Coll. Antropol. **35** (2011) Suppl. 1: 17–23
Original scientific paper

Gaze Differences in Processing Pictures with Emotional Content

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A B S T R A C T

The International Affective Picture System (IAPS) is a set of standardized emotionally evocative color photographs developed by NIMH Center for Emotion and Attention at the University of Florida. It contains more than 900 emotional pictures indexed by emotional valence, arousal and dominance. However, when IAPS pictures were used in studying emotions with the event-related potentials, the results have shown a great deal of variation and inconsistency. In this research arousal and dominance of pictures were controlled while emotional valence was manipulated as 3 categories, pleasant, neutral and unpleasant pictures. Two experiments were conducted with an eye-tracker in order to determine to what the participants turn their gaze. Participants were 25 psychology students with normal vision. Every participant saw all pictures in color and same pictures in black/white version. This makes 200 analyzed units for color pictures and 200 for black and white pictures. Every picture was divided into figure and ground. Considering that perception can be influenced by color, edges, luminosity and contrast and since all those factors are collapsed on the pictures in IAPS, we compared color pictures with same black and white pictures. In first eye-tracking IAPS research we analyzed 12 emotional pictures and showed that participants have higher number of fixations for ground on neutral and unpleasant pictures and for figure on pleasant pictures. Second experiment was conducted with 4 sets of emotional complementary pictures (pleasant/unpleasant) which differ only on the content in the figure area and it was shown that participants were more focused on the figure area than on the ground area. Future ERP (event related potential) research with IAPS pictures should take into consideration these findings and to either choose pictures with blank ground or adjust pictures in the way that ground is blank. For the following experiments suggestion is to put emotional content in the figure area and to use different non complementary pictures to see if there is difference between different emotional categories.

Key words: *visual perception, eye-tracking, emotional valence, International Affective Picture System*

Introduction

We receive information about the world through various sensory modalities. Most often it begins with perceiving and organizing simple patterns in front of our eyes. This makes vision the most dominant sense for humans[1]. Perception begins in receptor cells that are sensitive to specific kind of stimuli[2]. Limited capacity of visual system allows only a fraction of the information available from the visual scene on the two retinas to be processed; therefore, in order to perceive something visually, information is selectively filtered by visual attention[2]. Visual capacity is determined by retina and fovea, while acute visual perception occurs if the object of interest is in the visual field of fovea for at least few milliseconds[3]. Perceptual system is responsible for perceptual and cognitive representations of objects and events which are mediated by ventral visual stream[4]. Perceiving involves more than the detection of stimulus elements, it requires appropriate parsing of the input into its components, organization of the input into figure and ground and interpretation of the input's three dimensional configuration[1]. Interpretative steps of perceiving could depend on stimulus input because interpretation should be compatible with the information in the stimulus. However, as more than one interpretation is possible, process of analyzing

Received for publication October 15, 2009

perceived stimuli is not strictly driven by the stimulus itself[1]. Perceiving something depends on the stimulus itself and the interpretation of perceiver. Integration of information across the visual field is one step beyond the local analysis of features, such as color, orientation, direction of motion and depth[4]. Perception is purposeful, selective and it depends on our distinct attention and visual search[5]. Attention can be observed by measuring eye movements. Basic unit in eye movement data is eye fixation which refers to a pause between eye movements for a certain length of time allowing for the determination of the observer's gaze[3]. Only during fixations information processing on certain visual area of interest is taking place[6]. Longer duration of fixations means that more time is devoted to interpretation and information processing[7].

