How effective are 3D anaglyph stimuli? An analysis in emotional recognition

María del Carmen Moret-Tatay[1]
Núria Pérez-Mengual[1]
Begoña Sáiz-Mauleón[2]
Francesc Bañuls Lapuerta[1]

[1]*Universidad Católica de Valencia SM, Valencia, España*
[2]*Universitat Politècnica de València, Valencia, España*

Abstract
The aim of this study was to examine the role of virtual environments in visual recognition. A classic and economically accessible technique was chosen: anaglyph. A battery of images that differed in their emotional charge was developed. The emotional valence of the new stimulus was evaluated using the SAM battery. 2D and anaglyph modalities were also tested. 32 subjects participated in the first study and 42 subjects in the recognition task. The results: i) Participants were more accurate in classic 2D environments compared to 3D, ii) participants were more efficient in the negative 3D condition compared to the rest of the emotional conditions in this category, while the neutral environment was the most efficient for 2D. It is suggested that coding information would be simpler for a 2D stimulus, however, effects as robust as emotional charge would manifest more clearly in a deeper presentation.
Keywords: anaglyph; ecological environments; recognition; emotional valence; accuracy

Quão Eficazes são os Estímulos de Anáglifos 3D? Uma Análise no Reconhecimento Emocional

Resumo
O objetivo deste estudo foi examinar o papel dos ambientes virtuais no reconhecimento visual. Foi escolhida uma técnica clássica e economicamente acessível a todos: o anáglifo. Foi desenvolvida uma bateria de imagens que diferiam em sua carga emocional. Avaliou-se a valência emocional do novo estímulo por meio da bateria SAM. As modalidades 2D e anáglifo também foram testadas. Participaram 32 sujeitos no primeiro estudo e 42 sujeitos na tarefa de reconhecimento. Os resultados: i) Os participantes foram mais precisos nos ambientes 2D clássicos em comparação com os 3D; ii) os participantes foram mais eficientes na condição negativa 3D em comparação com o resto das condições emocionais nessa categoria, enquanto o ambiente neutro foi o mais eficiente para 2D. Sugere-se que a codificação da informação seria mais simples para um estímulo 2D, no entanto, efeitos tão robustos quanto a carga emocional se manifestariam mais claramente em uma apresentação mais profunda.
Palavras-chave: anaglifo; ambientes ecológicos; reconhecimento; valência emocional; precisão

¿Qué eficacia tienen los estímulos anaglifos 3D? Un análisis del reconocimiento emocional

Resumen
El objetivo de este estudio fue examinar el papel de los entornos virtuales en el reconocimiento visual. Se eligió una técnica clásica y económicamente accesible: el anaglifo. Se desarrolló una batería de imágenes que diferían en su carga emocional. La valencia emocional del nuevo estímulo fue evaluada a través de la batería SAM. Se probaron las modalidades 2D y anaglifo. 32 sujetos participaron en el primer estudio y 42 sujetos en la tarea de reconocimiento. Los resultados: i) los participantes fueron más precisos en entornos 2D clásicos en comparación con 3D, ii) los participantes fueron más eficientes en la condición 3D negativa en comparación con el resto de las condiciones emocionales en esta categoría, mientras que el entorno neutral fue el más eficiente para 2D. Se sugiere que la codificación de información sería más simple para un estímulo 2D, sin embargo, efectos tan robustos como la carga emocional se manifestarían más claramente en una presentación de mayor profundidad.
Palabras clave:anaglifo; entornos ecológicos; reconocimiento; valencia emocional; precisión

How humans have involved and use technology has greatly attracted the attention of researchers in the last decade concerning changes in behavior and the human brain itself. Various disciplines have tried to address the interaction of information technology and communication (ICT) in terms of human development, cognition, social support and emotional skills. More recent approaches have specialized in the study of ICT on basic cognitive functions. In particular, recent studies have attempted to examine the impact of ICT on mnemonic processes such as working memory (Dahlin et al, 2008; Jaeggi et al., 2008; Karbach & Kray, 2009; Katoni, 2021). Some of these approaches have produced promising results (Deakyne et al., 2021; Foroughi et al., 2016; Oliveira. et al., 2016; Simons et al., 2016; van der Maas & Nyamsuren, 2017). This type of validity refers to the artificiality of the instrument. When evaluating results, we not only focus on

