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## Unrealistic Optimism and 'Nosognosia': Illness Recognition in the Healthy Brain

RUNNING HEAD: Nosognosia and Optimism

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## Abstract

**Introduction:** At the centenary of research on anosognosia, the time seems ripe to supplement work in anosognosic patients with empirical studies on *anosognosia* in healthy subjects. To this end, we adopted a signal detection framework to investigate the lateralized recognition of illness words – an operational measure of anosognosia – in healthy participants. As positively biased reports about one’s current health status (anosognosia) and future health status (unrealistic optimism) have both been associated with deficient right hemispheric functioning, and conversely with undisturbed left hemispheric functioning, we hypothesised that more optimistic participants would adopt a more conservative response criterion, and/or display less sensitivity, when identifying illnesses in our anosognosia task; especially harmful illnesses presented to the left hemisphere via the right visual field.

**Material and methods:** Thirty-two healthy right-handed men estimated their own relative risk of contracting a series of illnesses in the future, and then completed a novel computer task assessing their recognition of illness names presented to the left or right visual field. To check that effects were specific to the recognition of illness (rather than reflecting recognition of lexical items *per se*), we also administered a standard lateralized lexical decision task.

**Results:** Highly optimistic participants tended to be more conservative in detecting illnesses, especially harmful illnesses presented to the right visual field. Contrary to expectation, they were also more sensitive to illness names in this half-field.

**Conclusions:** We suggest that, in evolutionary terms, unrealistic optimism may be an adaptive trait that combines a high perceptual sensitivity to threat with a high threshold for acknowledging its presence. The signal detection approach to anosognosia developed here may open up new avenues for the understanding of anosognosia in neurological patients.

**Key index words/phrases:** Anosognosia; Nosognosia; Unrealistic optimism; Illness Recognition; Signal Detection Theory.

## 1. Introduction

Just as phonagnosia denotes deficient voice recognition and prosopagnosia denotes deficient face recognition, *anosognosia* denotes an impairment in *disease* recognition. More specifically, anosognosic patients fail to recognize or acknowledge that they themselves are ill. A century of work on anosognosia (Babinski, 1914), however, has failed to illuminate the normal function that is disrupted in anosognosic patients. While work in patients with prosopagnosia has been continuously inspired by the findings of a rich body of research into the mechanisms of normal face recognition, anosognosia research has not been comparably informed by studies on the process of disease recognition in the healthy brain. In the present paper we begin to redress this imbalance, by adopting a signal detection framework to investigate the recognition of illness – ‘nosognosia’ - in healthy participants. In particular, we investigate the lateralized recognition of illness *words*, and its association with *unrealistic optimism* concerning future illness.

Unrealistic optimism refers to the robust and widespread tendency of healthy individuals to underestimate – or at least to *understate* (see below) - their likelihood of experiencing future misfortune, including future illness or disease (Weinstein, 1980, 1989; Sharot, 2011). For example, people typically report their own risks of contracting food poisoning or pneumonia to be lower than the risks of their peers (Weinstein, 1987). Anosognosia and unrealistic optimism share a number of intriguing links. First, they both appear to involve deficient updating of beliefs in response to evidence. Vocat et al. (2013) recently found that compared to control participants (both healthy controls and ‘nosognosics’, i.e., hemiplegic patients without anosognosia), anosognosic patients tended to stick to their former ‘false’ beliefs about the answer to a riddle instead of modifying them in light of new evidence. Meanwhile, recent neuroscientific work has indicated that unrealistic optimism is sustained by systematically biased belief updating, such that healthy individuals are relatively disinclined to revise their beliefs in response to undesirable information (Sharot et al., 2011; Eil & Rao, 2012).