In order to recognize an object visually, it is necessary to process visual image and then to compare the output with the material stored in memory, finally deciding whether or not the item is something one knows[8]. There is no agreement whether visual recognition is a knowledge driven process (top-down) or the product of automatic innate brain processes[8]. The image of an object or a scene is created by integration of attention and visual search, integration of focalization of important aspects of the visual field and more detailed exploration by linking several fixations on the same visual scene[5]. The connection between the material and the mental in vision is uncertain, but it is known that visual perception is determined by luminosity, color vision, visual edges and contrast[5]. One of the most basic issues in visual perception is to account for perceptual segregation or our ability to work out which parts of the visual information presented to us belong together and thus form separate objects[9]. According to the Gestalts, figure is perceived as having a distinct form or shape and being in front of the ground, whereas the ground lacks form[9]. One object or part of the visual field is identified as the figure, whereas the rest of the visual field is of less interest and forms the ground.

Visual perception starts with a raw visual material received by the eye transferred to and analyzed by the visual brain. The final system of visual concepts greatly depends on the range of imagery available through memory and organized by a total lifetime experience[5]. Emotions experienced in life can form the way someone can behave, perceive and act. Emotional information can be presented as stimuli in several ways, words, sounds and pictures. Numerous researches of emotional processing use International Affective Picture System (IAPS) emotional pictures. IAPS is a set of standardized emotionally evocative color photographs developed by NIMH Center for Emotion and Attention at the University of Florida[10]. It contains more than 900 emotional pictures indexed by emotional valence, arousal and dominance. Visual perceiving of emotional pictures is not a simple process to describe, mainly because emotional pictures consist of a lot of different elements. It is not clear which element of the picture contains emotional information and it is not clear whether the same elements of emotional pictures attract attention of all perceivers in the same way in the same amount.

In this research we analyzed pleasant, neutral and unpleasant pictures with an eye-tracker in order to determine to what the participants turn their gaze. Considering that perception can be influenced by color, edges, luminosity and contrast and since all those factors are collapsed on the pictures in IAPS, we compared color pictures with the same black and white pictures. Proving to be very useful for behavioral research, this database has also been used for ERP research, but with inconsistent results. We think that uncontrolled elements of these pictures can contribute to the inconsistency shown in ERP emotional research so far. We focused on two elements which could be the factors that contribute to the inconsistency, color and focus on certain area in the picture. Main goal of this research is to discover which elements of presented stimuli can affect one's perception with the goal of controlling emotional elements of stimuli. This would result in detecting better sets of stimuli or setting additional rules for stimulus selection from IAPS for the future ERP studies.

In the present study three problems related to the IAPS pictures are addressed:

- differences on gaze parameters depending on emotional valence of the picture (pleasant, neutral, unpleasant)
- differences among participants in looking at the figure and ground area of an emotional picture
- differences on gaze parameters depending on the color of the picture (color / black-white).

Materials and Methods

Pictures used in this study were chosen from IAPS data base. Pictures are categorized in three dimensions, valence, intensity and dominance evaluated on the scale of nine points. In both experiments we controlled intensity and dominance of the presented pictures in order to capture just the valence component of emotional pictures. We also divided every picture into figure and ground areas in order to compare differences in the way participants look at the picture. The same participants participated in both experiments and were tested on the valence of the picture, picture part and color of the picture in each experiment (repeated measure design). In the first experiment every participant was exposed to a set of 12 (4 pleasant, 4 neutral and 4 unpleasant) emotional color and 12 black and white pictures. In the second experiment every participant saw 8 pictures in color and the same pictures in black/white version (4 pleasant, 4 unpleasant). The pictures were constructed so that every pleasant picture has its unpleasant match that differs only in the figure (e. g. a man having an ice-cream in his hand or pointing a gun). In the first experiment pleasant pictures were the following: 1463, 2332, 2339 and 2388. Mean normative ratings for pleasant picures were: valence 7.31 [SD 1.54], arousal 4.18 [SD 2.15],

