

Vestibular stimulation reduces unrealistic optimism

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ABSTRACT

Unrealistic optimism (UO) refers to the tendency of healthy people to underestimate their risk of future misfortune. Just as left-ear caloric irrigation attenuates anosognosia (denial of manifest illness) in clinical patients, we found that it also reduces UO about future health risks in healthy individuals. This finding demonstrates asymmetric hemispheric involvement in emotion regulation and self-evaluation, and suggests that a similar neuropsychological process underpins anosognosia and healthy optimism.

Unrealistic optimism (UO) refers to the tendency of healthy people to systematically underestimate the likelihood that they will experience future misfortune, including illness (1). This phenomenon was originally reported by Weinstein, who observed that participants estimated their own chances of experiencing negative events, such as contracting lung cancer or developing a drinking problem, as lower than the chances of their peers (2). It is thought that this “illusion of invulnerability” derives mainly from the need to protect self-esteem and to cope with the fear of being harmed (1). Typically investigated in a social-psychological framework, we here postulate for the first time an association between this downplaying of threats to one’s own health and the well-known clinical phenomenon of anosognosia, which involves denial or unawareness of manifest illness or impairment, spectacularly evidenced by some patients with predominantly right hemisphere temporo-parietal-insular lesions (3). We specifically propose to conceptualize unrealistic optimism regarding future health as “prospective anosognosia”, i.e. the non-pathological denial of health risks.

Left-ear caloric irrigation (CI) with iced water is a potent means of stimulating the vestibular system. Beyond its contribution to orientation and physical balance, this system is also involved in maintaining one’s emotional equilibrium (4, 5). In connection with the affective and cognitive evaluation of one’s own health state, CI has been shown to temporarily alleviate anosognosic denial of left-sided paralysis (6), to influence mood and to reduce manic symptoms (7), presumably by boosting right hemisphere cortical networks subserving self-monitoring and insight. We therefore hypothesized that the same mechanism would transiently reduce unrealistic optimism about health risks in

healthy individuals.

Thirty-one healthy right-handed subjects (15 men, 20-40y) participated in this study. Prior to CI, each subject underwent an otological examination to ensure an intact tympanic membrane and, if necessary, to clear the external auditory canal. Subjects were then oriented in supine position with the head inclined 30° from the horizontal and cold water (24°C) was irrigated into the external auditory canal first of one, then of the other ear (8). Eye movement recordings with video-oculography verified successful vestibular stimulation. 30 seconds after CI of each ear was initiated, participants were asked to estimate their own risk, relative to that of their peers (same age, sex and education), of contracting a series of illnesses (Supplementary Methods and Tab. S1). CI continued throughout the risk-estimation period. The risk rating scale ranged from -6 (lower risk) to +6 (higher risk). Each participant was tested in three conditions, with 5 minutes rest between each: baseline with no CI (always first), left-ear CI and right-ear CI (order counterbalanced). Average UO per condition (mean of 10 ratings) was calculated for each participant. A two-way mixed-design ANOVA, with gender as between-subjects variable and condition (baseline, left, right) as within-subjects variable, revealed a significant main effect of condition on the magnitude of average UO ($F(30)=3.5$, $p=0.036$). Compared to baseline, average UO was significantly lower during left-ear CI ($t(30)=3.0$; $p=.016$), whereas it remained unchanged during right-ear CI ($t(30)=1.44$., $p=.476$) (Fig. 1a). Subjects' UO was thus reduced selectively after left-ear stimulation.

/* Figure 1 about here */

Cold-water CI of the ears predominantly activates brain areas in the contralateral hemisphere, in particular the parieto-insular cortex, which is considered the ‘core region’ of the multisensory vestibular cortex (9). In the right hemisphere, these regions also play a crucial role in self-awareness and their impairment may lead to anosognosia (3, 10). The finding that left-ear CI reduces UO in healthy subjects, possibly through activation of the right cerebral hemisphere, corroborates a neural basis of UO (11) and supports our hypothesis that a qualitatively similar neuropsychological process underpins anosognosia and healthy optimism. Notably, this reduction is already present with a moderate vestibular stimulation (24° C). Presumably iced water would have produced a larger effect. However, since ice-water irrigation causes nausea in many subjects, we opted for the weaker stimulus. We speculate that the absence of an *increase* in UO during right-ear CI is linked to the larger vestibular responsivity of the right hemisphere (12,13) and the reportedly strong ipsilateral activation after cold water irrigation of the right ear (14).