Second, anosognosia and unrealistic optimism have been independently associated with damaged or deficient right hemispheric functioning, and conversely with intact, undisturbed left hemispheric functioning. For example, Berti et al. (2005) found that the pars opercularis of the right inferior frontal gyrus (IFG) was damaged in 15 of 17 patients with anosognosia for left hemiplegia. Sharot et al. (2011) found that unrealistic optimism is associated with deficient coding of undesirable information in this brain region. In a subsequent study, Sharot et al. (2012) attenuated unrealistic optimism by disrupting the function of the left (but not right) IFG using transcranial magnetic stimulation, suggesting that left-hemispheric structures play a role in inhibiting the processing of undesirable information.

Third, there is evidence that both anosognosia (Cappa et al., 1987; Rode et al., 1992; Ramachandran, 1995) and unrealistic optimism (McKay et al., 2013) can be temporarily attenuated by vestibular stimulation, particularly by irrigation of the left (but not right) ear with cold water, a procedure known to activate the right inferior frontal region (Lobel et al., 1998; Fasold et al., 2002).

Given the above links between unrealistic optimism and anosognosia, we wondered whether unrealistic optimism would predict healthy participants' performance on an illness recognition (anosognosia) task. We were unsure, however, whether to expect a connection between unrealistic optimism and *sensitivity* on the task, or between unrealistic optimism and *response bias*. This distinction cuts to the heart of a long-standing debate in the literature on anosognosia (e.g., see Ramachandran, 1995; Nardone, Ward, Fotopoulou & Turnbull, 2007). Are anosognosic patients truly insensitive to their disability, or are they aware of this at some level but disinclined to acknowledge it (whether to themselves or to others)? If the latter is the case, it may be that anosognosic patients are best characterized as displaying a response bias: perhaps due to the emotional or perceived social cost of acknowledging their disability, they set an abnormally high threshold for reporting awareness of it. Likewise, healthy participants may have genuinely distorted beliefs about their prospects of contracting illnesses in the future (resulting in a reduction in sensitivity), or they may be biased against signaling their *accurate* beliefs to others or to themselves (Mijović-Prelec & Prelec, 2010).

To explore these possibilities, we developed a novel computer task to investigate the lateralized recognition of illness words. We predicted that more optimistic participants would adopt a more conservative response bias when detecting illnesses in this task, and/or that they would display less sensitivity. We reasoned that any such effects would be especially pronounced for more harmful illnesses, which are more personally consequential. Moreover, in light of the connection between normal left hemispheric functioning and unrealistic optimism (Sharot et al., 2012), we predicted that participants (especially optimistic participants) would respond more conservatively, and/or display less sensitivity, when illnesses were presented in the right visual field (and thus to the left hemisphere). Again, we expected that any such effects would be especially pronounced for more harmful illnesses. To check that effects were specific to the recognition of illness (rather than reflecting recognition of lexical items *per se*), we also administered a standard lateralized lexical decision task.

## **2. Material and methods**

### **2.1 Participants**

Participants were 32 right-handed men (mean age (*SD*) = 26.5 years (2.1 years)) recruited via convenience sampling. All had normal or corrected to normal vision and none had taken any medication for at least a week prior to testing. Handedness was verified with the ten item Flinders Handedness survey (FLANDERS; Nicholls, Thomas,

Loetscher & Grimshaw, 2013). A negative history of neuropsychiatrically relevant disorders (e.g., learning difficulties, substance abuse) was ascertained via a brief interview modeled after Campbell (2000). Written informed consent was obtained from all participants before testing began.

## **2.2 Tasks and procedure**

**2.2.1 Optimism measure:** Participants were asked to estimate their personal risk, relative to that of their peers (same age, sex and nationality), of contracting a series of 16 illnesses. We used a six point Likert-type risk rating scale ranging from -3 ('very much smaller') to +3 ('very much higher').