dominance 6.46 [SD 1.92]). Neutral pictures were: 2575, 5390, 7042 and 7496. Mean normative ratings for neutral picures: valence 5.63 [SD 1.40], arousal 3.98 [SD 2.08], dominance 6.10 [SD 1.90]). Following pictures were used as unpleasant stimuli: 2710, 2095, 3300 and 6213. Mean normative ratings for unpleasant picures were: valence 2.49 [SD 1.49], arousal 5.28 [SD 2.19], dominance 4.15 [SD 2.29]). The second experiment consisted of following pairs of unpleasant and pleasant pictures- Pleasant pictures: 2375.2, 2980, 2900, 2 and 6250.2. Mean normative ratings for pleasant picures were: valence 6.38 [SD 1.88], arousal 4.17 [SD 2.14], dominance 5.78 [SD 2.07]). Unpleasant pictures were: 2375.1, 2981, 2900.1 6250.1 Mean normative ratings for unpleasant picures were: valence 2.07 [SD 1.40], arousal 5.91 [SD 2.04], dominance 3.46 [SD 2.14]). Neutral pictures were not included in the second experiment because there are no complementary neutral pictures in the IAPS data base.

Participants in the eye-tracking experiment were 25 students with normal vision (24 female and 1 male, age range 20–23) from Psychology Department of Center for Croatian Studies at University of Zagreb, Croatia. They were put in front of the computer screen and their chin and forehead were fixed in the eye-tracking device (SMI iView). The distance between the head and the screen was fixed for every participant and it was 50 cm. The eye-tracker uses two points for the detection of the eye movements. First is the corneal reflection of the infra-red lamp positioned above the participant's head. The second point is the centre of the pupil automatically detected due to the good contrast between the pupil and the rest of the eye in the infrared light. The position of the eye is calculated as a vector between the corneal reflection (fixed point) and the centre of the pupil that moves as the gaze moves. The overall precision of the instrument is <0.5° of the visual angle and the 500 Hz sampling rate allows for recording one position of an eye in 2 ms (500 data points in one second). Blinks are recognized automatically and treated as »no data periods«. The gaze of each participant was calibrated on 13 points just before the experiment. The presentation of the pictures was controlled by E-prime[11]. Every picture was presented for 5 seconds. The whole experiment took about 5 minutes *per* participant.

Results

In both experiments number of fixations was measured. Results were analyzed in SPSS 16. For detecting differences in number of fixations General Linear Model (GLM) for repeated measures was used. Comparisons were made between different emotional values of pictures, figure and ground area and comparison between color and black and white pictures. Results are presented in the following order: emotional values, figure/ground, color/black and white, for the first experiment and are followed by the results of the second experiment.

In the first experiment 12 emotional pictures were presented to the participants with 4 pictures from each emotional category. When pleasant with unpleasant and neutral pictures are compared, participants have higher number of fixations on the figure area when they look at the pleasant color pictures (Figure 1, Table 1 and 2). Participants spent more time looking at the figure area of pleasant than when looking at the unpleasant and neutral color pictures. But, they direct their gaze more on the ground area when they look at the neutral and unpleasant color pictures in comparison with the same area of pleasant color pictures (Figure 1 and 2, Table 1 and 2). But, this difference is not visible on the black and white pictures. Number of fixations does not differ on pleasant

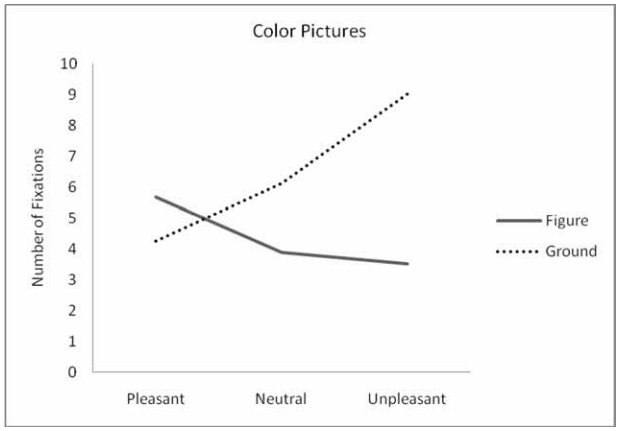

Fig. 1. Number of fixations on the figure and ground area for color pictures (first experiment – 12 emotional pictures; pleasant,

