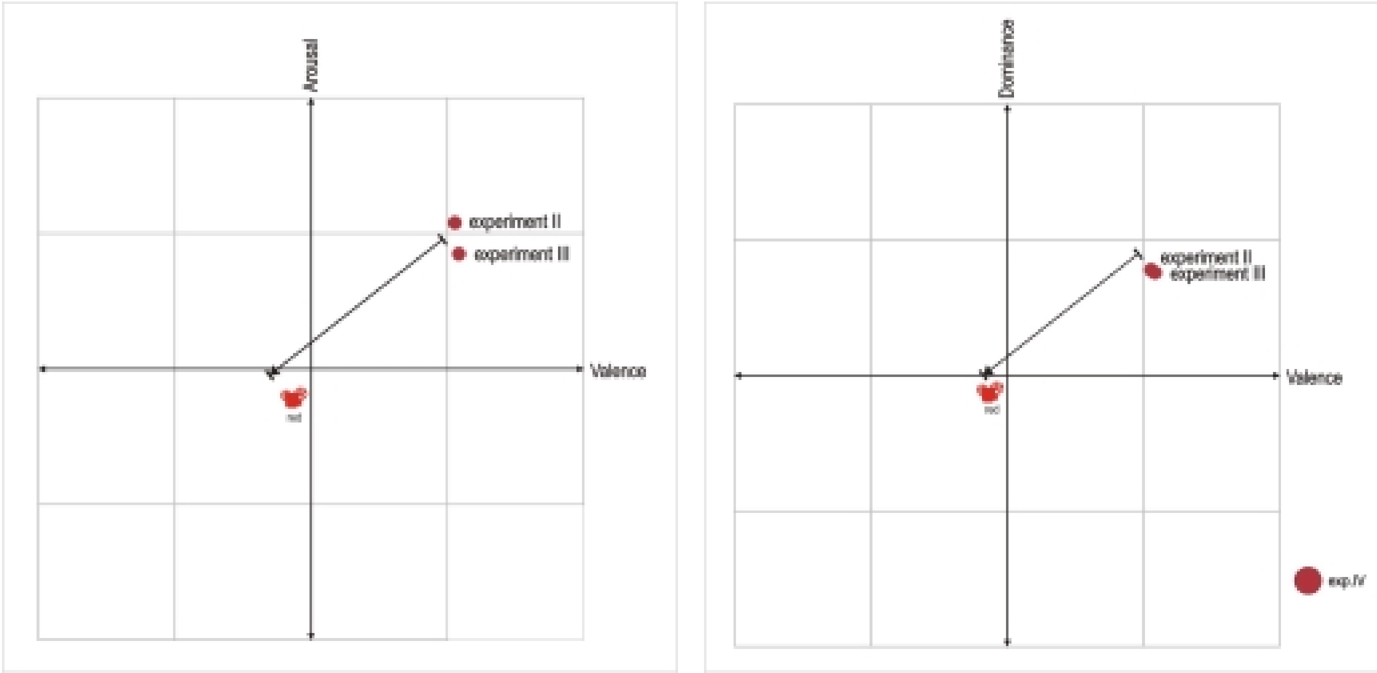


Figure 55. Plots of means of vivid red in three experiments:

Experiment II: ‘vivid red’ on A5-size color sheets by RAL DESIGN, shown among 37 color stimuli, N=36

Experiment III: ‘vivid red’ on CRT monitor, shown among other 35 color stimuli, N=46

Preliminary Test: ‘vivid red()’ on notebook computer, shown among other 18 film-clips, N=24.

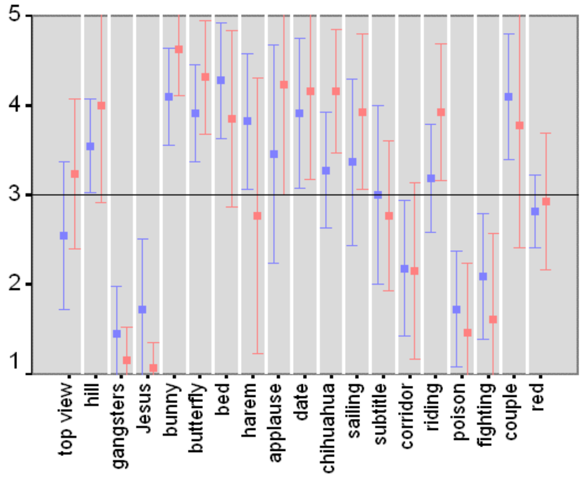
The manner in which ‘vivid red’ was assessed in this experiment implies that emotional responses to color stimuli are **weakened by a greater intensity of semantic contents**. As previously mentioned, there was no significant difference of ‘vivid red’ SAM ratings between Experiments II and III (t-test, p>.05 for valence, arousal, and dominance).

7.2.4.2 Gender as variable in affective judgment of film-clips

As discussed in section 6.5.1, another result was the noticeable difference between male and female subjects. There were five cases in valence (26.3%) and four cases in dominance (21.1%) which showed a significant difference at α level .05 (two-tailed). Those included film-clips such as ‘bunny’ and ‘chihuahua’, and induced much happier patterns of emotion from female subjects. This implies that female subjects reacted more sensitively with regard to topics like baby, young girl, and small animal than male subjects did.

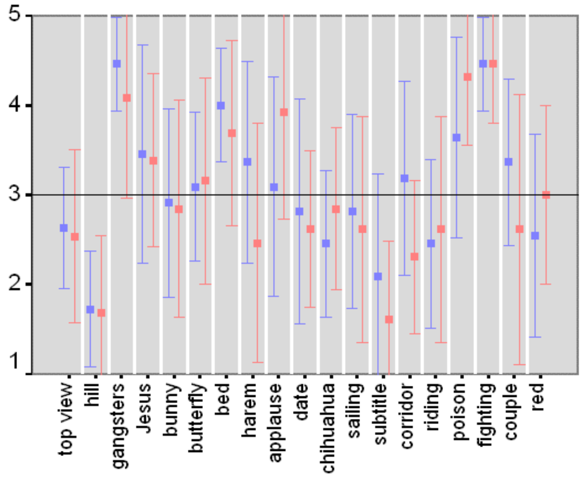
SAM ratings	film-clips with significant mean difference (t-test, p < .05, two-tailed) between male and female subjects.

valence



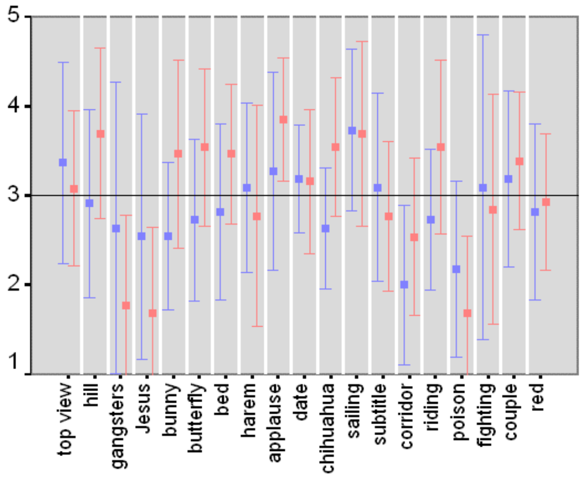
film acronym	mean of male subjects	mean of female subjects
Jesus	1.727	1.077
bunny	4.091	4.615
(harem)	3.818	2.769
chihuahua	3.273	4.154
riding	3.182	3.923

arousal



film acronym	mean of male subjects	mean of female subjects
corridor	3.182	2.308

dominance

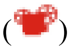


film acronym	mean of male subjects	mean of female subjects
bunny	2.545	3.462
butterfly	2.727	3.538
chihuahua	2.636	3.538
riding	2.727	3.538

Table 40. SAM ratings of movie clips by male and female, Preliminary Test

Film acronyms in parentheses: homogeneous variances are **not** assumed.

In general, emotional patterns of female subjects varied more strongly in both directions, '+' as well as '–'. This confirms previous studies on visual stimuli (i.e. Hagemann et al., 1999: Hemphill, 1996; Gross et al., 1995; Rottenberg, 2005).

In the rating the film clip 'red ()', no significant gender effect could be detected, confirming the results of Experiment II and III, in which male and female did not show any significant difference in judging 'vivid red'.

7.2.5 Summary and discussion of Preliminary Test

The film-clips in this Preliminary Test lasted 13 to 14 seconds and were repeated until subjects pressed any key. What distinguished the film-clips in this experiment was the movement as additional information. Thus, it was intended to distinguish film-clips from pictures, using as homogeneous film-clips as possible. Emotional responses to movie clips were assessed with SAM by pencil-and-paper.

As intended, similar topics were located close to each other in the emotion spaces (i.e. IAPS nr. 1750; two bunnies, or IAPS nr. 6230; aiming gun), thus supporting [H. 8].

In addition, the film clip 'red' induced average emotional response of 2.875 in valence, 2.792 in arousal, and 2.875 in dominance, which is close to the origin, (0, 0, 0). In fact, vivid red has been assessed as one of the most positive, excited, and dominant colors among color stimuli. The judgmental shift is illustrated in Figure 54. It is assumed that the affective judgment of color stimuli appears in a weaker pattern due to the contrast effect in terms of semantic contents. In Experiment IV, this is going to be more systemically examined by employing various types of stimuli: film-clips, colors, pictures, and adjectives.

Note that the reliability coefficients were not satisfactory. It is thus still unclear whether the movie clips were robust enough to induce certain type of emotion (α=.537: valence; α=.683: arousal; α=.380: dominance). Through a larger number of subjects, future research is expected to yield better internal consistency.

7.3 EXPERIMENT IV

7.3.1 Goals and Hypotheses

Stimulus context provides a frame of reference, anchoring the scale of judgment (Russell et al., 1987). The purpose of Experiment IV was to observe and analyze the **judgmental shift caused by cross-modality stimulus contexts**, such as colors, chromatic and achromatic pictures, film-clips, and adjectives.

As shown with the film clip 'red', a weaker pattern of emotional response to colors is observed when they are presented along with other types of visual stimuli with a higher intensity of semantic content. Moreover, the instruction of the experiment may influence the process of judgment. Parducci, Knobel, and Thomas (1976) examined the effect of instructions. They presented to subjects a series of small squares and large circles, each of which had a separate scale of size. When subjects were instructed to establish separate scales of size for squares and for circles, the scale established for each shape was independent from the other. However, when the stimuli were presented under the instruction to ignore shape, most subjects were able to integrate both stimulus types (shape domains) into a single context. Considering the potentially manipulating effect of instruction, the subjects of Experiment IV were told that they would be viewing various types of graphics.

[H. 9] Stimulus context affects emotional responses to colors: stimuli with higher intensity of semantic contents anchor the referential emotion and produce negative distance effects on the rest towards a neutral state of emotion. Accordingly, emotional responses to colors appear weaker.

On the other hand, within a stimulus type, the emotional response to stimuli may appear in a similar pattern as if they were assessed only among themselves, as in Experiments I, II, III, and Preliminary Test.

[H. 10] Despite of the contextual effect of [H. 9], the pattern of emotional responses within colors remains unchanged.

Lastly, the inclusion of adjectives was aimed at finding out whether there were similar regularities of stimuli. Four categories of pictorial stimulus (colors, achromatic and chromatic pictures, and film-clips) were differentiated from one type of verbal stimulus (adjectives). According to Haubensak (1985), stimuli from disparate categories should induce little anchor effect due to the lack of common regularities. Petzold et al. (2004) asserted that judgments seem to reflect a compromise between separate reference (i.e. within the stimulus type) and integrated reference.

The judgmental shift, a displacement in emotion space defined by valence, arousal, and dominance, was compared with the results of previous experiments.

[H. 11] Adjectives, as verbal stimuli, are little influenced by context effects caused by pictorial stimuli.

Figure 56 shows an overview of the employed stimulus modalities in Experiment IV, arranged in terms of information properties. Moreover, the three hypotheses are presented in relation to the concerns. For example, two outer clusters drawn with dotted line indicate between modality conditions [H. 10].

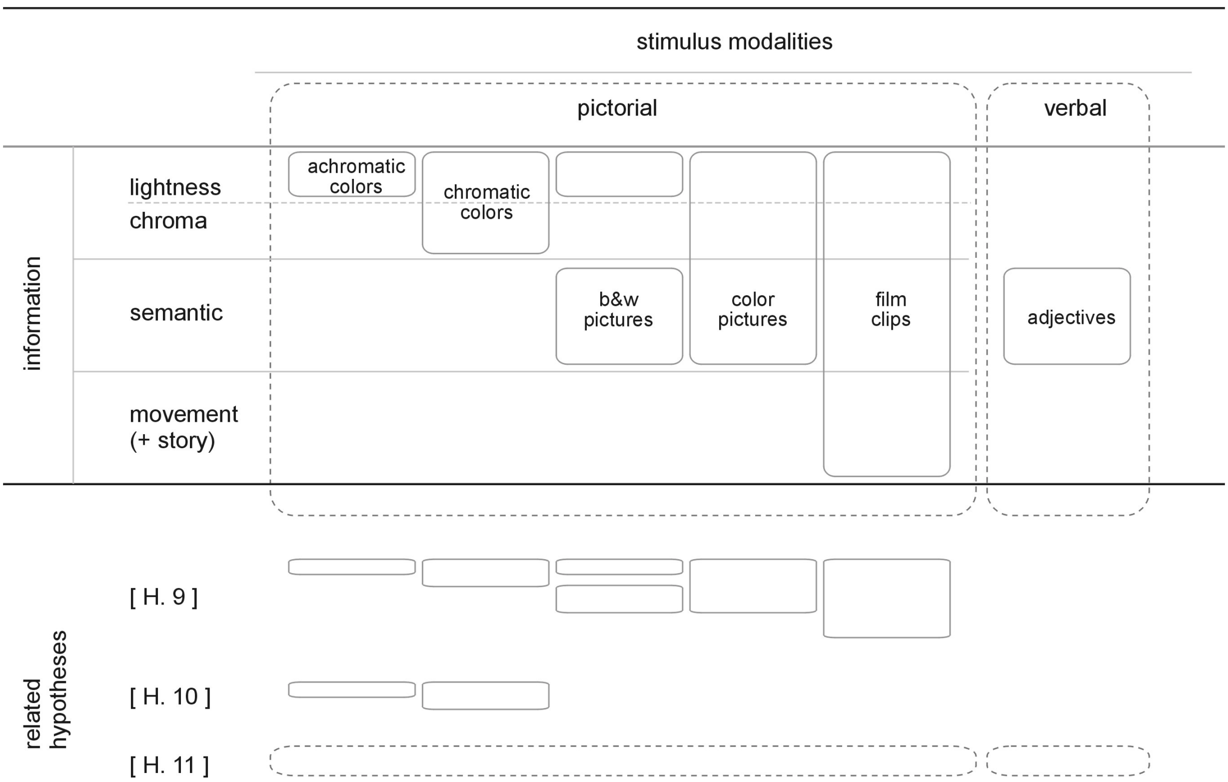


Figure 56. An overview of stimulus modalities and related hypotheses, Experiment IV.

7.3.2 Methods

7.3.2.1 Subject

The Experiment IV was announced with flyers at the University of Mannheim and 49 subjects participated. They were either paid € 6.00 or given course credit for their participation. The data of four subjects was excluded, as the first two evaluated the picture of two bunnies extremely negative in the valence dimension, while the latter two rated the picture of skier extremely relaxed. Thus, 45 subjects were taken into account.

	Number of survey subjects		Age			
	male	female	min.	max.	M	SD
Mannheim, Germany	24	21	19	69	26.76	10.578

Table 41. Subjects of Experiment IV.

7.3.2.2 Stimuli

Four stimuli modalities were used in this experiment: colors, pictures (Chromatic as well as achromatic), film-clips, and adjectives. Two CRT monitors on which the stimuli were displayed were calibrated with Gretag MacBeth Eye One Spectral Photometer before the experiment. All subjects were exposed to the same stimuli in random to avoid sequential dependencies.

● Target stimuli: colors

Chromatic color stimuli were collected from three tone categories: 'dark', 'vivid', and 'light'. Each of the hue-categories 'red', 'yellow', 'green', and 'blue' possessed three tone categories. A vivid violet was included on behalf of colors in vivid hue category, in order to reduce the number of stimuli, if possible. In previous experiments, the colors in violet hue category did not follow the general tendencies as those in other hue categories did (see Figure 41).

As achromatic color stimuli, dark and light gray were added and light warm gray and light cool gray were included. In sum, there were 17 color stimuli, which had all been rated by SAM scales in Experiments II and III. Color stimuli were displayed centered on the monitors, in dimension of 22.1 cm width × 14.9 cm height.

modality	stimuli				
color	dark red	dark yellow	dark green	dark blue	
	vivid red	vivid yellow	vivid green	vivid blue	vivid violet
	light red	light yellow	light green	light blue	
	dark gray	light gray	light warm gray	light cool gray	

Table 42. Stimuli of Experiment IV, stimulus modality: color.

● **Background stimuli: pictures**

Four chromatic and four achromatic IAPS pictures were shown. The four chromatic pictures were the baseline pictures used in previous experiments. Pictures were presented in an identical size of color stimuli, in dimension of 22.1 cm width × 14.9 cm height.

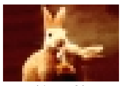
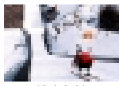
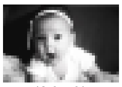
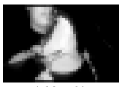
modality	stimuli			
chromatic picture, (IAPS nr.)	 (1750)	 (6230)	 (7175)	 (8030)
picture, achromatic (IAPS nr.)	 (2070)	 (6350)	 (7010)	 (5621)

Table 43. Stimuli of Experiment IV, stimulus modality: picture (static image).

● **Background stimuli: film-clips**

From the 19 film-clips used in Preliminary text, nine were selected, representing certain patterns of emotions. For instance, the film clip ‘gangsters’ and ‘fighter’ induced similar emotional responses. Thus, the ‘gangster’ clip was chosen, on behalf of semantic contents related to ‘violence’.

Since film-clips were in different formats, PXLab© software adjusted them either to size of 19.0 cm width × 14.9 cm height or to that of 22.1 cm width × 14.9 cm height. Therefore, all film-clips were presented in the same height as colors and pictures.

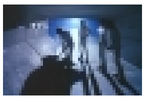
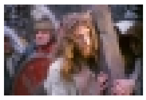
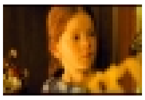
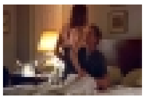
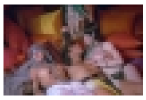
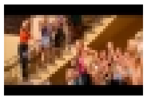
modality	stimuli				
film-clip (acronym)	 (top view)	 (hill)	 (gangsters)	 (Jesus)	 (bunny)
	 (butterfly)	 (bed)	 (harem)	 (applause)	

Table 44. Stimuli of Experiment IV, stimulus modality: film-clip (moving images).

● Background stimuli assigned to disparate categories: adjectives

Nine adjectives were displayed one by one among other groups of stimuli in ‘Arial’ typeface, in height of 3.5 cm and in gray (Lightness= 30). The background color remained in lighter gray (Lightness= 70).

modality	stimuli				
adjective (in English)	laut (loud)	langweilig (boring)	hektisch (hectic)	leicht (light)	aktiv (active)
	dynamisch (dynamic)	gesund (healthy)	urban (urban)	modern (modern)	

Table 45. Stimuli of Experiment IV, stimulus modality: adjective.

Taken together, a set of 43 stimuli and SAM pictograms were implemented by PXLab© software in Experiment IV. All the stimuli were displayed in a random order. Each subject was exposed to all stimuli and no missing data occurred.

7.3.2.3 Procedure

The physical environment of Experiment IV was identical to that of Experiment III, so that external variances caused by different circumstances were minimized. A modified version of the instruction used in Experiment III was printed out in four A4-size pages.

Figure 57. Experiment IV and example IAPS picture (nr. 7211) shown at the beginning of the experiment.

On the last page of the new instructions, an IAPS picture (nr. 7211, a clock) and a set of SAM pictograms were presented and subjects were asked to rate it. The intention was to let subjects exercise SAM pictograms, and thus an IAPS picture was chosen, which should induce neutral emotion in all dimensions (Lang et al., 2005). The instructions used for Experiment IV are appended in Appendix K.

After subjects read through the instruction, the computer-based experiment was started. At first, IAPS picture (nr. 7211, a clock) was shown again, so that subjects would get used to the interface of the experiment. ‘Beispielbild’ (example picture) was written in the picture. Subjects were placed approximately 40 cm from the monitor.

Below every stimulus, a row of SAM pictograms was presented and subjects could select any of five by mouse click. Pressing a space bar, the next row of SAM appeared in an order of valence, arousal, and dominance. Once a stimulus was assessed by all three dimensions, the next stimulus was provided. All subjects were exposed to all stimuli.

7.3.3 Results

Cronbach’s alpha was calculated and provided satisfactory level of reliable internal consistency. Mean and standard deviation values of SAM ratings of all stimuli are appended (Appendix I). Herein below, five judgmental shifts are investigated in comparison with the results of previous Experiments II, III, or Preliminary Test:

<table>
<tr><th></th><th>valence</th><th>arousal</th><th>dominance</th></tr>
<tr><td rowspan="2">17 color stimuli + four IAPS chromatic + four IAPS achromatic pictures + nine movie clips + nine adjectives=43 variables</td><td>.729</td><td>.919</td><td>.842</td></tr>
<tr><td colspan="3">.874 (on 129 variables)</td></tr>
</table>

Table 46. Reliability coefficients of Experiment IV. Cronbach’s alpha, N=45.

7.3.3.1 Target stimulus: color

Mean values of valence, arousal, and dominance of the 17 colors used are depicted based on Experiment III (left) and on Experiment IV (right) in Figure 59 (valence × arousal). The shaded polygonal (convex hull) identifies the area in which the 17 colors are distributed and illustrates trends of judgmental shifts (Figure 58).

Experiment III ⇒ **Experiment IV- main**

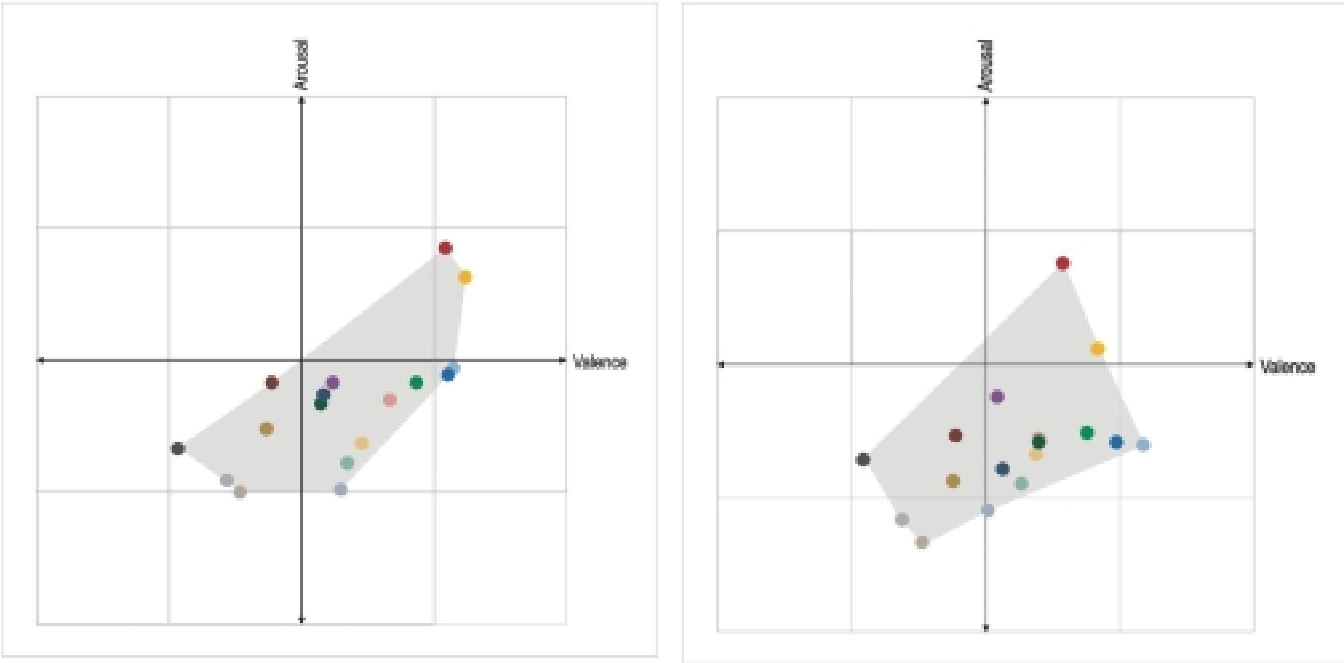


Figure 58. Plots of means of 17 colors demonstrated in emotion space, Experiment IV defined by: valence (abscissa) × arousal (ordinate)
left: results from Experiment III, right: results from Experiment IV.