Our procedure for selecting the 16 illnesses used in this study was as follows:

- Flammer, Reisbeck and Stadler (1985) published a list of 142 illnesses spontaneously named by 286 Swiss students (age range 16-30 years) in a one minute category fluency task (category: illnesses and diseases).
- From this list of 142 illnesses, we pooled all illness names with a length of four to seven letters, and added "AIDS" and "EBOLA" due to their publicity in the intervening period. This resulted in a pool of 52 illnesses.
- We then obtained ratings of the harmfulness of these 52 illnesses (ratings were made on a six point scale by 56 independent raters). From this pool of 52, we subsequently chose the eight illnesses judged least harmful (AKNE = acne; ANGINA; EKZEM = eczema; FIEBER = fever; GRIPPE = flu; HUSTEN = cough; KARIES = tooth decay; MASERN = measles; mean harmfulness rating = 1.960,  $SD = 0.300$ ) and the eight illnesses judged most harmful<sup>1</sup> (AIDS; CHOLERA; EBOLA = ebola virus; EMBOLIE= embolism; INFARKT= infarct; LEPRA = leprosy; PEST = plague; TUMOR; mean harmfulness rating = 5.311,  $SD = 0.317$ ). The harmfulness ratings of the latter eight illnesses were significantly higher than those of the former eight ( $t_{14} = 21.4, p < .0001$ ), but the two groups did not differ in terms of word length, Mannheim wordform frequency or Mannheim lemma frequency (all  $ps > .05$ ). The latter lexical variables were obtained from the WebCelex site (Max Planck Institute for Psycholinguistics, 2001).

**2.2.2 Nosognosia task:** The task comprised 64 trials. On each trial two words were simultaneously presented onscreen for 150ms, one to the left and one to the right of a central fixation cross. Stimulus eccentricities varied between two and six degrees of visual angle horizontally. On *non-target* trials the two words were (different) animal names, whereas on *target* trials one of the words referred to an animal and the other to an illness. Participants were required to press a left-sided response key for an illness in the left visual field, a right-sided key for an illness in the right visual field, and the space bar for (*non-target*) trials that did not contain any illness names.

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<sup>1</sup> Excluding the item KREBS (cancer), which was rated as one of the most harmful illnesses but which was not selected because in German the word also refers to an animal (crab).

The 16 illness names from the optimism measure (eight harmful, eight harmless) were used as target stimuli in this task. Forty-eight animal names (word length between four and seven letters) were used as non-targets. These were taken from the sources listed in Flammer et al. (1985) and thus corresponded to those animals most frequently named in category fluency tasks by independent subject groups.

Each participant completed 32 *non-target* trials and 32 *target* trials. The *non-target* trials comprised two presentations each of 16 different animal-animal pairs (each pair was presented once as animal A / animal B and once as animal B / animal A; the items in each pair were always coupled together). The *target* trials comprised two presentations each of 16 different animal-illness pairs (each pair was presented once as animal / illness and once as illness / animal; again, the items in each pair were always coupled together). Each word (whether animal or illness) was thus presented twice, once to the left and once to the right of fixation. The sequence of 64 unique trials was randomized individually for each participant.

2.2.3 Lexical decision task: In addition to the nosognosia task, our participants also completed a lexical decision analogue of this task. All parameters were as for the nosognosia task, except that i) *non-target* trials involved the presentation of two (different) non-words and *target* trials involved the presentation of a non-word alongside a real word; ii) the target stimuli (real words) were not split into two categories (cf. the nosognosia task where target stimuli were either harmless or harmful illnesses); and iii) stimuli always consisted of four letters, whereas in the nosognosia task they varied between four and seven letters.

The above tasks were administered in the following invariant order: optimism measure, lexical decision task, nosognosia task.