TABLE 1
WITHIN SUBJECTS EFFECTS (FIRST EXPERIMENT, 12 PICTURES)

Source	Sum of squares	df	Mean square	F	Significance
Picture part	694.64	1	694.64	43.60	0.000*
Emotional valence	31.63	2	15.82	7.03	0.002*
Color of the picture	2.61	1	2.61	0.46	0.504
Picture part * Emotional valence	216.86	2	108.43	37.71	0.000*
Picture part * Color of the picture	1.69	1	1.69	0.38	0.541
Emotional Valence * Color of the picture	0.65	2	0.32	0.19	0.830
Picture part * Emotional valence * Color of the picture	14.60	2	7.30	3.83	0.029*

* $p<0.05$

TABLE 2
COMPARISON OF PLEASANT, NEUTRAL AND UNPLEASANT PICTURES (FIRST EXPERIMENT, 12 PICTURES)

Picture part	Color of the picture	Emotional valence (I)	Emotional valence (J)	Mean difference (I-J)	Standard error	Significance
Figure	Color of the picture	Pleasant	Neutral	1.79	0.38	0.000*
			Unpleasant	1.51	0.37	0.001*
		Neutral	Unpleasant	–0.28	0.36	1.000
	Black and white	Pleasant	Neutral	1.38	0.38	0.004*
			Unpleasant	0.65	0.34	0.205
		Neutral	Unpleasant	–0.73	0.47	0.405
Ground	Color of the picture	Pleasant	Neutral	–2.9	0.31	0.000*
			Unpleasant	–1.1	0.36	0.016*
		Neutral	Unpleasant	1.8	0.39	0.000*
	Black and white	Pleasant	Neutral	–2.17	0.47	0.000*
			Unpleasant	0.2	0.45	1.000
		Neutral	Unpleasant	2.37	0.64	0.003*

* $p<0.05$

and unpleasant black and white pictures in the figure or ground area. When the gaze on the figure and the gaze on the ground area are compared, the results show that participants spend more time looking at the ground area on neutral and unpleasant color and black and white pictures (Figure 1 and 2, Table 1 and 3). Ground on the pleasant black and white pictures also attracts more attention than the figure area but on the color pleasant pictures figure attracts more attention than the ground area. Previous tests showed differences between number of fixations on the figure and ground area between pleasant and unpleasant color pictures and no difference on the black and white pictures. But, a comparison of the numbers of fixations on the figure and ground area between black and white and color pictures reveals no difference (Figure 1 and 2, Table 1 and 4).

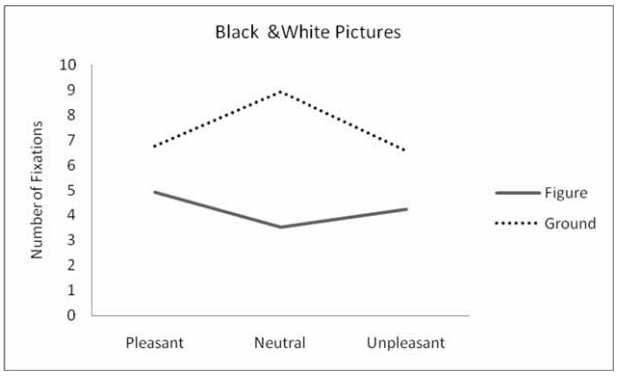

Fig. 2. Number of fixations on the figure and ground area for black and white pictures (first experiment – 12 emotional pictures; pleasant, unpleasant, neutral).