In Figure 59, the displacements of colors are depicted with arrows (vectors). The starting point of each arrow indicates the respective mean values of valence (abscissa) and arousal (ordinate) obtained in Experiment III, while the end point indicates the mean obtained in Experiment IV. Thus, the arrows explain the direction and magnitude of judgmental shifts. Emotional responses to the 17 colors in the cross-modality stimulus context tended to shift towards negative ('–' valence) and calm ('–' arousal).

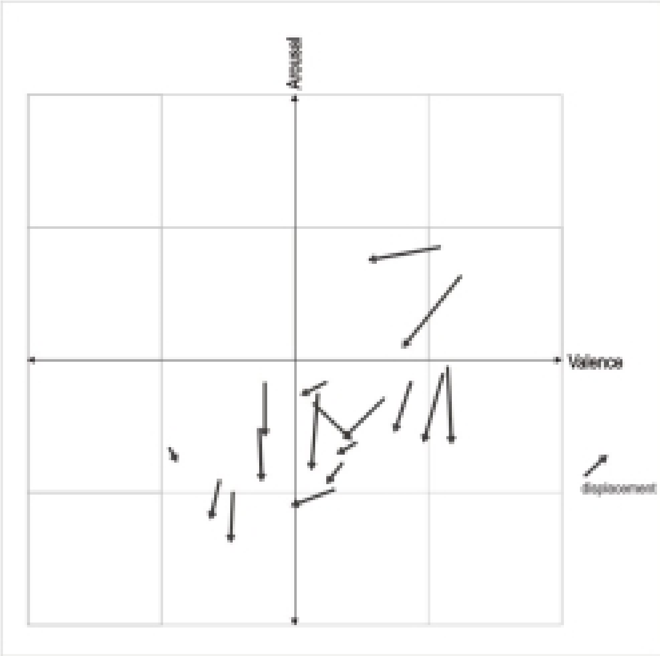


Figure 59. The displacements of 17 colors from Experiment III to Experiment IV, illustrated with vectors in emotion space defined by valence (abscissa) × arousal (ordinate).

Likewise, the mean SAM ratings on dominance were rather larger in Experiment IV, as shown in Figure 61. In Experiment IV, the mean values of 13 out of 17 colors (76.5%) decreased ('–' valence). In the arousal dimension, the shaded polygonal is shifted towards less excited, as all means of arousal decreased ('–' arousal). In the dominance dimension, more than the half of the colors (11 of 17) shifted towards greater dominance ('+' dominance in Figure 60).

Experiment III ⇒ **Experiment IV- main**

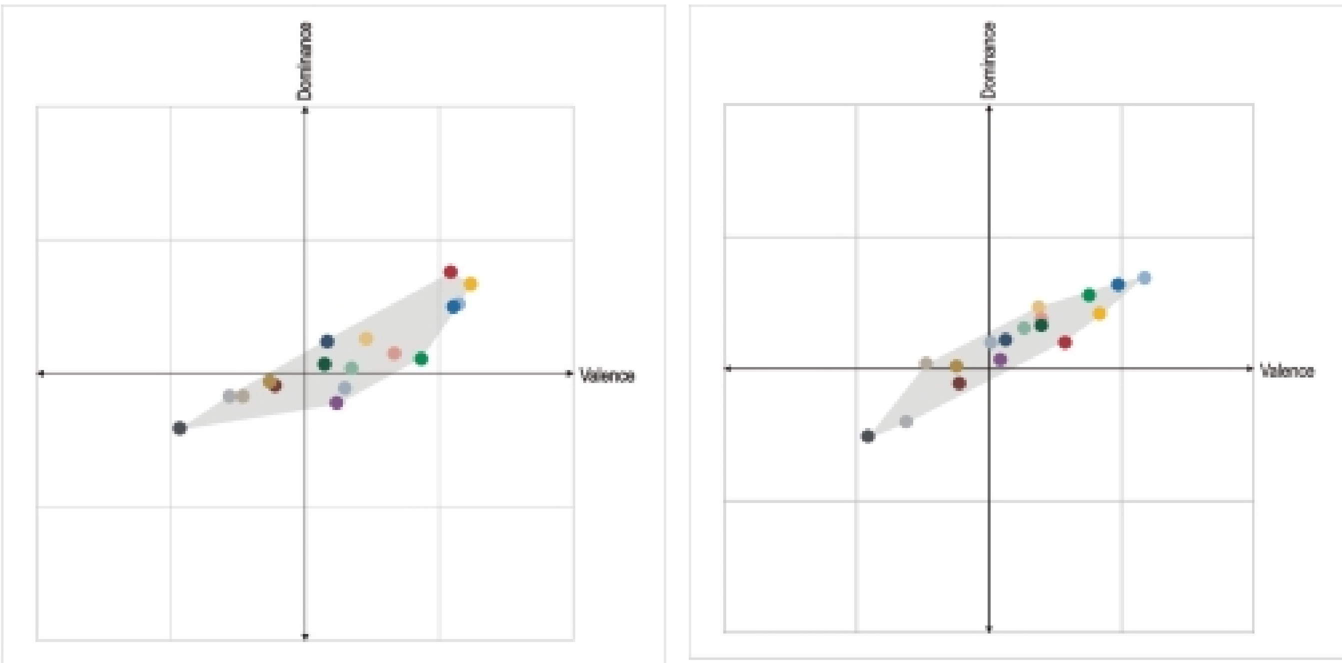


Figure 60. Plots of means of 17 colors demonstrated in emotion space, Experiment IV

defined by: valence (abscissa) × dominance (ordinate)

left: results from Experiment III, right: results from Experiment IV- main.

All these observations were statistically examined with two-way ANOVA with repeated measurement on one factor: colors. As shown in Table 46, the difference between Experiments III and IV is significant in the arousal dimension [F (1, 89)=5.002, p =.028*], whereas judgmental shifts in the other dimensions were not significant (α=.05).

As the second main factor, it was tested whether different colors induced different emotional responses. The results confirm the hypotheses of the previous experiments ([H. 1], [H. 7]), showing significant values (p<.000***) for the three dimensions of emotion (valence, arousal, and dominance) resulting from the ANOVA with repeated measurement. No significant *experiment * stimulus* interaction was found.

factor	valence	arousal	dominance
experiment (between)	**F(1, 89)= 1.814, p=.181**	**F(1, 89)=5.002, p=.028***	**F(1, 89)=.534, p=.467**
stimulus: colors (within)	F(9.906, 881.620)=43.131, p=.000***, ε=.619	F(10.298, 916.507)=25.876, p=.000***, ε=.644	F(10.253, 912.530)=9.425, p=.000***, ε=.641
exp.(between)*stimulus (within)	F(9.906, 881.620)=.923, p=.542, ε=.619	F(10.298, 916.507)=.782, p=.650, ε=.644	F(10.253, 912.530)=1.606, p=.098, ε=.641

Table 47. Result of two-way ANOVA with repeated measurement on one factor: color, Experiments III versus IV.

Secondly, individual SAM ratings of every single color of Experiments III and IV are compared. The results are presented in Table 47, in which pairs of individual colors are compared at a significance level of .05. Cases marked with '*' indicate that SAM ratings of colors significantly differ between Experiments III (N= 36) and IV (N= 45): one case in valence, three cases in arousal, and two cases in dominance.

Among those few cases that show a significant difference, colors belonged more frequently to the vivid tone category.

In addition, all three colors of the hue category **'blue'** differed significantly in the arousal dimension: dark blue, vivid blue, and light blue were assessed as less exciting in Experiment IV than in Experiment III.

colors	Mean comparison (p values yielded by t-test, two-tailed, df=89)								
	valence			arousal			dominance		
	M (III)	M (IV)	p	M (III)	M (IV)	p	M (III)	M (IV)	p
dark red	2.783	2.778	.980	2.826	2.467	.098	2.913	2.889	.916
vivid red	4.087	3.578	**.016***	3.848	3.756	.673	3.761	3.200	**.010***
light red	3.674	3.400	.195	2.696	2.467	.335	3.152	3.378	.328
dark yellow	2.739	2.756	.933	2.478	2.133	.084	2.935	3.022	.700
vivid yellow	4.239	3.844	.068	3.630	3.156	.055	3.674	3.422	.306
light yellow	3.457	3.378	.703	2.370	2.333	.875	3.261	3.467	.384
dark green	3.152	3.400	.234	2.674	2.422	.263	3.065	3.333	.183
vivid green	3.87	3.756	.540	2.826	2.489	.155	3.109	3.556	**(.028*)**
light green	3.348	3.267	.690	2.217	2.111	.637	3.044	3.311	.240
dark blue	3.174	3.133	.840	2.739	2.222	**.010***	3.239	3.222	(.943)
vivid blue	4.109	3.978	.461	2.891	2.422	**.049***	3.500	3.644	.544
light blue	4.152	4.178	.872	2.935	2.400	**.035***	3.522	3.689	.456
vivid violet	3.239	3.089	.463	2.826	2.756	.755	2.783	3.067	.173
dark gray	2.065	2.089	.903	2.326	2.289	.880	2.587	2.489	.698
light gray	2.435	2.378	.749	2.087	1.844	.257	2.826	2.600	.310
light warm gray	2.544	2.533	.963	2.000	1.667	.081	2.826	3.044	.353
light cool gray	3.304	3.022	.145	2.022	1.911	.581	2.891	3.200	(.187)

Table 48. Comparisons of means of SAM ratings of color stimuli by t-test

* t-test yielded significance (p<.05), p value in parentheses: homogeneous variances are not assumed.

N of Experiment III=46, N of Experiment IV=45.

In Figure 54, the two plots illustrate means of ‘vivid red’ based on four experiments. As discussed, the ‘vivid red’ film clip ( ) was assessed with greater displacement in Preliminary Test. However, SAM ratings of ‘vivid red’ in Experiment IV lie between those of Experiments II or III and film-clips in both charts. The blue vector in each plot indicates the shift of ‘vivid red’ from Experiment III to Experiment IV.

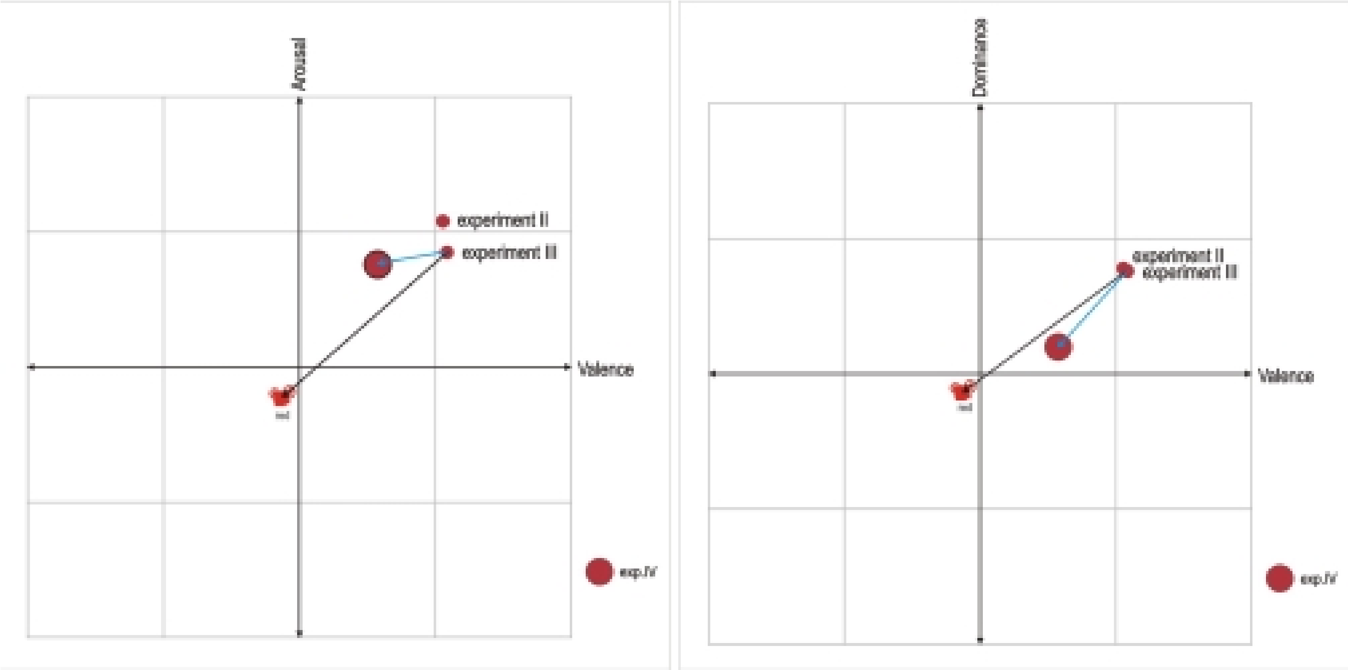


Figure 61. Averaged SAM ratings of 'vivid red' in different stimulus contexts

black arrow: Shift of SAM ratings of 'vivid red' from Experiment III to Preliminary Test

blue vector arrow: Shift of SAM ratings of 'vivid red' from Experiment III to Experiment IV.

In fact, the stimulus quality of the color vivid red in Experiment IV was weaker than the vivid red in Preliminary Test. Based on affective adaptation, as proposed by Helson (1964, p. 329), it might be that the stimulus context during Experiment IV did not provide sufficient affective contrast. The proportion of color stimuli in Experiment IV was 39.5% (17 of 43), whereas it was 5.3% during the Preliminary Test (1 of 19). Besides, it seems probable that subjects consciously applied **adjusted reference scales for every different stimulus modality** and thus were able to assess the emotional responses to a color in comparison with other color stimuli during Experiment IV.

7.3.3.2 Within stimulus modality: SAM ratings of 17 colors

At the beginning of Experiment IV, it was hypothesized that tendencies of emotional response to color would be stable, regardless of the judgmental shift of colors as a stimulus modality ([H. 10]). Based on the result presented in Table 46, emotional responses to color were significantly changed in arousal dimension in comparison with those in Experiment III.

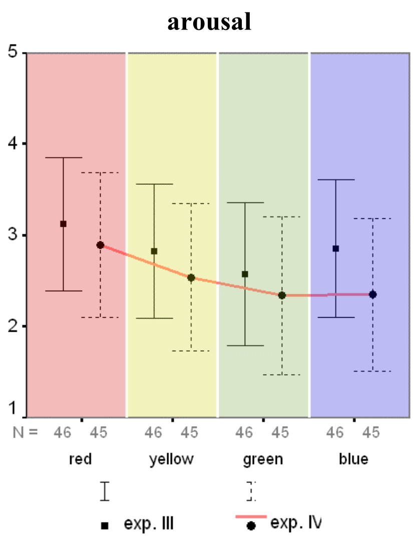
Accordingly, the analysis of comparison of emotional responses within colors was conveyed focusing on arousal dimension. SAM ratings of colors in Experiment IV are viewed in terms of **(a)** hue and **(b)** tone categories:

(a) Emotional responses to hue categories

For individual subjects, the SAM ratings of colors in light, vivid, and dark tones within the same hue category were averaged, resulting in a representative mean for each hue category.

$$\frac{SAM\ rating\ of\ \left\{ {}^{dark}_{red} + {}^{vivid}_{red} + {}^{light}_{red} \right\}}{3} = a\ representative\ SAM\ rating\ for\ red \qquad \text{Equation 4}$$

In this way, the representative SAM ratings were calculated for subjects and each subject could provide four (red, yellow, green, and blue) inputs. The vivid category was excluded in following plot, since neither light violet nor dark violet were employed in Experiment IV.



Thus, the bars in Figure 62 illustrate the distribution of the representative means of **hues**. Within each pair, the line on the left side corresponds to Experiment III (N=46), and the dotted line corresponds to Experiment IV (N=45). The pink line links the results of Experiment IV.

Figure 62. Averaged SAM ratings of hue categories, Experiment IV.

As seen in Table 47, the judgmental shift of blue colors in the arousal dimension was significant, implying that that **blue colors in Experiment IV elicited less excited emotion** than in Experiment III. Accordingly, in chart 63, the pink line is not showing a U-shaped curve. This was due to the fact that blue did not elicit more arousal than did green in Experiment IV.

By running pair-wise comparisons (LSD; least significant difference, Table 48) between hue categories, it was discovered that in Experiment IV the category red was distinguished from the other hue categories.

This explains that **red colors induced more excited emotions** than the other colors in the cross-modality stimulus context. In other words, **non-red colors induce similar amount of emotion with respect to the arousal dimension**, when colors are compared among different kinds of stimulus modalities.

The pair-wise comparisons (LSD) between hue categories for Experiment III revealed that each category differs from each other, except one pair: yellow and blue.

		arousal			
		Experiment III		Experiment IV	
(I) hue	(J) hue	MD	SE	MD	SE
red	yellow	.297(*)	.098	.356(*)	.116
	green	.551(*)	.125	.556(*)	.114
	blue	.268(*)	.121	.548(*)	.122
yellow	red	-.297(*)	.098	-.356(*)	.116
	green	.254(*)	.122	.200	.132
	blue	-.029	.123	.193	.113
green	red	-.551(*)	.125	-.556(*)	.114
	yellow	-.254(*)	.122	-.200	.132
	blue	-.283(*)	.117	-.007	.122
blue	red	-.268(*)	.121	-.548(*)	.122
	yellow	.029	.123	-.193	.113
	green	.283(*)	.117	.007	.122

Table 49. Pair-wise comparison with LSD among hue categories, Experiments III and IV

MD: mean difference, SE: standard error, (*) Mean difference is significant at the .05 level (two-tailed).

(b) Emotional responses to tone categories: Chroma level

Secondly it was analyzed, whether emotional responses to Chroma levels appeared in the same pattern. For individual subject, the SAM ratings of colors within the same Chroma level were averaged, resulting in a representative mean for each Chroma level.

Therefore, the bars in the following charts show the distribution of the representative means of Chroma. Within each pair, the line on the left side corresponds to Experiment III (N=46), and the dotted line corresponds to Experiment IV (N= 45).

As deep and brilliant tones were not included in Experiment IV, the Chroma consists of three levels, such as achromatic, dark/light, and vivid.

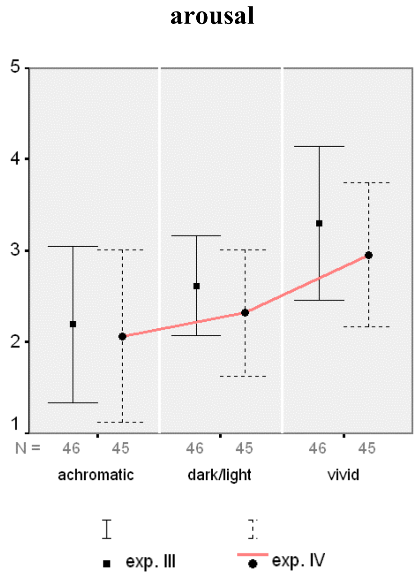


Figure 63. Averaged SAM ratings of Chroma levels, Experiment IV.

As in Experiment III, a positive linear relationship is observed, illustrated by the pink line in Figure 63. Therefore, based on the representative means of each Chroma level, correlation analysis was conducted.

- Pearson's *r*

  Experiment III: *r*=.511**, Experiment IV: *r*=408**

- Spearman's rho

  Experiment III: r=.493**, Experiment IV: r=412**

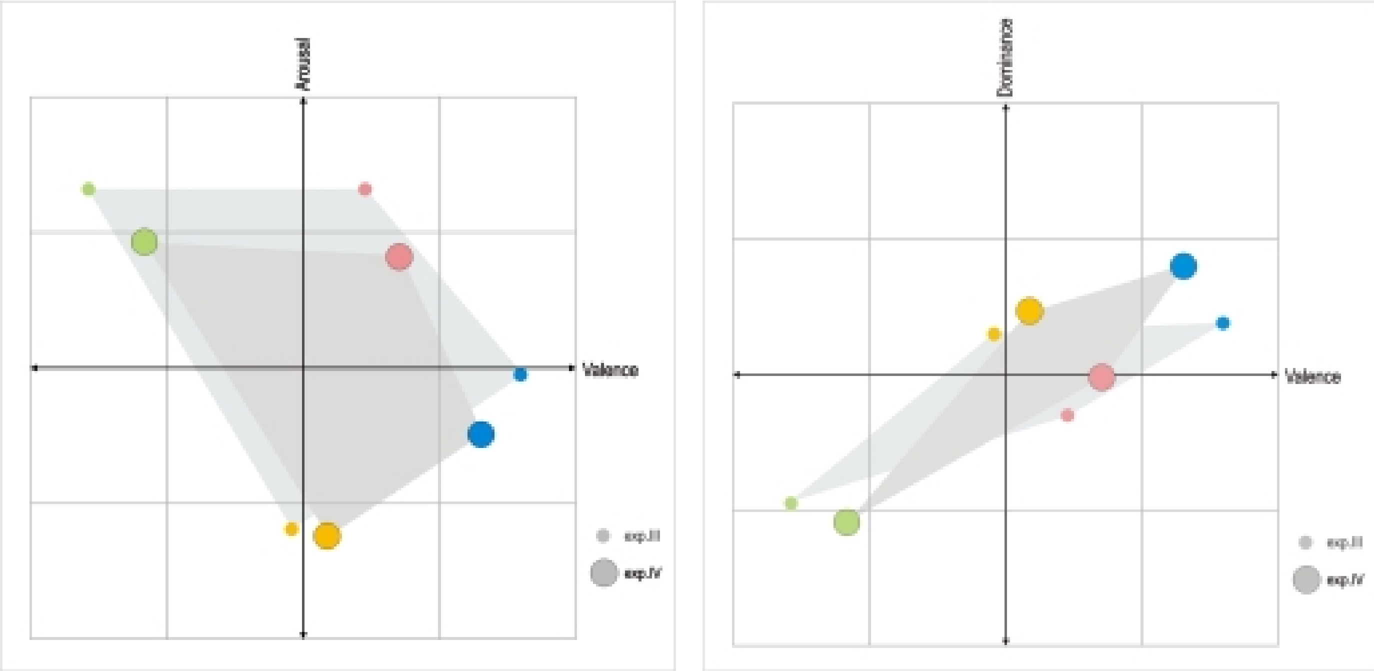
** Correlation is significant at the .01 level (two-tailed).

Although the correlation coefficients obtained in Experiment IV are smaller than in Experiment III, it seems plausible to conclude that the **positive correlation between Chroma level and arousal dimension consistently appeared in Experiment IV**, as colors were assessed among other stimulus modalities.

As the comparison analyses in Table 48 show, the differences of emotional responses to most of the colors were not significant with respect to valence and dominance dimensions. Based on this observation, [H. 10] is confirmed. Therefore, the similarity of patterns of emotional responses to color with regard to valence and dominance dimensions between Experiments III and IV are not taken into account.