### 3. Results

#### 3.1 Computation of key variables

3.1.1 Optimism: We performed an initial analysis to establish evidence of unrealistic optimism in our sample.<sup>2</sup> The average risk estimate (mean of 16 ratings) was calculated for each participant and reversed (multiplied by -1) to produce an optimism score with higher scores indicative of greater optimism. We used a one-sample *t* test to compare the average optimism score for our 32 participants to the chance value of zero. Overall, our participants were unrealistically optimistic about their chances of contracting illnesses (Mean risk estimate = 0.65, *SD* = 0.77;  $t_{31} = 4.79$ ,  $p < .001$ , two-tailed). For factorial analyses we used a median split to convert the continuous optimism scores into a categorical between-participants factor (optimism: low, high). For these analyses

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<sup>2</sup> Our estimation method can only be used to detect unrealistic optimism at group level. Many individuals will, as a matter of fact, be less at risk of contracting certain illnesses than others, so it is not possible to identify any individual as unrealistically optimistic with this method (cf. Sharot et al., 2011).

three participants with an optimism score at the median ( $=0.75$ ) were excluded, reducing the sample size to  $n=29$  (low optimism  $n=15$ ; high optimism  $n=14$ ).

**3.1.2 Bias:** As a metric of bias we computed  $C$ , the criterion score, a measure of a respondent's willingness to report that the target signal (an illness in the case of the nosognosia task, a real word in the case of the lexical decision task) was present. The formula for  $C$  is  $-0.5*(z(FA) + z(H))$ , where  $z(FA)$  is the z-transformed False Alarm rate and  $z(H)$  the z-transformed Hit rate. Positive values of  $C$  denote a conservative response bias, whereas negative values denote a liberal response bias.

**3.1.3 Sensitivity:** We computed  $d'$  ('d-prime'), the most widely used sensitivity metric in signal detection theory. The formula for  $d'$  is  $z(FA) - z(H)$ . Higher values of  $d'$  reflect greater sensitivity.

### **3.2 Bias Analyses**

To investigate the relationship between optimism and bias in illness recognition (taking into account illness harmfulness and visual field of presentation), we performed a 2 (visual field: left, right; within-subjects)  $\times$  2 (harmfulness: harmless, harmful; within-subjects)  $\times$  2 (optimism: low, high; between-subjects) mixed-design analysis of variance (ANOVA) on the bias scores ( $C$ ) in the nosognosia task. This analysis revealed a significant main effect of harmfulness ( $F_{1,27} = 9.70, p = .004, \eta^2 = .264$ ), such that a more liberal response criterion was adopted for harmful illnesses (mean  $C$  ( $SE$ ) =  $.25$  ( $.12$ )) than harmless illnesses ( $.39$  ( $.13$ )).<sup>3</sup> There were no other significant main effects or interactions (all  $ps > .139$ ).

As the above factorial analysis was conducted using a median split of the optimism variable, we may have lost considerable statistical power (Cohen, 1983). We therefore ran some follow-up correlational analyses, correlating our continuous optimism variable with each of four log-transformed bias variables (left visual field harmless, left visual field harmful, right visual field harmless, right visual field harmful). All four correlations were positive, although only that between optimism and the right-visual-field-harmful bias variable was significant, Pearson  $r = .40, p = .023$  (uncorrected),  $n=32$ , two-tailed (see Figure 1). Thus, using the full spectrum of optimism scores, a trend emerged for more optimistic participants to be more conservative in detecting illnesses, especially harmful illnesses presented to the right visual field.

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(Insert Fig. 1 about here)

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<sup>3</sup> As the data violated assumptions of normality and homoscedasticity, this analysis was repeated after applying log-transformations that corrected for these problems (each score was subtracted from the maximum score + 1 before taking the logarithm; resulting scores were reversed; Field, 2013). Results were identical (a significant main effect of harmfulness, no other significant effects).

