A TIME-WARPING METHOD FOR THE CONCENTRATION OF NEARLY PERIODIC SIGNALS IN EEG SPECTRUM

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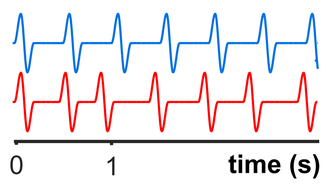
INTRODUCTION

Measuring the amplitude of specific frequencies in the spectrum of the EEG signal is a technique that is increasingly used to study the cortical activities related to rhythmic activities, such as the processing of acoustic rhythms, or the performance of periodic movements (i.e. 1) : the periodic activities appear as clear peaks that can be easily distinguished from background noise.

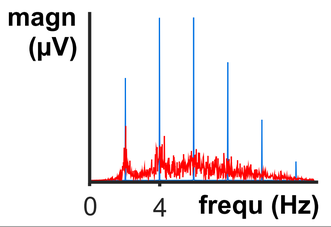
However, many rhythms are not strictly periodic and rather have a period that fluctuates over time. The nearly periodic activities are blurred in the EEG spectrum, as the peaks are spread out to neighboring frequencies and add up to the background noise.

Here, we introduce a time-warping method to align nearly-periodic EEG signals on a constant period and therefore concentrate the signal in the frequency spectrum.

time course of synthetic signals

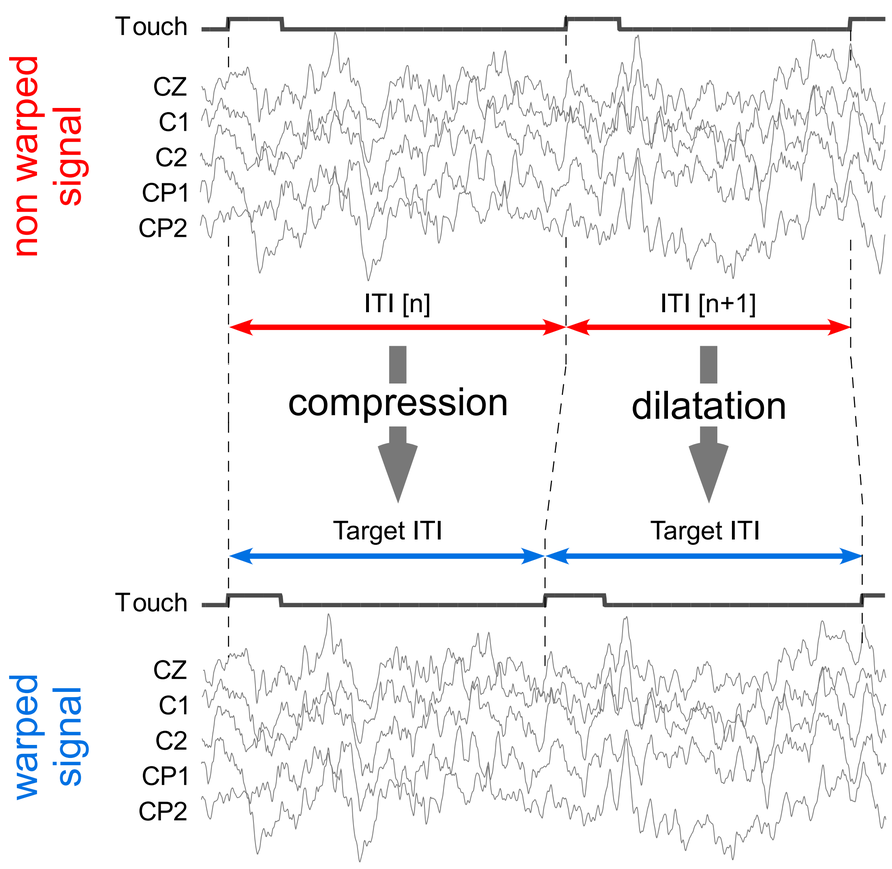


spectrum of synthetic signals



METHODS

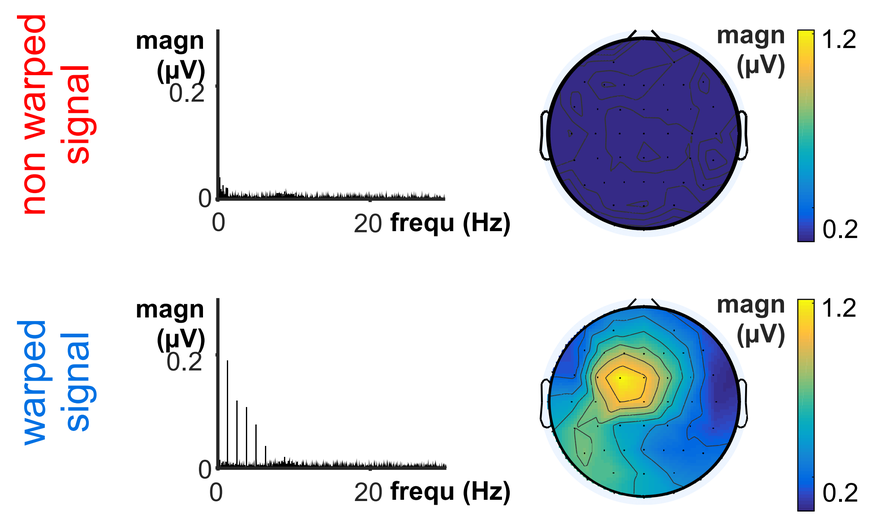
The EEG recorded in participants tapping with their right index at a paced tempo of 1.25 Hz was time warped in order to adjust the originally fluctuating Inter-Tap-Intervals (ITI) to a constant target ITI of 800 ms.