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ease of use by the user, if not in the vicinity of the virtual environment to real life, which ultimately is what is sought in related research: an outcome applicable to our daily lives (Mühlberger et al., 2020). Bear in mind that in many cases, when working in an artificial laboratory environment, the results obtained in it are far from those obtained in real life by the excessive control exercised in the control of underlying variables (e.g. noise or light), among many others). In fact, the use of virtual environments has been exponentially implemented in recent years through the development of a hyper-realistic trend in the use of images, trying to turn the burden of implementing ecology (Phillips et al., 2008; Schöne et al., 2017).

For several decades, virtual environments have been used for cognitive rehabilitation and for evaluation, although the latter to a lesser degree. Virtual reality is a new technology that through it you can create a cyberspace in which the person can interact with anything. The user, in addition to having the sensation and perception of being in the environment that is being shown, can also interact in real time in the same. In this paper we are interested in the ecological validity of these environments for evaluation and/or stimulation of basic cognitive processes, and more specifically, the emotional component. Well there are multiple variables that help coding information, in this case we have opted for one of the most studied in the field. In this way, a large amount of research on the mnesic processes maintains that to understand the relationship between emotional charge and memory, it is necessary to manipulate the emotional valence within a laboratory (Moreno-Cid et al., 2015; van Damme et al., 2017). Through various researches and studies, it has been shown that evidence for emotionally charged events (either positive or negative) are remembered more easily than neutral ones (Buchanan & Adolphs, 2002; Reisberg & Heuer, 2004). In this line, you can consider the emotional memory as a set of information that at the time of storage was accompanied by some factor from the alert system that promoted the information be set more easily (Psyrdellis et al., 2014).

To examine memory, different tasks have been described, among them, free recall, signaling and recognition tasks. One of the fields applied with the most recognition has been the one that uses decision tasks for the advantages in terms of measurement that it offers (Gordillo León et al., 2010, Moret-Tatay, et al., 2014). In this regard, it is proposed to assess both variables through the exhibition of classic 3D stimuli: anaglyph images. These are composed of two color layers, superimposed, but offset slightly filtered color (one for each eye) which allows the depth effect. The visual cortex of the brain fuses this into perception of a scene depth.

The main objectives focused on the ecological validity of the environment and emotional stimuli. This battery for 3D and 2D images that differentiated between positive, negative and neutral emotional valence was developed. Thus, the hypotheses developed were as follows. On the one hand, the hypotheses examined were: i) 3D environments have greater ecological validity than 2D in terms of visual recognition of emotional images, ii) images with negative emotional charge are remembered more accurately than other images, neutral and positive. Finally, it is expected that, if 3D environments really seem to show greater ecological validity, this also shows up in the type of emotional charge.

Method

Participants

This study is divided into two parts involving different types of participants: generating a battery of stimuli in 2D and 3D and a recognition task of them. Firstly, a sample of 42 subjects was selected voluntarily and for convenience. The mean age was 26.05 with a standard deviation of 4.79 and with an age range of 19-42 years. From this sample, 64% were women and 36% were men.

In the second stage, a similar selection was made to the previous phase, where a total of 32 people comprised between 19 and 36 years of age participated, and with an average of 26.65 years (standard deviation of 4.86). From this sample, 47% were women and 53% were men. All participants were college students who previously completed a collaboration with informed consent.

Instruments

The task was performed with the program SuperLab by Haxby, Parasuraman, Lalonde and Abboud (1993). This software was used for the random exposure of stimuli. With regard to the nature of the variables, the emotional load is selected depending on the characteristics adapted from the International Affective Picture (IAPS, Lang et al., 1999) in the Spanish adaptation of Moltó et al. (1999).