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### 3.3 Sensitivity Analyses

To investigate the relationship between optimism and sensitivity of illness recognition (taking into account illness harmfulness and visual field of presentation), we performed a 2 (visual field) x 2 (harmfulness) x 2 (optimism) mixed-design ANOVA on the sensitivity scores ( $d'$ ) in the nosognosia task. This analysis revealed significant main effects of visual field ( $F_{1,27} = 12.06, p = .002, \eta^2 = .309$ ), harmfulness ( $F_{1,27} = 9.69, p = .004, \eta^2 = .264$ ) and optimism ( $F_{1,27} = 6.41, p = .017, \eta^2 = .192$ ). Sensitivity was greater when stimuli were presented in the right visual field (mean  $d'$  ( $SE$ ) = 1.67 (.17)) than in the left visual field (1.02 (.15)), and greater for harmful illnesses (1.49 (.13)) than harmless illnesses (1.2 (.14)). Contrary to our predictions, more optimistic participants (1.67 (.19)) evinced a *greater* sensitivity than less optimistic participants (1.02 (.18)). None of the interactions were significant (all  $ps > .139$ ).

The right visual field variables in the above analysis violated assumptions of normality and homoscedasticity. Log-transformations corrected these problems, but unfortunately when these transformations were applied to the left visual field variables they caused those variables to become skewed. To check the robustness of the above analysis, we therefore ran follow-up analyses for the left and right visual field variables separately. A 2 (harmfulness) x 2 (optimism) mixed-design ANOVA on the (untransformed) sensitivity scores ( $d'$ ) for targets presented to the left visual field in the nosognosia task revealed no main effects and no significant interaction (all  $ps > .085$ ). However, the same analysis performed on the log-transformed sensitivity scores ( $d'$ ) for targets presented to the right visual field revealed significant main effects of harmfulness ( $F_{1,27} = 7.22, p = .012, \eta^2 = .211$ ) and optimism ( $F_{1,27} = 4.33, p = .047, \eta^2 = .138$ ). Sensitivity was greater for harmful illnesses than for harmless illnesses, and more optimistic participants were more sensitive than less optimistic participants. The interaction between harmfulness and optimism was non-significant ( $p = .152$ ).

To check whether the main effect of optimism reported above was specific to the nosognosia task or was a lexical effect *per se*, we subsequently ran a 2 (task: nosognosia, lexical decision; within-subjects) x 2 (optimism) mixed-design ANOVA on the log-transformed sensitivity scores ( $d'$ ) for targets presented to the right visual field. This analysis revealed a significant main effect of task ( $F_{1,27} = 24.24, p < .001, \eta^2 = .473$ ), qualified by a significant task x optimism interaction ( $F_{1,27} = 6.50, p = .017, \eta^2 = .194$ )<sup>4</sup>. Planned contrasts with a Bonferroni adjustment revealed that whereas more optimistic participants were more sensitive than less optimistic participants on the nosognosia task ( $p = .040$ ), they were not more sensitive on the lexical decision task ( $p = .877$ ). Thus

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<sup>4</sup> Although the lexical decision task data violated the assumption of homoscedasticity ( $F_{1,27} = 4.73, p = .039$ ), the fact that the larger sample in this analysis (the low optimism group) had the larger variance means the  $F$ -ratio would tend to be, if anything, too conservative (Field, 2013).



the greater sensitivity of optimistic participants was specific to the illness context.

As per the bias analyses, we ran some final follow-up analyses, correlating our continuous optimism variable with each of four sensitivity variables (left visual field harmless, left visual field harmful, right visual field harmless, right visual field harmful). A log-transformation was applied to the right (but not left) visual field variables before running these analyses. All four correlations were positive, although only that between optimism and the right-visual-field-harmless sensitivity variable was significant, Pearson  $r = .41$ ,  $p = .020$  (uncorrected),  $n=32$ , two-tailed (see Figure 2). Thus, when using the full spectrum of optimism scores, the sensitivity advantage for optimistic participants appeared more pronounced when harmless illnesses were presented to the right visual field.

