Annex 1. Other neural correlates of well-being

A large and growing literature on so-called resting-state fMRI has emerged over the past decade.[1] In a study of the resting state correlates of happiness, Luo et al.[2] examined regional homogeneity in resting state fMRI, when participants simply rest in the scanner without completing a specific task. This method quantifies the similarity between activity in a specific brain region and the activity of its nearest neighbors. Recent evidence suggests that this is one of most highly reliable (test-retest reliability) of any of the metrics commonly extracted from resting state fMRI measures.[3] Using a large initial sample of undergraduates, these investigators selected two small groups of very happy and very unhappy people based upon the Subjective Happiness Scale, a four-item measure developed by Lyubomirsky & Lepper[4] that contains items such as "In general, I consider myself a…" and then the respondent chooses on a 1-7 scale ranging from "not a very happy person" to "a very happy person;" and "Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?" The respondent chooses from 1 ("not at all") to 7 ("a great deal"). As in the study by Kong et al.,[5] they reported a complex pattern of differences that distinguished between the happy and unhappy participants. The happy participants showed higher levels of regional homogeneity within the medial prefrontal cortex, medial temporal lobe, superior temporal lobe, and retrosplenial cortex. They also showed lower levels of regional homogeneity (compared to unhappy participants) within the dorsolateral prefrontal cortex, middle cingulate gyrus, putamen, and thalamus. It is not entirely clear how to interpret these findings and also not clear what the relation is between the measure of regional homogeneity and low frequency fluctuations that were studied in a report by Kong et al.[6] We expect there to be increased use of resting state measures to examine the neural correlates of well-being because the measure is easily obtained and features of the extracted signal have been demonstrated to be fairly stable across time,[7] a characteristic that is required for a measure to be used as a trait-like index that may be associated with other trait-like indices such as well-being. Moreover, resting state measures of fMRI are by definition stimulus-independent and so might better reflect more enduring psychological characteristics that are less dependent upon the immediate stimulus environment, a feature that might be especially relevant to well-being.

Efforts are now being made to identify possible structural variations in the brain that are related to well-being. In a recent study of 299 college students, Kong et al.[8] examined variations in gray matter volume that are associated with Diener's Satisfaction with Life Scale.[9] They found that participants with higher levels of life satisfaction had greater gray matter volume in the right parahippocampal region and less gray matter volume in the left precuneus and left ventromedial prefrontal cortex (both regions commonly associated with ruminative and self-focused thought, among other things). Importantly each of these effects remained after controlling for trait positive and negative affect. As with the measures of resting state connectivity, it is not clear what this complex pattern of correlation means and what this may imply about the neural circuits that mediate well-being. Future studies of anatomical variation, as well as resting state measures, might well incorporate the measurement of affective constructs outside the scanner that may be proximal constructs that underlie well-being, such as the sustained maintenance of positive affect and recovery from negative challenges. It would be informative to understand if any of the neural correlates of well-being in resting state or anatomical measures are related to affective processes that may be key elemental constituents of well-being.

Measurement of resting brain electrical activity (EEG) preceded resting state fMRI as a measure of individual differences in specific patterns of neural activation that may predict important features of cognitive and emotional style.[10] EEG measures have the virtue of being relatively inexpensive and easily obtained, and the disadvantage of having relatively poor spatial resolution compared with fMRI. The use of EEG as a tool to interrogate baseline patterns of brain function began more than 20 years ago, and preceded the discovery of fMRI.[11] In a representative study from this body of research, Urry et al.[12] tested 84 adults between the ages of 57-60 years and obtained EEG measures while participants were simply sitting, along with measures of psychological well-being using one of the commonly deployed self-report measures of well-being and positive and negative affect. They found that participants with greater relative left-sided prefrontal activation derived from the EEG measures at baseline predicted higher levels of well-being, even after controlling for positive affect. It will be necessary to replicate and extend these findings in larger samples and to examine the relations between individual differences in frontal EEG asymmetry and resting state fMRI measures in order to better understand more mechanistically what the variations in EEG frontal asymmetry might be reflecting.

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[1] See Power et al. (2014) for review.
[2] Luo et al. (2014).
[3] Zuo et al. (2014).
[4] Lyubomirsky & Lepper (1999).
[5] Kong et al. (2014).
[6] Kong et al. (2014).
[7] Zuo & Xing (2014).
[8] Kong et al. (2014).
[9] SWLS: Diener & Emmons (1985).
[10] See Davidson (2004) for review.
[11] See e.g., Davidson (1992).
[12] Urry et al. (2004).