Neural Delay and Cognitive Performance Over the Adult Lifespan

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Introduction

- It has been hypothesised that age related slowing is partly responsible for cognitive decline[1]
- Age related slowing of evoked responses has been observed previously in both early and late components of the evoked response[1-2]
- Late ERF components thought to be involved in attention / neural inhibition[3,5]
- Attention / inhibition deficits are thought to be involved in cognitive decline[5]
- Is delay in late components related to age related deficits in fluid intelligence?

Aims

- Investigate latency of evoked responses to simple sensory stimuli (both audio and visual) (Fig 1) in an audio / visual task over the adult lifespan (18-88 years)
- Investigate the relationship between neural delay in late components and fluid intelligence

Methods

Subjects: Cam-CAN 700 dataset: N=407. All subjects completed the Cattell fluid Intelligence test, vision and sight tests outside the scanner.

Hardware: Data were acquired using the planar gradiometer configuration (204 sensors) of an Elekta Neuromag, sampled at 1000Hz. Max Filter 2.2 was applied to correct for continuous head movement, and realign to a standard space. Data were then converted to SPM12 format, de-noised (ICA) and low-pass filtered (<32Hz). MRI scans were obtained using a Siemens 3T at 1mm^3 isotropic resolution (T1 and T2).

PCA decomposition: Subject trial averages (a, v) were computed and data were concatenated resulting in a 2D matrix (N_{chans} x N_{subs}*N_{time}). PCA was performed on this matrix to derive a spatial profile and time-course for each experimental condition. These time-courses were separated to produce a separate time-course for each subject, and a single spatial profile for the entire group. The spatial profile was then inverted using the multiple sparse priors algorithm[4] in SPM12 using a single representative subject as an anatomical template.

ERF Fitting: An ERF template was derived from the group average PCA temporal component. A gradient descent fitting algorithm was employed to minimise RMSE between the template and the subject's ERF (Fig 2).

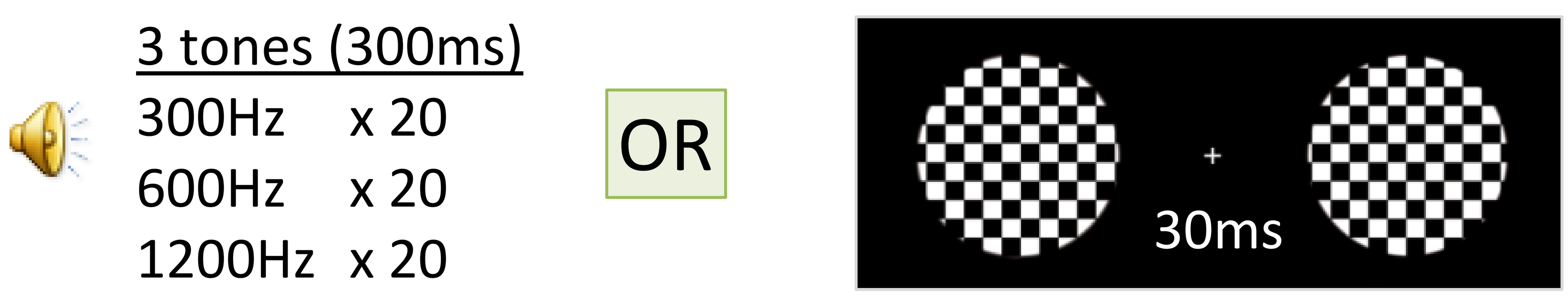

Fig 1. AV passive task consisted of audio and visual stimuli presented separately. No motor response was required. Evoked responses from all audio frequencies were averaged together.

