

## Quantifying willpower

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Willpower is an important variable in decision making, in particular, when decisions are difficult or require effort. It can be defined as the quantitative aspects of volition, a set of self-regulatory functions that enables subjects to realize their chosen intentions, based on anticipated future outcomes and to pursue their long-term goals in the face of conflict, temptations and distractions. Empirical studies have investigated volitional subfunctions often under the heading of executive or cognitive control, including the active maintenance of goal representations, the inhibition of prepotent responses, the flexible switching between cognitive sets, the monitoring of errors and conflicts, or the regulation of emotional and motivational states (1,2). Volition is important when subjects have to solve dilemmas such as between short term and long term benefits, persistence and flexibility or between exploitation and exploration. Psychological experiments have shown that willpower is an exhaustible resource that can be used up resulting in impaired self-control.

Willpower has been implicated in the control of emotional and motivational states, in psychiatric disorders and in health related behaviour. It has been shown that it is possible to obliterate genetically determined emotional sensitivity of the amygdala (3). On the other hand, the cognitive subfunctions of willpower are themselves determined by genetic, environmental and behavioural factors (4). Cognitive neuroscience is in principle able to quantify willpower by using neuropsychological and neuroimaging methods. It has been shown that genetic factors associated with health problems, e.g. for obesity, as well as antisocial behaviour, do impact brain regions relevant for decision making.

In order to quantify willpower, to determine genetic contributions and to evaluate its relevance in disorders and health related behaviour, it is important to develop a battery of short, reliable, and effective neuropsychological test and imaging paradigms, to establish standard values and determine effects size for volitional subfunctions. This task of the applicant is to establish such a battery in a sufficient large cohort and to correlate it with genetic variations. The project will serve as the basis for several larger projects in the research area A of the proposed excellence cluster as well as for the research on decision making within the CILS.

- (1) Rangel, A., Camerer, C., Montague P.R. (2008) A framework for studying the neurobiology of value-based decision-making. *Nature Reviews Neurosci* (9) 467- 479.
- (2) Walter, H. (2010) Contributions of Neuroscience to the Free Will Debate. From random movement to intelligible action. To appear in: Kane, R. (ed.) *Oxford Handbook of Free Will*. 2<sup>nd</sup> edition.
- (3) Schardt, D.M., Erk, S., Nüsser, C., Nöthen, M.M., Cichon, S., Rietschel, M., Treutlein, J., Goschke, T., Walter, H. (2009) Volition diminishes 5-HTTLPR mediated amygdala hyperreactivity. *NeuroImage*, 2009 Dec 5. [Epub ahead of print].
- (4) Esslinger, C. Walter, H, Kirsch, P., Erk, S., Schnell, K., Arnold, C., Haddad, L., Mier, D., Opitz von Boberfeld, C., Raab, K., Witt, S.H., Rietschel, M., Cichon, S., Meyer-Lindenberg, A. (2009) Genome-wide significant neurogenetic risk mechanisms for psychosis. *Science* 324: 605.