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EXTRA TIME AND FOCUS DO NOT HELP TO ACHIEVE A MORE ACCURATE VISUAL PERCEPTION FOR A FEW-SECOND INTERVAL

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ABSTRACT

Whether increased attention leads to better perception is a debate that has been going on for decades. The presented experiment investigated this relationship in situations of interest to Consumer Neuroscience: respondents had to evaluate two stimuli in the same visual field containing distractors in a short interval, from two to six seconds. The perceived relative sizes of the two stimuli were self-reported, while data obtained from EEG metrics, eye-tracker, and time were used as measures of attention; all led to positive correlation coefficients with perception error (measured as the difference from the actual ratio of the two sizes), although some were statistically significant while others were not.

Keywords: Attention, Perception, EEG, Eye-tracking, Size Judgment, Visual Stimuli, Consumer Neuroscience, Perception Error

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1. Introduction

Attention and visual perception most often constitute the beginning of consumer decision–making - and consumer behavior models (Plassman, Ramsøy, & Milosavljevic, 2012; Hoyer, MacInnis, & Pieters, 2024). The interaction of three processes (eliciting bottom-up attention by modulating stimuli characteristics, exerting top-down attention, and obtaining an informative perception) is thereby critical for marketing researchers and practitioners alike.

As of today, all studies agree that visual attention modulates perception, with different conclusions only regarding the moment, in milliseconds, when it begins to do so (Bao et al., 2010; Briggs, Mangum, & Usrey, 2013; Slotnick, 2022). But if it helps to a more accurate perception or a distorted one is far from a consensus, various experiments leading to apparently opposite results. On one side, there is a long history of common wisdom and early cognitive models in which increased attention lets the observer see a stimulus in better detail. A series of experiments conducted by a group of researchers coordinated by Maria Carrasco found that increased attention made identical stimuli to be perceived as sharper, more colorful, and faster (Carrasco, Ling, and Read, 2004; De Freitas and Liverence, 2012). Many studies in recent decades support the model of recruitment of more neurons and their increased activation to process sensory information from stimuli that attract our attention (Petersen et al., 1994; Chawla, Ress, and Friston, 1999).

However, there is increased evidence and acceptance that the same brain processes sometimes lead to over-representation of the attended stimuli, distorting the perception rather than improving it (Connor, Gallant, & Van Essen, 1996). Suzuki and Cavenagh (1997) discovered the attention repulsion effect" – two perfectly aligned lines were perceived as misaligned, an attention attracting cue "pushing" the line appearing after its flashing. Ono and Watanabe (2011) confirmed Suzuki and Cavenagh findings; moreover, they discovered that the attention cue would cause an attraction effect if it is flashed immediately after the second line presentation – and disappearance from the screen. Liverance and Sholl (2011) found that the two effects coexisted within a multiple object tracking experiment; after all the presented moving objects disappeared from the screen, respondents reported that targets were closer and distractors were further away than their real positions. Not only is visual perception negatively impacted by increased attention, but other processes are also hampered, such as creative problem-solving (Wegbreit et al., 2012).

While the visual system is one of the best understood in neuroscience, the same cannot be said for attention (including visual attention), despite sustained efforts in the field and evident advances. Carrasco (2011) identified about 2400 scientific articles on visual attention between 1980 and 2011. As of February 2025, a search on the same keywords in PubMed yields more than 70,000 titles (almost 500 in Journal of Marketing and 350 in Journal of Consumer Psychology). However, a full description of the brain structures and brain mechanisms involved in various types of attention, their precise functioning, and interactions with other brain processes is not close. Researchers in different fields (medical area, psychologists, neuroscientists) use various models and classifications of attention, focusing on their supporting brain structures. Moreover, starting from early models of attention, which decomposed it into different subsystems, such as orientation to significant events, detection of the signals to be consciously processed, and maintaining an overall alert state (Posner & Boies, 1971, Kahneman, 1973), imagistic studies revealed different brain structures activated for each of these distinct functions as well as for purposefully restricting the processing of one stimulus to facilitate better processing of another and various stimuli characteristics, such as movement and contrast (Posner & Petersen, 1990, Büchel et al., 1998, Petersen & Posner, 2012, Wimmer et al., 2015, Frank et al., 2020). Some brain structures' activations appear in several attention-related processes and in other cognitive or emotional states.