7.3.3.3 Background stimulus: picture

SAM ratings of the four chromatic IAPS pictures were compared between Experiments III and IV. The shaded polygonal appears slightly smaller (in left chart) and rotated counter-clockwise (in right chart) in Experiment IV. Three of the four pictures were assessed **more positive and more dominant**, while all four pictures were assessed **less excited**. Although not all differences were significant (see Table 51), the observation suggest the necessity of a further study, increasing either the number of the pictorial stimuli or the contrast quality among stimulus modalities.



blue dot:  IAPS Nr.1750

green dot:  IAPS Nr.6230

orange dot:  IAPS Nr.7175

pink dot:  IAPS Nr.8030

Figure 64. Plots of means of four IAPS pictures demonstrated in affective spaces

defined by : valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right

smaller plots without outline: results of Experiment III

bigger plots with black outline: results of Experiment IV.

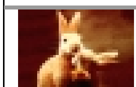
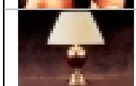
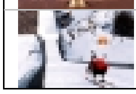
pictures (IAPS nr.)		mean comparison (p values yielded by t-test, two-tailed, df=89)								
		valence			arousal			dominance		
		M (III)	M (IV)	p	M (III)	M (IV)	p	M (III)	M (IV)	p
	(1750)	4.595	4.311	.105	2.946	2.511	.138	3.378	3.800	.103
	(6230)	1.432	1.844	**(.026*)**	4.324	3.933	.131	2.054	1.911	.650
	(7175)	2.919	3.178	.165	1.811	1.756	.774	3.297	3.467	.511
	(8030)	3.46	3.711	(.319)	4.324	3.822	**.020***	2.703	2.978	.299

Table 50. Comparisons of means of SAM ratings of pictures by t-test

* t-Test yielded significance (p < .05), p value in parentheses: homogeneous variances are not assumed.

N of Experiment III=46, N of Experiment IV=45.

In addition to chromatic pictures, the SAM ratings of four achromatic pictures were compared with those from in Experiment II, where pictures were provided on DIN A5-size sheets. In Experiment IV, the stimulus context for the four achromatic pictures was changed in terms of **modalities** as well as **media**. No systematic tendency of judgmental shifts was found in both visual observations as well as in mean comparison (t-test, Table 52).

In Experiment IV, pictures were employed **as background stimuli** positioned between colors and film-clips in terms of semantic intensity. Further research can focus on the effect of pictures, such as static image against moving images (see 8.3.3.1).

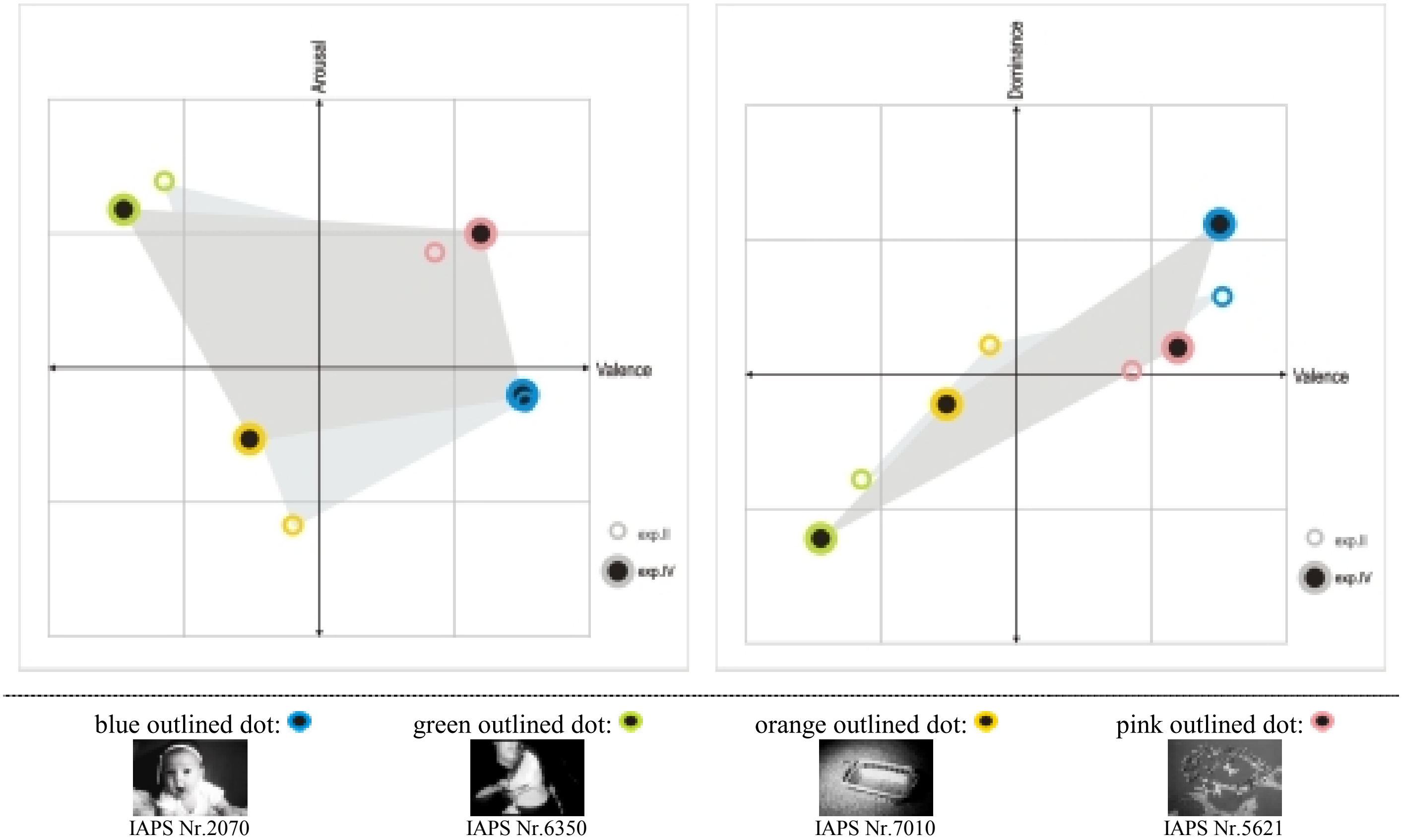


Figure 65. Plots of means of four achromatic IAPS pictures demonstrated in affective spaces defined by valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right smaller plots not filled: results from Experiment II bigger plots filled with black: results from Experiment IV.

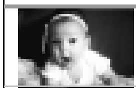
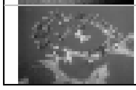
pictures (IAPS nr.)		mean comparison (p values yielded by t-test, two-tailed, df= 79)								
		valence			arousal			dominance		
		M (II)	M (IV)	p	M (II)	M (IV)	p	M (II)	M (IV)	p
	(2070)	4.528	4.511	.907	2.750	2.800	.865	3.583	4.156	**.005***
	(6350)	1.861	1.556	.075	4.389	4.178	.225	2.222	1.778	.084
	(7010)	2.806	2.489	.076	1.833	2.467	**(.004)***	3.222	2.778	(.073)
	(5621)	3.861	4.200	.140	3.861	4.000	.590	3.028	3.200	(.540)

Table 51. Comparisons of means of SAM ratings of achromatic pictures by t-test

* t-test yielded significance (p<.05), t value in parentheses: homogeneous variances are not assumed.

N of Experiment II=36, N of Experiment IV=45.

7.3.3.4 Background stimulus: film-clip

The SAM ratings of film-clips of Preliminary Test and those of Experiment IV were compared. Contrary to colors, it was supposed that the contrast effect would lead film-clips to be assessed in a stronger pattern.

In Figure 66, plots symbolized with the icon () indicate mean values of valence, arousal, and dominance as assessed in Experiment IV. The arrows indicate the displacement originated from the points where the film-clips were assessed in the Preliminary Test. In the chart on the left side, defined by valence (abscissa) and arousal (ordinate), it can be observed that the icons (, Experiment IV) shifted in the direction of '+' valence and '+' arousal. Eight out of nine film-clips (88.9%) exhibited this tendency. In the dominance dimension (right side in Figure 61), a **stronger pattern of emotion** can be observed: less dominant film-clips were assessed relatively lower (e.g. 'gangsters' and 'Jesus') and more dominant film-clips were assessed relatively greater (e.g. 'butterfly', 'hill', 'applause', and 'bed').

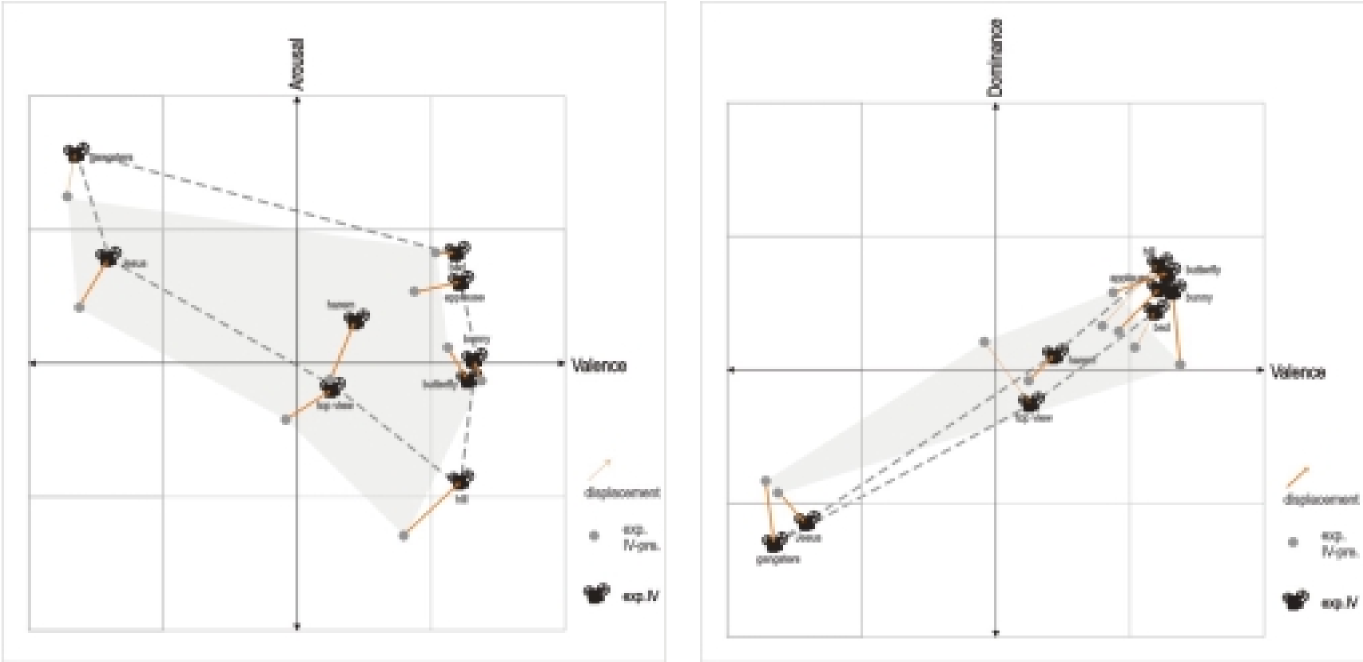


Figure 66. Plots of means of nine film-clips demonstrated in affective spaces
defined by: valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right.

As with colors, the tendencies of displacement were examined statistically. A two-way ANOVA with repeated measurement on one factor, films showed that the judgmental shift between Preliminary Test and Experiment IV with regard to the valence dimension was significant [F (1, 67)=5.935, p=.018*] (see Table 51).

factor	valence	arousal	dominance
experiment (between)	**F(1, 67)= 5.935, p=.018***	**F(1, 67)= 2.545, p=.115**	**F(1, 67)= 1.043, p=.311**
stimulus: film-clip (within)	F(5.172, 346.533)=107.543 p=.000***, ε=.647	F(6.460, 432.795)=34.360, p=.000***, ε=.807	F(5.420, 363.150)= 22.628, p=.000***, ε=.678
exp.(between)*stimulus (within)	F(5.172, 346.533)=107.543 p=.747, ε=.647	F(6.460, 432.795)=.844, p=.544, ε=.807	**F(5.420, 363.150)= 2.318, p=.038*, ε=.678**

Table 52. Result of two-way ANOVA with repeated measurement on one factor: film-clips, Preliminary Test vs. Experiment IV.

In addition, the interaction between experiment and stimulus was significant with regard to the dominance dimension. This explains the observed judgmental shift in Figure 66: film-clips were assessed relatively more dominant or more submissive in Experiment IV.

Finally, individual pairs of film-clips were compared with a t-test: the judgmental shift of “hill” was significant in the valence dimension and the shift of “butterfly” was significant in the dominance dimension.

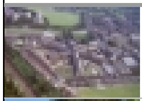
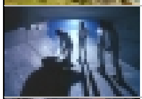
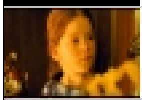
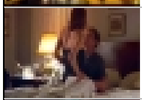
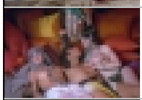
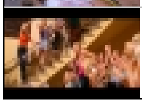
film-clips (acronym)	mean comparison (p values yielded by t-test, two-tailed, df= 67)								
	valence			arousal			dominance		
	M (IV- pre)	M (IV)	p	M (IV- pre)	M (IV)	p	M (IV- pre)	M (IV)	p
 (top view)	2.917	3.267	(.162)	2.583	2.822	(.338)	3.208	2.756	(.123)
 (hill)	3.792	4.289	**.031***	1.708	2.133	.105	3.333	3.8	.093
 (gangsters)	1.292	1.356	.703	4.25	4.578	.104	2.167	1.711	.138
 (Jesus)	1.375	1.6	.278	3.417	3.8	.156	2.083	1.867	.460
 (bunny)	4.375	4.333	.805	2.875	3.044	.538	3.042	3.6	.055
 (butterfly)	4.125	4.289	(.359)	3.125	2.889	.445	3.167	3.733	**.019***
 (bed)	4.042	4.2	.496	3.833	3.844	.961	3.167	3.467	.231
 (harem)	3.25	3.489	.471	2.875	3.333	.111	2.917	3.156	.450
 (applause)	3.875	4.267	(.183)	3.542	3.622	.777	3.583	3.622	.874

Table 53. Comparisons of means of SAM ratings of film-clips by t-test

* t-test yielded significance (p<.05), p values in parentheses: homogeneous variances are not assumed.

N of Preliminary Test=24, N of Experiment IV=45.

7.3.3.5 Background stimulus: adjective

Lastly, the SAM ratings of adjectives in Experiments II and IV were compared. As adjectives were considered to be assigned in a **disparate category**, it was hypothesized that pictorial stimulus modalities would affect verbal modality (adjectives) less ([H. 11]).

In Figure 68, it is observed that adjectives were assessed **in a weaker pattern** (arousal dimension) for most of the adjectives and thus the perceptive reference scale shrinks. Accordingly, a two-way ANOVA with repeated measurement on one factor, adjectives, was run (see Table 53). No significant difference between the experiments was found (α=.05).

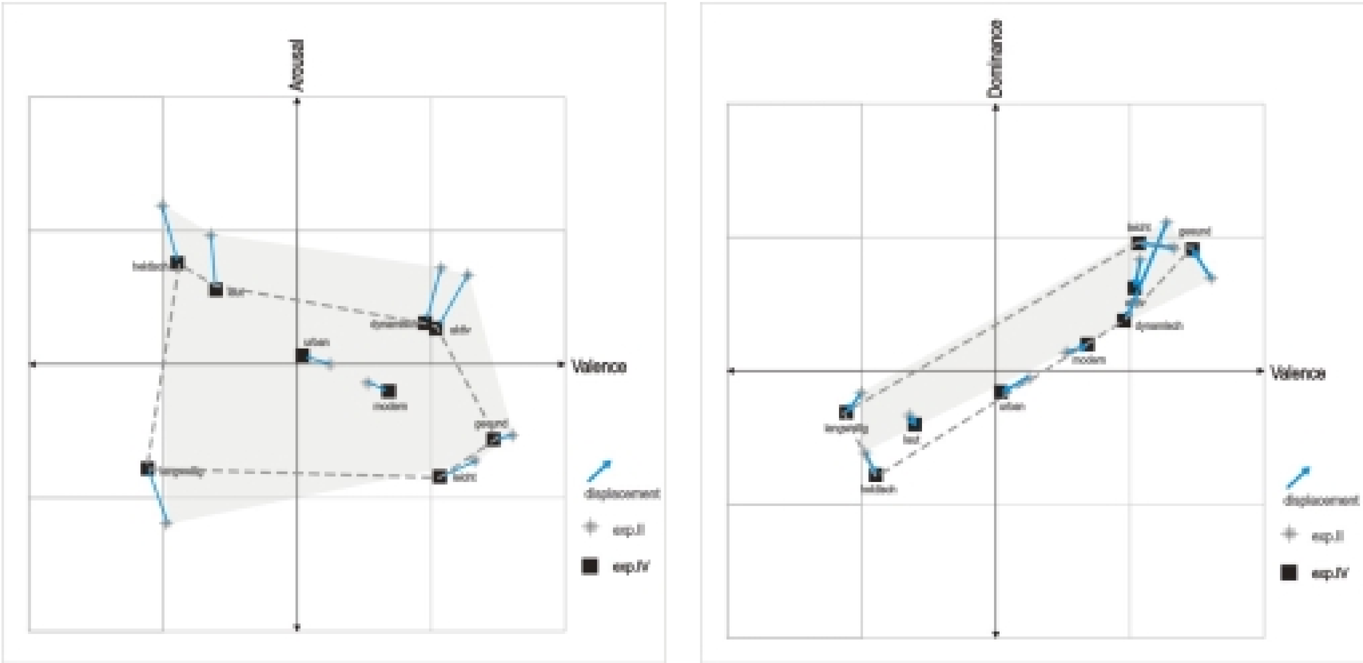


Figure 67. Plots of means of nine adjectives demonstrated in affective spaces

defined by: valence (abscissa) × arousal (ordinate) on left, valence (abscissa) × dominance (ordinate) on right

gray quadrates with cross ( ) represent results from Experiment II

black quadrates ( )represents results from Experiment IV.

factor	valence	arousal	dominance
experiment (between)	**F(1, 79)= 1.480, p=.227**	**F(1, 79)= 1.256, p=.266**	**F(1, 79)= 1.759, p=.189**
stimulus: adjective (within)	F(6.103, 482.168)=114.114, p=.000***, ε=.763	F(5.703, 450.548)=42.943, p=.000***, ε=.713	F(6.481, 512.002)=26.783, p=.000***, ε=.810
exp.(between)*stimulus (within)	F(6.103, 482.168)=.693, p=.658, ε=.763	F(5.703, 450.548)=1.853, p=.091, ε=.713	F(6.481, 512.002)=.977, p=.443, ε=.810

Table 54. Result of two-way ANOVA with repeated measurement on one factor: adjective, Experiments II vs. IV.

Moreover, individual pairs of adjectives were compared between Experiments II and IV. The context differs from each other in terms of stimulus context as well as media. Adjectives were presented on DIN A5-size paper during Experiment II. Only one case (‘aktive’ (active), dominance) with a statistically significant difference could be identified (α=.05). The results provided evidence that adjectives were not influenced by cross-modality stimulus context, as hypothesized in [H. 11].

Nevertheless, the nine adjectives employed in Experiment IV- main were, in fact, **not representative for different emotional profiles but selective,** especially as adjectives were drawn from a semantic network presented in section 4.2.2.2. In order to examine the context stimulus effect on the weaker pattern as a general tendency, it is recommended to test adjectives which occupy positions in a representative way in emotion space.

adjectives (English)	mean comparison (p values yielded by t-test, two-tailed, df= 79)								
	valence			arousal			dominance		
	M (II)	M (IV)	p	M (II)	M (IV)	p	M (II)	M (IV)	p
laut (loud)	2.361	2.400	.855	3.972	3.556	(.053)	2.667	2.600	.802
langweilig (boring)	2.028	1.889	.468	1.806	2.222	(.142)	2.833	2.689	.561
hektisch (hectic)	2.000	2.111	.600	4.194	3.756	.055	2.389	2.222	.483
leicht (light)	4.333	4.067	.133	2.278	2.156	.616	3.917	3.956	.870
aktiv (active)	4.278	4.044	.152	3.667	3.267	.088	4.111	3.622	**.011***
dynamisch (dynamic)	4.083	3.956	.509	3.722	3.311	.070	3.833	3.378	.082
gesund (healthy)	4.611	4.467	.365	2.472	2.444	.916	3.694	3.911	.365
urban (urban)	3.250	3.044	.341	3.000	3.067	.810	2.944	2.844	.689
modern (modern)	3.528	3.689	.389	2.861	2.800	.781	3.139	3.200	.783

Table 55. Comparisons of means of SAM ratings of adjectives by t-test, Experiment IV

* t-test yielded significance ($p<.05$), t value in parentheses: homogeneous variances are not assumed.

N of Experiment II=36, N of Experiment IV=45.

7.4 SUMMARY AND DISCUSSION OF EXPERIMENT IV

In Experiment IV, it was examined whether anchor effects on emotional reference occurred in cross-modality stimulus context and it was hypothesized that emotional responses to color would appear in a weaker pattern due to film-clips, which contain a higher degree of semantic intensity [H. 9].

Five different stimulus modalities were employed and four of them were ordered according to the intensity of semantic contents: colors (the lowest), achromatic pictures, chromatic pictures, and film-clips (the greatest). In addition to those four stimulus modalities, adjectives were added and it was hypothesized that they would be little affected by the cross-modality stimulus context, since adjectives are little governed by the common regularities [H. 11]. In sum, 43 stimuli were employed. They were 17 colors, four achromatic pictures, four chromatic pictures, nine film-clips, and nine adjectives. Colors, pictures, and adjectives were selected from previous experiments and film-clips were chosen from a preliminary study presented in 7.2.

During Preliminary Test, 19 film-clips had been examined in order to pre-determine their respective emotional profile, and nine of them were embedded in Experiment IV. During Preliminary Test, a plain colored scene (vivid red) was assessed close to neutral with regard to all dimensions of emotion, supporting [H. 9] (also see 7.2.4.1).

Based on SAM ratings of 43 stimuli, the coefficients of internal consistency provide a satisfactory level of reliability: valence (α=.729), arousal (α=.919), and dominance (α=.842) were adequate to describe emotional profiles of different stimulus modalities.

The SAM ratings of stimuli in Experiment IV were compared with those of previous experiments (baseline) in which emotional responses were tested within stimulus modalities:

(a) 17 colors:	**compared with Experiment III**	**(in 8.3.3.1)**
(b) four achromatic pictures:	compared with Experiment II	(in 8.3.3.3)
(c) four chromatic pictures:	compared with Experiment III	(in 8.3.3.3)
(d) nine film-clips:	compared with Preliminary Test	(in 8.3.3.4)
(e) nine adjectives:	compared with Experiment II	(in 8.3.3.5)

It was observed that emotional responses to each stimulus modality shifted toward certain directions: (a) shifted in direction to '–' valence, '–' arousal, and '+' dominance; (d) shifted towards the positive '+' valence , '+' arousal, and '+' dominance.

For both of (a) and (d), a two-way ANOVA with repeated measurement on one factor (stimuli) yielded significant results:

(a) 17 colors	**in arousal dimension: less excited**	**$F (1, 89)=5.002$, $p=.028$***
(d) nine film-clips	in valence dimension: more positive	$F (1, 67)=5.935$, $p=.018$*

As hypothesized in [H. 10], it was analyzed whether the tendencies of color affectivity were maintained despite of the judgmental shift of color modality in the emotion space: with respect to the **arousal dimension**. As presented in 7.3.3.2, the SAM ratings of hue categories and Chroma levels from Experiment IV were compared with those from Experiment III. The emotional responses to hue categories were not consistent between two experiments, nevertheless a **positive linear correlation between Chroma level and emotional response in both experiments** was found. [H. 10] was thus confirmed in terms of the color attribute (Chroma) with respect to the arousal dimension.

