Comparing phase coherence and phase lag z-scores between qEEG-Pro and Neuroguide

Methods:

In order to analyse the agreement between the qEEG-Pro database and the Neuroguide database for connectivity measures (Phase Lag and Phase Coherence), we analysed 10 different EEGs and calculated z-scores for ages ranging between 6 and 60 years old, with 2 year intervals (e.g. 6-8-10-12 etc). This created a data matrix with a total of 10 EEGs * 171 channel combinations * 28 ages = 47880 data points, for Delta, Theta Alpha and Beta1. These frequency bands were chosen because the frequency definitions matched sufficiently between the two databases.

Results:

Table 1 and Table 2 show the correlations between the qEEG-Pro database and the Neuroguide database for Phase Coherence z-scores and Phase Lag z-scores, respectively. The Phase Coherence results show positive correlations for corresponding frequency bands (the green cells) and considerably lower positive correlations for non-corresponding frequency bands. The Phase Lag results show much smaller positive correlations for corresponding frequency bands (the green cells) compared with Phase Coherence. The non-corresponding frequency bands generally show even smaller positive correlations.

		Neuroguide			
		Delta	Theta	Alpha	Beta1
qEEG-Pro	Delta	0,856	0,684	0,484	0,592
	Theta	0,604	0,859	0,688	0,694
	Alpha	0,420	0,645	0,886	0,734
	Beta1	0,451	0,644	0,698	0,839

Table 1. Correlations between qEEG-Pro and Neuroguide for Phase Coherence.

		Neuroguide			
		Delta	Theta	Alpha	Beta1
qEEG-Pro	Delta	0,377	0,446	0,233	0,111
	Theta	0,194	0,511	0,298	0,078
	Alpha	0,182	0,358	0,426	0,163
	Beta1	0,191	0,341	0,376	0,244

Table 2. Correlations between qEEG-Pro and Neuroguide for Phase Lag.

Discussion:

The results show that there is a large degree of overlap between the z-scored Phase Coherence measures that are generated based on either the qEEG-Pro database or the Neuroguide database, for Delta, Theta, Alpha and loBeta. However, the Phase Lag z-scores show a considerably smaller overlap. For Phase Coherence the average correlation is .86 and for Phase Lag the average correlation is .39, for corresponding frequency bands.

We did two post-hoc analyses to shed more light on the agreement between qEEG-Pro and Neuroguide and why this agreement is much better for Phase Coherence than for Phase Lag.

First, it has been shown that the Neuroguide database exhibits age discontinuities for amplitudes across different frequency bands, especially in high frequencies. In other words, the development of z-scores across age exhibit sudden jumps, even in adult age ranges. These observations have been presented at the ISNR conference of 2015:

https://qeegpro.eegprofessionals.nl/wp-content/uploads/2014/09/ISNR2015_Keizer.pdf

A post-hoc analyses of the current results revealed that the Neuroguide database shows similar discontinuities in Phase Coherence (for example, see figure 1, left) and Phase Lag (for example, see figure 1, right panel). These discontinuities are likely to result in smaller correlations between qEEG-Pro and Neuroguide.