In the second experiment 4 pairs of complementary emotional pictures were presented to the participants. In the second experiment the difference between emotional complementary pictures was found in the number of fixations on the figure area between pleasant and unpleasant pictures color and black and white pictures (Figure 3 and 4, Table 5 and 6). Participants have higher number of fixations in the figure area for both color and black and white pictures when they look at the pleasant pictures. This means that participants spent more time looking at the figure area on the pleasant pictures than on the unpleasant pictures. Although there is higher number of fixations in the figure area for pleasant pic-

TABLE 3
COMPARISON OF FIGURE AND GROUND (FIRST EXPERIMENT, 12 PICTURES)

Emotional valence	Color of the picture	Picture part (I)	Picture part (J)	Mean difference (I-J)	Standard Error	Significance
Pleasant	Color	Figure	Ground	–0.46	0.71	0.525
	Black and white	Figure	Ground	–1.86	0.66	0.009*
Neutral	Color	Figure	Ground	–5.15	0.58	0.000*
	Black and white	Figure	Ground	–5.41	0.49	0.000*
Unpleasant	Color	Figure	Ground	–3.07	0.68	0.000*
	Black and white	Figure	Ground	–2.31	0.65	0.002*

* $p<0.05$

TABLE 4
COMPARISON OF COLOR WITH BLACK AND WHITE PICTURES (FIRST EXPERIMENT, 12 PICTURES)

Picture part	Emotional valence	Color of the picture (I)	Color of the picture (J)	Mean difference (I-J)	Standard error	Significance
Figure	Pleasant	Color	Black and white	0.76	0.59	0.208
	Neutral	Color	Black and white	0.35	0.38	0.361
	Unpleasant	Color	Black and white	–0.10	0.45	0.827
Ground	Pleasant	Color	Black and white	–0.64	0.54	0.250
	Neutral	Color	Black and white	0.09	0.40	0.825
	Unpleasant	Color	Black and white	0.66	0.49	0.190

TABLE 5
WITHIN SUBJECTS EFFECTS (SECOND EXPERIMENT, 8 PICTURES)

Source	Sum of squares	df	Mean square	F	Significance
Picture part	36.75	1	36.75	1.45	0.242
Emotional valence	13.28	1	13.28	4.31	0.049*
Color of the picture	11.26	1	11.26	2.16	0.155
Picture part * Emotional valence	14.36	1	14.36	6.94	0.015*
Picture part * Color of the picture	3.13	1	3.13	1.38	0.251
Emotional Valence * Color of the picture	2.30	1	2.30	1.55	0.225
Picture part * Emotional valence * Color of the picture	1.33	1	1.33	0.54	0.470

* $p<0.05$

tures than for the unpleasant, participants kept their gaze in the figure area in both conditions. There is no difference comparing participants' gaze on the figure and ground area of the pictures (Table 7). Also, no gaze difference was found between color and black and white pictures (Table 8).

Discussion and Conclusion

Results of the first experiment show that there is a difference between gaze on the figure and ground for pictures with different emotional valence while in the second experiment with complementary pictures no difference between the direction of the gaze on the figure and ground areas was found. In the second experiment ground area did not attract attention of participant since it didn't contain any emotional content and it was the same for pairs of complementary pictures. In the first experiment, participants directed their gaze to the figure area more on the pleasant pictures in comparison with the unpleasant and neutral pictures. When both figure and

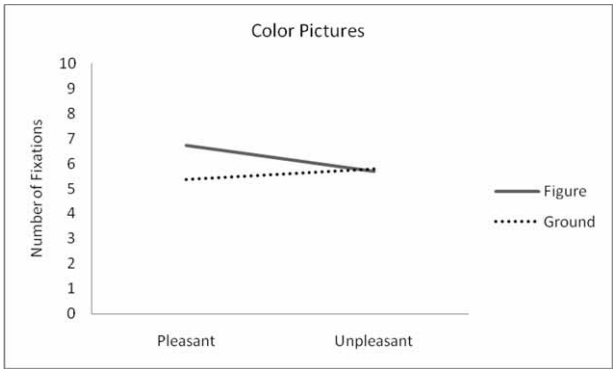

Fig. 3. Number of fixations on the figure and ground area for color pictures (second experiment – 8 emotional complementary pictures; pleasant, unpleasant).

