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Choice of Scan Length Impacts ICA Dimensionality and Network Features

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***Abstract*— An important practical question, given various sources of noise in resting state fMRI images, is how much data to acquire to get identifiable and stable independent component analysis (ICA) networks in MRI scans. Here, we investigate how ICA dimensionality, stability of the estimated independent components, and the features of the extracted networks are affected by scan length. Our results show that the length of scan clearly influences the network dimensionality, spectral power, and functional network connectivity (FNC). Using minimum description length criterion, we observed that dimensionality decreased as the scan length decreased from 12 to 2 minutes. In addition, due to decreased dimensionality in shorter scans, some networks such as the ventral attention and subcortical networks could not be extracted. But the networks that could be identified in shorter scans including the anterior and posterior default-mode, salience, and self-referential networks were stable (cluster quality index Iq > 0.8). Spectral parameters (the dynamic range and fractional of amplitude of low frequency fluctuation; fALFF), and FNC also changed with the scan length with shorter scans having lower values. Future studies using larger sample sizes are warranted to further assess the implications of the scan length on ICA outcome measures.**

I. Introduction

Previous fMRI studies almost exclusively focused on the effect of scan length on seed-based functional connectivity. However, estimation of model order and identification of stable networks are a necessary first step before one can examine other ICA outcome measures such as functional network connectivity (FNC). In this preliminary study, we examine how the choice of scan length affects ICA model order, stability of extracted networks, and network features.

II. Materials and Methods

Resting state fMRI was collected from 20 healthy subjects (10 females, mean age 36.55 ± 10.67 years) on a 3.0T scanner. Preprocessing in SPM12 included motion and slice time correction, spatial normalization and spatial smoothing with Gaussian smoothing kernel (FWHM = 8 mm). Data were divided to scans with l volumes of the time series with $l \in \{60, 120, 180, ..., 360\}$. With a TR of 2 s, the resulting time series ranged from 2 to 12 minutes in duration. Minimum description length (MDL) criterion was used for estimating data dimensionality. Group ICA with infomax algorithm was performed using GIFT toolbox.

III. Results

Result of model order estimation is shown in Fig. 1. Fig. 2 shows the 2D curvilinear component analysis projections of the clustered IC estimates at different subspaces as processed in ICASSO software. FNC correlations of selected networks are shown in Fig. 3. Spectral properties are listed in Table 1.

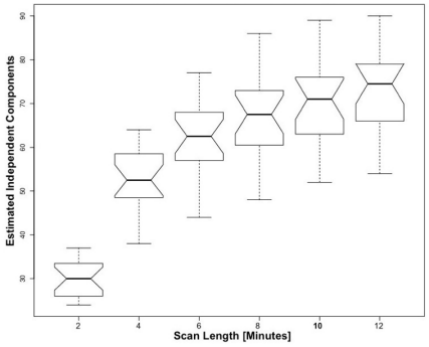

Figure 1. Model order estimation by MDL criterion.

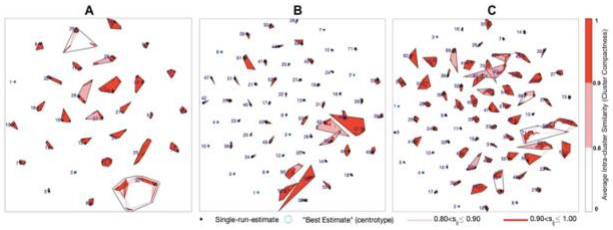

Figure 2. 2D curvilinear IC analysis projections of the component estimates for (A) 2-min, (B) 6-min, (C) 12-min scans.

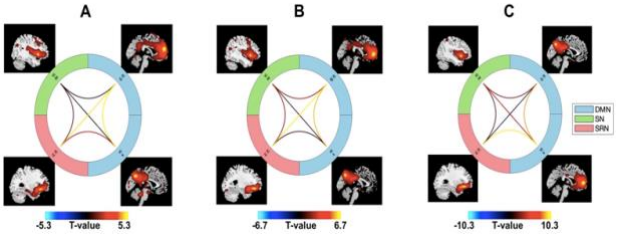

Figure 3. FNC for (A) 2-min, (B) 6-min, (C) 12-min scans (p < 0.05).

Table 2.	Network Classification	IC Number	Peak Coordinates (mm)	Dynamic Range	fALFF
2-min Scan	Posterior DMN	9	(0, -64, 38)	0.107	9.577
	Anterior DMN	13	(0, 56, 17)	0.092	5.458
	SN	25	(42, 17, -4)	0.077	3.830
	SRN	12	(-27, 35, -10)	0.070	2.317
6-min Scan	Posterior DMN	3	(0, -67, 38)	0.046	14.577
	Anterior DMN	20	(0, 53, 2)	0.043	7.153
	SN	42	(45, 17, -4)	0.042	7.046
	SRN	14	(-27, 35, -13)	0.035	2.179
12-min Scan	Posterior DMN	13	(0, -67, 38)	0.029	15.286
	Anterior DMN	9	(0, 56, 2)	0.028	6.988
	SN	34	(-42, 14, -7)	0.035	10.035
	SRN	12	(-30, 29, -13)	0.034	2.628

IV. Conclusion

Choice of scan length impacts the outcome measures of ICA-based resting-state fMRI data analysis. Limitations of shorter scan length are lower dimensionality, inability to extract certain networks, fuzzier spectra and lower FNC.

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