On the other hand, (e) showed weaker pattern of emotional reaction in the arousal dimension in the cross-modality stimulus context. However, **there was no statistical evidence for the existence of a stimulus context effect, supporting [H. 11].** Regarding valence and dominance dimensions, no tendency or statistical evidence of judgmental shifts was found.

Concerning (b) and (c), judgmental shift could not be systematically analyzed, as the number of stimuli was too small.

In addition, the film-clips and adjectives employed in Experiment IV as **background stimuli are not representing each of the modalities.** Therefore the judgmental shifts of (d) and (e) are limited to those modalities, which were employed in Experiment IV.

Although such tendencies of displacement were observed and partially confirmed to be significant (α=.05), the judgmental shifts were weaker in Experiment IV than anticipated. In particular, this could be observed by the weak judgmental shift for the 'vivid red' in Experiment IV.

According to the theory on adaptation levels of Helson (1964), the psychophysical judgments depend on the relative frequencies with which the stimuli are presented. Therefore, during the Preliminary Test, subjects were exposed to the 'vivid red' () film clip, among other 18 film-clips. In contrast, in Experiment IV, the 43 stimuli included 17 colors, representing 39.5% of the entire stimuli. Also, Garner (1974) referred to the set of possible stimuli as the "inferred set", which indicates that judgments of **perceived intensity or quality depend on the set of possible stimuli.** Therefore, as the proportion of colors increased (from 5.3% to 39.5%), the contrast effect was reduced respectively.

Also, it is assumed that subjects were able to apply **individual reference scales for each stimulus modality**. Subjects were aware of different stimulus modalities and adjusted the frequency of range scaling according to the identified stimulus modality. Thus, they assigned the stimuli of each category to a respective frame of reference. For future research, it is suggested to **increase the number of stimulus modalities**, so that category membership of stimulus may be weakened and the frame of reference can be formed with respect to all presented stimuli.

In addition, the sequential effect was not examined in Experiment IV. Instead, it was assumed that **a sequential effect would occur and generate judgmental shifts overall**, since the order of stimuli had been randomized every time. In future research, it is suggested to test not only contrast effects caused by semantic intensity, but also the **sequential dependencies** to obtain more contrastive results.

7.5 CHAPTER REVIEW

• The necessity of research on emotional responses to colors in the respective context is addressed. Color as a target stimulus in an empirical study of the cross-modality stimulus context is considered.
Previous theoretical literature on context effects was reviewed and some empirical studies on stimulus context, reference scale, sequential dependency (7.1.1), judgmental shift (7.1.2), etc. were described. A few early studies on context effects and color affectivity were introduced (7.1.2.1).

• With regard to the stimulus modality, some recent empirical studies were summarized. They revealed that the task performance is better, when stimuli are governed by the same regularities (7.1.3). Based on this review, it was assumed that adjectives may be less manipulated by the pictorial stimulus context.

• Prior to the cross-modality experiment, a Preliminary Test was carried out. Supported by several empirical studies, it was assumed that film-clips would induce reliable patterns of emotional responses (7.2.1). Nineteen film-clips were edited from commercial films and employed in the Preliminary Test (N=26). Film-clips were assessed with SAM and the test was conveyed as paper-and-pencil test (7.2.2). In doing so, it was hypothesized that the selected films would elicit a similar pattern of emotion as IAPS pictures, when the contents are comparable [H. 8]. The hypothesis was supported by empirical results. Among the 19 film-clips, a plain colored screen (vivid red) was employed and it was observed that emotional responses with respect to the three dimensions were close to neutral. Emotional responses to the 'vivid red' in previous experiments were compared and a contrast effect caused by intensity of semantic contents in cross-modality stimulus context was predicted (7.2.4.1). Gender difference affecting emotional responses to film-clips was discussed (7.2.4.2).

• In Experiment IV three hypotheses were formulated. The semantic intensity of the stimulus affects the reference scale of the individual stimulus modality; the emotional responses to color (low semantic intensity) appear in a weaker pattern (smaller reference scale), due to the contrast effect caused by film-clips (high semantic intensity) [H. 9]. The tendencies of emotional responses are kept within a stimulus modality and thus color affectivity remains [H. 10]. Due to insufficient common regularities, emotional responses to adjectives will not be influenced by the other stimulus modalities [H. 11] (7.3.1).

• Five sets of stimuli were introduced: they were 17 colors, four achromatic pictures, four chromatic pictures, nine film-clips, and nine adjectives. Each stimulus was presented in random order and subjects were confronted with all complete stimuli (7.3.2.2).

• SAM ratings of previous experiments were provided as baseline and the SAM ratings of each modality were compared by means of illustrations in the emotion space as well as statistical analyses. Color was the modality of target stimuli (7.3.3.1) against other four types of modalities as background stimuli, such as chromatic and achromatic pictures (7..3.3.3), film-clips (7.3.3.4), and adjectives (7.3.3.5). In general, some patterns of judgmental shift were observed and a two-way ANOVA with repeated measurement on one factor: stimulus was run. It was revealed that **colors were shifted towards '–' valence and '–' arousal. The displacement in the arousal dimension was significant (α=.05).**

• In order to examine [H.10], the SAM ratings of colors in the arousal dimension in Experiment IV were compared with those in Experiment III. Emotional responses to hue categories were not consistent, whereas those to Chroma levels were coherent: a positive linear relationship between Chroma level and arousal dimension was found (7.3.3.2). Film-clips were shifted more toward '+' valence and '+' arousal and the displacement in the valence dimension was significant. Adjectives elicited a weaker pattern of emotion and no statistical significance was yielded, thus supporting [H. 11].

8. GENERAL DISCUSSION

8.1 DISCUSSION

Patterns of emotional responses to colors were addressed based on four main empirical studies. In order to quantify affectivity, alternative approaches to conceptualize and measure emotion or color were debated. The methodological aspect of the experiments in this dissertation was supported by many theories and empirical studies and provided not only empirical evidence, but also an application tool for marketing purposes.

In the following three sections, the methodological approach driven by theoretical background is discussed and major empirical findings from the four experiments are explained according to the following points: emotional profile of color (8.1.1), affective judgment in cross-modality stimulus context (8.1.2), and proposal of a practical application tool (8.1.3)

8.1.1 Emotional profile of color

The main purpose of the study was to characterize emotional profile of color. Prior to the experiments, theories on emotion and measurement systems thereof were reviewed in order to outline the framework to design the experiments. Beginning with the terminological issues, different views of emotional process were described. The dimensional approach was advocated and emotion spaces were utilized to reconcile both dimensional and discrete approach of conceptualizing emotion. As a measurement tool, a non-verbal assessment system, the SAM (Lang, 1980) was introduced. Previous empirical studies in which SAM was used to profile emotional characters of various types of stimuli were summarized. SAM consists of three rows of five pictograms where each row represents valence, arousal, or dominance dimensions of emotion respectively. The dimensional structure of the SAM was derived from the semantic differential of Osgood et al. (1957)' and later revised as PAD (pleasure, arousal, and dominance) theory by Mehrabian (1972; 1978).

The assessment of color affectivity was conceptualized in this way. Applying the theoretical framework of emotion studies, color stimuli were assessed with SAM, which evaluated the emotional response to color in terms of valence, arousal, and dominance dimensions. SAM with a range from 1 to 5 was used to measure each dimension. In doing so, the respective means of valence, arousal, and dominance of colors were depicted in two emotion spaces, which were defined by valence (abscissa) × arousal (ordinate) or valence (abscissa) × dominance (ordinate). The emotion space provided a geometric metaphor for the internal scale on which the colors experience was judged (see Figures 19 and 33).

Based on SAM ratings of colors, internal consistency-reliability alpha coefficients provided evidence of satisfactory levels of internal consistency for dependent measures of emotion (Experiment I, Table 11; Experiment II, Table 21; Experiment III, Table 32; Experiment IV, Table 46). Furthermore, [H. 1], [H. 3], and [H. 7] were supported accordingly.

Moreover, the medium effect was investigated by examining the emotional responses to 36 identical colors presented differently: surface color (representing object reflected color) vs. digital color (representing self illuminating color on digital media). The 36 color stimuli were employed in Experiments II and III: as surface color (object reflected color, DIN A5-size paper) and as digital color (self-illuminating color, CRT monitor) respectively. The pattern of averaged SAM ratings of colors did not differ between two experiments (Table 33), and paired comparisons done individually between surface and digital colors did not yield significant differences in general (Table 34). Accordingly, [H. 7] was confirmed.

Analyzing the SAM ratings on three dimensions, the characteristics of emotional profile of color were addressed according to color attributes such as hue, Chroma, and lightness, following the CIELab Lch system. The effects of color attributes on affective judgment were tested in each experiment and proven to be significant at the α=.05 level with one-way ANOVA with repeated measurements. Herein below, major findings are summarized in each aspect of color attributes: hue, Chroma, and lightness (8.1.1.1).

8.1.1.1 Emotional profile of color attributes

- **Emotional profile of color attribute: hue**

  Although there was statistical evidence that hue influences SAM ratings of color (e.g. Table 23), emotional responses to hue varied in weak patterns and no systemic clarification between hue and emotional dimensions has yet been found.

Nevertheless, in all experiments, colors **in the blue hue category** turn out to be significantly more positive and more dominant than the others (Figures 20, 34, 49, and 62). In connection with previous studies on color preference, the empirical results showed consistently that blue induces positive emotional reaction in general (Adams et al., 1973; Burda Advertising Center, 1998; Guilford et al., 1959). In section 8.3.2, issues regarding color preference and its application are discussed.

Concerning the color red, empirical evidence offers less remarkable than anticipated phenomena. Within the hue category of red, emotional responses to the variation with Chroma and lightness followed the general trend. The cross-cultural study in South Korea showed a stronger pattern of emotional reaction in arousal. Koreans assessed colors in red hue category exciting (>3.0, arousal), while Germans rated red colors rather less arousing (<3.0, arousal). Nevertheless, red is the hue category that induced the highest arousal level in both groups (Figure 25) as well as for most of the results of the further experiments.

• Emotional profile of color attribute: Chroma

Following previous studies (Adams et al., 1973; Arnheim, 1956; Guilford, 1959; Simmons, 2006; Valdez et al., 1994), it was hypothesized that emotional responses vary more strongly with regard to Chroma and lightness than with regard to hue [H. 3]. Empirical results from four experiments provided a **positive linear correlation** between Chroma and SAM ratings with regard to all dimensions (Figures 21, 37, 50, and 63) with significant correlation coefficients (Tables 12 and 25).

Tone categorization was introduced to select representative Chroma and lightness for each hue category, emphasizing the cognitive quantity of color perception. Tone categorization combined Chroma and lightness levels based on ISCC-NBS block separation for subjective variables for cognitive quantity of colors. Five categories were applied to all hue, and in doing so, the analyses referred to color perception and a systemic explanation about Chroma and lightness levels across hue categories was made possible ([H. 4]).

• Emotional profile of color attribute: lightness

The SAM ratings of lightness of chromatic and achromatic colors were separately analyzed.

Since lightness and Chroma are related, an inverted U-shape (∩) between lightness (predictor) and SAM ratings was expected. Although the trend was observed (Figures 40 and 51), the statistical significance was too weak to conclude this tendency (Table 26).

Concerning achromatic colors, it was found that the bigger discrepancy between stimulus (lightness) and context induced greater SAM ratings in all three dimensions (Figures 42 and 52). Emotional responses appeared in U-shape (∪), thus indicating that lightness is not the common parameter to predict color affectivity for both chromatic and achromatic colors, even if it is the only attribute that both colors have in common.

8.1.1.2 Other variables

Some other variables that may influence affective judgment of color, such as color nuance, cultural context, and gender, were also investigated.

/ Color nuances and emotion: warm and cool

The nuance referred to slight deviations, and it was hypothesized that gray nuances such as 'cool (bluish) gray' and 'warm (yellowish) gray' influence emotional responses. It was shown that valence and dominance were influenced by temperature nuances as supposed to neutral grays [H. 5]. Further research could focus on nuance effects on different cognitive performance.

/ Demographic character as variable: German subjects versus Korean subjects

The module of Experiment I was translated into Korean and applied to 17 subjects in South Korea. Based on the SAM ratings of Korean subjects, similar patterns of emotional response to hue (Figure 25), Chroma (Table 15), and lightness (Figure 26) were observed.

It should be noted that neither group should be considered representative of the whole population because of the similar age ($M_{Germans}$=21.96, $M_{Koreans}$=16.24) and occupation (i.e. students) of the sample. In spite of cultural differences such as language and traditions, both groups do have some common aspects in terms of pop culture, technology, and communications. Thus the findings are rather focused on the specific demographic groups in both countries.

/ Demographic character as variable: gender

Summing up the results from Experiments II and III, the SAM ratings of colors of male and female subjects were compared. The results did not show any significant difference and suggest that emotional responses to colors do not differ by gender, in line with recent studies by Bradley et al. (2001b), Schupp et al. (2004), and Valdez et al. (1994).

8.1.1.3 Affective judgment of color: what was judged? What determined?

Although empirical evidence provides various tendencies of emotional response to color, the discussion regarding internal processes of affective judgment of color for individual subjects remains. In particular, exactly what has been judged should be made clear. After that is explained, the question of what determined such judgment arises. These two points are thought in terms of emotional process and color-viewing aspects.

Regarding the process of emotion, it was resumed that emotions are the results of the **cognitive judgment** of transactions between individuals and the environment in general (Arnold, 1960; Clore et al., 1987; Elliot et al., in press; Mehrabian et al., 1974; Schachter et al., 1962). Emphasizing the involvement of the cognitive judgment during an emotional process, Shaver et al. (1987) explained that emotion implicates subjects' accounts of **self and typical emotion episodes**. In line with this, the semantics of color were discussed in section 3.1.2 and some major issues such as social and cultural contexts were addressed.

On the other side, researchers such as Duffy (1948), Helson (1964), and Zajonc (1980) have asserted that **sensorial processes produce emotions** arise immediately from changes in basic physiological patterns of response to muscular, visceral, and organic activities. Based on their argument, a person can come to like or even develop pleasant feelings for something without the intervention of any cognition. Lüscher (1971) empirically presented physiological responses to color and showed that the color red resulted in the subjects' faster heart beat, increased pulse, increased blood pressure, and faster breathing frequency. Valdez et al. (1994) summarized that many studies (i.e. Kaiser, 1984 or Wilson, 1966) on physiological measurement of emotional response to color revealed that the color red (or long wavelength) is more arousing than blue (or short wavelength).

Dealing with these two different perspectives, Gellatly (2002) drew a distinction between visual experience ('seeing as') and visual information processing ('seeing'). "In truth, any form of 'seeing' is some form of 'seeing as'" (p. 85). Nevertheless, the distinction is useful for drawing attention to many different ways in which any one visual scene may be consciously experienced (Gellatly, 2002).

With regard to color, some recent studies (i.e. Bornstein, 1997; MacLaury, 1992) agree that biology may constrain the potential recognition of color experience, such as color categorization, although it cannot determine how colored objects will be 'seen as'. The studies pointed out the relevance of the cognitive performance subject to color stimuli without semantic association. During experiments, once subjects perceived color, they were expected to evaluate their **immediate response** to the color in terms of three continua of emotional dimension. That way, **the emotional implications of associated semantics** were avoided.

According to Gellatly's distinction, **'seeing' color** was desired in experiments as the **input of the emotional process**. In section 3.1, the five aspects of the viewing of color were defined from color match to color semantic. The input process of the affective judgment of a color stimulus during experiments was supposed to the **'color perception'** among the five aspects. The color perception and the color aesthetics are distinguished from color semantic, but their aspects are broader than color match and color sensation. During the experiments, no semantic cues were provided in order to avoid the emotional influence of semantic associations or mediated objects. On the other hand, color stimuli were selected by means of hue and tone categories so that subjects might perceive the **cognitive quantity of the colors**. This distinguishes color perception from color sensation. The independent measurements of input (color stimulus) were the evaluations of affectivity in terms of valence, arousal, and dominance; thus, the aspect of viewing color during experiments did not deal with aesthetic quantity.

Accordingly, the area marked bluish in Figure 68 indicates the aspect of color perception, which was assumed as the viewing of color during experiments.

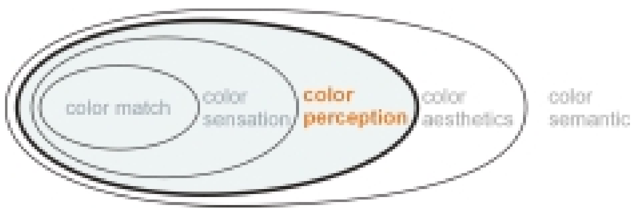


Figure 68. Different aspects of viewing color and the aspect of 'color perception'.

Some empirical evidence shows that subjects made affective judgment of color perception excluding semantic association and also that the evaluation was an immediate response to stimuli. As reviewed in 3.1.2, color semantic is an association between color hue and social and cultural context. Throughout all four experiments, a positive linear relationship between Chroma and all dimensions of emotion was shown. Particularly, emotional response varied more strongly with regard to Chroma than with regard to hue (see Figure 44). In this aspect subjects assessed emotional response to cognitive quantity of color (or color perception), since the correlation provides a systematic relationship between emotional response and color attribute.

Described in chapter 3, color is a salient and resonant visual feature of those seen in early vision (Garber et al., 2003). This makes color a compelling visual cue for persuasive communication purposes. Consequently, color contributes to preference and appreciation of products, improving the efficacy of messages and increasing likelihood of purchase (Birren, 1945; Hine, 1995; Lee, 2002; Miller et al., 2002). In fact, such **impact** stems from the principle of immediate emotional response to color perception.

8.1.1.4 Categorization of color in emotion space

Describing emotion space in 2.3.3.1, it was discussed that emotional terms are not homogenously distributed and that when emotional intensity is high, some emotional terms are closer to the periphery (Russell et al., 1997). In line with this, 956 pictures of IAPS (Lang et al., 2005) were divided into eight categories, each of which determined by dichotomic values ('+' or '–') within valence, arousal, and dominance respectively (section 2.4.3.2). Interestingly enough, it was found that the pictures are not equally distributed among the eight categories. For example, 331 from the 956 pictures (34.62%) belong to the category profiled with '+' valence , '–' arousal, and '+' dominance (see Tables 1 and 3).

This way, the color stimuli employed in Experiments II and III[8] are categorized into eight emotional profiles, according to the averaged SAM ratings. Consequently each category of emotional profile obtains sets of adjectives, IAPS pictures (the quantity), and color stimuli, as presented in Table 56. Adjectives in Table 56 were originally derived from ratings of 240 emotions on the PAD scales (Mehrabian, 1978; Russell et al., 1977).

[8] Identical color stimuli were employed in both cases: as surface color in Experiment II and as digital color in Experiment III.

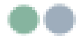
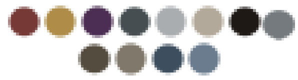
dichotomized dimensions			categorized adjectives, pictures, and colors		
V	A	D	adjectives	% (IAPS pictures)	color stimuli
+	+	+	admired, bold, creative, powerful, vigorous	16.95% (162)	
+	+	–	amazed, awed, fascinated, impressed, infatuated	2.51% (24)	
+	–	+	comfortable, leisurely, relaxed, satisfied, unperturbed	34.62% (331)	
+	–	–	consoled, docile, protected, sleepy, tranquilized	.73% (7)	
–	+	+	antagonistic, belligerent, cruel, hateful, hostile	.73% (7)	
–	+	–	bewildered, distressed, humiliated, in pain, upset	25.73% (246)	
–	–	+	disdainful, indifferent, selfish-uninterested, uncaring, unconcerned	10.67% (102)	
–	–	–	bored, depressed, dull, lonely, sad	8.05% (77)	

Table 56. Categorization of adjectives, IAPS pictures (%) and colors into eight emotional profiles

V: valence, A: arousal, D: dominance; Total number of IAPS pictures: 956.

The dichotomization of each dimension of emotional response to color provides an implication of **similar emotional profiles** across different stimulus type: emotion terms, pictures, and colors. For example, the profile of '+' valence , '+' arousal, and '+' dominance contains emotional terms, such as:

{ admired, bold, creative, powerful, vigorous }

and the following colors were matched from Experiment II and III:

{  }

which are all chromatic colors and most of them also highly **saturated**.

According to hue and tone categorizations, the 36 color stimuli were selected in order to be able to represent the full range of the color space including achromatic as well as chromatic colors. However, since the 36 color stimuli were not selected with regard to even distances from each other in color space, the number of color stimuli in Table 56 does not necessarily correspond to the frequency of colors of each emotional profile.

Another implication thereof is that some emotional categories of emotional profiles (e.g. '–' valence, '+' arousal, and '+' dominance) may be difficult to obtain through any color stimulus. Lang et al. (1999) discussed the different number of IAPS pictures in each dichotomized category of emotion. In a similar way, each category occupies different number of colors and the contrast is noticeable. On the other hand, this corresponds to the **diagonal cluster** of colors in emotion space depicted in Figures 19, 33, 48, 59, or 60. The same work also suggests future research on additional factors, which may drive emotional response to color toward certain directions.

8.1.2 Affective judgment of colors in cross-modality stimulus context

Affective judgment of color stimuli was assessed not only within colors (i.e. Experiments I, II, or III), but also between colors and other types of stimulus modalities. In Experiment IV, anchor effect was investigated in a cross-modality stimulus context. Recall that it had been hypothesized that the emotional response to color would appear in a weaker pattern due to film-clips, which contain higher degree of semantic intensity [H. 9].

Five different stimulus modalities were employed: colors, chromatic and achromatic pictures, film-clips, and adjectives. Since adjectives as verbal stimulus modality are little governed by the common regularities with other pictorial stimulus modalities, it was expected that they would be little affected by cross-modality stimulus context [H. 11].

The SAM ratings of 43 stimuli in Experiment IV were compared with those of previous baseline experiments, in which emotional responses were tested within stimulus modality.

In general, it was observed that the reference fields of emotional responses to each stimulus modality did not shrink or enlarge. Instead, in valence and arousal dimensions, emotional response to colors became rather negative ('–' valence, '–' arousal) and those to film-clips shifted toward more positive ('+' valence , '+' arousal). Running two-way ANOVA with repeated measurement on one factor (stimulus) revealed that the judgmental shift of **colors in arousal dimension (less excited)** and that of film-clips in valence dimension (more positive) were significant at α=.05 level (two-tailed).

Consequently, the tendencies of emotional responses to color in arousal dimension were analyzed in order to find out if the consistent pattern of color affectivity still remained, despite of the context effect on the stimulus modality. Hue was not more consistent but did show a positive linear correlation between Chroma and SAM ratings on arousal dimension, partially supporting [H.10].

As it was hypothesized in [H. 11], no statistical evidence of judgmental shift of adjectives was provided. Nevertheless, it was observed that the affective judgment of adjectives in arousal dimension shrunk.

Since the selection of the film-clips and adjectives were not representative of the whole stimuli set of each modality, further research would be required to provide any generalization of the judgmental shift of film-clips and adjectives in cross-modality stimulus context.

8.1.3 Proposal of a practical application tool

For this dissertation I developed a methodology based on theory reviews, created an original color solution, and provided evidence by conveying a case study. Basically, the concept was that the color mediated in a product is supposed to be coherent with the image or function. Outlined by ERM (emotional resonance model; Figure 15) by Getz et al. (2000), the framework proposed was that the **emotional profile of color concept and that of product concept** should form a metaphor that links both color concept and product concept (Figure 16).