TABLE 6
COMPARISON OF PLEASANT, NEUTRAL AND UNPLEASANT PICTURES (SECOND EXPERIMENT, 8 PICTURES)

Picture part	Color of the picture	Emotional valence (I)	Emotional valence (J)	Mean difference (I-J)	Standard error	Significance
Figure	Color	Pleasant	Unpleasant	1.02	0.41	0.019*
	Black and white	Pleasant	Unpleasant	1.13	0.37	0.006*
Ground	Color	Pleasant	Unpleasant	–0.41	0.58	0.487
	Black and white	Pleasant	Unpleasant	0.36	0.36	0.317

* $p<0.05$

TABLE 7
COMPARISON OF FIGURE AND GROUND (SECOND EXPERIMENT, 8 PICTURES)

Emotional valence	Color of the picture	Picture part (I)	Picture part (J)	Mean difference (I-J)	Standard error	Significance
Pleasant	Color	Figure	Ground	1.33	0.68	0.062
	Black and white	Figure	Ground	1.51	0.74	0.052
Unpleasant	Color	Figure	Ground	–0.09	1.03	0.928
	Black and white	Figure	Ground	0.75	0.79	0.352

TABLE 8
COMPARISON OF COLOR WITH BLACK AND WHITE PICTURES (SECOND EXPERIMENT, 8 PICTURES)

Picture part	Emotional valence	Color of the picture (I)	Color of the picture (J)	Mean difference (I-J)	Standard error	Significance
Figure	Pleasant	Color	Black and white	–0.79	0.52	0.144
	Unpleasant	Color	Black and white	–0.69	0.59	0.254
Ground	Pleasant	Color	Black and white	–0.61	0.47	0.206
	Unpleasant	Color	Black and white	0.16	0.33	0.640

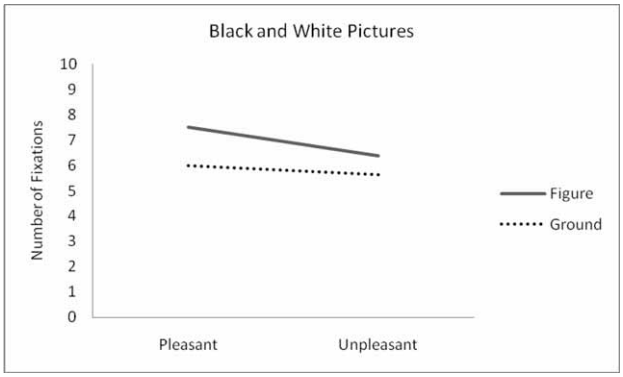

Fig. 4. Number of fixations on the figure and ground area for black and white pictures (second experiment – 8 emotional complementary pictures; pleasant, unpleasant).

ground are filled with presumably emotional content, participants directed their gaze more to the ground on the unpleasant and neutral pictures. These findings raise a question about what participants actually look at when we present them picture with emotional content. We only assume that their attention is focused on the emotional element of the picture, but it doesn't have to be the case. More precisely, our results show that when looking at the unpleasant pictures participant's gaze is focused more on the ground area. This can imply that the participants tried to avoid looking at the unpleasant elements of the picture usually placed in the figure area. If we deliberately direct attention of participants on the figure area (as in complementary pictures in the second experiment), difference between figure and ground area is not found. However, when we present those pictures with the emotional content on both figure and ground, the participants can choose to direct their gaze to any area of picture or to avoid the figure area in the case of unpleasant pictures. This leaves us without control of what our subjects are really looking at.

Experiments with IAPS pictures performed so far did not control for what people really look at. This can explain the mentioned inconsistencies in the ERP studies of emotion using IAPS. Weisstein and Wong[12] have also shown that there was more attention to the figure than to the ground. They flashed vertical lines and slightly tilted lines onto the faces-goblet figure giving their participants the task of deciding whether the line was vertical. When the line was presented to what the participants perceived as the figure, performance was three times better than when the line was presented to the ground. Results in our second experiment match their findings and these results are consistent no matter whether the pictures are in color or black and white. Participants spent more time looking at the figure than ground area on both color and black and white pictures. According to Sekuler and Blake[13] color vision helps in distinguishing object and its ground and facilitates making fine discriminations between objects. In our research there was no difference between color and black and white pictures in the way participants looked at the picture. In general, color of the pictures did not matter; color did not play a role in directing the participants' gaze on the pictures with different emotional valence.

