CORTEX 64 (2015) 20–28

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Research report

Resting BOLD fluctuations in the primary somatosensory cortex correlate with tactile acuity

Lauren M. Haag [a,*], Stefanie Heba [a], Melanie Lenz [a], Benjamin Glaubitz [a], Oliver Höffken [a], Tobias Kalisch [b], Nicholaas A. Puts [c,d], Richard A.E. Edden [c,d], Martin Tegenthoff [a], Hubert Dinse [b] and Tobias Schmidt-Wilcke [a]

[a] Department of Neurology, BG-University Clinic Bergmannsheil, Ruhr University Bochum, Bochum, Germany
[b] Institute of Neuroinformatics, Ruhr University Bochum, Bochum, Germany
[c] Russell H. Morgan Department of Radiology and Radiological Science, The Johns Hopkins University School of Medicine, Baltimore, MD, USA
[d] F.M. Kirby Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, USA

ARTICLE INFO

Article history:
Received 3 April 2014
Reviewed 17 June 2014
Revised 8 August 2014
Accepted 26 September 2014
Action editor Pia Rotshtein
Published online 7 October 2014

Keywords:
Fractional amplitude of low frequency fluctuations
Regional homogeneity
Resting state fMRI
Tactile perception

ABSTRACT

Sensory perception, including 2-point discrimination (2ptD), is tightly linked to cortical processing of tactile stimuli in primary somatosensory cortices. While the role of cortical activity in response to a tactile stimulus has been widely investigated, the role of baseline cortical activity is largely unknown. Using resting state fMRI we investigated the relationship between local BOLD fluctuations in the primary somatosensory cortex (the representational field of the hand) and 2ptD of the corresponding index finger (right and left). Cortical activity was measured using fractional amplitudes of the low frequency BOLD fluctuations (fALFF) and synchronicity using regional homogeneity (ReHo) of the S1 hand region during rest. 2ptD correlated with higher ReHo values in the representational areas of the contralateral S1 cortex (left hand: $p = .028$; right hand: $p = .049$). 2ptD additionally correlated with higher fALFF in the representational area of the left hand ($p = .007$) and showed a trend for a significant correlation in the representational area of the right hand ($p = .051$). Thus, higher BOLD amplitudes and synchronicity at rest, as measures of cortical activity and synchronicity, respectively, are related to better tactile discrimination abilities of the contralateral hand. Our findings extend the relationship seen between spontaneous BOLD fluctuations and sensory perception.

© 2014 Elsevier Ltd. All rights reserved.

Abbreviations: 2ptD, two-point discrimination; BA, Brodmann Area; BOLD, Blood Oxygenation Level Dependent; fMRI, functional magnetic resonance imaging; GM, gray matter; S1, primary somatosensory cortex; SPM, statistical parametric mapping; fALFF, fractional amplitude of low frequency fluctuations; ReHo, regional homogeneity.

* *Corresponding author*. Department of Neurology, BG-University Clinic Bergmannsheil, Ruhr University Bochum, Bochum, Germany.
E-mail addresses: lauren.haag@rub.de (L.M. Haag), stefanie.heba@rub.de (S. Heba), melanie.lenz@rub.de (M. Lenz), benjamin.glaubitz@rub.de (B. Glaubitz), oliver.hoeffken@rub.de (O. Höffken), tobias.kalisch@rub.de (T. Kalisch), nickputs@gmail.com (N.A. Puts), raee2@mri.jhu.edu (R.A.E. Edden), martin.tegenthoff@bergmannsheil.de (M. Tegenthoff), hubert.dinse@rub.de (H. Dinse), tobias.schmidt-wilcke@bergmannsheil.de (T. Schmidt-Wilcke).
http://dx.doi.org/10.1016/j.cortex.2014.09.018
0010-9452/© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Sensory perception is tightly linked to cortical representation in primary somatosensory cortices (S1). For example, tactile discrimination abilities, have consistently shown relationships with a number of cortical processing markers. Predictive measures include changes in S1 cortical activity (Hoeffken et al., 2007; Pleger et al., 2006, 2001; Ragert et al., 2003; Tegenthoff et al., 2005), finger map size (Duncan & Boynton, 2007), and EEG oscillations (Adhikari, Sathian, Epstein, Lamichhane, & Dhamala, 2014), confirming that activity in S1 is related to task performance.

Tactile discrimination performance could additionally be predicted by blood oxygen level dependent (BOLD) responses evoked by tactile stimulation using fMRI (Pleger et al., 2003; Stilla, Deshpande, LaConte, Hu, & Sathian, 2007; Zhang et al., 2005), extending the behavioral link between tactile performance and cortical activity to even a relatively slow, but indisputably relevant (Logothetis, Pauls, Augath, Trinath, & Oeltermann, 2001), measure of cortical activity. This was independent of whether tactile discrimination was measured using two-point discrimination (2ptD) thresholds (Pleger et al., 2003) or using grating orientation discrimination (Stilla et al., 2007; Zhang et al., 2005), suggesting that both are reliable measures of tactile discrimination and relate in a similar way to the BOLD response in S1.

