

# **The Neural Substrates Underlying the Relationship between the Traumatic Experience of Betrayal and Loss Aversion during Risky Decision-Making in North Korean Refugees**

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## **ABSTRACT**

### **Background**

Prior studies have shown that people have tendency to be risk-averse when making decisions under uncertainty, for example when investing in stocks or purchasing a new model of products rather than an accustomed old model. The prospect theory has provided the concept of 'loss aversion' for this tendency to maintain the status quo rather than risking the possibility of gaining or losing. Contrary to the expectation that the fear or anxiety brain circuitry would be related to the sensitivity to potential losses, the neural substrates of loss aversion have been suggested to be the hypo-activity of the gain-sensitive brain reward system including the striatum. However, there have not been any studies that investigated whether this would still be true in the case of individuals with a traumatic experience of life-threatening betrayal of trusted ones, who might display anxiety response to potential loss.

Since the famine crises of the mid-1990s, North Korean (NK) people have been leaving the country in large numbers at the risk of losing their lives, a phenomenon known as the exodus of North Koreans. Many endure human smuggling in order to cross the NK border, with a substantial number being unsuccessful and facing compulsory repatriation from China to NK and

probable capital punishment. Along the way, approximately half of them experienced a serious betrayal by someone trusted, leaving them in grave danger.

## **Methods**

Through the advertisement posted at the resettlement centers, we recruited twenty-two NK refugees, who agreed to undergo functional magnetic resonance imaging (fMRI)(**Table 1**). The fMRI data were acquired while the refugees decided whether to accept or to turn down mixed gambles offering fifty-fifty odds to gain or lose presented amounts of money (**Fig. 1**).

## **Results**

NK refugees with an experience of being betrayed exhibited greater sensitivity to losses than to comparable gains in comparison with NK refugees without an experience of being betrayed. NK refugees with an experience of betrayal did not show greater decrease in the striatum compared to those without under potential loss situation but they have shown the hyper-reactivity of the amygdala (**Fig. 2**).

## **Discussion**

Our data suggest that greater loss aversion tendency in NK refugees with an experience of being betrayed was predicted by a neural measure of a negative affective response involving the brain fear system. This finding implicates that neural substrates of loss aversion may diverge among individuals with different trust-related traumatic experiences.

## **Keywords**

Loss aversion, prospect theory, functional magnetic resonance imaging, betrayal, North Korean refugee

**Table 1.** Demographic and clinical characteristics of North Korean refugees with (n=10) and without (n=12) an experience of betrayal

Demographic and clinical variables	North Korean refugees with an experience of betrayal (n=10)		North Korean refugees without an experience of betrayal (n=12)		P value <sup>a</sup>
	Mean (n)	SD (%)	Mean (n)	SD (%)	
Age (years)	31.2	2.89	33.0	2.93	0.68
Sex (woman)	6	60.0	7	58.3	1.00
Depressive symptom score <sup>b</sup>	1.8	0.15	1.7	0.19	0.74
Anxiety symptom score <sup>c</sup>	1.7	0.18	1.6	0.25	0.72

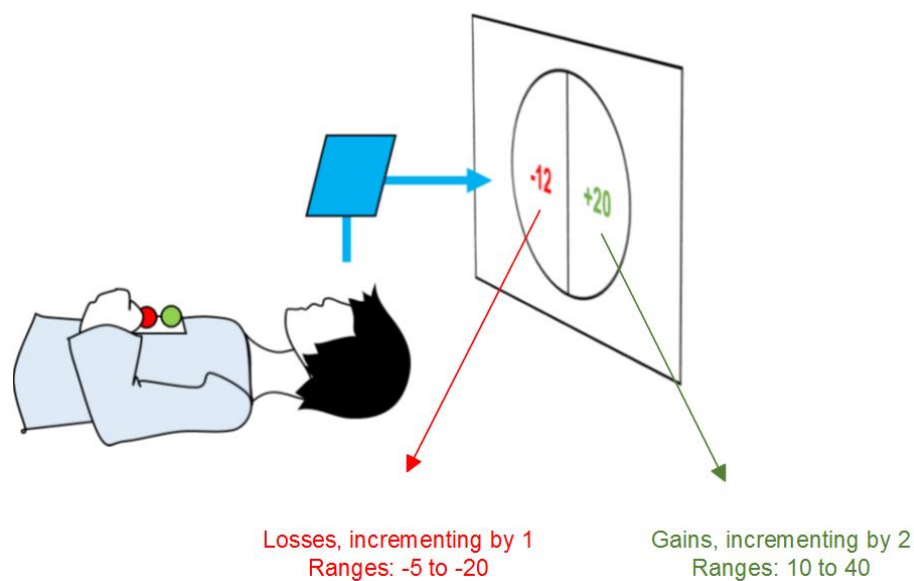
Abbreviations: PTSD, posttraumatic stress disorder; SD, standard deviation; CAPS; Clinician-administered PTSD scale.

<sup>a</sup> Independent t test and Fisher's exact test were used for continuous and categorical variables, respectively.

<sup>b</sup> Depressive symptom severity was measured using the 15-item depression subscale of the Hopkins Symptom Checklist-25. A mean cumulative symptom score higher than 1.75 could be used as a criterion to identify a probable case of current depression.

<sup>c</sup> Anxiety symptom severity was measured using the 10-item anxiety subscale of the Hopkins Symptom Checklist-25.

**Figure 1.** The illustration depicts the functional magnetic resonance imaging (fMRI) session. The even-related task design was used. For each trial, 3-second visual stimulus displaying the amount of potential gain in green font and that of potential loss in red font was presented to the participant. Participants were asked to choose among "strongly accept, weakly accept, weakly reject, to strongly reject," as soon as the stimuli were given. Between the stimuli, a variable interval was given to allow for deconvolution of fMRI responses (ISI mean=3.0 s, SD=1.3 s). One unit represented 1,000 Korean Won (approximately 1 USD). Sizes of gains and losses were changed independently in every session (Total 256 sessions).



**Figure 2.** Hyper-reactivity of the right amygdalar region is shown in North Korean refugees with an experience of life-threatening betrayal (n=10) compared to those without (n=12), while making decisions under potential loss situation. Uncorrected  $P < 0.001$ , voxel size  $k > 10$ .