A total of 48 images were selected, of which 24 were visualized in the "target" phase, where there were 8 images per condition, that is, 8 images with positive

Figure 1. Proposal of Images Developed According to Emotional Valence and 2D and 3D Environment Developed by the Authors. Target Images

valence, others with 8 with neutral valence and another 8 with negative valence. And in the second "distractor" phase, 48 were displayed, that is, twice as many photographs for each condition.

To control the emotional load of new images adapted, the Maniquin Self Assessment task (also called SAM and created by Lang in 1980), was widely used by other authors such as Moltó et al. (1999). The SAM task consists of a scale of nine Likert-type anchoring points, which allows the subjects to evaluate their presentation in the post-hoc experiments. Specifically, the scale assesses three aspects:

- *Emotional valence*: Assesses how much emotional charge the image from 1 to 9 in Likert format suggest.
- *Arousal or level of activation*: Rate how much activation the image suggests from 1 to 9 in Likert format.
- *Dominance*: Refers to the level of perceived control over the image. That is, how much presence is there within the frame of the picture. Values of 1 indicate a non-dominant theme, while values of 9 indicate a very dominant theme.

Procedure

First, the SAM scale was administered. As described above, through this scale, a total of 42 people evaluated the images according to their emotional arousal and valence dominance.

When the results were extracted, the images were classified as positive, negative and neutral so that they could be delivered later in the experiment.

Subsequently, an experiment was carried out on 32 subjects. This consisted of a recognition task. Specifically, the task was based on a series of images that participants had a relaxed view of. Next, they were presented with the images on paper, a total of 48 images, among which were the target images (that is, the previous images) and the distractors. At this time, the subjects were to say what image they remembered seeing. The images were presented in four counterbalanced orders for the purpose of avoiding biases (see design section). Therefore, some first visualized 3D images in first order and others 2D. Once the first task was done, a test of attention was carried out. In this case, we selected a simple task, the faces Test (CARAS-R, Thurstone & Yela, 2012), to avoid overloading the attentional demands, since it is a relatively simple task developed primarily for children. This task has a three-minute timing, whose function was a distracting task. Then, participants presented another block of counterbalancing images.

Design

As regards the first phase of the work, a survey methodology was carried out. In the second phase, an experimental methodology was used. We are in this case before a design of repeated measures, that is, all the participants underwent all the experimental conditions. These types of approaches have certain advantages in

terms of sample size, since they allow samples lower than other types of studies, in addition to reducing false positives. On the other hand, the order of presentation of experimental blocks was counterbalanced. This allows to control the effects of presentation order. Finally, the final analyzes were performed using the statistical package Statistical Package for Social Sciences (SPSS), version 20. Descriptive statistics (number of subjects, mean and standard deviation) were calculated and, finally, an analysis of variance was performed for the experimental phase with 3x2 repeated measures, that is, emotional valence x environment.

Ethics

All participants gave informed consent to participate in the study. The research was approved by the University ethical committee: UCV2017-2018-31.

Results

After the selection of the proposed images, we proceeded to the assessment of the emotional charge of the images, as described in the procedure section. For this, an online survey which asked about the assessment in terms of emotional valence, arousal and dominance of the photographs was applied. These were presented in 2D. The following table shows the results obtained from the evaluation of the images.

A total of 44 subjects selected for convenience evaluated photographs. A student t test was performed to assess differences between images of the target group and distracting images. None reached the level of statistical significance. Secondly, we proceeded to the experimental phase. To do this, an analysis of the variance was made on the hit rate of the participants. This new sample had 32 subjects, all different from the previous sample.

As can be seen in Table II, the hit rate was higher for 2D images. Furthermore, as shown in Table 2, the variability was greater for 3D images.

After analysis of variance statistically significant differences between 2D and 3D images found: F (1,31) = 10.07; MCE =.12; $p < .005$; $\eta^2 = .24$. On the other hand, the role of emotional valence was examined, reaching the level of statistical significance: F (2.62) = 10.64; MCE = .05; $p < .001$; $\eta^2 = .25$.