These findings should be taken into consideration in future research with IAPS pictures; either pictures with the same ground should be chosen (as in our second experiment) or they should be adjusted in the way that the ground is blank. We have shown that participants have higher number of fixations on ground area when the ground varied in the stimulus pictures. Showing that participants are more focused on the figure area when ground does not attract attention implies that if we put emotional stimuli in the figure area, we can be more certain that participants are actually looking at the presented stimuli, and therefore, that they are really exposed to emotional stimuli that the experiemntator wants to manipulate with. This is particularly important in pre-

paring stimuli for ERP research where precise gaze on the presented stimuli is important for connecting presented emotional picture and ERP component related to specific stimuli. As Gazzaniga et al.[14] indicated, »Visual perception is a divide-and-conquer strategy. Rather than have each visual area represent all attributes of an object, each area provides its own limited analysis making processing distributed and specialized«.

Acknowledgements

The study was financed by the project funded by Croatian Ministry of Science, Education and Sport, No. 013-0131484-1488 (»Higher cortical functions and language: Developmental and acquired disorders«, Head of the project Melita Kovačević, full professor).

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USMJERAVANJE POGLEDA ZA VRIJEME OBRADE FOTOGRAFIJA S RAZLIČITIM EMOCIONALNIM SADRŽAJEM

SAŽETAK

Internacionalna baza afektivnih fotografija (International Affective Picture System, IAPS) predstavlja set standardiziranih emocionalno pobuđujućih fotografija u boji koje su razvijene u Centru za emocije i pažnju na Sveučilištu u Floridi. Sadrži više od 900 emocionalnih slika koje su indeksirane prema emocionalnoj vrijednosti, intenzitetu i dominantnosti. Istraživanja emocionalnih evociranih potencijala u kojima su se upotrebljavale fotografije iz IAPS-a nisu pokazala dosljednost i konzistentnost. U ovom istraživanju kontrolirale su se varijable intenziteta i dominantnost emocionalnih fotografija, a ispitivao se utjecaj varijable emocionalne vrijednosti (ugodne, neutralne i neugodne fotografije). Provedena su dva eksperimenta sa sustavom za praćenje pokreta oka radi određivanja usmjeravanja pogleda ispitanika. U istraživanju je sudjelovalo 25 studenata psihologije. Svaki ispitanik je vidio sve fotografije u boji i u crno bijeloj verziji. Svaka fotografija je podijeljena na figuru i pozadinu. Budući da na percepciju mogu utjecati boja, rubovi, osvjetljenje i kontrast a navedeni faktori nisu izjednačeni na fotografijama u IAPS bazi, usporedili smo i fotografije u boji sa crno bijelim fotografijama. U prvom IAPS istraživanju mjerenja pokreta oka analizirali smo 12 emocionalnih fotografija i pokazali da ispitanici imaju veći broj fiksacija za pozadinu na neutralnim i neugodnim slikama te za figuru na ugodnim slikama. Drugi eksperiment je proveden s 4 para emocionalno komplementarnih slika (ugodne/neugodne) koje se međusobno razlikuju samo prema sadržaju u području figure. Pokazano je da su ispitanici više usmjereni na područje figure nego na područje pozadine. Buduća istraživanja emocionalnih evociranih potencijala u kojima će se koristiti fotografije iz baze IAPS trebala bi uzeti u obzir rezultate ovog istraživanja te prema tome ili odabrati fotografije sa praznom pozadinom ili prilagoditi fotografije tako da sa pozadine uklone elementi koji odvlače pažnju, tj. da pozadina bude prazna.