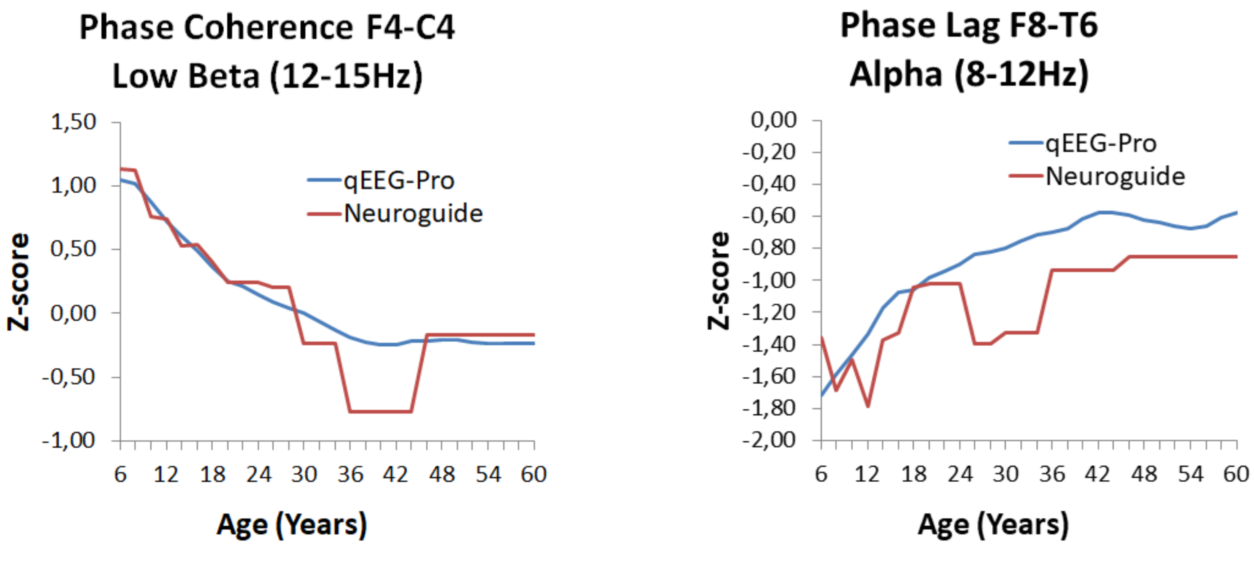

Figure 1. Age discontinuities in the Neuroguide database for Phase Coherence (left) and Phase Lag (right).

Even though it is possible that the differences in the severity of these age discontinuities may be different for Phase Coherence and for Phase Lag, it is still remarkable that the correlations between qEEG-Pro and Neuroguide for Phase Coherence are much higher than the correlations for Phase Lag. In order to investigate what may be causing this decreased correlation, we did an additional post-hoc analysis, based on the assumption that Phase Coherence and Phase Lag are inversely related.

This inverse relationship has been described before by Horvat (2007) and Hammond (2005).

Horvat (2007) states:
"Reduced coherence and/or increased phase delay often is related to reduced connectivity between two brain regions, and often is clinically correlated with white mailer or axonal injury as well as gray matter dysfunction. Significant decreases in coherence are often correlated with increased phase delays."

Hammond (2005) states:
"Significant decreases in coherence are often correlated with increased phase delays."

When Phase Coherence and Phase Lag are inversely related, as one might expect, there should be a negative correlation between z-scores of these two measures within a particular database. Table 3 shows the correlations between Phase Coherence and Phase Lag for the qEEG-Pro database. The results show a clear significant negative correlation (<-.7) for corresponding frequency bands. Table 4 shows the correlation between the Phase Coherence and Phase Lag for the Neuroguide database. The results show that these negative correlations are far less significant (<-.27) compared with the qEEG-Pro database. We can only hypothesize why Neuroguide shows such a small inverse relationship between Phase Coherence and Phase Lag, but it seems very plausible that this underlies the rather small correlation between the two databases for Phase Lag.

		qEEG-Pro Coherence			
		Delta	Theta	Alpha	Beta1
qEEG-Pro Lag	Delta	-0,766	-0,579	-0,358	-0,435
	Theta	-0,610	-0,779	-0,590	-0,602
	Alpha	-0,392	-0,536	-0,710	-0,671
	Beta1	-0,347	-0,468	-0,596	-0,757

Table 3. Correlations between Phase Coherence and Phase Lag for the qEEG-Pro database.

		Neuroguide Coherence			
		Delta	Theta	Alpha	Beta1
Neuroguide Lag	Delta	-0,500	-0,380	-0,214	-0,256
	Theta	-0,275	-0,444	-0,259	-0,242
	Alpha	-0,109	-0,308	-0,253	-0,062
	Beta1	-0,256	-0,342	-0,245	-0,270

Table 4. Correlations between Phase Coherence and Phase Lag for the Neuroguide database.

References.

Hammond . 2003. “Compendium of Common Terms in EEG & Neurofeedback”.

Horvat. 2007. Coherence and the quirks of Coherence/Phase training: A Clinical Perspective. In: Evans, J.R., editors. Handbook of Neurofeedback, Dynamics and Clinical Applications. New York (NY): Haworth Medical Press. p. 215.