For consumer neuroscience, the most used dichotomy is between top-down (voluntary, purposefully deployed) and bottom-up (involuntary, stimulus-triggered) attention. For the first, we have consensus that the dorsolateral prefrontal cortex and posterior parietal cortex are involved in attentional control, while intraparietal sulcus and frontal eye fields are activated for spatial attention allocation; for the second, the temporoparietal junction and ventral frontal cortex are activated by attention capturing stimuli, while the anterior insula and anterior cingulate cortex are involved in detecting and orienting towards the salient stimuli; finally, attention control is dynamically realized by the pulvinar nucleus of the thalamus and the superior colliculus mediating between the top-down and bottom-up attention supporting structures (Fiveable, 2024). Nevertheless, it is worth mentioning that a) specific brain structures are activated depending on the sense(s) the stimulus is salient for or towards which we direct attention and b) new structures and new mechanisms have been discovered to process the salient signals (Liang, Mouraux, & Iannetti, 2013), to inhibit the processing of some for better processing of others (Bisley, 2011, Frank et al., 2020), and responsible for biases (Beck & Kastner, 2009). Finally, it is widely accepted that the mechanisms and structures involved by the bottom-up attention take about 120ms to activate and remain so for about 300ms, while the top-down attention takes about 300ms to deploy but can be maintained for as long as the task to be fulfilled requires it (Ling & Carrasco, 2006). The previous considerations are intended to draw attention to the limits of metrics developed based on electroencephalogram (EEG) readings, one of the techniques based on neuroscience most used in marketing and this study. Although the explaining and prediction power based on EEG alone is far superior to the one based on traditional methods, especially to the one based on self-responses, and some developments are promising (Peelen & Downing, 2023), their accuracy is currently in the range of 80% (Byrne, 2022). For a marketing researcher, using EEG recordings-based metrics is a very convenient way to use the effectiveness of a neuroscience method without becoming a neuroscientist. The first such metrics were analytically developed, such as the frontal asymmetry index as a metric for pleasure and approachability, and they have already performed much better than the traditional methods (Herman-Jones, Gable, & Petersen, 2010). Currently, emotional and cognitive states are elicited by various techniques (Gross & Levenson, 1995, Kenneth, Quamme, & Newman, 2008; Pacheco, Garcia, & Reynes, 2018; Mashail, Malak, & Mohammed, 2024), readings of EEG sensors are recorded, and various artificial neural networks are trained and tested for improved prediction power of the respective states. Several companies have offered such metrics for over a decade, but their openness in disclosing the specifics of metrics construction and performance is still low. Similarly, by training artificial neural networks with thousands of images and heat maps developed with eye-tracking devices, specialized software computer applications achieve over 90% prediction accuracy (Neurons, 2025, Feng-Gui, 2025) in a fast and convenient way.

2. Method

Two groups of 33 respondents had to evaluate the size ratio of two parallel straight segments in the so-called Ponzo illusion (Appendix A) and two cars in a picture illustrating this illusion in the real world (Sanders, 2021, Appendix B). The actual ratio was subtracted from the perceived one, resulting in the perception error. Four orientations of the lines image were used – upward, Image 5, leftward, Image 2, downward, Image 3, and rightward, Image 4. Image number 1 is the cars' picture.

One group (Group EEG) wore an Emotiv EEG headset Epoc X with 14 channels, and the EMOTIV metrics of Engagement and Attention were recorded both when respondents were exposed to the images and in the four seconds they had after each image to put down the answer on an answer sheet. A similar distribution concerning order of appearance and exposure duration was ensured for each image 2-5; image 1 appeared first every time and had an exposure duration of 4 seconds. Some distractors (Doodle images and objects, Doodle, 2021) were added to images 2-5 for a more balanced distribution of attention as predicted by a visual analytics software (Feng-Gui). The other group (Group Eye) performed the task in front of an eye-tracking device provided by Captiv NeuroLab. All images were presented for four seconds, always in the same order.

3. Results

The mean errors of the two groups were very similar, as shown in Table I: Perception errors - descriptive statistics, generated with the Data Analysis module of Excel, (the computed t-statistic for means difference is 0.516 vs. the critical value of 1.968 – significance level 0.05, two-tailed, df=328).