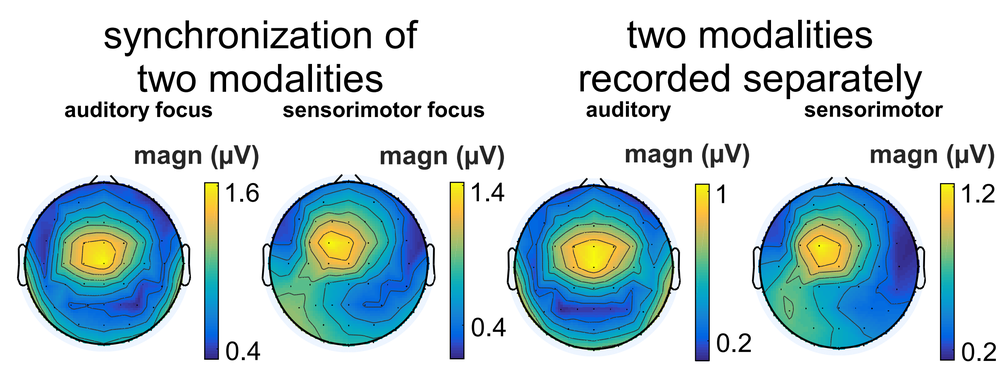
Additionally, the EEG was recorded in the same participants listening to a 1.25 Hz acoustic rhythm, and tapping on the same rhythm.
The EEG recorded in the tapping on acoustic rhythm condition was time-warped in order to adjust the ITIs to a constant length of 800 ms. This process introduced fluctuations in the length of the Inter-*Beat*-Intervals.

RESULTS

The non-warped EEG signals recorded when participants spontaneously tapped their right index showed no response in the frequency domain. The same EEG signals showed clear responses in the frequency domain when they were time-warped using the tapping latencies.



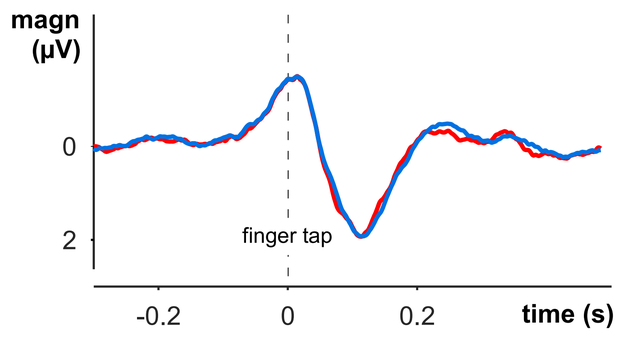
The non-warped EEG signals recorded when participants tapped their finger in synchrony with an acoustic rhythms had a similar topography to passive listening to the acoustic rhythm, while the time-warped signals resembled closely to the taping alone condition.



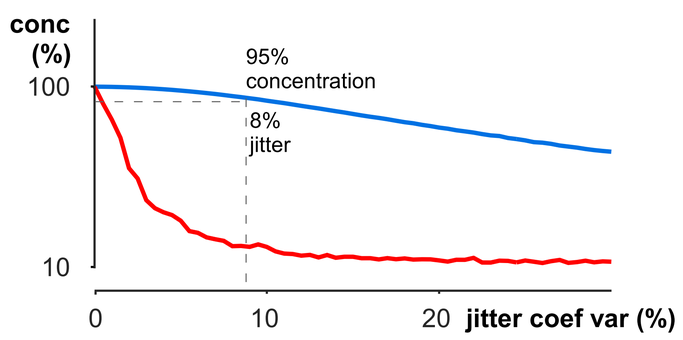
DISCUSSION: validity and perspectives

As for any signal processing procedure, a certain amount of distortion is introduced in the signal. This distortion was evaluated both qualitatively and quantitatively, and, under large conditions of use, is negligible as compared to the gain to signal noise ratio.

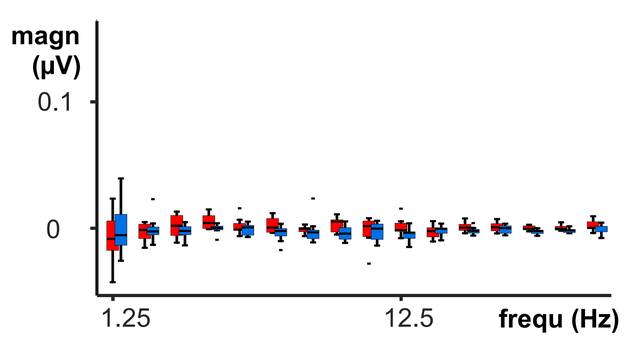
A visual inspection of the non warped and the warped EEG waveforms revealed negligible distortion of the signal.



A comparison of tagged frequencies in warped vs isochronous synthetic signals assessed the effect of jitter magnitude on the procedure effectivity.



Applying the time-warping to resting EEG signals showed that the method does not generate any artefactual response at the tagged frequencies.



The time-warping of EEG signals is a simple and effective method to concentrate non strictly-periodic EEG responses in the frequency domain. Furthermore, the time-warping procedure can be used to disentangle, in the frequency domain, two concomitant streams of EEG activity.

1. Nozaradan, S. et al. (2011) J. Neurosci. 31(28): 10234-10240

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