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The Neural Basis of Always Looking on the Bright Side

OWEN P. O'SULLIVAN

St. John of God / St. Vincent's University Hospital / University College, Dublin (Ireland)

Humans generally exhibit a pervasive future bias in favour of optimism. We overestimate the likelihood of success in work, relationships and financial investments. Similarly, we underestimate the probability of experiencing negative events such as, serious illness or financial ruin. The optimism bias is widely considered as one of the most reproducible, prevalent and robust cognitive biases observed in psychology and behavioural economics. The catastrophic impact of the recent economic collapse has laid this cognitive bias bare. In this introductory overview, current understanding of the neural basis of the optimism bias is explored. Topics considered include: converse negative biases in depressive illnesses, the role of dopamine in optimism bias generation and modulation and evidence from functional neuroimaging studies. Research on the optimism bias has afforded us a unique window into decision-making, reward-processing and the potential for systematic irrationality in the human mind.

Key words: *Cognitive science, Anticipation, Psychological, Humans, fMRI, Habituation, Psychophysiologic.*

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INTRODUCTION

Children growing up in modern Western society are actively encouraged to adopt a positive outlook. From a young age, they are coached by parents and teachers alike to recognise the value of their individual skills and attributes regardless of their objective ranking compared to their peers. In fact, to convey to a child otherwise would widely be considered as tantamount to abuse. They are bombarded with messages about "unleashing your potential". Pragmatism, a trait once viewed as virtuous and desirable, has been denigrated. It is now seen as something outdated: the hallmark of a 21st century Luddite. In our classrooms and through our media, children are repeatedly being given the distinct message that "nothing is impossible"; or rather, "impossible is nothing" as in the case of one particular sportswear company. Consequently, a culture of unbridled self-confidence married with expectant self-entitlement has emerged within the ranks of Western adolescents, particularly so in North America. The modern cult of celebrity, wherein success and talent are viewed as by-products of fame - rather than the other way around - complicates matters further. However, despite this willful promotion of unrelenting positivity and optimism, mental illnesses such as depressive disorders, bi-polar affective disorder and anxiety disorders are being diagnosed more than ever before and at increasingly younger ages. Whilst differing international psychiatric diagnostic criteria, traditions and prescribing patterns are certainly major factors to consider in these changes, we must also look to cultural change and psychology for insight. The collectivistic-individualistic dichotomy is no longer sufficient a platform from whence to extrapolate inter-cultural variation in terms of trends in unrealistic optimism; we now know socioeconomic status must also be borne in mind (Joshi and Carter, 2013). We are learning that cultural variation in terms of this self-enhancing bias is far more nuanced than previously thought.

THE ALLURE OF A COHERENT NARRATIVE

We consistently simplify how situations will unfold in our minds and repeatedly overestimate how successful we will be in our various endeavours. This pattern follows us from childhood well into adulthood. We discount the statistical likelihood of experiencing a negative event such as the death of a loved one, being diagnosed with a serious illness, or suffering an accident (Weinstein, 1980). Instead, we are drawn to envisage a

more favourable future for ourselves free of all life's grim inevitabilities. To illustrate the point, the blissful denial displayed by many cigarette smokers regarding the harmful effects of their habit offers a good example of this fascinating behaviour. It exemplifies how irrational our decisions and actions can be: they understand and appreciate the risks, but nonetheless are often wholly convinced that they will not suffer at the hands of their addiction. Furthermore, many smokers will vociferously discredit the reported difficulties others experience in trying to quit, citing that they can stop whenever they decide to and physicians are no exception. Although smoking is an addiction, some smokers' attitudes to their habits neatly illustrate several relevant psychological phenomena such as, temporal discounting and selective updating.

Construal level theory proposes that temporal distance to imagined future events - such as, potentially developing a smoking-related illness - modulates our evaluative representations of these outcomes such that the greater the distance, the more likely the event is to be conceptualised in terms of fewer abstract features thereby divorcing us cognitively from the reality of likely undesirable eventualities. Temporal discounting thus impacts on evaluation, prediction and ultimately decision-making (Trope and Liberman, 2003). Selective updating refers to differential belief updating in favour of incoming positive information (See: "How we systematically deceive ourselves"). The aforementioned phenomena are important to consider when attempting to dissect the irrational decisions humans make every day and the unrealistic expectations we harbor in the face of, oftentimes, overwhelming contrary evidence.

