

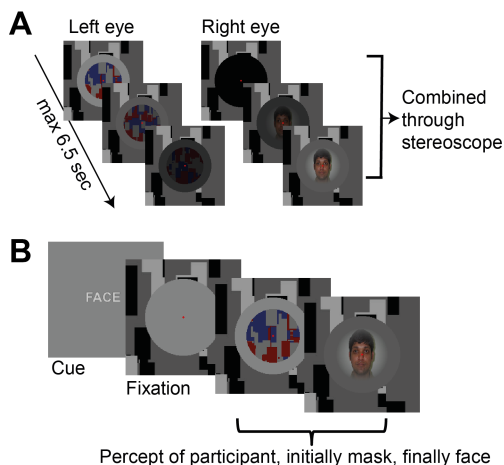
**Marie Curie Intra-European grant: PIEF-GA-2011-300184: Expect\_Conscious Final Report, August 2015**

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The current project has investigated the impact of expectations, or predictive coding, on conscious visual perception. Predictive coding – or more generally the Bayesian brain – is an increasingly influential framework within cognitive science that sees perception as the result of the brain’s (Bayesian) inferences about the causes of sensory signals. While a large body of evidence now supports this general framework, little is known about the relations between perceptual predictions and conscious contents. We started with a simple question: do expected (as compared to unexpected) stimuli gain easier access to consciousness?

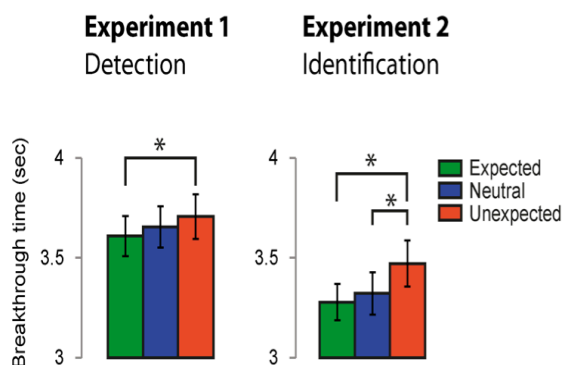
The main impact of the project has been a publication in the influential *Journal of Vision* (Pinto, van Gaal, de Lange, Lamme & Seth, 2015.

<http://jov.arvojournals.org/article.aspx?articleID=2337707>). In this article we describe a series of studies involving “breakthrough against continuous flash suppression (CFS)”, see Figure 1.



*Figure 1: A typical example of a CFS breakthrough trial involving a valid cue. Participants first saw the cue (“FACE”). Then one eye (the left in panel A of this example) was presented with changing Mondrian patterns, which were fully visible at the start, but which gradually diminished in contrast/visibility. At the same time, the contrast of the target image in the other eye was gradually increased leading to a sudden transition in inter-ocular suppression and the experience of an image “popping into consciousness” (panel B).*

We discovered that breakthrough against continuous flash suppression is affected by expectations. Specifically, when subjects expect to see a certain object, for instance a house, this object enters conscious awareness faster, than when this object is unexpected, or than a neutral object about which the subject has no expectations. Moreover, unexpected objects are slower to gain access to consciousness than neutral objects. So, a simple hierarchy exists in the relation between expectations and access to consciousness, expected objects enter consciousness fastest, followed by neutral objects, followed by unexpected objects. This holds for both detection, i.e. participants respond whenever *any* object pops into awareness, and identification (respond when a house or a face pop into awareness); see Figure 2.



*Figure 2: Breakthrough times for expected (green), neutral (blue) and unexpected (red) stimuli in Experiments 1 and 2. Asterisks indicate significant differences between conditions. In both experiments expected stimuli broke through more quickly than neutral and unexpected stimuli. Note that if subjects participated in both experiments (which all but one did), they performed Experiment 1 first. This practice effect was the likely cause of the lower response times in Experiment 2. Error bars indicate between subjects standard error.*

Crucially, by conducting a number of control studies we were able to exclude alternative explanations such as subjects being more inclined to simply respond that they had seen the expected object (without an actual change in their perception), or a change in perception that was driven by different attentional strategies, rather than by different expectations. Altogether then, our research has provided strong evidence that expectations alter basic perceptual processes. Furthermore, not only has our research led to a publication in an internationally renowned, peer reviewed, scientific journal, this research also answers the central question of our Marie Curie proposal, namely how (if at all) do expectations affect access to consciousness.

In addition to the above study, we are in the process of writing up the findings of another set of experiments which focusses on the relation between expectations and conscious memory. We were interested here to examine the influence of expectations not on current perception (as in the first study) but on our visual memory for recent events. We have found that as memory deteriorates, the influence of expectations increases. So, with the passing of time (interestingly, in the order of seconds, and perhaps even on a sub second scale) memory becomes less a representation of the world, and more a representation of what we expect the world to be like. The results of this work were recently presented as a talk at the recent meeting of the Association for the Scientific Study of Consciousness (ASSC, Paris, July 2015).

In summary, we have delivered two research projects, which both show that expectations can have an important influence on both perception and memory. Our findings challenge classical theories that claim that perception/memory is mainly a process of 'bottom up' elaboration of sensory input. Instead, they provide strong empirical support for 'Bayesian brain' ideas which see perception as a generative act of inference on the causes of sensory data. Many further experimental opportunities are opened up by our results, which we look forward to pursuing.

#### Societal impact

The discovery that expectations influences both how fast items enter consciousness, and the contents of memory, shows that awareness of expectations, or biases, could be relevant for a range of situations. Especially when fast reactions are required, for instance in situations of medical urgency, or in certain lines of police work, having the wrong, or too strong, biases could have detrimental effects. Similarly, when reliance on memory is important, for instance in traffic situations, or with eye witness accounts, it could again be important to know the biases of the observers, and how this could affect their performance.

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#### Reference:

Pinto, Y., van Gaal, S., de Lange, F. P., Lamme, V. A., & Seth, A. K. (2015). Expectations accelerate entry of visual stimuli into awareness. *Journal of Vision*, 15(8), 13-13.