More recently, cortical activity's relevance to task performance has been extended past the "task-on" phases to periods where the task is not present. Pre-stimulus cortical activity, for example, has proven its predictive potential in pain to a laser stimulus (Boly et al., 2007), a visual perception task (Hesselmann, Kell, Eger, & Kleinschmidt, 2008), and even a frequency-discrimination task (Haegens, Händel, & Jensen, 2011). While these examples represent "task-free" phases, since they are before the stimulus, there is an indirect task effect that cannot be resolved using activity shortly following or even prior to an expected task. As such, pre-stimulus activity is distinctly different from a baseline condition, which is measured over a task-free period with no expectation or immediate memory of a task. This "task-free", or baseline, condition is termed "resting state". It has, to date, been shown that resting state BOLD activity has predicted performance in other modalities, such as in motor (Fox, Snyder, Vincent, & Raichle, 2007) and visual tasks (Baldassarre et al., 2012). It is not yet clear, however, if tactile discrimination is also related to baseline activity, even though it has been shown to be related to task-evoked activity.

Therefore, we used resting state fMRI to investigate whether tactile discrimination, specifically 2ptD, could be reflected by baseline brain activity. Resting state activity was measured using the fractional amplitudes of the low frequency fluctuations (fALFF) of the BOLD signal during resting state, which provide a ratio of the power of low frequency fluctuations to all frequencies measured (Song et al., 2011; Zou et al., 2008), and which are believed to be related to spontaneous cortical activity in gray matter. Regional synchronicity (ReHo), a measure the synchronicity of the BOLD fluctuations in a given region, was additionally assessed (An et al., 2013; Liu et al., 2008; Zang, Jiang, Lu, He, & Tian, 2004).

Since the amplitudes of resting BOLD fluctuations have previously been shown to predict task-evoked BOLD activation as well as relate to cognitive performance (Feng, Feng, & Chen, 2013; Hao et al., 2013; Mennes et al., 2011; Wang et al., 2013; Wei et al., 2012; Xu et al., 2014), and ReHo has been shown to be elevated in the S1 cortex of acupuncturists (known for having high tactile discrimination ability) (Dong et al., 2013), we hypothesized that the local fALFF and ReHo values in the S1 hand region would likewise relate to sensory performance, here in terms of tactile acuity.

2. Experimental procedures

2.1. Subjects and behavioral measures

Twenty-four right-handed subjects participated in this study. Five subjects were excluded from further analysis due to either excessive movement in the scanner, incomplete data, or use of medication. This resulted in 19 subjects (11 men, 8 women; aged 24 ± 3.8 years) included in the analysis, all of whom fell within the normal range of depression and trait anxiety levels, as assessed using the Beck Depression Inventory (BDI, Beck, 1987) and State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), respectively. 2ptD thresholds of the index fingerpad of the left and right hands were measured outside the scanner using an in-house constructed device (see below). The study was performed in accordance with the Declaration of Helsinki and had been approved by the local ethics committee of the Ruhr-University Bochum. Prior to enrollment study participants gave written, informed consent.

2.2. Two-point discrimination thresholds

2-point discrimination (2ptD) thresholds were assessed on the tip of the index finger (D2) of both hands by using the method of constant stimuli (Kalisch, Ragert, Schwenkreis, Dinse, & Tegenthoff, 2009). A custom-made device was used to measure the 2ptD thresholds at a fixed location on the skin of the fingertips by rapidly switching between stimuli (Fig. 1). The device has been proven to reliably stabilize the hand and blind the subjects to avoid pressure-related and anticipatory confounds. The stimuli consisted of seven pairs of brass needles with individual spacing (ranging from .7 to 2.5 mm in increments of .3 mm) and a single needle as zero distance (control condition). Brass pins were .7 mm thick with blunt tips of approximately 200 μm in diameter. Tactile stimuli were applied for approximately 1 sec (estimated range: 700–1300 sec) with application forces ranging between 150 and 200 mN. The participants were instructed to place their finger on the support and to maintain this initial position of the finger throughout the experiment. Probes were presented ten times in randomized order resulting in 80 trials per session. Application force was controlled by the fixed set up and by an experienced investigator (TK). Any variation in application force is therefore expeded to be minimal and controlled for via repetitions. Participants were not informed about the ratio of paired to single needles being 7:1. The participants had

Download English Version:

https://daneshyari.com/en/article/7314780

Download Persian Version:

https://daneshyari.com/article/7314780

Daneshyari.com