As showed in Experiment I, colors and terms (i.e. 'low fat' in the case study; Figure 18) were assessed within the emotion space, a geometric relationship of the internal scale.

After undertaking the case study, three major methodological advantages were identified:

- it follows a logical and systemic approach,
- it provides versatile usage for different topics, and
- it offers a color solution in a flexible way.

The need of such interdisciplinary studies is more extensively addressed in section 8.2.4.

8.2 SUMMARY

For this dissertation, both theories and previous studies on emotion and color affectivity were reviewed and applied for structuring experiments designed to investigate emotional responses to color. Advocating dimensional approach to conceptualize emotion, SAM (Self Assessment Manikin) developed by Lang (1980) as a non-verbal measurement system, was used to assess emotional response to stimuli in dimension of valence, arousal, and dominance.

Color stimuli were collected based on CIELab Lch system, in which color attributes are defined as hue, Chroma, and lightness. In Experiment I (N=48), it was shown that valence and arousal dimension were adequate to describe emotional profile of colors. The module of Experiment I was translated in to Korean and carried out in South Korea (N=17). Similar tendencies of emotional response were assumed due to the demographic and contemporary commonality between both subject groups (Germans and Koreans).

Color stimuli were then selected in terms of hue and tone category, according to the cognitive quantity of color. In Experiment II (N=36) color stimuli were presented on DIN A5-size glossy paper (RAL DESIGN System™) and in Experiment III (N=46) they were displayed on CRT monitors. The difference in media was not significant. Across the three experiments, a significantly positive correlation (α=.001) between Chroma and all dimensions of emotion was found. The tone category supported the tendency in a more systemic way. Emotional responses varied more with tone categories than with hue categories.

In addition to colors, different stimulus modalities were examined and their emotional responses were also measured with SAM. Based on empirical results of emotional responses to colors, a case study was conveyed and a practical application tool was proposed. The emotional profiles (adjectives) of a product concept were defined in terms of valence, arousal, and dominance. Color stimuli were done and the results were overlapped in the emotion space in which colors were distributed. Through a qualitative setting, a cluster of colors and adjectives may be found. The advantages of the methodology were addressed for the development of a product-color scheme.

As another stimulus modality, still images were used. Four chromatic and four achromatic pictures were chosen from the IAPS (International Affective Picture System, Lang et al., 2005) and the chromatic pictures were used also as baseline, since the SAM ratings were already known in IAPS.

In Experiment IV (N=46), color affectivity was investigated in a cross-modality stimulus context, which consisted of colors, chromatic pictures, achromatic pictures, film-clips, and adjectives. A Preliminary Test (N=24) had been carried out to select film-clips. Stimulus modalities were compared considering their semantic intensity, which pushed or pulled judgmental shifts. The significant displacements (α=.05) implied that colors induced less excited emotion and film-clips induced more positive emotion. As expected, verbal stimulus modality (adjectives) was not significantly affected by the other pictorial stimulus modalities.

The 11 hypotheses proposed earlier can be grouped into three sets:

I: emotional response to color in terms of valence, arousal, and dominance

II: emotional response to color attributes and Chroma as the decisive factor

III: color affectivity in cross-modality stimulus context

In the following Table, each hypothesis is categorized into a group (the left column) and summarized (in the middle). Finally, the corresponding empirical results are provided in the right column.

Group of hypotheses I	II	III	The hypotheses	Empirical results	Exp.
H. 1			Color stimuli elicit emotions as pictures do.	Confirmed only for valence and arousal dimensions.	I
	H. 2		Emotional response to color varies more strongly with Chroma and lightness rather than with hue.	Confirmed (not yet statistically tested)	I
H. 3			Three dimensions of emotion can describe emotional profile of surface color.	Confirmed.	II
	H. 4		Tone categorization is more adequate to investigate emotional response to the perception of Chroma and lightness than to the physically measured Chroma and lightness.	Confirmed.	II
	H. 5		Gray nuances influence emotional responses.	Confirmed only for valence and dominance dimension	II
H. 6			Emotional profile of digital color can be characterized by valence, arousal, and dominance.	Confirmed.	III
H. 7			Digital colors elicit emotion in the way surface colors do.	Confirmed.	III
		H. 8	Moving and static images activate similar emotional circuits, when both communicate similar semantic contents.	Confirmed (not yet statistically tested)	preliminary
		H. 9	Stimuli with higher intensity of semantic contents (e.g. film-clip) anchor the referential emotion and produce a negative distance effect on the colors: Emotional responses to colors appear in a weaker pattern.	Partially confirmed for arousal dimension; judgmental shift rather than shrinkage	IV
		H. 10	Despite of the contextual effect of [H. 9], the pattern of emotional responses within colors is consistent.	Partially confirmed: positive linear correlation between Chroma level and arousal.	IV
		H. 11	Adjectives, as verbal stimuli, are little influenced by context effect caused by pictorial stimuli.	Confirmed.	IV

Table 57. Hypotheses of dissertation.

In sum, the entire contents of the dissertation are illustrated. Figure 69 shows that the review on emotion and color affectivity provided a framework of measuring emotional response to color. A series of four experiments was carried out. The hypotheses tested with each experiment are illustrated in detail the following Figure.

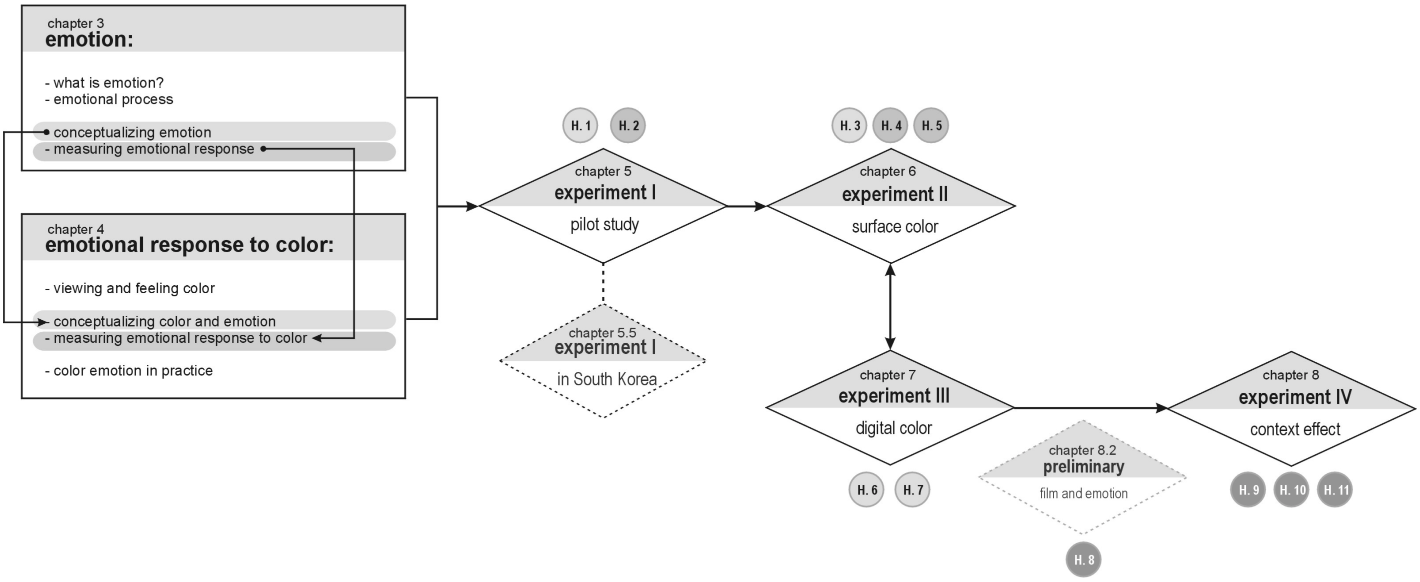


Figure 69. Overview of the dissertation.

8.3 FUTURE RESEARCH: EXTENSIONS AND APPLICATIONS

Resuming the empirical findings of this dissertation, it is expected that future research will extend or deepen the theme on color and emotion in terms of theory and methodology, mediated reference, stimulus context, and interdisciplinary studies. Respectively, related issues are discussed in the following four sections: quantifying qualitative substance (8.3.1), color preference (8.3.2), relativity of emotional judgment (8.3.3), and interdisciplinary research on color bridging theory and practice in 8.3.4.

8.3.1 Quantifying qualitative substance

Products aesthetically complex such as works of art and musical compositions cannot be ordered on linear dimensional perceptual continua. Supposing that they may be, nevertheless, ordered on affective continua, substances were assessed in terms of their affectivity.

Gellatly (2002) concentrates on two distinctions that are important in understanding any kind of visual perception, not least of which is the perception of color. The first is between ‘being responsive to variations along a physical stimulus dimension’ on one hand, and ‘conscious experience of the variations along that dimension’ on the other. In other words, between visual information processing and visual experience. The first distinction is particularly relevant to understand infant or animal vision by means of techniques such as habituation, preferential looking, or other behavioral or physiological discriminations, as discussed in terms of color match or color sensation in section 3.1. The second distinction is elaborated dealing with cognitive quantity, upon the notion of 'visual experience'. To extend this second distinction, color aesthetics and semantics were described in 3.2. Gellatly's argument distinguishes between 'seeing' and 'seeing as', and it is particularly relevant to determine whether or not there are any differences in the way adults of different cultures perceive color. Therefore, the process of quantifying the qualitative substance, such as 'color perception' and 'emotion', required a theoretical support to conceptualize the structures of both substances, as discussed in chapters 2 and 3.

Focusing on the 'affectivity of perceived color', emotional responses were judged in terms of valence, arousal, and dominance in a series of experiments. The SAM was used to assess emotional response to color, pictures, film-clips, and adjectives. Bradley et al. (1994) pointed out that SAM is an inexpensive method for quickly and easily assessing reports of affective response in many different kinds of context. SAM has been advocated by many recent studies and is frequently used to measure affectivity of various stimulus types, including life experience.

In the experiments, emotional responses to different stimulus modalities were quantified by means of SAM. For example, adjectives were assessed with SAM and the results were compared with the SAM ratings of colors. The intention was to provide a qualitative setting among different substances (i.e. color and product concept) and SAM made possible to order affectivities in terms of emotional profiles of two different substances. The SAM used in the experiments provided a reliable and internally consistent way of judging affectivity of colors on valence, arousal, and dominance.

Concerning the quantification of emotional response to color, it was not only a matter of measurement but also of defining color substance, since people perceive color subjectively, which differs from physically measured values. Thus, hue and tone categorization was applied for the color selection for Experiments II, III, and IV. In line with this, an increasing number of practical color studies refer to color systems, which concern the cognitive quantity of perceived color (i.e. NCS[9]).

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[9] [9] Natural Color System®©: Set up by Scandinavian Colour Institute, the NCS system starts with six elementary colours that are perceived by human beings as being "pure". The six elementary colors – white (W), black (S), yellow (Y), red (R), blue (B), and green (G) - correspond with the perception of color in our brain. The NCS notations describe the purely visual properties of the color: the visual amount of whiteness, blackness and chromaticness. The notions do not refer to any physical measurement of color attributes, such as the mixing of pigments or reflection curves etc (Silvestrini et al., 2002; NCS homepage: http://www.ncscolour.com)

Nevertheless, it is expected that further studies on color and emotion will develop new approaches to enrich the theoretical evidence of color affectivity.

8.3.2 Color preference

A review by Kaiser (1984) proposed isolating non-associative scales of color preference. Based on laboratory testing, this was widely accepted and promoted. It is also often used by marketing organizations for commercial purposes (Gage, 1995).

Adams et al. (1973) noted that blue is the most highly evaluated concept and the one that felt most familiar. More recently, Burda Advertising Center (1998) conducted a survey with more than 10,000 subjects in Germany. According to this report, 24.8% of the subjects chose 'Blau' (blue) as their favorite color.

In Experiments II, III, and IV in this dissertation, every subject was asked to write down his or her favorite color at the beginning. In cases in which more than one color terms was given, only first term was considered for the study.

From a total of 127 subjects, 45 (35.4%) answered 'Blau' (blue), 19 (15.0%) answered 'Grün' (green), and 24 (11.0%) answered 'Rot' (red). Figure 70 shows that 'Blau' (blue) was most frequently stated as the favorite color in all three experiments.

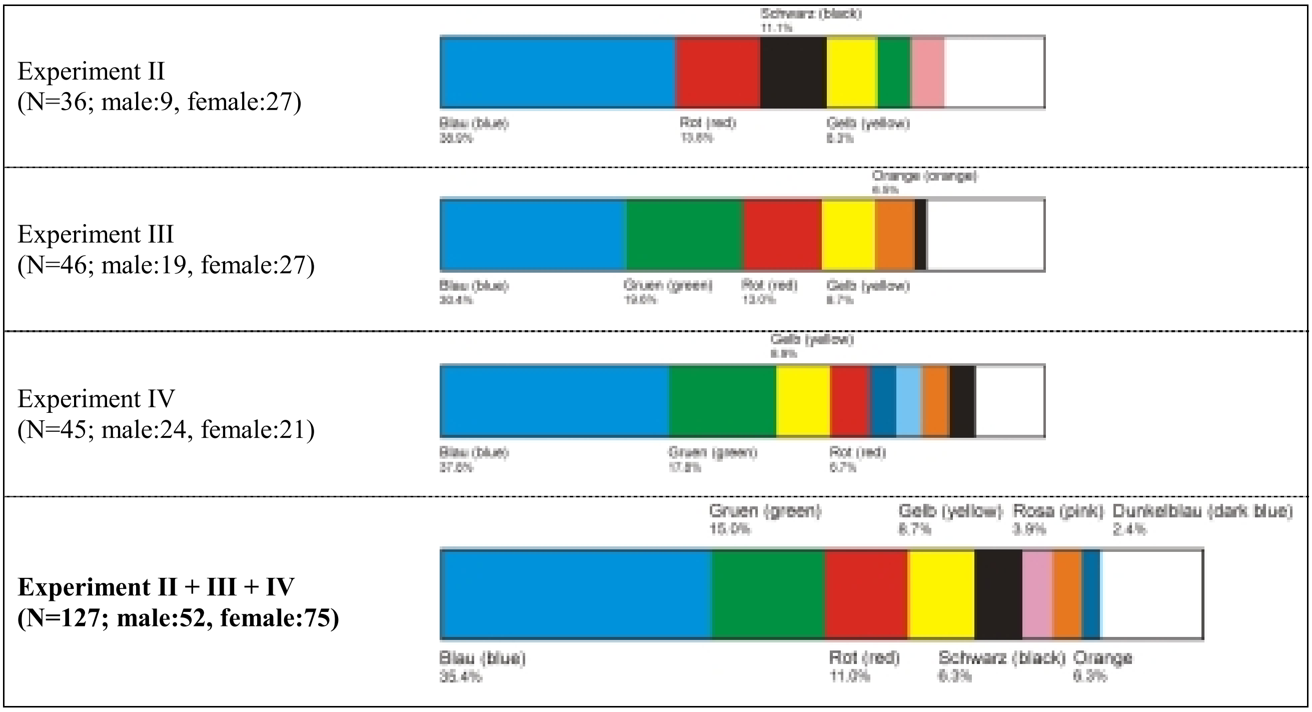

Figure 70. Favorite colors from three experiments

Moreover, both men and women followed the same order: Blau, Grün, Rot. Response differences within gender were also quite homogeneous, to the point that 34.6% of male subjects and 36.0% of female subjects replied ‘Blau’ as their favorite color.

Since the favorite color was asked for at the beginning of the experiments, in accordance with Hunt’s “mental color” theory (Hunt et al., 1937), it is predictable that the favorite color exerted an anchor effects on affective judgments in terms of “pleasantness”, which implies a positive (+) effects upon valence.

Investigations in color preferences have been mainly concerned with the colors people prefer, because such information is of great interest to companies. Also, since much of the work in ‘experimental aesthetics’ (Arnheim, 1956, p. 282) is based on the notion that the principal function of art is to please people, if a color elicits attractiveness, it is expected to be related with positive evaluation.

Color preferences evoke great interest and many studies have examined possible relations with demographic characteristics such as age (Terwogt et al., 2001), gender (Gelineau, 1981), ethnic groups or nationalities (Choungourian, 1968), personalities (Choungourian, 1972; Birren, 1973; Gelineau, 1981), and social behavior (i.e. life style) (Lüscher, 1971; BAC Burda Advertising Center, 1998).

• Limitation of color preference

Color preferences interact with social and personal factors (Garber et al., 2003). As explained by Arnheim (1956, p. 282), one difficulty in studying color preferences is the fact that a given color could provoke different reactions depending on its use. A color may be suitable for a man’s car but not necessarily for his toothbrush. When a person is asked about ‘favorite color’ during a survey, which in most cases tries to eliminate all the intervening factors, there is no certainty as to the extent in which the result could have some practical application. Garber et al. (2003) pointed out that people may say that they prefer blue to red. Nevertheless, red is successfully used by organizations and brands like Coca-Cola, McDonald’s, Colgate, KFC, and Marlboro, among others. It has been shown in section 4.5.1.1, that vivid red is one of the dominant colors used by many companies among those chosen by BusinessWeek (2005) as the world’s best.

In this respect, it is suggested for future studies on color preference to bind color to specific objects, instead of experimenting with colors ‘as such’, in order to control for this factor. By such a method, it should become possible to isolate some of the many motives that determine color preference.

8.3.3 Relativity of emotional judgment

It might be thought that an absolute standard could be found in an expert's judgment, or in the judgment of the person experiencing the emotion. But these judgments are also made in some context and may be dependent on that context. Therefore, no privileged context could serve as the unarguable standard for an absolute judgment (Russell et al., 1987). When new stimuli are presented to the individual, they are judged in relation to the respective frame of reference (Petzold et al., 2004).

Based on theoretical review, it was supposed in Experiment IV that the frame of reference for emotional judgment of color would shrink and that of film-clips would be enlarged. The intensity of semantic contents was the dimension that distinguished the level of emotional impact. In general, film-clips show greater emotional impact than colors. The assumption accorded with the assertion of Petzold et al (2004) that combining range effects and sequential dependencies, both the extremes of the range and the traces of previous stimuli constitute frames of reference.

Based on the SAM ratings corresponding to Experiment IV, some judgmental shifts were observed. The assessment of arousal dimension of colors, for example, became less excited in cross-modality stimulus context ('–' arousal), whereas film-clips elicited more positive ('+' arousal) than they had during the Preliminary Text. Although they were not statistically significant at α=.05 level, some judgmental shifts were indeed observed: colors were assessed more negative and more dominant, film-clips were assessed more excited, and adjectives were assessed weaker in arousal dimension.

Although color affectivity was compared within a complex degree of semantic contents (i.e. film-clips), the impact from the stimulus might have still been limited. Helson (1964, p.331) stated a question: "if affects can be ordered on unidimensional continua, does it follow that all pleasant affects and all unpleasant affects are alike?" The pleasantness of food differs from that of colors, and the unpleasantness of loud tones differs from that of losing money. It asserted that quantified results are not equivalent with qualitative substance. The basic idea of Experiment IV was to verify whether it was possible to quantify color affectivity among various substance qualities. Nevertheless, a greater contrast of semantic contents of stimuli was desired in order to observe a more significant context effect. Accordingly, future research is proposed to examine the relationship between the quality of semantic contrast of stimulus composition and the anchor effect in cross-modality stimulus context.

Moreover, the stimulus context could be extended in terms of modals of emotion elicitor. Shaver (1987) noted that, aside from these outcomes, studies of emotion knowledge should open up new avenues for research on social perception and memory for social events.

8.3.3.1 Extended multi componential stimulus context

One of the factors Rottenberg et al. (in press) pointed out in favor of the use of film-clips to elicit emotion is the fact that the stimulus content, presentation apparatus, and viewing conditions can all be tightly controlled with film-clips. The level of standardization provided by films is high, therefore allowing for the potential replication of effects across laboratories. Films share this high degree of standardization with other normative media such as slides (i.e. IAPS) and music.

In Experiment IV, moving images were chosen according to similar semantic contents of IAPS picture in order to induce similar emotional reactions. However, film-clips contained not only similar semantic topics but also different contents such as costumes, acquaintances of actor/actress, and historical features. In order to investigate the function of movement as such, static images could be extracted directly from the film-clips, so that the comparison may occur based on common variables.

Figure 71. Suggestion for future research: movement as a factor for emotional response.

8.3.4 An interdisciplinary research on color bridging theory and practice

"Color effect is highly interactive with the other visual features of which an object is composed, all of which must be integrated before an object or image can be recognized and its meaning to the viewer established" (Garber et al., 2003, p. 316).

Based on the theoretical approach, a successful interdisciplinary research may provide hands-on practical advice for designers. This is a domain that needs much exploration and integration into other aspects of visual research.

A large number of empirical studies offer scientific evidence of color and emotion; nevertheless, they are still seldom applied. Instead, qualitative works are often used to reach a color solution, in which the intuitive and creative ability of designers is crucial in the decision making process. Ideally, theoretical research should be the basis for designers, guiding and helping them to obtain objective insights into the people's emotional response to color.

Unfortunately, there is a lack of common communication platforms. How many designers would read journal articles in psychology? How many psychologists would publish their research in design magazines? This is a general issue concerning interdisciplinary research. Unfortunately, the disciplinary distance between psychology and design is particularly large.

In fact, given the lack of previous interdisciplinary studies, there are many research opportunities in these fields. Academic exchange between both curricula is suggested and further interdisciplinary studies are necessary in order to bring them closer. It is indeed in this regard that I covered perspectives from both disciplines for this dissertation.

Lastly, concerning the "experimenter effect", Mäder (2005) pointed out the "trade-off" between laboratory and field experiments; describing laboratory experiments as artificial environments that allow the experimenter to control or to manipulate the variables according to the requirements of the study and pointing out the difficulties to control disordering variables in field experiments. The result of field experiments is, however, much easier to apply to natural situations. The field experiments could be completed in terms of physical surroundings or mediated objects such as textiles or wallpaper, among others. Color, which interacts with the characteristics of the mediated object, may enhance the target emotion.

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- **Sources of the websites**

Coca Cola <http://www.cocacola.com>

Color Order Systems in Art and Science <http://www.colorsystem.com>

GE Color Express <http://www.gecolorxpress.com>

RAL Color system <http://www.ral.de>

Volkwagen <http://www.volkswagen.de>

- **Magazines**

BusinessWeek (2005) August

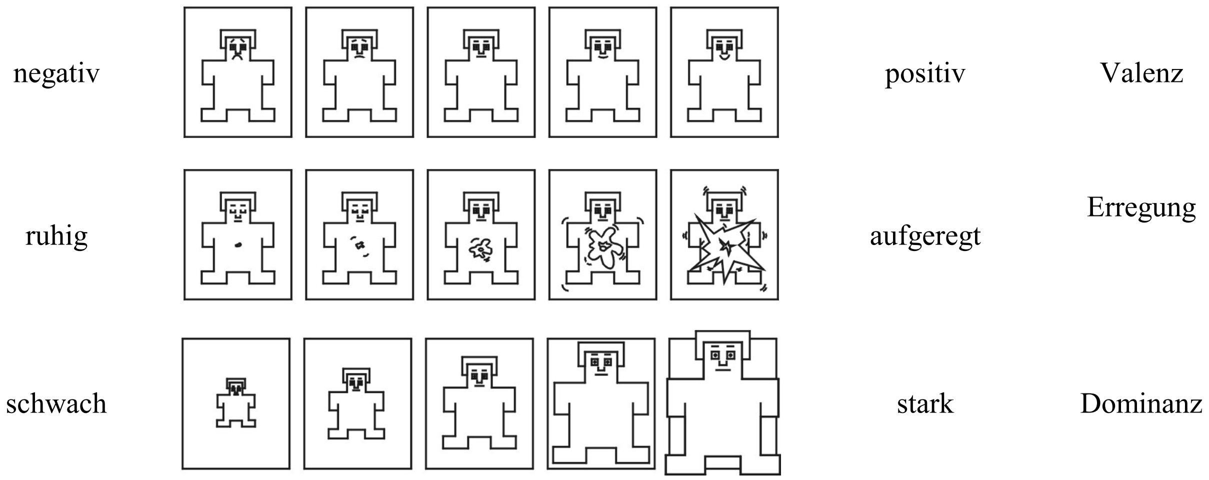
Monthly Design, (2006) February Vol. 332, Design House Inc. Seoul, ISSN 1227- 1160

Appendix A. Introduction, Experiment I

Vielen Dank für ihre Teilnahme an unserem Experiment.