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(Insert Fig. 2 about here)

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#### 4. Discussion

The present study was designed to investigate the lateralized recognition of illness words, an operational measure of *nosognosia*, in healthy participants varying in optimism concerning future illness. In view of various connections between unrealistic optimism and anosognosia, the first hypothesis we tested was that more optimistic participants would adopt a more conservative response criterion when identifying illnesses in our nosognosia task; especially harmful illnesses presented in the right visual field. We found some qualified support for this hypothesis: although a factorial analysis revealed no main effect of optimism or interactions between optimism and the harmfulness or visual field variables, follow-up analyses using the full spectrum of optimism scores suggested that optimistic participants were more conservative in detecting illnesses, especially harmful illnesses presented to the right visual field.

The second hypothesis we tested was that more optimistic participants would display less sensitivity than less optimistic participants on our nosognosia task, being particularly insensitive to harmful illnesses presented in the right visual field. Contrary to this prediction, however, we found that optimistic participants were actually *more* sensitive. Although a factorial analysis revealed that, overall, sensitivity was greater when stimuli were presented in the right visual field, optimism did not interact with this variable. However, follow-up analyses suggested that the sensitivity advantage of optimistic participants was primarily observed when illnesses were presented to the right visual field. Moreover, this sensitivity advantage was not a general effect across

tasks (thus reflecting greater sensitivity to lexical items *per se* in the linguistically dominant left hemisphere), but was specific to the nosognosia task.

The fact that optimistic participants evinced *greater* sensitivity on our nosognosia task is surprising, but raises an intriguing possibility. 'Positive illusions' like unrealistic optimism are associated with psychological health (Taylor & Brown, 1988; Strunk et al., 2006; Sharot, 2011), and McKay and Dennett (2009) have argued that they may be not just psychologically but biologically adaptive. The notion that optimistic participants are biased against acknowledging illnesses, especially harmful illnesses, is consistent with this claim<sup>5</sup>. A tendency to avoid acknowledging the possibility of harmful illness to *oneself* may be adaptive insofar as this constrains harmful recurrent activation of the autonomic nervous system and the hypothalamic-pituitary-adreno-cortical (HPA) axis (see Taylor et al., 2000, 2003). Meanwhile, avoiding acknowledgment of vulnerability or frailty to *others* may enhance one's apparent value as a social or reproductive partner (Kurzban, 2010; Trivers, 2000; von Hippel & Trivers, 2011).

Blissful ignorance, however, has its limitations as an adaptive strategy. Any organism needs to be able to respond appropriately to threats of different kinds, taking evasive action or precautionary measures as necessary. So this presents something of a dilemma: how can one be both sufficiently cognizant of threatening information to initiate relevant protective behaviours, yet sufficiently *incognizant* to avoid the dangers of chronic cardiovascular and neuroendocrine stress responses? The answer may be to compartmentalize: Some aspects of the mind have access to veridical information about threats, and others (e.g., conscious aspects) are relatively shielded from this information. The aspects with access regulate the dissemination of information to the conscious aspects (and thence to other individuals) by setting an appropriately conservative response criterion. When action is judged necessary, the criterion is lowered and the individual becomes consciously aware of the threat. The most adaptive individuals (unrealistic optimists?) would be highly sensitive to potential threats, but able to minimize the physiological costs of full awareness by setting an optimal threshold for consciously 'acknowledging' such threats. In other words, the optimal phenotype would be both sensitive and conservative.

Although speculative, such ideas are influential in evolutionary psychology (e.g., Kurzban, 2010; von Hippel & Trivers, 2011). Continuing in this vein, we speculate that whereas unrealistic optimism may represent a biologically adaptive strategy – optimal nosognosia – anosognosia may involve severely impaired sensitivity, coupled with an extreme, dysfunctional, conservative bias. Anosognosic patients thus have difficulty detecting their impairments, and are extremely reluctant to acknowledge any evidence of impairment they do acquire. In advancing these suggestions, we emphasize a key