THE OPTIMISM BIAS

In an attempt to reconcile all this information we are led to pose some very intriguing questions regarding human nature with reference to the origins and accuracy of our predictions and their influence, in turn, on our future planning behaviour. But is this predilection for "always looking on the bright side", so to speak, something new? This cognitive bias is neither new, nor culture-bound. It is called the optimism bias and transcends gender, race, nationality and age. It was first demonstrated by Weinstein (1980) and refers to a bias whereby, "people rate negative events as less likely to happen to themselves than to the average person and positive events as more likely to happen to themselves than to the average person" (Harris and Hahn, 2011). It is widely considered to be one of the most reproducible, prevalent and robust cognitive biases observed in psychology and behavioural economics (Sharot, 2011a). It can be defined as a mismatch resulting from one's future expectations exceeding the reality of the outcome. Evidence gathered from studies involving non-humans subjects have also supported the theory that this bias is consistent across species. Specifically, research has demonstrated the optimism bias using similar experimental models in both birds (Matheson et al., 2008) and mice (Harding et al., 2004).

THE PESSIMISM BIAS

A converse pessimistic bias has also been documented (Wisco, 2009) in patients suffering from depressive disorders. They overestimate the likelihood of a negative outcome and underestimate that of a positive future. Interestingly, a systematic negative bias has only been observed in those affected by severe depression rather than milder forms of the illness. Patients with mild depression did not demonstrate such a bias on testing. In fact, notably, such groups were found to be unbiased in their predictions (Strunk et al., 2006) suggestive of mild depressive states exerting a dampening effect on the influence of the optimism bias. The role of dopamine in this negative bias is unclear however, research supports therapeutic interventions for major depression known to induce positive biases (Hallion & Ruscio, 2011).

Regarding susceptibility to negative health outcomes, evidence from non-depressed subjects has shown that individuals tend to be comparatively optimistic. A very strong association was observed between comparative optimism concerning health outcome severity and optimism concerning susceptibility. This tells us that people systematically underplay their susceptibility to illness and indeed how severe these illnesses can be (Hevey and French, 2012). The optimism bias is pervasive, relatively stubborn and notori-

ously unwavering to contradiction.

HOW WE SYSTEMATICALLY DECEIVE OURSELVES

Humans demonstrate selective attention toward incoming positive information concerning the future. Beliefs are then differentially updated in favour of this preferred positive information (Eli and Rao, 2011). This process is termed selective updating and occurs in regions of the frontal cortex involved in monitoring prediction errors (Sharot et al., 2012). Prediction errors refer to discrepancies between anticipated and actual outcomes. The signals to code for prediction errors associated with negative updates are much weaker (Sharot et al., 2011b) and consequently selective updating in favour of more palatable positive information takes precedence. The search for the neuromodulatory origins of these signals led researchers to the neurotransmitter, dopamine.

A ROLE FOR DOPAMINE - CULPRIT AND SAVIOUR?

The following serves as an introduction to the central role of dopamine in neural reward systems. For a comprehensive review on reward processing dysfunction, we refer readers to Whitton et al. (2015). The brain's reward system involves the caudate nucleus and limbic system. Dopamine has a central role in reward stimuli processing. Reward anticipation and actual reward involve activation of different brain regions. Reward anticipation is mediated by the anterior cingulate cortex (ACC) and nucleus accumbens (Bush et al., 2002), with amygdala activation associated with prediction of a large positive reward (Hommer et al., 2003). The medial prefrontal cortex (PFC) mediates reward response (Knutson et al., 2001). Dopamine dysregulation is implicated in a wide array of psychiatric disorders in addition to schizophrenia; such as, depression (Papakostas, 2006), addiction (Berke and Hyman, 2000) and attention-deficit hyperactivity disorder (ADHD) (Tripp and Wickens, 2009). Dopamine also has pivotal role in learning (Schultz et al., 1997).

Dopamine belongs to the group of neurotransmitters known as catecholamines. This group has L-DOPA (dihydroxy-L-phenylalanine) as its precursor. Dopamine cannot cross the blood-brain barrier hence, L-DOPA is used clinically as a psychotropic: once across the blood-brain barrier it is converted to dopamine. In Parkinson's disease, administration of L-DOPA elicits an asymmetrical influence on learning relating to positive and negative outcomes, favouring the former (Frank et al., 2004). Dopamine has a critical role to play in modulating the subjective enjoyment derived from future life events. It has been found to enhance expectation of pleasure in humans (Sharot et al., 2009). But could this expectation be modulated in the laboratory? Researchers administered L-DOPA under experimental conditions in a double-blind placebo-controlled pharmacological intervention study to see whether the optimism bias could be manipulated (Sharot et al., 2012). Their results were novel and showed that the optimism bias is malleable: selective updating was enhanced by administration of L-DOPA.