Wir möchten mit dieser Studie untersuchen, wie Personen auf verschiedene Farben, Adjektive und Bilder reagieren.

In den nächsten 30 Minuten werden Sie unterschiedliche Darbietungen auf dem Bildschirm sehen. Ihre Aufgabe ist es, zu beurteilen, wie diese auf folgenden drei Dimensionen auf Sie wirken:



Wählen Sie jeweils mit der Maus die Stufe, die ihrer emotionalen Reaktion entspricht und bestätigen Sie mit der Leertaste.

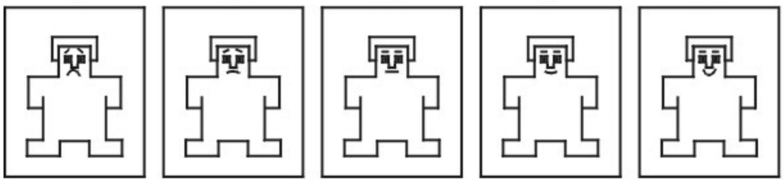
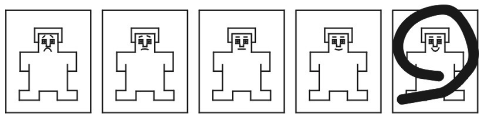
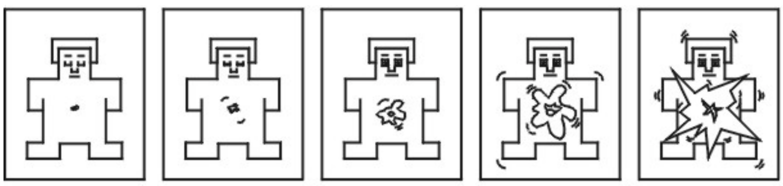
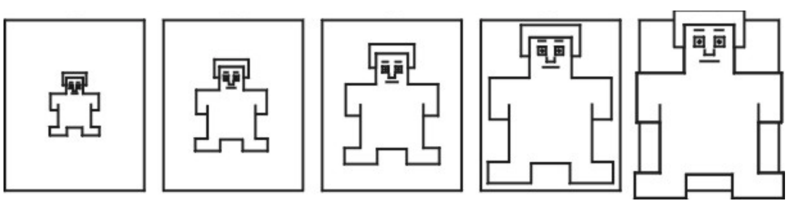
Es gibt keine richtigen oder falschen Antworten, ihr subjektiver Eindruck ist uns wichtig.

Nachdem Sie jedes Bild bewertet haben, folgt eine kurze Pause; dann geht es automatisch weiter.

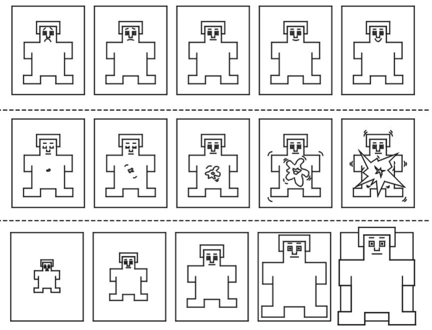
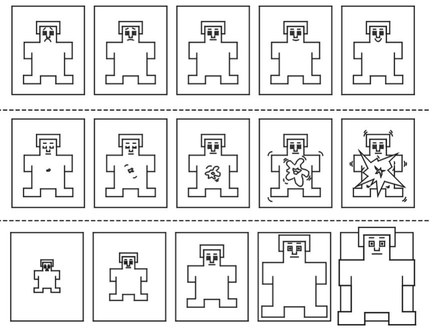
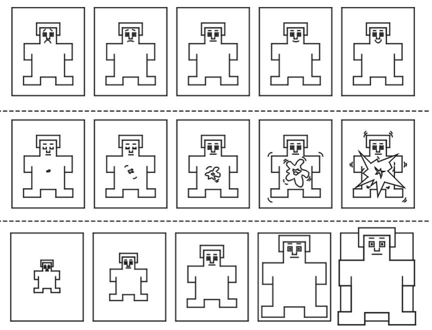
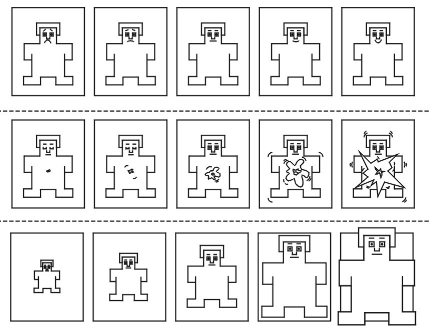
Zunächst werden Ihnen 5 Übungsdurchgänge präsentiert, dann erfolgt die eigentliche Datenerhebung.

Wenn Sie diese Anleitung gelesen haben und keine weiteren Fragen haben, starten Sie das Experiment mit der Leertaste.

Appendix B. Introduction, Experiment I in South Korea

실험제목	**SAM 모델을 이용한 색채와 감성에 대한 실험**
실험주관	만하임대학 심리학과, 독일
실험참가자 기재사항	• 참가번호: _______ • 연령: 만______세 • 성별: 남 / 여 • 좋아하는 색:_________________ • 저지방 음식에 대한 관심도 없다 / 별로없다 / 보통 / 있다 / 아주많다
SAM 모델 기초설명	실험 시작하기 전 SAM 모델에 대한 **지도 교사의 설명**을 잘 들어주시기 바랍니다. 최근 심리학 분야에서 감성평가에 널리 사용되고 있는 SAM 은 인간의 느낌, 감정 등의 정도를 측정하는 효과적인 방법으로 인정받고 있습니다. 주어진 자극(예:사진, 그림 등)에 대하여 • 첫째: (맨 좌측)부정적,불행, 슬픈 등 ↔ 긍정적,행복, 기쁜 등(맨 우측)  예를 들어, 주어진 사진이나 색채가 아주 긍정적/행복/기쁜 느낌일 경우  위의 그림과 같이 해당 모델을 선택해 주시기 바랍니다. • 둘째: (맨 좌측)차분한, 고요한 등↔ 흥분된, 감정이 고조된 등(맨 우측)  • 셋째: (맨 좌측)압도당한, 수동적인 등 ↔ 압도하는, 적극적인 등 (맨 우측) 

<table>
<tr><td>실험진행
구조</td><td colspan="2">실험은 총 4 부분으로 구성되어 있습니다.
• 단계 1: 4 장의 흑백 사진에 대한 감성을 평가합니다.
지도 교사의 설명에 따라 SAM 모델 활용 방법을 연습하는 단계입니다.
• 단계 2: 38 가지 색상에 대한 감성을 평가합니다.
• 단계 3: 13 가지 형용사에 대한 감성을 평가합니다.
• 단계 4: 4 장의 칼라 사진에 대한 감성을 평가합니다.

실험에 소요되는 시간은 총 20 여 분으로 예상합니다.</td></tr>
<tr><td rowspan="2">흑백사진 4 장</td><td>(아기 사진)
</td><td>(범죄사진)
</td></tr>
<tr><td>(바구니 사진)
</td><td>(점프 사진)
</td></tr>
</table>

SAM 모델을 활용한 감성 평가에 대한 이해가 되셨습니까?

그러면 페이지를 넘겨 주시기 바랍니다.

Since the experiment was a paper-pencil survey, each subject received additional sheets filled with SAM pictograms.

Appendix C. Means and standard deviations, Experiment I

(N = 48 , male: 10, female: 38)

type: (picture)		description	Affective judgment					
			valence		arousal		dominance	
	IAPS nr.	detail	**M**	*SD*	**M**	*SD*	**M**	*SD*
	1750	bunnies	4.660	*0.563*	2.958	*1.254*	3.042	*1.166*
		modified by equation 1*	8.319	*1.125*	4.917	*2.508*	5.083	*2.332*
	6230	aimed gun	1.354	*0.729*	4.604	*0.676*	4.542	*1.031*
		modified by equation 1*	1.708	*1.458*	8.208	*1.352*	8.083	*2.061*
	7175	lamp	2.894	*0.759*	1.458	*0.771*	1.729	*0.961*
		modified by equation 1*	4.787	*1.517*	1.917	*1.541*	2.458	*1.924*
	8030	skier	3.438	*1.319*	4.688	*0.468*	4.167	*0.808*
		modified by equation 1*	5.875	*2.639*	8.375	*0.937*	7.333	*1.616*
	2070	baby**	4.617	*0.610*	2.479	*1.010*	2.833	*1.294*
	5621	sky divers**	3.909	*1.030*	3.745	*1.052*	3.435	*0.935*
	6350	attack(with a nife) **	1.396	*0.736*	4.375	*0.703*	3.938	*1.119*
	7010	basket**	2.957	*0.698*	1.458	*0.798*	1.596	*0.825*

* {1, 2, 3, 4, 5}×2 -1 = {1, 3, 5, 7, 9}, modified to be compared with IAPS data
** presented achromatic

type: (word)	description		Affective judgment					
			valence		arousal		dominance	
	adjective	in English	**M**	*SD*	**M**	*SD*	**M**	*SD*
	laut**	loud	2.417	*0.942*	3.938	*0.976*	3.833	*0.996*
	langweilig**	boring	1.766	*0.840*	1.708	*1.010*	2.375	*1.160*
	hektisch**	hectic	1.872	*0.924*	4.277	*0.902*	3.957	*0.977*
	leicht*	light	4.000	*0.808*	2.167	*1.098*	2.625	*1.160*
	aktiv*	active	4.083	*0.647*	3.771	*0.928*	3.521	*0.875*
	dynamisch*	dynamic	3.979	*0.635*	3.688	*1.035*	3.479	*0.799*
	gesund*	healthy	4.404	*0.712*	2.625	*1.044*	3.500	*0.945*
	urban*	urban	2.813	*0.842*	2.542	*1.202*	2.396	*1.125*
	modern*	modern	3.771	*0.881*	2.771	*1.016*	3.063	*1.019*
	maechtig**	mighty, privileged	2.813	*0.842*	3.688	*0.971*	4.167	*1.059*
	bloed**	stupid	1.625	*0.640*	2.813	*1.232*	2.667	*1.209*
	gefährlich**	dangerous	1.938	*1.019*	4.313	*0.803*	4.104	*0.831*
	nahrhaft*	nutritious	3.574	*0.773*	2.479	*1.148*	2.729	*1.086*
	sportlich*	sportive	3.915	*0.952*	3.625	*0.937*	3.333	*0.953*
	spontan*	spontaneous	4.188	*0.704*	3.708	*1.129*	3.604	*0.917*
	spritzig*	zippy	3.854	*0.772*	3.542	*1.091*	3.333	*0.930*
	frisch*	fresh	4.146	*0.618*	3.063	*1.156*	3.167	*0.975*
	innovativ*	innovative	4.022	*0.683*	3.458	*0.988*	3.667	*0.859*
	feminin*	feminine	3.894	*0.787*	2.854	*1.111*	3.354	*1.101*

* extracted from semantic network
** added to counter balance

type: (color)	description				Affective judgment					
					valence		arousal		dominance	
	naming category	L	c	h	**M**	*SD*	**M**	*SD*	**M**	*SD*
	red	30	20	40	2.583	*1.028*	2.146	*0.850*	2.792	*0.849*
	red	40	30	40	3.125	*0.841*	2.500	*1.011*	2.792	*0.849*
	red	40	50	40	3.500	*0.851*	3.396	*1.198*	3.604	*1.005*
	red	40	67	40	3.426	*1.175*	4.000	*1.220*	4.229	*1.036*
	red	50	20	40	2.875	*0.981*	2.208	*0.824*	2.375	*0.841*
	red	50	40	40	3.255	*0.846*	2.688	*1.055*	3.021	*0.989*
	red	60	30	40	3.106	*1.068*	2.563	*0.943*	2.792	*0.922*
	red	70	20	40	3.167	*1.078*	2.333	*0.996*	1.729	*0.844*
	orange	50	20	65	2.021	*0.863*	2.125	*0.866*	2.333	*0.859*
	brown	30	20	80	2.085	*1.080*	2.188	*0.982*	2.792	*1.091*
	yellow	40	30	85	2.000	*0.875*	2.042	*0.824*	2.500	*0.923*
	yellow	50	40	85	2.283	*0.958*	2.277	*0.852*	2.532	*0.856*
	yellow	60	30	85	2.313	*0.829*	1.917	*0.767*	2.083	*0.846*
	yellow	70	20	85	2.396	*0.893*	2.313	*0.971*	1.750	*0.812*
	yellow	80	40	85	3.313	*1.075*	2.479	*1.031*	2.479	*1.010*
	yellow	80	60	85	3.875	*1.024*	3.208	*1.051*	3.250	*1.158*
	yellow	80	85	85	4.000	*1.167*	3.750	*1.345*	3.896	*1.016*
	green	30	20	160	3.063	*1.080*	2.354	*1.062*	2.375	*0.890*
	green	40	30	160	3.667	*0.930*	3.104	*1.077*	3.458	*0.922*
	green	50	60	160	2.826	*0.996*	2.313	*0.854*	2.957	*0.932*
	green	50	20	160	3.292	*0.944*	2.333	*0.975*	3.000	*1.072*
	green	50	40	160	2.958	*0.967*	2.063	*0.755*	2.521	*0.772*
	green	60	30	160	3.583	*0.964*	2.708	*0.922*	3.000	*1.011*
	green	70	20	160	3.191	*1.014*	2.500	*1.011*	2.729	*1.005*
	blue	30	20	270	3.125	*1.123*	2.333	*0.930*	2.854	*0.922*
	blue	30	45	270	3.894	*0.914*	2.917	*1.007*	3.458	*1.031*
	blue	40	30	270	3.958	*0.743*	2.667	*1.059*	3.188	*1.024*
	blue	50	20	270	3.438	*0.897*	2.396	*0.869*	2.583	*0.794*
	blue	50	40	270	3.938	*0.861*	3.125	*1.160*	3.542	*0.922*
	blue	60	30	270	3.854	*0.922*	2.583	*1.088*	2.792	*0.967*
	blue	70	20	270	3.681	*0.935*	2.396	*1.047*	2.604	*0.962*
	violet	30	20	320	3.370	*0.878*	2.313	*1.014*	2.313	*0.971*
	violet	30	37	320	2.938	*1.019*	2.542	*1.031*	3.000	*0.945*
	violet	40	30	320	3.458	*0.988*	2.917	*1.108*	3.375	*0.981*
	violet	50	20	320	3.250	*0.812*	2.688	*1.055*	2.938	*0.885*
	violet	50	40	320	3.106	*1.005*	2.333	*0.883*	2.583	*0.871*
	violet	60	30	320	3.340	*0.962*	2.833	*1.173*	3.125	*1.003*
	violet	70	20	320	3.354	*1.062*	2.625	*0.981*	2.625	*0.937*
	black	0	0	360	1.813	*0.762*	2.271	*0.939*	2.729	*1.144*
	gray	30	0	360	2.333	*1.018*	1.958	*1.010*	2.042	*0.922*
	gray	50	0	360	2.604	*1.300*	3.167	*1.449*	3.917	*1.350*
	gray	70	0	360	2.089	*1.041*	1.854	*0.714*	2.128	*0.875*
	white	100	0	360	2.792	*1.166*	3.104	*1.505*	3.438	*1.486*

Appendix D. Means and standard deviations, Experiment I in South Korea

(N = 17, male:7 , female:10)

type: (picture)	IAPS nr.	description detail	valence M	valence SD	arousal M	arousal SD	dominance M	dominance SD
	1750	bunnies	4.353	*0.606*	2.706	*1.160*	2.941	*0.827*
		modified by equation 1*	7.706	*1.213*	4.412	*2.320*	4.882	*1.654*
	6230	aimed gun	1.824	*0.636*	4.353	*1.169*	3.118	*1.728*
		modified by equation 1*	2.647	*1.272*	7.706	*2.339*	5.235	*3.456*
	7175	lamp	3.118	*0.781*	1.882	*0.781*	2.471	*0.943*
		modified by equation 1*	5.235	*1.562*	2.765	*1.562*	3.941	*1.886*
	8030	skier	4.000	*0.935*	4.235	*0.831*	3.353	*1.367*
		modified by equation 1*	7.000	*1.871*	7.471	*1.663*	5.706	*2.733*
	2070	baby**	4.235	*0.752*	2.882	*1.166*	3.647	*0.862*
	5621	sky divers**	3.353	*1.222*	3.353	*1.455*	3.176	*1.590*
	6350	attack(with a nife) **	1.353	*0.493*	4.471	*0.514*	4.059	*1.391*
	7010	basket**	3.294	*1.213*	2.706	*1.611*	2.706	*1.404*

* {1, 2, 3, 4, 5}×2 -1 = {1, 3, 5, 7, 9}, modified to be compared with IAPS data
** presented achromatic

type: (word)	adjective	description in English	valence M	valence SD	arousal M	arousal SD	dominance M	dominance SD
	시끄러운**	loud	2.059	*1.088*	4.412	*1.064*	3.471	*1.231*
	지루한**	boring	1.588	*0.795*	2.824	*1.425*	2.824	*1.334*
	호들갑스러운**	hectic	2.824	*1.334*	4.235	*0.664*	3.353	*1.498*
	가벼운*	light	3.765	*0.831*	2.647	*1.272*	2.471	*1.179*
	활동적인*	active	4.471	*0.717*	4.412	*0.795*	4.118	*1.219*
	역동적인*	dynamic	3.824	*1.185*	3.882	*1.166*	4.176	*1.074*
	건강한*	healthy	4.294	*0.686*	3.588	*1.004*	3.706	*1.047*
	도회적인*	urban	3.059	*1.088*	3.706	*1.312*	3.235	*1.437*
	모던한*	modern	3.059	*0.966*	3.235	*1.147*	2.941	*0.966*
	권력의**	mighty, privileged	3.235	*1.033*	4.235	*0.831*	3.941	*1.298*
	한심한**	stupid	1.824	*0.809*	3.647	*1.320*	2.706	*1.359*
	위험한**	dangerous	1.529	*0.514*	4.647	*0.606*	2.529	*1.700*
	영양가있는*	nutritious	3.765	*0.752*	3.176	*0.951*	3.176	*0.809*
	스포티한*	sportive	4.529	*0.624*	3.824	*1.131*	3.824	*0.951*
	자연스러운*	spontaneous	3.882	*0.781*	2.176	*1.131*	3.000	*0.935*
	활기찬*	zippy	4.588	*0.507*	4.000	*0.866*	4.000	*0.935*
	신선한*	fresh	4.353	*0.702*	3.235	*1.147*	3.412	*0.939*
	혁신적인*	innovative	3.706	*0.920*	3.588	*1.064*	3.471	*1.463*
	여성적인*	feminine	3.529	*0.943*	2.882	*1.111*	2.941	*1.029*

* extracted from semantic network
** added to counter balance

type: (color)	description				Affective judgment					
					valence		arousal		dominance	
	naming category	L	c	h	**M**	*SD*	**M**	*SD*	**M**	*SD*
	red	30	20	40	2.588	*0.939*	3.294	*0.772*	3.176	*1.185*
	red	40	30	40	2.176	*0.636*	2.824	*0.883*	2.765	*0.752*
	red	40	50	40	3.000	*1.225*	4.118	*0.857*	3.471	*1.007*
	red	40	67	40	3.118	*1.364*	4.294	*0.985*	3.588	*1.417*
	red	50	20	40	2.353	*0.606*	2.471	*1.068*	3.176	*0.809*
	red	50	40	40	3.235	*1.033*	3.471	*0.943*	3.235	*0.970*
	red	60	30	40	3.412	*1.064*	3.059	*1.144*	3.059	*0.899*
	red	70	20	40	3.412	*0.712*	3.059	*1.144*	2.353	*0.702*
	orange	50	20	65	2.176	*0.636*	2.118	*0.928*	3.000	*0.866*
	brown	30	20	80	2.059	*0.899*	2.118	*0.928*	2.529	*1.068*
	yellow	40	30	85	2.824	*0.883*	2.353	*0.996*	2.941	*0.899*
	yellow	50	40	85	2.294	*0.686*	2.529	*0.800*	3.118	*0.781*
	yellow	60	30	85	2.824	*0.728*	2.000	*0.866*	2.647	*0.862*
	yellow	70	20	85	2.765	*0.831*	3.118	*0.928*	2.706	*0.920*
	yellow	80	40	85	3.588	*0.795*	3.353	*1.057*	3.294	*1.213*
	yellow	80	60	85	3.882	*0.857*	3.471	*1.068*	3.235	*1.147*
	yellow	80	85	85	3.529	*1.125*	3.235	*1.522*	3.529	*1.281*
	green	30	20	160	3.118	*0.857*	2.176	*0.951*	3.059	*1.197*
	green	40	30	160	3.471	*0.943*	2.588	*1.064*	3.059	*1.029*
	green	50	60	160	2.118	*0.781*	2.059	*1.029*	2.529	*1.007*
	green	50	20	160	3.059	*0.899*	2.000	*0.707*	2.647	*0.606*
	green	50	40	160	2.529	*0.800*	2.000	*0.612*	2.294	*0.686*
	green	60	30	160	3.235	*0.752*	2.294	*0.920*	2.765	*0.664*
	green	70	20	160	3.412	*0.712*	2.706	*0.920*	2.765	*0.903*
	blue	30	20	270	2.529	*0.874*	2.706	*1.047*	2.647	*0.862*
	blue	30	45	270	3.353	*0.931*	3.353	*1.115*	3.471	*1.231*
	blue	40	30	270	3.765	*1.033*	3.000	*0.935*	3.353	*0.931*
	blue	50	20	270	3.471	*0.874*	2.588	*1.064*	2.941	*0.966*
	blue	50	40	270	3.647	*0.931*	3.176	*1.074*	3.294	*0.772*
	blue	60	30	270	3.882	*0.781*	2.765	*0.831*	3.471	*0.717*
	blue	70	20	270	3.647	*1.272*	2.412	*1.064*	3.059	*0.899*
	violet	30	20	320	3.235	*0.903*	2.765	*0.970*	3.176	*1.015*
	violet	30	37	320	1.824	*0.809*	2.647	*1.115*	2.765	*1.033*
	violet	40	30	320	2.588	*1.064*	3.118	*1.054*	2.882	*0.993*
	violet	50	20	320	2.588	*0.795*	3.059	*0.966*	2.882	*0.993*
	violet	50	40	320	2.353	*0.702*	2.412	*0.795*	2.882	*0.928*
	violet	60	30	320	3.176	*0.951*	3.000	*0.791*	3.471	*1.007*
	violet	70	20	320	3.353	*1.115*	2.941	*1.029*	3.294	*0.849*
	black	0	0	360	1.765	*0.831*	2.059	*0.966*	2.529	*1.231*
	gray	30	0	360	2.588	*0.870*	1.882	*0.928*	2.471	*1.125*
	gray	50	0	360	1.824	*0.951*	2.000	*1.414*	3.118	*1.616*
	gray	70	0	360	2.118	*1.111*	1.941	*0.748*	2.059	*0.966*
	white	100	0	360	3.588	*1.064*	3.294	*1.448*	2.765	*1.300*

Appendix E. Paper-pencil survey form, Experiment II

FARBE ALS REIZ FÜR EMOTIONEN

Anleitung

Wir freuen uns, dass Sie heute an unserer Untersuchung teilnehmen. In dieser Untersuchung wollen wir herausfinden, ob Farben Emotionen auslösen, wie Bilder das tun.
Für ca. 30 Min, werden Ihnen 8 Bilder, 19 Wörter und 42 Farben gezeigt und Sie werden danach gefragt, wie Sie sich fühlen. Es gibt keine richtigen oder falschen Antworten.