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<sup>5</sup> The fact that Sharot and colleagues (e.g., Sharot et al., 2011) have identified biological mechanisms underpinning unrealistic optimism is also consistent with this evolutionary claim (and inconsistent with the suggestion that such phenomena are a cultural and historical curiosity; e.g., see Konecni, 2009).

limitation of our study: our nosognosia paradigm, which involved the recognition of illness *words*, may be a questionable proxy for the recognition of actual signs of illness in oneself. A complementary approach could involve judging the health of faces (e.g., Zaidel et al., 2005), where the stimulus faces could be morphed to a greater or lesser degree with the participant's own face. In any case, a century after the publication of Babinski's (1914) seminal paper on anosognosia, we believe that the time has come to develop a science of nosognosia, and we hope that our study is a first step in this direction.

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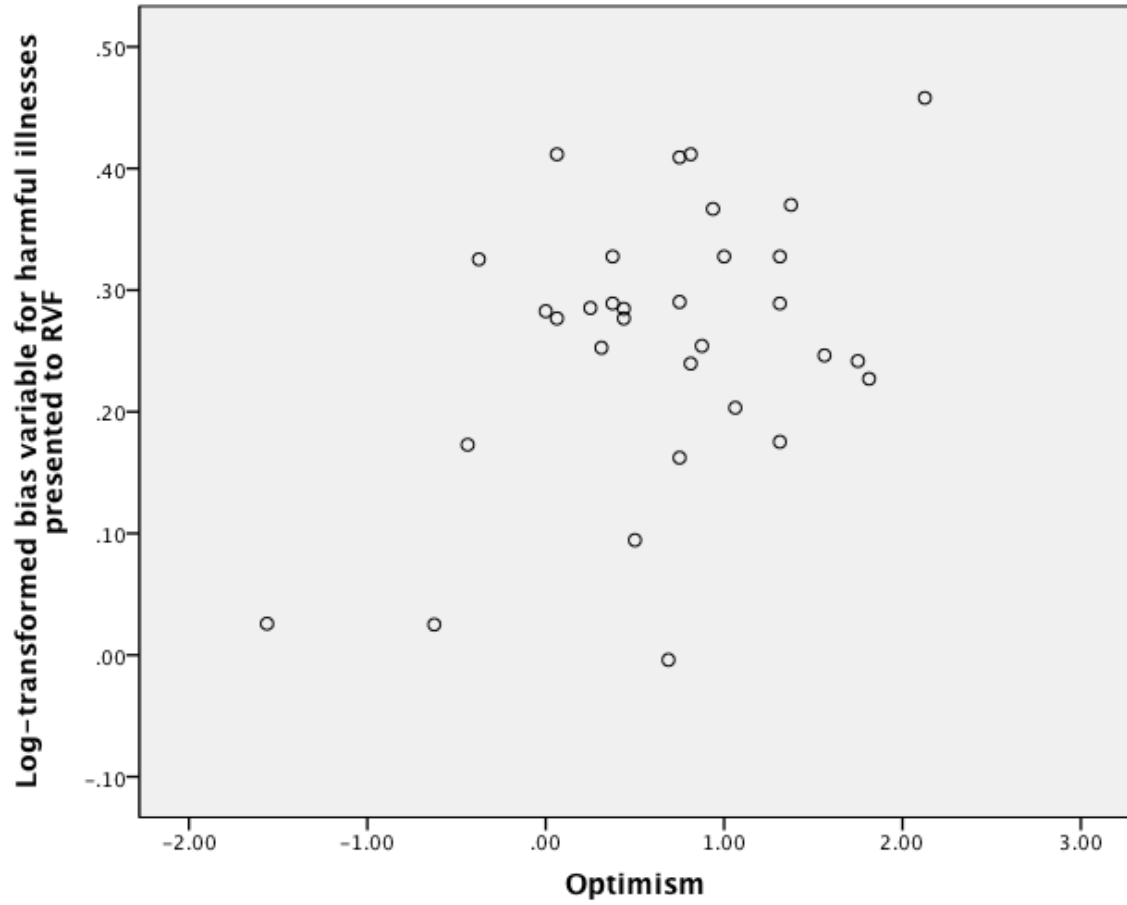


Figure 1: Scatterplot depicting the relationship between optimism and the log-transformed bias variable for harmful illnesses presented to the right visual field.