They acknowledged that an optimism bias may not necessarily be generated, maintained and updated by dopamine alone and refer to memory, emotions and other neurotransmitters such as, serotonin, as possibly being involved. Nevertheless, the significance and potential future impact of this discovery for the treatment of mental illnesses is clear. Whitton et al. (2015) offer insight into novel neurobiological approaches to studying symptom patterns which transcend diagnostic boundaries. Specifically, they reference major depression, bipolar affective disorder and schizophrenia. Knowledge drawn from the our understanding of the neural basis of the optimism bias has informed such work and could potentially impact on the development of new pharmacological and neuropsychological interventions in the future which are targeting symptom-clusters as opposed to discrete psychiatric diagnoses.

LESSONS FROM NEUROIMAGING - IS IT ALL IN OUR HEADS?

We know that the optimism bias is pervasive and has almost been shown to be universal. But, what can be learned about this peculiar cognitive bias from neuroimaging? And what more can we learn about the generation and perpetuation of this apparent flaw in our thinking? Activity in the rostral ACC has been correlated with

trait optimism. The amygdala and rostral ACC are known to be affected in depression (Drevets et al., 1997) and pessimism (Strunk et al., 2006). Sharot et al. (2007b) sought to use functional magnetic resonance imaging (fMRI) to gain a greater understanding into exactly how the brain generates this bias. Participants were scanned while they were asked to think of an autobiographical event. They were cued as to whether the event should be in the past or imagined in the future. The memories were then rated for emotional arousal and valence. After scanning, they completed a standardised assessment - Life Orientation Test-Revised (LOT-R) - of trait optimism and were ranked according to their score on this scale. These data were then correlated with both the behavioural measures and the region of interest analyses (ROI) performed using fMRI. In this context, ROI analyses refers to the extraction of signal from specific brain regions in order to identify areas that are activated above a certain threshold (Poldrack, 2007). Participants rated future positive events more positively than past positive events. They imagined future positive events to be closer in time than future negative events and all past events. Negative future events were experienced with weaker valence and the memories were less personalised and embellished. Optimism, as measured on the LOT-R, was correlated with closer proximity of imagined future positive events and stronger emotional valence.

The functional ROIs were the rostral ACC, ventromedial PFC, posterior cingulate cortex, dorsomedial PFC and amygdala. All of these ROIs, with the exception of the amygdala, had previously been identified as having a role in autobiographical memory and imagining future events (Addis et al., 2007) whereas, the amygdala is known to be involved in the influential role of emotion on memory (Sharot et al., 2007a). The results of the fMRI data suggest a key role for the rostral ACC in modulating both emotional processing and autobiographical retrieval. Functional connectivity mapping demonstrated extensive correlation between the rostral ACC and the amygdala during imagining of future positive events and restricted correlation during imagining of future negative events. It is suggested, based on these data, that the rostral ACC has a crucial part to play in creating positive images of the future and ultimately, in ensuring and maintaining the optimism bias.

CONCLUSION

The optimism bias has consistently been proven to be robust and pervasive in psychological experiments. Pharmacological interventions using L-DOPA have shown that it can be modulated. The advent of fMRI has shed light on patterns of neural connectivity and activation involved in its generation and maintenance. Naturally, unyielding optimism can be harmful: the perils of poor planning and carelessness are obvious (Lovallo and Kahneman, 2003). However, from an evolutionary and philosophical perspective, it has been concluded that these "positive illusions" (Taylor and Brown, 1994) are the only group of adaptive false beliefs (McKay and Dennett, 2009).

Excessive optimism is the result of a facile illusion we create for ourselves. In visualising an uncomplicated future, we rise above the myriad of possible outcomes to focus on a simplified positive endpoint. Admittedly, to reconcile the full spectrum of conceivable eventualities would be endlessly time-consuming and tortuous. And it is as such, that the optimism bias exists as a heavily-biased heuristic to satiate our hunger for certainty - even if it is one of our own creation.

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Corresponding Author:

Dr Owen P. O'Sullivan

St. John of God/St. Vincent's University Hospital/ University College Dublin Basic Specialist Training Scheme in Psychiatry, St. John of God Hospital, Stillorgan, Co. Dublin (Ireland)

E-mail: owenosullivan@rcsi.ie