Nun möchten wir Ihnen Details erklären. (Sie werden jetzt ein Blatt erhalten.)
Auf dem Blatt finden Sie 3 Reihen von 5 Piktogrammen. Bitte legen Sie die Seite neben sich und lesen Sie diese Anleitung weiter.

Nach einem Bild / Wort / Farbbogen werden Sie gebeten, 3 Bewertungen anzugeben. Diese Piktogramme illustrieren 3 unterschiedliche Aspekte der Gefühle: **[Unglücklich vs. Glücklich]**, **[Ruhig vs. Aufgeregt]**, und **[Kontrolliert vs. Kontrollierend].**

Sie sehen, dass die Piktogramme in jeder Reihe entlang der Skala ihren Inhalt ändern.

<u>Die 1. Reihe:</u> die obere Reihe ist die „Unglücklich-Glücklich“ Skala, die von Unzufriedenheit bis Lächeln reicht. Am Rand (rechts) dieser Reihe fühlen Sie sich zufrieden, glücklich, erfreut, hoffnungsvoll, ausgeglichen entspannt, usw. Wenn Sie sich vollständig glücklich fühlen, während Sie ein Bild, ein Wort oder einen Farbbogen anschauen, können Sie das letzte Piktogramm (rechts) ankreuzen. Das andere Ende (links) ist dafür, wenn Sie sich vollkommen unzufrieden, unglücklich, genervt, verzweifelt, schwermüg oder gelangweilt fühlen. Wenn Sie sich neutral fühlen, weder glücklich noch unglücklich, kreuzen Sie bitte das Piktogramm in der Mitte an.

<u>Die 2. Reihe:</u> die in der Mitte dargestellte Reihe ist der zweite Aspekt des Gefühls, die Dimension Ruhig-Aufgeregt. Wenn Sie Sich völlig rasend, erregt, zappelig, hellwach, aufgeregt oder stimuliert fühlen, kreuzen Sie bitte das Piktogramm am Rand (rechts) an. Im Gegensatz dazu steht das Piktogramm am anderen Ende (links) für die Gefühle, träge, enerregt, lahm, schläfrig, ruhig oder entspannt zu sein. Wenn Sie Sich weder aufgeregt noch ruhig fühlen, kreuzen Sie bitte das Piktogramm in der Mitte an.

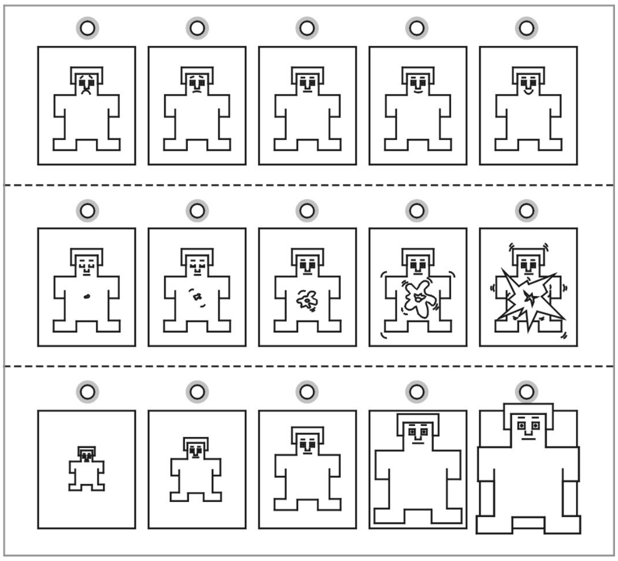
<u>Die 3. Reihe:</u> die letzte Reihe, die Sie bewerten werden, ist die Skala der Gefühle von Kontrolliert-Kontrollierend. Das letzte Piktogramm (rechts) ist dafür, wenn Sie sich ganz dominant, kontrollierend, einflussreich, autonom oder wichtig fühlen. Wenn Sie sich submissiv, kontrolliert, beeinflusst, geführt, ehrfürchtig oder versorgt fühlen, kreuzen Sie bitte das erste Piktogramm (links) an. Auch hier können Sie das Piktogramm in der Mitte ankreuzen, wenn Sie sich weder kontrollierend noch kontrolliert fühlen.

* * *

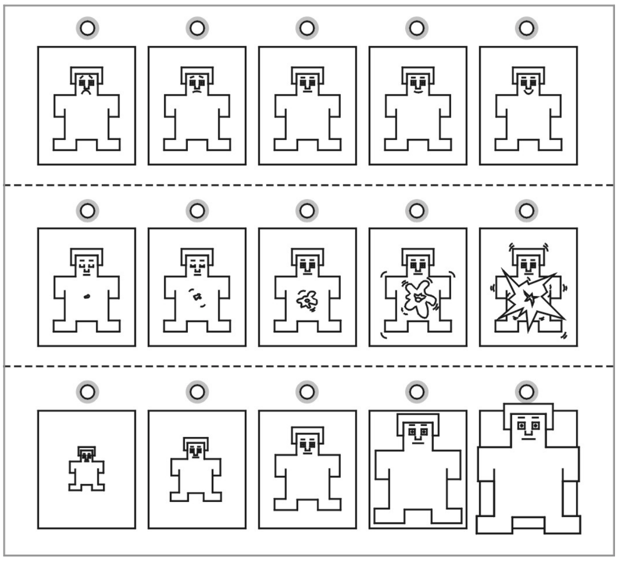
Wenn Sie bereit Sind, werden Ihnen 4 Bilder gezeigt.

Bitte beurteilen Sie Ihre Gefühle dazu.

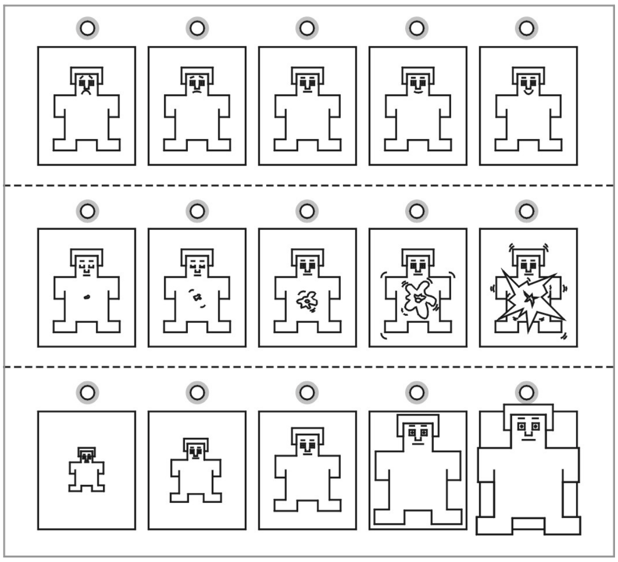
ID: ______________________



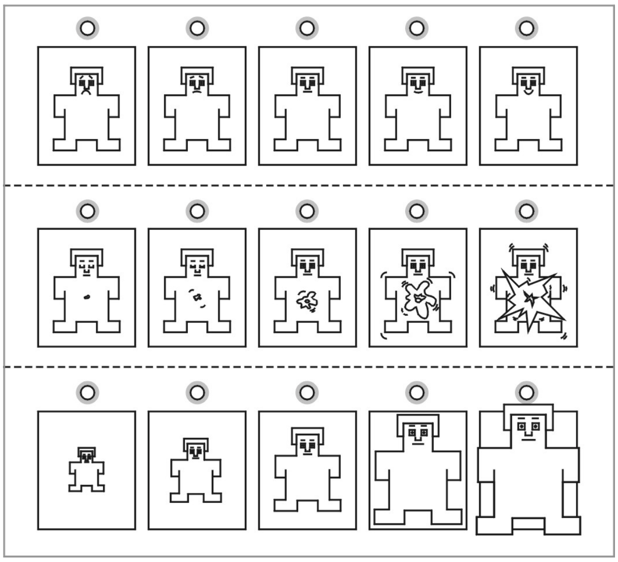
ID: ______________________



ID: ______________________



ID: ______________________



Was ist Ihre Lieblingsfarbe?

____

During Experiment II enough SAM pictograms were provided to assess all the stimuli. The pictograms were presented in the same size.

Appendix F. Means and standard deviations, Experiment II

(N= 36, male= 9, female= 27)

type: (picture)	description		Affective judgment					
			valence		arousal		dominance	
	IAPS nr.	detail	**M**	*SD*	**M**	*SD*	**M**	*SD*
	1750	bunnies	4.444	*0.773*	2.861	*1.246*	3.444	*0.939*
		modified by equation 1*	7.889	*1.545*	4.722	*2.491*	5.889	*1.879*
	6230	aimed gun	1.667	*0.956*	4.528	*0.810*	1.722	*1.085*
		modified by equation 1*	2.333	*1.912*	8.056	*1.620*	2.444	*2.171*
	7175	lamp	3.083	*1.228*	1.806	*0.951*	3.111	*1.141*
		modified by equation 1*	5.167	*2.455*	2.611	*1.902*	5.222	*2.282*
	8030	skier	3.250	*1.296*	4.333	*0.793*	2.750	*1.442*
		modified by equation 1*	5.500	*2.591*	7.667	*1.586*	4.500	*2.883*
	2070	baby**	4.528	*0.609*	2.750	*1.317*	3.583	*0.806*
	5621	sky divers**	3.861	*1.018*	3.861	*1.199*	3.028	*1.108*
	6350	attack(with a knife) **	1.861	*0.833*	4.389	*0.599*	2.222	*1.198*
	7010	basket**	2.806	*0.822*	1.833	*0.811*	3.222	*0.898*

* {1, 2, 3, 4, 5}×2 -1 = {1, 3, 5, 7, 9}, modified to be compared with IAPS data
** presented achromatic

type: (word)	description		Affective judgment					
			valence		arousal		dominance	
	adjective	in English	**M**	*SD*	**M**	*SD*	**M**	*SD*
	laut**	loud	2.361	*0.867*	3.972	*0.736*	2.667	*1.242*
	langweilig**	boring	2.028	*0.736*	1.806	*1.167*	2.833	*0.971*
	hektisch**	hectic	2.000	*0.926*	4.194	*0.951*	2.389	*0.994*
	leicht*	light	4.333	*0.756*	2.278	*1.059*	3.917	*1.131*
	aktiv*	active	4.278	*0.701*	3.667	*1.014*	4.111	*0.820*
	dynamisch*	dynamic	4.083	*0.692*	3.722	*0.944*	3.833	*1.134*
	gesund*	healthy	4.611	*0.645*	2.472	*1.183*	3.694	*1.064*
	urban*	urban	3.250	*1.025*	3.000	*1.352*	2.944	*0.984*
	modern*	modern	3.528	*0.774*	2.861	*0.961*	3.139	*0.931*
	maechtig**	mighty, privileged	3.222	*1.017*	3.556	*0.969*	3.889	*1.430*
	bloed**	stupid	2.194	*1.117*	2.667	*0.926*	2.778	*1.017*
	gefährlich**	dangerous	2.361	*1.099*	4.278	*0.741*	2.528	*1.298*
	nahrhaft*	nutritious	3.556	*0.877*	2.417	*1.025*	3.111	*0.708*
	sportlich*	sportive	3.583	*1.052*	4.333	*0.756*	2.278	*1.059*
	spontan*	spontaneous	4.167	*1.000*	3.806	*0.980*	3.583	*1.052*
	spritzig*	zippy	4.000	*0.894*	3.583	*1.079*	3.444	*0.809*
	frisch*	fresh	4.306	*0.710*	3.028	*0.941*	3.500	*0.737*
	innovativ*	innovative	4.139	*0.798*	3.250	*0.806*	3.583	*0.996*
	feminin*	feminine	4.083	*0.874*	2.944	*1.094*	3.389	*1.128*

* extracted from semantic network
** added to counter balance

type: (color)	description			Affective judgment					
				valence		arousal		dominance	
naming category	L	c	h	**M**	*SD*	**M**	*SD*	**M**	*SD*
dark red	30	30	30	2.778	*1.098*	2.694	*1.009*	3.028	*0.774*
deep red	30	45	30	3.889	*0.820*	3.139	*1.099*	3.528	*0.941*
vivid red	40	60	30	4.056	*0.893*	4.083	*0.874*	3.778	*1.198*
brilliant red	50	40	30	3.056	*0.826*	2.667	*1.121*	2.972	*0.910*
light red	70	30	30	3.028	*1.230*	2.611	*1.178*	2.889	*1.166*
dark yellow	60	40	80	2.472	*1.134*	2.278	*0.974*	2.806	*0.920*
deep yellow	60	70	80	2.556	*0.939*	2.917	*1.079*	2.639	*0.961*
vivid yellow	80	90	80	4.333	*0.986*	3.694	*1.215*	3.917	*1.052*
brilliant yellow	80	60	80	4.139	*0.931*	3.472	*1.055*	3.639	*1.018*
light yellow	80	40	80	3.472	*0.910*	2.389	*1.022*	3.056	*0.893*
dark green	30	30	160	3.806	*0.786*	2.667	*0.986*	3.444	*0.969*
deep green	40	45	160	3.833	*0.941*	3.028	*1.055*	3.556	*1.081*
vivid green	50	60	160	3.583	*1.025*	3.389	*1.022*	3.667	*0.828*
brilliant green	40	40	160	3.444	*0.909*	2.972	*1.055*	3.194	*0.889*
light green	70	20	160	3.111	*0.979*	2.278	*0.974*	2.778	*0.929*
dark blue	30	20	260	3.472	*1.108*	2.389	*1.103*	3.250	*1.105*
deep blue	40	30	260	3.639	*0.961*	2.444	*1.107*	3.389	*0.903*
vivid blue	40	45	260	4.111	*0.950*	3.444	*1.229*	3.944	*0.791*
brilliant blue	60	35	260	4.139	*0.762*	2.917	*1.180*	3.694	*0.920*
light blue	70	25	260	3.778	*1.098*	2.667	*1.014*	3.444	*0.909*
dark violet	20	25	320	3.417	*1.156*	2.889	*1.116*	3.583	*0.967*
deep violet	30	35	320	3.500	*1.056*	3.472	*0.878*	3.222	*1.124*
vivid violet	40	40	320	3.389	*1.337*	3.389	*1.022*	3.056	*1.040*
brilliant violet	50	30	320	3.444	*1.132*	3.167	*1.183*	3.222	*0.898*
light violet	70	20	320	3.528	*1.207*	3.000	*1.014*	3.028	*1.082*
dark gray	30	0	--	2.167	*1.028*	2.500	*1.056*	2.667	*1.195*
medium gray	50	0	--	2.167	*0.910*	2.361	*1.099*	2.611	*1.022*
light gray	70	0	--	2.444	*0.909*	2.028	*0.878*	2.944	*0.893*
dark warm gray	30	10	80	2.056	*0.893*	2.306	*0.822*	2.528	*0.845*
medium warm gray	50	10	80	2.139	*1.018*	2.222	*0.959*	2.472	*1.082*
light warm gray	70	10	80	2.111	*0.854*	2.111	*0.919*	2.500	*0.941*
dark cool gray	30	10	260	2.611	*0.838*	2.417	*0.937*	2.722	*1.059*
medium cool gray	50	10	260	2.694	*0.822*	2.250	*0.906*	3.083	*0.604*
light cool gray	70	10	260	3.222	*0.898*	1.944	*0.924*	3.056	*1.013*
white	100	0	--	3.333	*0.956*	2.611	*1.202*	3.472	*0.941*
black	0	0	--	2.472	*1.134*	2.611	*1.271*	2.889	*1.304*
gold	--	--	--	3.472	*1.230*	2.889	*1.116*	3.222	*1.098*
silver	--	--	--	3.083	*0.996*	2.722	*1.162*	3.194	*0.889*

Appendix G.Introduction, Experiment III

Digitalfarbe und Emotion

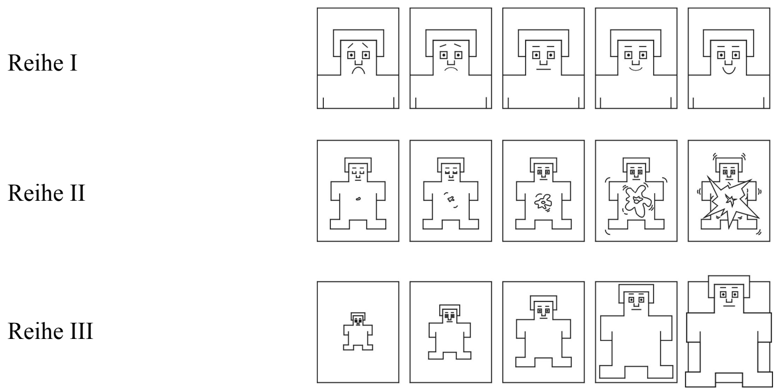
Allgemeine Psychologie, Universität Mannheim

• Ihre individuelle Kennung: __ __ __ • Geschlecht: ___ männlich ___ weiblich • Alter: ______ • Beruf: _________________ • Was ist Ihre Lieblingsfarbe? _____________________________

Wir danken Ihnen, dass Sie heute gekommen sind und freuen uns über Ihre Teilnahme an diesem Experiment. Im Rahmen dieser Studie sind wir daran interessiert, wie Menschen auf Farben reagieren.

In diesem Experiment werden Sie Farben sehen, die auf dem Bildschirm vor Ihnen dargestellt werden.

Bitte beurteilen Sie jede Farbe in Hinblick darauf, **wie Sie sich fühlen**, wenn Sie sie betrachten. Es gibt keine richtigen oder falschen Antworten, antworten Sie bitte ehrlich, nur Ihrem Gefühl entsprechend.
Wir beschreiben jetzt die Skalen, auf denen Sie Ihre Antworte abgeben.
Sie sehen 3 Reihen bestehend aus jeweils 5 Bilder (Abbildung 1).



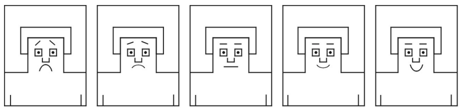
(Abbildung 1. SAM 3 Reihen)

Jede dieser Reihen ist entlang eines Kontinuums angeordnet. Sie werden diese Bilder verwenden, um zu beurteilen, wie Sie sich gefühlt haben, während Sie jede einzelne Farbe betrachtet haben.

Beurteilen Sie bei jeder Farbe, die Sie betrachten werden, alle drei Reihen.
Sie sehen, dass sich jedes Bild entlang der Skala verändert.

Die erste Reihe ist die „unglücklich – glücklich"- Skala, welche sich von einem trübsinnigen Gesichtsausdruck bis zu einem Lächeln hin verändert (Abbildung 2). An dem einen Extrem der glücklich-unglücklich- Skala haben Sie sich glücklich, erfreut, zufrieden, hoffnungsvoll gefühlt. Wenn Sie sich komplett glücklich gefühlt haben, während Sie die Farbe betrachtet haben, können Sie dies ausdrücken, in dem Sie das Bild ganz **rechts** anklicken. Das andere Ende der Skala steht für den Fall, dass Sie sich vollkommen unglücklich, genervt, unbefriedigt, melancholisch , verzweifelt, gelangweilt gefühlt haben, während Sie den Reiz betrachtet haben. Wenn Sie sich vollkommen unglücklich gefühlt haben, können Sie dies durch Auswahl das Bild ganz **links** ausdrücken. Die Bilder ermöglichen auch dazwischen liegende Emotionen zu beschreiben, indem Sie eine der anderen Bilder anklicken. Wenn Sie sich vollständig neutral gefühlt haben, weder glücklich noch unglücklich, klicken Sie das Bild in der Mitte an.

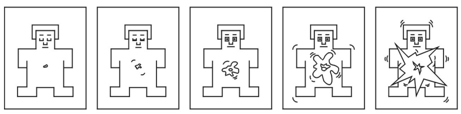
Reihe I



(Abbildung 2. 5 Bilder der „unglücklich – glücklich"- Skala)

Die zweite Reihe ist die „ruhig – aufgeregt"- Skala (Abbildung 3).
Auf der einen Seite, am einen Extrem der Skala haben Sie sich stimuliert, aufgeregt, nervös, rasend, hellwach, aktiviert gefühlt. Wenn Sie sich voll und ganz erregt gefühlt haben, während Sie die Farbe betrachtet haben, wählen Sie bitte das Bild ganz **rechts** aus. Auf der anderen Seite, am anderen Ende der Skala, haben Sie sich vollkommen entspannt, ruhig, träge, gelangweilt, schläfrig oder unaufmerksam gefühlt. Sie können ausdrücken, dass Sie sich komplett ruhig gefühlt haben, indem Sie das Bild ganz **links** anklicken. Wenn Sie sich vollständig neutral gefühlt haben, also weder aufgeregt noch ruhig, während Sie die Farbe betrachtet haben, wählen Sie das Bild in der Mitte aus.

Reihe II

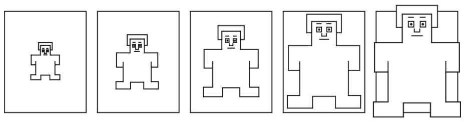


(Abbildung 3. 5 Bilder der „ruhig – aufgeregt"- Skala)

Die letzte Reihe ist die „kontrolliert – kontrollierend“- Skala (Abbildung 4).

An dem einen Ende der Skala haben Sie das Gefühl, die Situation unter Kontrolle zu haben, fühlen sich einflussreich, wichtig, dominant und autonom. Sie können verdeutlichen, dass Sie sich so gefühlt haben, indem Sie das Bild ganz **rechts** auswählen. Am anderen Ende der Skala fühlen Sie sich absolut kontrolliert, beeinflusst, versorgt, eingeschüchtert**,** submissiv, fremd gesteuert. Bitte veranschaulichen Sie, dass Sie sich kontrolliert fühlen, indem Sie das Bild **links** anklicken. Bitte beachten Sie, dass das Bild groß ist, wenn ***Sie*** sich wichtig und einflussreich fühlen und sehr klein sofern ***Sie*** sich kontrolliert und fremd gesteuert fühlen. Wenn Sie sich weder kontrolliert noch kontrollierend fühlen, sollten Sie das Bild in der Mitte anklicken.