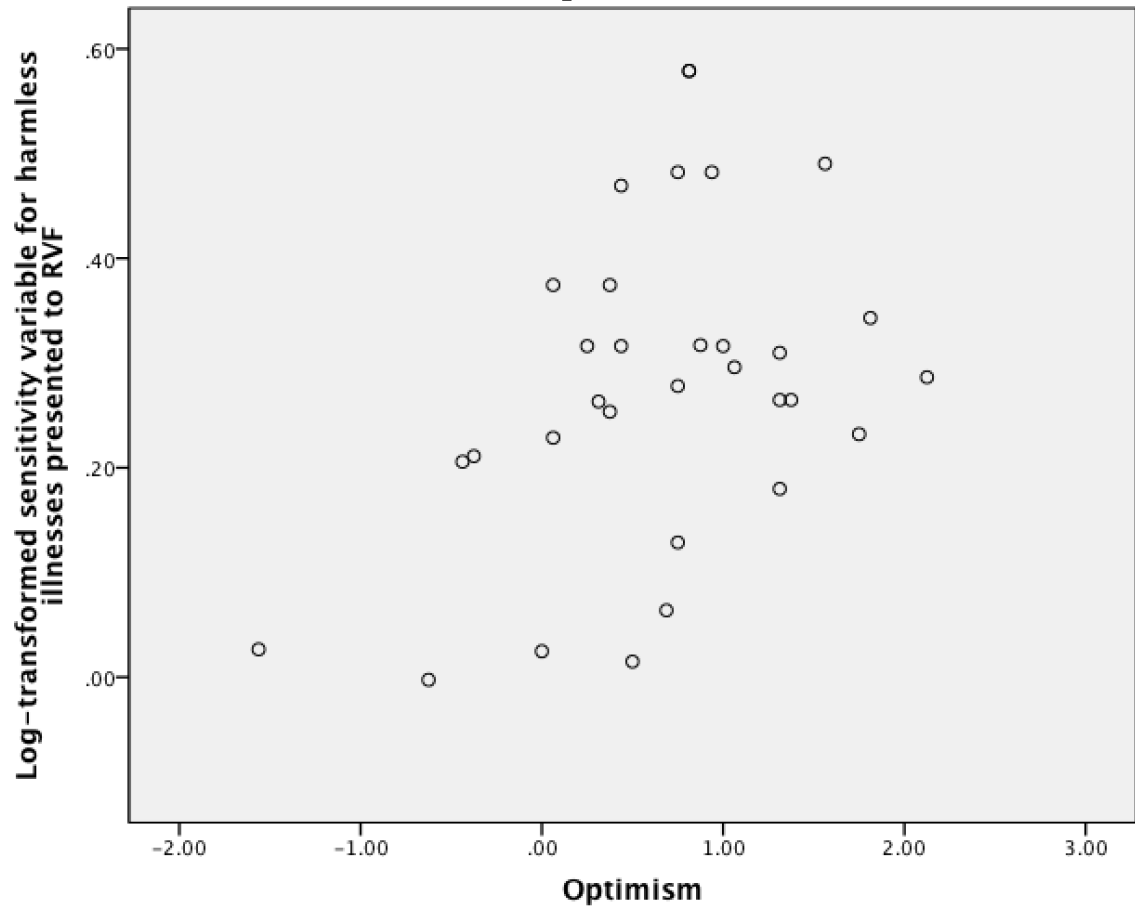


Figure 2: Scatterplot depicting the relationship between optimism and the log-transformed sensitivity variable for harmless illnesses presented to the right visual field.