Table I: Perception errors - descriptive statistics

Group Eye			*Group EEG*	
Mean	0.394798		Mean	0.361383
Standard Error	0.015084		Standard Error	0.034874
Median	0.4		Median	0.2
Mode	0.4		Mode	0.2
Standard Deviation	0.193751		Standard Deviation	0.447962
Sample Variance	0.03754		Sample Variance	0.20067
Kurtosis	1.219255		Kurtosis	21.685
Skewness	1.028216		Skewness	4.004189
Range	1		Range	3.5
Minimum	0		Minimum	0
Maximum	1		Maximum	3.5
Sum	65.14172		Sum	59.62818
Count	165		Count	165

For each of the five images, the mean errors in the two groups are presented in Table II: Perception errors by image

Table II: Perception errors by image

Image	Group EEG	Group Eye
Image 1	49%	54%
Image 2	31%	42%
Image 3	38%	31%
Image 4	35%	37%
Image 5	28%	33%

Cars image (Image 1) generated by far the largest errors in the EEG group, and, as mentioned, was always presented first. Further analysis continued with similar line images – Image 2 to Image 5; Image 1 is excluded as its different nature might have distorted the attention-related metrics correlations with the perception errors. Correlation coefficients of the perception errors were computed with the apparition Order, exposure Time, Engagement, and Attention metrics during exposure and during answer writing, EngA and EngB, AttA and AttB, respectively – results in Table III: Group EEG correlations – lines images

Table III: Group EEG correlations – lines images

	Error	*Order*	*Time*	*EngA*	*EngB*	*AttA*	*AttB*	*t-computed*
Error	1							
Order	0.146	1						1.683
Time	0.202	0.116	1					2.339
EngA	0.053	0.046	0.243	1				0.594
EngB	0.021	0.007	0.198	0.935	1			0.239
AttA	0.002	0.007	0.064	0.292	0.241	1		0.025
AttB	0.038	0.102	0.022	0.296	0.243	0.922	1	0.434

Only the correlation coefficient of exposure time is statistically significant compared with the critical t-value of 1.9784 (0.05 significance level, two-tailed, df=130). Even if the apparition Order was also closed to qualifying as significant, for technical reasons, the images were presented to the Group Eye participants in the same order and for the same time duration - four seconds.

There are many metrics usually computed based on eye-tracking recordings, thought to be indicative of visual attention, including Total Fixation Duration (associated with top-down attention), Time to First Fixation, First Fixation Duration, and Fixation Count (Ramsøy, 2015). Recordings from the Group Eye were aggregated in FocA, FocB, Foc(A+B), and Foc (A-B), respectively, where:

Foc(a) = (Time to fixate object a)/(Total exposure time)

Foc(b) = (Time to fixate object b)/(Total exposure time)

Foc(a+b) = (Total fixation time on any of the two objects)/(Total exposure time)

Foc(a-b) = (Difference in fixation time)/(Total exposure time).

The correlation coefficients and the computed t-statistics are presented in Table IV: Group Eye correlations – lines images (the cars image, Image 1, was excluded from this analysis as for Group EEG).

Table IV: Group Eye correlations – lines images

	Error	*Foc(a)*	*Foc(b)*	*Foc(a-b)*	*Foc(a+b)*	*t-computed*
Error	1					
Foc(a)	0.594	1				9.429
Foc(b)	-0.319	-0.112	1			-4.293
Foc(a-b)	0.629	0.804	-0.680	1		10.320
Foc(a+b)	0.276	0.748	0.575	0.208	1	3.670

All correlation coefficients are statistically significant at 0.05 (t-critic is 1.9784 for two-tailed, df=130) and 0.001 significance levels (t-critic is 3.367 for two-tailed, df=130). The negative correlation coefficient between Foc(a) and Foc(b) – also significant at 0.05 – may suggest a general pattern of sharing the attention budget between the two objects to be evaluated.

4. Discussion and further developments

In the range of two to six seconds of exposure time, paying more attention and time did not lead to a more objective visual perception. For longer time intervals, we could reasonably guess that superior cognitive functions may come into place to decrease or even remove perception errors. Nevertheless, many buying and other decisions are made in less than two seconds of low-effort processes. The initial design of this study involved time intervals of one second, but technical constraints would have rendered unreliable results. We may also question if the respondents' overall attention during the experiments was similar to the one in low-effort buying situations and speculate that we may have an optimum attention level to minimize the perception errors. For instance, more data would make investigating such a hypothesis possible by cluster analysis. For now, the overall Engagement and Attention in Group EEG were 65 and 43 on a 1 to 100 scale, so we do speak of moderate levels of attention.