The conceptualization of a person’s underestimation of future health risks as “prospective anosognosia” may open up new research avenues bridging the gap between neurology and psychology. It enables the investigation of nosognosia as a continuum function, ranging from the “hyponosognosia” of conversion disorders, through the unrealistic pessimism of the hypochondriac (15), to healthy optimism and its pathological exaggeration in the overt denial of illness. Our findings highlight the asymmetric involvement of the left and right hemispheres in emotion regulation and realistic self-evaluation. They identify the right hemisphere parieto-insular cortex as a core region for the evaluation of one’s well-being and the anticipatory awareness of one’s future state (10). The human capacity to perceive the present and to project one’s self into the future

may rely on a delicate functional balance between the two cerebral hemispheres.

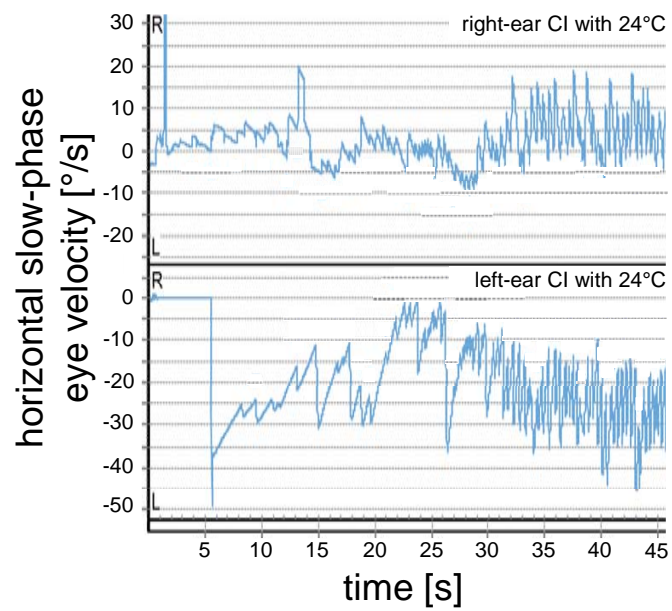
REFERENCES

1. Weinstein, N.D. *Science* **246**, 1232 (1989).
2. Weinstein, N.D. *J Pers Soc Psychol* **39**, 806 (1980).
3. Orfei, M.D., *et al.*, *Brain* **130**, 3075 (2007).
4. Soza Ried, A.M., Aviles, M. *Neuroscience* **144**, 128 (2007).
5. Carmona, J.E., Holland, A.K., Harrison, D.W. *Psychol Bull* **135**, 286 (2009).
6. Cappa, S., Sterzi, R., Vallar, G., Bisiach, E. *Neuropsychologia* **25**, 775 (1987).
7. Dodson, M.J. *J Neurol Neurosurg Psychiatry* **75**, 163 (2004).
8. Fitzgerald, G., Hallpike, C., *Brain* **65**, 115 (1942).
9. Guldin, W.O., Grüsser, O.J. *Trends Neurosci* **21**, 254 (1998).
10. Craig, A.D. *Nature Reviews Neuroscience* **10**, 59 (2009).
11. Sharot, T., Riccardi, A.M., Raio, C.M., Phelps, E.A. *Nature* **450**, 102 (2007).
12. Bottini, G., *et al.*, *Exp Brain Res* **99**, 164 (1994).
13. Dieterich, M., *et al.*, *Cereb Cortex* **13**, 1047 (2003).
14. Suzuki, M., *et al.*, *Cog Brain Res* **12**, 441 (2001).
15. Barsky, A.J., *et al.*, *Am J Psychiatry* **158**, 783 (2001).

FIGURE LEGENDS

Figure 1. (a) Right-ear cold-water (24°C) caloric irrigation (CI) in one typical subject. Note the similar strength of nystagmus, quantified by the eye movement velocity during the nystagmic slow-phase, for right- (60°/s) and left-ear (55°/s) CI (lower panel). Over all subjects, nystagmus during right-ear CI (mean \pm SEM: 28.7°/s \pm 2.5) was not significantly different from that during left-ear CI (27.6°/s \pm 2.8; paired t-test: p=0.56). Unrealistic optimism (UO) assessment started after 30 seconds of CI. Nystagmus was present throughout the risk-estimation period.

(b) Compared to baseline (mean \pm SEM: -1.62 \pm 0.23), UO was reduced under left-ear cold-water CI (-1.22 \pm 0.28). No comparable effect was found during right-ear CI (-1.42 \pm 0.26).

a**b**