Reihe III



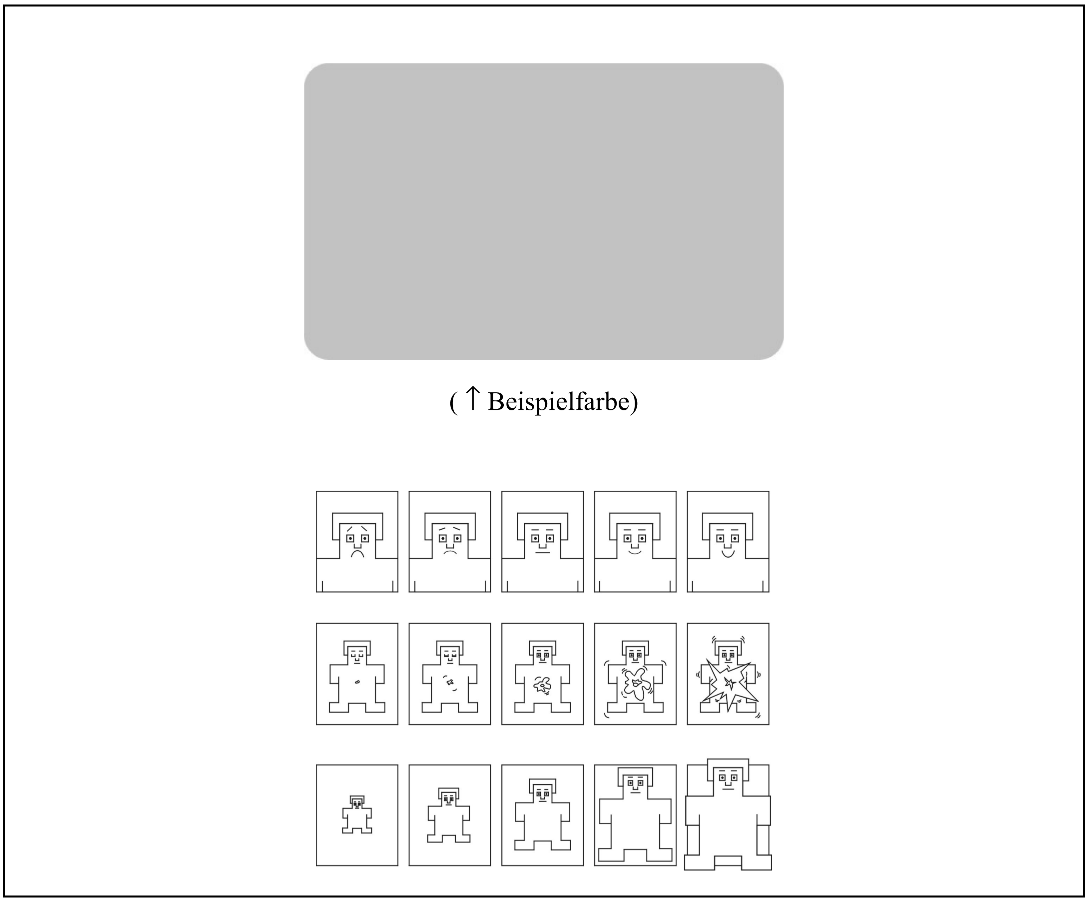
(Abbildung 4. 5 Bilder der „kontrolliert – kontrollierend“- Skala)

Einige der Farben werden emotionale Erfahrungen induzieren, andere werden relativ neutral erscheinen. Die Bewertung jeder Farbe soll **Ihre unmittelbare, spontane persönliche Erfahrung widerspiegeln,** sonst nichts.

Bitte bewerten Sie jede Farbe, so wie Sie sich gefühlt haben, während Sie sie betrachtet haben.

Bevor wir beginnen sehen Sie eine Beispielfarbe. Bitte beurteilen Sie jetzt zur Übung eine Farbe.

• Beispieltest



Wenn Sie noch Fragen haben, wenden Sie sich bitte jetzt an den Versuchsleiter.

Wenn Sie keine Fragen mehr haben, können Sie mit dem Experiment beginnen.

Appendix H. Means and standard deviations, Experiment III

(N =46, male: 19, female: 27)

type: (picture)	description		Affective judgment					
			valence		arousal		dominance	
	IAPS nr.	detail	**M**	*SD*	**M**	*SD*	**M**	*SD*
	1750	bunnies	4.595	*0.725*	2.946	*1.373*	3.378	*1.320*
		modified by equation 1*	8.189	*1.450*	4.892	*2.747*	5.757	*2.640*
	6230	aimed gun	1.432	*0.603*	4.324	*1.180*	2.054	*1.598*
		modified by equation 1*	1.865	*1.206*	7.649	*2.360*	3.108	*3.195*
	7175	lamp	2.919	*0.924*	1.811	*0.938*	3.297	*1.266*
		modified by equation 1*	4.838	*1.849*	2.622	*1.876*	5.595	*2.533*
	8030	skier	3.460	*1.260*	4.324	*0.818*	2.703	*1.222*
		modified by equation 1*	5.919	*2.521*	7.649	*1.637*	4.405	*2.443*

* {1, 2, 3, 4, 5}×2 -1 = {1, 3, 5, 7, 9}, modified to be compared with IAPS data

type: (color)	description			Affective judgment					
				valence		arousal		dominance	
naming category	L	c	h	**M**	*SD*	**M**	*SD*	**M**	*SD*
dark red	30	30	30	2.783	*0.892*	2.826	*1.081*	2.913	*1.189*
deep red	30	45	30	3.457	*1.005*	3.348	*0.948*	3.326	*0.967*
vivid red	40	60	30	4.087	*1.007*	3.848	*0.988*	3.761	*0.993*
brilliant red	50	40	30	3.478	*0.781*	2.891	*0.924*	3.044	*1.032*
light red	70	30	30	3.674	*0.967*	2.696	*1.051*	3.152	*1.135*
dark yellow	60	40	80	2.739	*0.976*	2.478	*0.913*	2.935	*1.083*
deep yellow	60	70	80	3.304	*1.245*	3.109	*1.159*	2.957	*1.115*
vivid yellow	80	90	80	4.239	*0.947*	3.630	*1.199*	3.674	*1.301*
brilliant yellow	80	60	80	4.022	*0.977*	3.261	*1.124*	3.413	*1.222*
light yellow	80	40	80	3.457	*1.026*	2.370	*1.082*	3.261	*1.201*
dark green	30	30	160	3.152	*1.053*	2.674	*0.990*	3.065	*1.041*
deep green	40	45	160	3.761	*0.923*	2.609	*1.125*	3.130	*1.128*
vivid green	50	60	160	3.870	*1.002*	2.826	*1.141*	3.109	*1.120*
brilliant green	40	40	160	3.522	*1.090*	2.565	*1.088*	3.130	*1.046*
light green	70	20	160	3.348	*1.016*	2.217	*1.114*	3.044	*1.264*
dark blue	30	20	260	3.174	*0.902*	2.739	*0.953*	3.239	*1.286*
deep blue	40	30	260	3.696	*0.891*	2.761	*0.970*	3.348	*1.059*
vivid blue	40	45	260	4.109	*0.795*	2.891	*1.197*	3.500	*1.206*
brilliant blue	60	35	260	4.326	*0.818*	3.217	*1.209*	3.652	*1.269*
light blue	70	25	260	4.152	*0.842*	2.935	*1.254*	3.522	*1.110*
dark violet	20	25	320	2.522	*1.110*	2.848	*1.032*	2.522	*1.150*
deep violet	30	35	320	3.109	*0.948*	3.087	*0.985*	2.913	*1.007*
vivid violet	40	40	320	3.239	*0.993*	2.826	*1.081*	2.783	*1.073*
brilliant violet	50	30	320	3.348	*0.971*	2.544	*0.982*	3.217	*0.964*
light violet	70	20	320	3.609	*0.906*	2.174	*0.950*	3.087	*1.112*
dark gray	30	0	--	2.065	*0.998*	2.326	*1.136*	2.587	*1.309*
medium gray	50	0	--	2.196	*0.910*	2.174	*1.122*	2.630	*1.103*
light gray	70	0	--	2.435	*0.860*	2.087	*1.050*	2.826	*1.039*
dark warm gray	30	10	80	1.957	*0.988*	2.370	*1.181*	2.696	*1.171*
medium warm gray	50	10	80	2.239	*0.874*	2.022	*0.830*	2.674	*1.156*
light warm gray	70	10	80	2.544	*1.048*	2.000	*0.894*	2.826	*1.102*
dark cool gray	30	10	260	2.283	*0.861*	2.239	*1.015*	2.587	*1.166*
medium cool gray	50	10	260	2.565	*0.834*	2.174	*0.950*	2.761	*1.139*
light cool gray	70	10	260	3.304	*0.866*	2.022	*0.931*	2.891	*1.320*
white	100	0	--	3.239	*1.196*	2.457	*1.277*	3.152	*1.366*
black	0	0	--	2.152	*1.135*	3.087	*1.396*	2.696	*1.685*

Appendix I. Means and standard deviations, Preliminary Test

(N= 24; male= 11, female= 13)

Film-clips	description		Affective judgment					
			valence		arousal		dominance	
	acronym	resource	**M**	*SD*	**M**	*SD*	**M**	*SD*
	top view	A Clockwork Orange, S. Kubrick (1971)	2.917	*0.881*	2.583	*0.830*	3.208	*0.977*
	hill	Le Papillon, P. Muyl (2003)	3.792	*0.884*	1.708	*0.751*	3.333	*1.050*
	gangsters	A Clockwork Orange, S. Kubrick (1971)	1.292	*0.464*	4.250	*0.897*	2.167	*1.373*
	jesus	A Clockwork Orange, S. Kubrick (1971)	1.375	*0.647*	3.417	*1.060*	2.083	*1.213*
	bunny	Amélie, J.P. Jeunet (2001)	4.375	*0.576*	2.875	*1.116*	3.042	*1.042*
	butterfly	Le Papillon, P. Muyl (2003)	4.125	*0.612*	3.125	*0.992*	3.167	*0.963*
	bed	Unfaithful, A. Lyne (2002)	4.042	*0.859*	3.833	*0.868*	3.167	*0.917*
	harem	A Clockwork Orange, S. Kubrick (1971)	3.250	*1.327*	2.875	*1.296*	2.917	*1.100*
	applause	Legally blond, R. Luketic (2001)	3.875	*1.262*	3.542	*1.250*	3.583	*0.929*
	date	Barry Lyndon, S. Kubrick (1975)	4.042	*0.908*	2.708	*1.042*	3.167	*0.702*
	chihuahua	Legally blond, R. Luketic (2001)	3.750	*0.794*	2.667	*0.868*	3.125	*0.850*
	sailing	Barry Lyndon, S. Kubrick (1975)	3.667	*0.917*	2.708	*1.160*	3.708	*0.955*
	subtitle	Eyes wide shut, S.Kubrick (1999)	2.875	*0.900*	1.833	*1.007*	2.917	*0.929*
	corridor	A Clockwork Orange, S. Kubrick (1971)	2.167	*0.868*	2.708	*1.042*	2.292	*0.908*
	riding	Barry Lyndon, S. Kubrick (1975)	3.583	*0.776*	2.542	*1.103*	3.167	*0.963*
	poison	Barry Lyndon, S. Kubrick (1975)	1.583	*0.717*	4.000	*0.978*	1.917	*0.929*
	fighting	A Clockwork Orange, S. Kubrick (1971)	1.833	*0.868*	4.458	*0.588*	2.958	*1.459*
	couple	Eternal Sunshine of the Spotless Mind, M. Gondry (2004)	3.917	*1.100*	2.958	*1.301*	3.292	*0.859*
	red	A Clockwork Orange, S. Kubrick (1971)	2.875	*0.612*	2.792	*1.062*	2.875	*0.850*

Appendix J. Instruction, Experiment IV

Multimedia und Emotion

Allgemeine Psychologie, Universität Mannheim

- Ihre individuelle Kennung: __ __ __
- Geschlecht: ( ) männlich ( ) weiblich
- Alter: ______ • Beruf: _________________
- Was ist Ihre Lieblingsfarbe? ______________________________

Wir danken Ihnen, dass Sie heute gekommen sind und freuen uns über Ihre Teilnahme an diesem Experiment. Im Rahmen dieser Studie sind wir daran interessiert, wie Menschen auf verschiedene Reize reagieren.

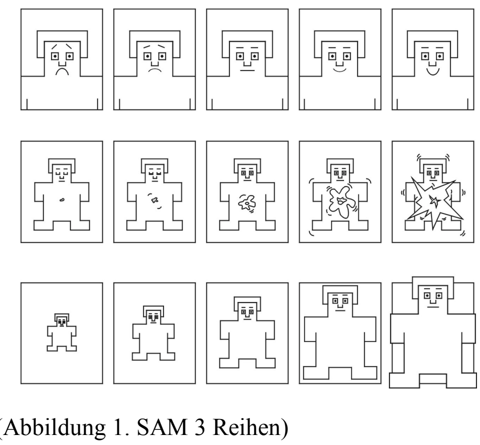
In diesem Experiment werden Sie Filmsequenzen, Bilder, Farben und Wörter sehen, die auf dem Bildschirm vor Ihnen dargestellt werden.

Bitte beurteilen Sie jeden dieser Reize in Hinblick darauf, **wie Sie sich fühlen**, wenn Sie ihn betrachten. Es gibt keine richtigen oder falschen Antworten, antworten Sie bitte ehrlich, nur Ihrem Gefühl entsprechend.
Wir beschreiben jetzt die Skalen, auf denen Sie Ihre Antworte abgeben.
Sie sehen 3 Reihen bestehend aus jeweils 5 Bilder (Abbildung 1).

Reihe I

Reihe II

Reihe III

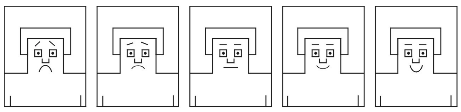


(Abbildung 1. SAM 3 Reihen)

Jede dieser Reihen ist entlang eines Kontinuums angeordnet. Sie werden diese Bilder verwenden, um zu beurteilen, wie Sie sich gefühlt haben, während Sie jeden einzelnen Reiz betrachtet haben.
Beurteilen Sie bei jedem Reiz, den Sie betrachten werden, alle drei Reihen.
Sie sehen, dass sich jedes Bild entlang der Skala verändert.

Die erste Reihe ist die „unglücklich – glücklich"- Skala, welche sich von einem trübsinnigen Gesichtsausdruck bis zu einem Lächeln hin verändert (Abbildung 2). An dem einen Extrem der glücklich-unglücklich- Skala haben Sie sich glücklich, erfreut, zufrieden, hoffnungsvoll gefühlt. Wenn Sie sich komplett glücklich gefühlt haben, während Sie den Reiz betrachtet haben, können Sie dies ausdrücken, in dem Sie das Bild ganz **rechts** anklicken. Das andere Ende der Skala steht für den Fall, dass Sie sich vollkommen unglücklich, genervt, unbefriedigt, melancholisch , verzweifelt, gelangweilt gefühlt haben, während Sie den Reiz betrachtet haben. Wenn Sie sich vollkommen unglücklich gefühlt haben, können Sie dies durch Auswahl das Bild ganz **links** ausdrücken. Die Bilder ermöglichen auch dazwischen liegende Emotionen zu beschreiben, indem Sie eine der anderen Bilder anklicken. Wenn Sie sich vollständig neutral gefühlt haben, weder glücklich noch unglücklich, klicken Sie das Bild in der Mitte an.

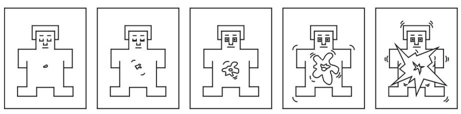
Reihe I



(Abbildung 2. 5 Bilder der „unglücklich – glücklich"- Skala)

Die zweite Reihe ist die „ruhig – aufgeregt"- Skala (Abbildung 3).
Auf der einen Seite, am einen Extrem der Skala haben Sie sich stimuliert, aufgeregt, nervös, rasend, hellwach, aktiviert gefühlt. Wenn Sie sich voll und ganz erregt gefühlt haben, während Sie den Reiz betrachtet haben, wählen Sie bitte das Bild ganz **rechts** aus. Auf der anderen Seite, am anderen Ende der Skala, haben Sie sich vollkommen entspannt, ruhig, träge, gelangweilt, schläfrig oder unaufmerksam gefühlt. Sie können ausdrücken, dass Sie sich komplett ruhig gefühlt haben, indem Sie das Bild ganz **links** anklicken. Wenn Sie sich vollständig neutral gefühlt haben, also weder aufgeregt noch ruhig, während Sie den Reiz betrachtet haben, wählen Sie das Bild in der Mitte aus.

Reihe II

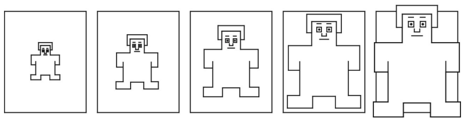


(Abbildung 3. 5 Bilder der „ruhig – aufgeregt"- Skala)

Die letzte Reihe ist die „kontrolliert – kontrollierend“- Skala (Abbildung 4).

An dem einen Ende der Skala haben Sie das Gefühl, die Situation unter Kontrolle zu haben, fühlen sich einflussreich, wichtig, dominant und autonom. Sie können verdeutlichen, dass Sie sich so gefühlt haben, indem Sie das Bild ganz **rechts** auswählen. Am anderen Ende der Skala fühlen Sie sich absolut kontrolliert, beeinflusst, versorgt, eingeschüchtert**,** submissiv, fremd gesteuert. Bitte veranschaulichen Sie, dass Sie sich kontrolliert fühlen, indem Sie das Bild **links** anklicken. Bitte beachten Sie, dass das Bild groß ist, wenn ***Sie*** sich wichtig und einflussreich fühlen und sehr klein sofern ***Sie*** sich kontrolliert und fremd gesteuert fühlen. Wenn Sie sich weder kontrolliert noch kontrollierend fühlen, sollten Sie das Bild in der Mitte anklicken.

Reihe III

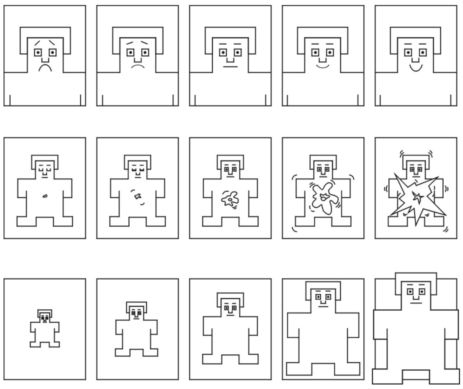


(Abbildung 4. 5 Bilder der „kontrolliert – kontrollierend“- Skala)

Einige der Reize werden emotionale Erfahrungen induzieren, andere werden relativ neutral erscheinen. Die Bewertung jedes Reizes soll **Ihre unmittelbare, spontane persönliche Erfahrung widerspiegeln,** sonst nichts.

Bitte bewerten Sie jeden Reiz, so wie Sie sich gefühlt haben, während Sie ihn betrachtet haben.

Bevor wir beginnen sehen Sie einen Beispielreiz. Bitte beurteilen Sie jetzt zur Übung ein Beispielbild.



Wenn Sie noch Fragen haben, wenden Sie sich bitte jetzt an den Versuchsleiter.

Wenn Sie keine Fragen mehr haben, können Sie mit dem Experiment beginnen.

Appendix K. Mean and standard deviation values of SAM ratings, Experiment IV

(N= 45; male= 24, female= 21)

type: pictorial (colors)	naming category	description L	c	h	Affective judgment: valence M	valence SD	arousal M	arousal SD	dominance M	dominance SD
	dark red	30	30	30	2.778	*0.902*	2.467	*0.968*	2.889	*0.982*
	vivid red	40	60	30	3.578	*0.965*	3.756	*1.090*	3.200	*1.036*
	light red	70	30	30	3.400	*1.031*	2.467	*1.198*	3.378	*1.051*
	dark yellow	60	40	80	2.756	*0.883*	2.133	*0.968*	3.022	*1.076*
	vivid yellow	80	90	80	3.844	*1.086*	3.156	*1.127*	3.422	*1.011*
	light yellow	80	40	80	3.378	*0.936*	2.333	*1.108*	3.467	*1.036*
	dark green	30	30	160	3.400	*0.915*	2.422	*1.138*	3.333	*0.853*
	vivid green	50	60	160	3.756	*0.743*	2.489	*1.100*	3.556	*0.755*
	light green	70	20	160	3.267	*0.915*	2.111	*1.027*	3.311	*0.848*
	dark blue	30	20	260	3.133	*1.014*	2.222	*0.927*	3.222	*0.927*
	vivid blue	40	45	260	3.978	*0.892*	2.422	*1.033*	3.644	*1.048*
	light blue	70	25	260	4.178	*0.650*	2.400	*1.116*	3.689	*1.019*
	vivid violet	40	40	320	3.089	*0.949*	2.756	*1.069*	3.067	*0.889*
	dark gray	30	0	--	2.089	*0.848*	2.289	*1.199*	2.489	*1.079*
	light gray	70	0	--	2.378	*0.834*	1.844	*0.976*	2.600	*1.074*
	light warm gray	70	10	80	2.533	*1.036*	1.667	*0.905*	3.044	*1.127*
	light cool gray	70	10	260	3.022	*0.965*	1.911	*0.973*	3.200	*0.842*

type: pictorial (pictures)	IAPS nr.	description: detail	Affective judgment: valence M	valence SD	arousal M	arousal SD	dominance M	dominance SD
	1750	bunnies	4.311	*0.821*	2.511	*1.254*	3.800	*0.991*
		modified by equation 1*	7.622	*1.642*	4.022	*2.509*	6.600	*1.982*
	6230	aimed gun	1.844	*1.021*	3.933	*1.136*	1.911	*1.240*
		modified by equation 1*	2.689	*2.043*	6.867	*2.272*	2.822	*2.480*
	7175	lamp	3.178	*0.747*	1.756	*0.802*	3.467	*1.057*
		modified by equation 1*	5.356	*1.495*	2.511	*1.604*	5.933	*2.115*
	8030	skier	3.711	*0.944*	3.822	*1.051*	2.978	*1.158*
		modified by equation 1*	6.422	*1.889*	6.644	*2.101*	4.956	*2.316*
	2070	baby**	4.511	*0.661*	2.800	*1.307*	4.156	*0.952*
	5621	sky divers**	4.200	*1.014*	4.000	*1.108*	3.200	*1.408*
	6350	attack(with a knife) **	1.556	*0.693*	4.178	*0.886*	1.778	*1.085*
	7010	basket**	2.489	*0.757*	2.467	*1.100*	2.778	*1.295*

* {1, 2, 3, 4, 5}×2 -1 = {1, 3, 5, 7, 9}, modified to be compared with IAPS data
** presented achromatic

type: pictorial (film-clips)	description		Affective judgment					
			valence		arousal		dominance	
	acronym	resource	**M**	*SD*	**M**	*SD*	**M**	*SD*
	top view	A Clockwork Orange, S. Kubrick (1971)	3.267	*1.136*	2.822	*1.211*	2.756	*1.228*
	hill	Le Papillon, P. Muyl (2003)	4.289	*0.895*	2.133	*1.140*	3.800	*1.100*
	gangsters	A Clockwork Orange, S. Kubrick (1971)	1.356	*0.743*	4.578	*0.723*	1.711	*1.100*
	jesus	A Clockwork Orange, S. Kubrick (1971)	1.600	*0.889*	3.800	*1.057*	1.867	*1.120*
	bunny	Amélie, J.P. Jeunet (2001)	4.333	*0.707*	3.044	*1.065*	3.600	*1.176*
	butterfly	Le Papillon, P. Muyl (2003)	4.289	*0.843*	2.889	*1.318*	3.733	*0.915*
	bed	Unfaithful, A. Lyne (2002)	4.200	*0.944*	3.844	*0.903*	3.467	*1.014*
	harem	A Clockwork Orange, S. Kubrick (1971)	3.489	*1.290*	3.333	*1.022*	3.156	*1.313*
	applause	Legally blond, R. Luketic (2001)	4.267	*0.863*	3.622	*1.051*	3.622	*0.984*

type: verbal (adjectives)	description		Affective judgment					
			valence		arousal		dominance	
	adjective	in English	**M**	*SD*	**M**	*SD*	**M**	*SD*
	laut**	loud	2.400	*1.009*	3.556	*1.159*	2.600	*1.136*
	langweilig**	boring	1.889	*0.935*	2.222	*1.363*	2.689	*1.203*
	hektisch**	hectic	2.111	*0.959*	3.756	*1.048*	2.222	*1.106*
	leicht*	light	4.067	*0.809*	2.156	*1.107*	3.956	*0.999*
	aktiv*	active	4.044	*0.737*	3.267	*1.053*	3.622	*0.860*
	dynamisch*	dynamic	3.956	*0.976*	3.311	*1.041*	3.378	*1.173*
	gesund*	healthy	4.467	*0.757*	2.444	*1.159*	3.911	*1.062*
	urban*	urban	3.044	*0.903*	3.067	*1.136*	2.844	*1.205*
	modern*	modern	3.689	*0.874*	2.800	*0.991*	3.200	*1.036*