Data obtained in the Eye Group thoroughly supported previously mentioned findings that focusing on something will lead to a distorted image. EEG data failed to be conclusive. It cannot be said now if this comes from the inherent less than 100% accuracy of EEG-based metrics for attention, data collection errors, inter-group differences, or all of them; a study in which respondents' activity is monitored at the same time by the EEG headset and the Eye-tracker sensor (as the current study had been originally designed) will reduce these uncertainties. On the other hand, using two samples allowed for identifying robust results (no significant mean differences between reported perceived size ratios of any of the five images, especially if we consider only the ones resulted from the 4” exposures within the EEG group to compare with the 4” only exposures in the Eye group) and more unstable ones (the ranking of images perception errors across the two groups, as we shall see in the next paragraph, deviation, kurtosis and skewness within the two groups). Additionally, the ways respondents looked at the images as succession and duration of saccades and fixations on the stimuli to evaluate were more heterogeneous than Yarbus (1967) would have predicted; a possible explanation for that is the much fewer saccades and fixation points the time and images in the current experiment allowed for as compared to the one of Yarbus.

Regardless how significant the attention is in explaining the magnitude of the perception error, there are many other influencing factors; one of the most often invoked when trying to explain the Ponzo illusion is orientation, according to which the linear perspective would lead to a higher magnitude error for an upright image position (such as in our Image 5). Although this study had in no way the intention to investigate the causes of Ponzo illusion – it just used the available images – it may be useful to say that orientation seems to be a very unstable explanator of error differences. Not only does the ranking of the error magnitudes differ between our two groups as presented in Table II: Perception errors by image, but it also differs from the previous study of Poom (2019) – the magnitudes of the errors are not directly comparable as images, available time, and appraisal process differ. Table V: Average perception error magnitude by image orientation summarizes these differences (1, the largest error, 4, the smallest):

Table V: Average perception error magnitude ranking by image orientation

Image	Poom	Group EEG	Group Eye
Upward	1	4	3
Leftward	2-3	3	1
Downward	4	1	4
Rightward	2-3	2	2

5. Conclusions

In its weakest form, based on the results of the Group EEG, the first conclusion is that more attention, be it overall engagement or sustained focus, does not help to a more accurate visual perception on two to six seconds exposure times. Given the attention metrics construction and performance considerations presented earlier in the article, and the findings from Group Eye data, this conclusion might be strengthened: more focused attention allocated to a stimulus makes it look bigger as compared to an identical one placed in the same visual field, with direct implications in several marketing practices (e.g. product placement and point of sales materials). More fixation time allocated to a stimulus makes it look bigger, while shifting the focus between the stimuli to compare helps to better visual perception. Orientations of the apparent convergence (vanishing) point in the standard Ponzo lines image (upward, leftward, downward, and rightward) failed to provide significant differences in perception errors, as did the images' appearance order.

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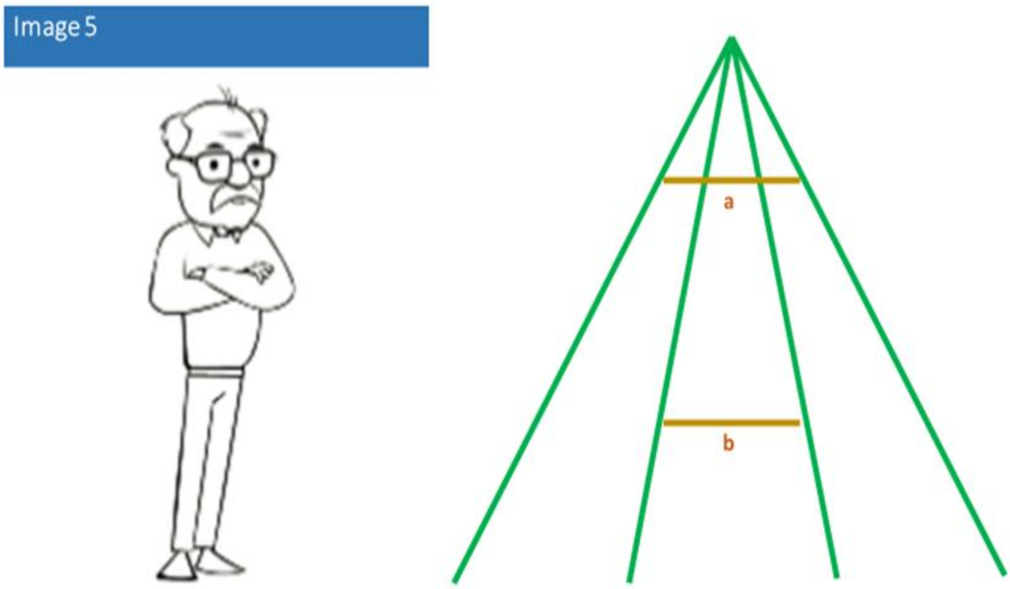
Appendix A: Ponzo illusion, standard version



Appendix B: Ponzo illusion, real world

Source: Sanders, T., 2021

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