Discussion and Conclusions

The aim of this study was to examine the role of virtual environments in visual recognition of images related to memory (e.g. environments or elements, following the guidelines of the IAPS battery). Likewise, a classic effect was selected and has proven its sturdiness through a large number of papers in the literature: the emotional valence. Thus, it sought to examine whether virtual environments have greater than classic environments, possessing higher signal quality information, according to classical theories such as detection theory ecological validity. Also, evaluate the emotional charge

Table 2.
Efficiency (Percentage of Correct Answers) and Variability (SD) as Emotional Condition and Block Employee

	Emotional charge	Hit rate	*SD*
2D	Neutral	98.44%	.04
	Negative	97.27%	.06
	Positive	92.19%	.11
3D	Neutral	91.80%	.12
	Negative	93.36%	.10
	Positive	87.89%	.13

Table 1.
Counterbalance Stimulus and Blocks Used According to Conditions of Images Developed for this Study

		Neutral	Negative	Positive
Target	Valencia	4.8 (.63)	3.74 (.68)	6.39 (.64)
	arousal	4.62 (.51)	5.25 (.80)	4.89 (1.32)
	dominance	5.07 (.23)	5.24 (.36)	5.62 (.43)
Distractor	Valencia	5.19 (.83)	3.37 (.74)	6.54 (.79)
	arousal	5.58 (.39)	4.97 (1.09)	4.92 (.50)
	dominance	5.48 (.39)	5.95 (.36)	5.40 (.33)

in these two environments, it allows us to see if the pattern is similar for both or different. To achieve these objectives, it conducted two strategies; the development of a new battery of stimuli, and a task visual recognition thereof. According to the results the following conclusions were obtained: i) The participants were more accurate generally in classical environments 2D versus 3D, ii) particular, participants were more efficient in the negative condition 3D versus other emotional conditions in this category, while the neutral environment was the most efficient for 2D.

Regarding the first objective, which argued that the 2D environments have lower ecological validity in this study, the opposite result was found. In this way, one aspect that has not been considered is the familiarity of the participants with this virtual environment. Qualitatively, participants have reported that this was not a common scenario for them. Therefore, more research is needed in this field, following previous studies in the literature (Chaytor et al., 2003; Oliveira et al., 2016).

On the other hand, the second objective was to examine whether the negative images were remembered more efficiently in both environments form can be accepted. The results obtained after the data statistically pass after the experiment concluded that negative images were remembered best as the revised mark a priori 3D environments literature. However, in the 2D environment it was the neutral condition the one that depicted more accurate results. In this regard, the 3D manipulation showed a similar manner described in theoretical models (Moreno-Cid et al., 2015; Moret-Tatay et al., 2014).

Some limitations emerged in the current research. The most important limitations of this study are the participant's familiarity of 3D anaglyph. As previously mentioned, there are very innovative 3D techniques that manage to create very realistic, or even hyperrealistic (Sanders et al., 2017)., environments. However, the costs thereof are often unattainable for therapists or citizens. In this case, we have opted to work from the most basic approaches to be increasing complexity in future research. We also believe that it is a technique economically achievable for everyone.

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About the authors:

María del Carmen Moret-Tatay – Lecturer at the Universidad Católica de Valencia San Vicente Martir. PhD Mathematics and Psychology.
ORCID: https://orcid.org/0000-0002-2867-9399
E-mail: mariacarmen.moret@ucv.es

Núria Pérez-Mengual – PhD student at the Sede Padre Jofre (Psicología).
ORCID: https://orcid.org/0000-0002-5749-7818
E-mail: nuria.perez@mail.ucv.es

Begoña Sáiz-Mauleón – Lecturer at the Polytechnic University of Valencia. PhD Fine Arts. Master in photonics and laser Technologies.
ORCID: https://orcid.org/0000-0002-8650-0916
E-mail: bsaizma@ega.upv.es

Francesc Bañuls Lapuerta – Lecturer in Occupational Therapy. Sede Padre Jofre (Psicología).
ORCID: https://orcid.org/0000-0001-6550-4590
E-mail: francesc.banuls@ucv.es

Contact:

María del Carmen Moret-Tatay
Sede Padre Jofre (Psicología)
Av. de la ilustración 4. 46100
Burjassot, Valencia