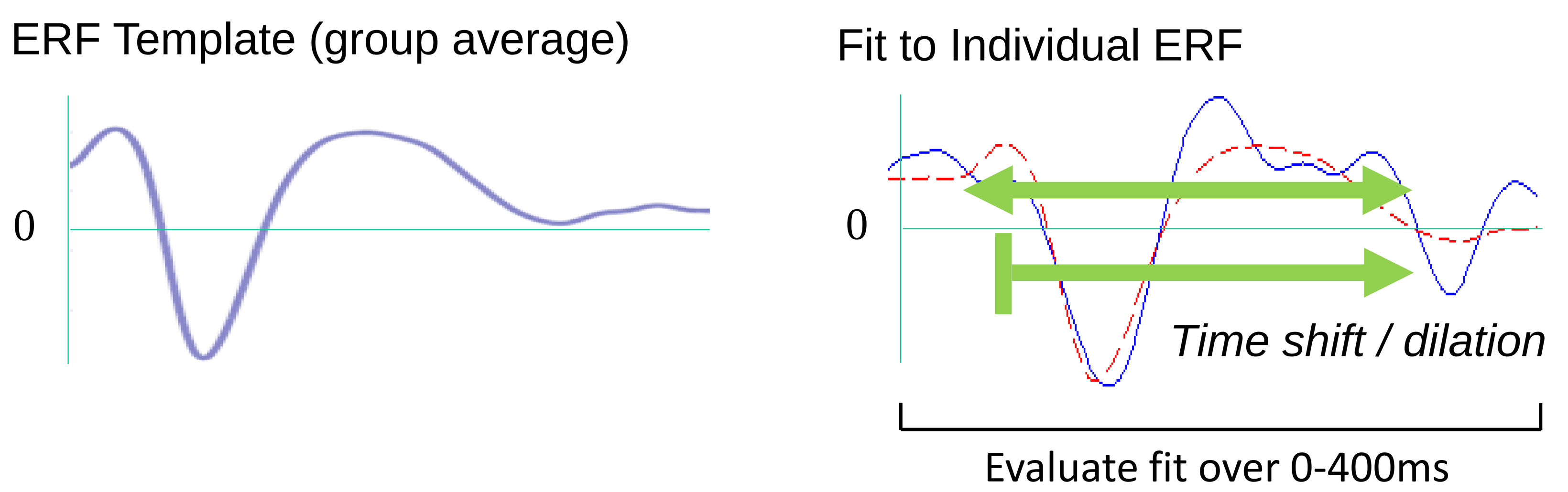

Fig 2*. To obtain constant (time shift) and cumulative (time dilation) delay parameters, group average template was fit to the subject trial average using an iterative least squares fit by modulating the temporal shift and temporal dilation of the template ERF.*

Results

- Fig 3 shows the first principal component from the PCA of audio and visual components
- Source inversion of spatial components suggests sources in primary audio and visual cortices
- **ERF fitting in Fig 4 revealed a strong effect of age on cumulative delay in the auditory condition, and a moderate effect of age on constant delay in the visual condition**
- **Regression analysis revealed a significant Age x Auditory Cumulative Delay interaction on fluid intelligence**

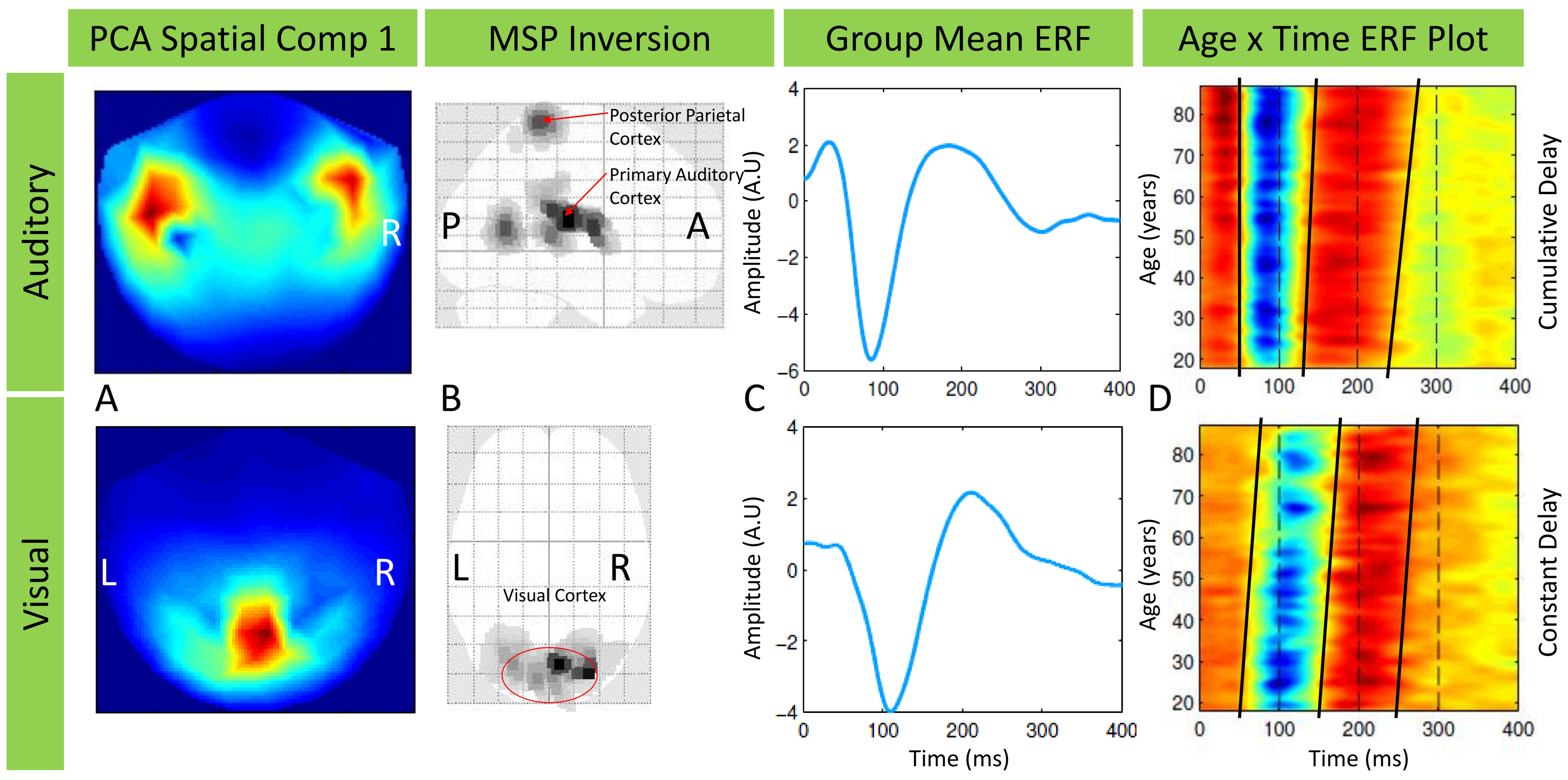

Fig 3*. PCA of temporally concatenated trial averages results in a spatial (single component for the whole group) and a temporal component (for each subject). A) Spatial PCA component. B) MSP inversion of A. C) Grand mean time-course for PCA component. D) Subject time-courses extracted from PCA temporal component suggests 2 distinct types of age related delay, constant and cumulative.*

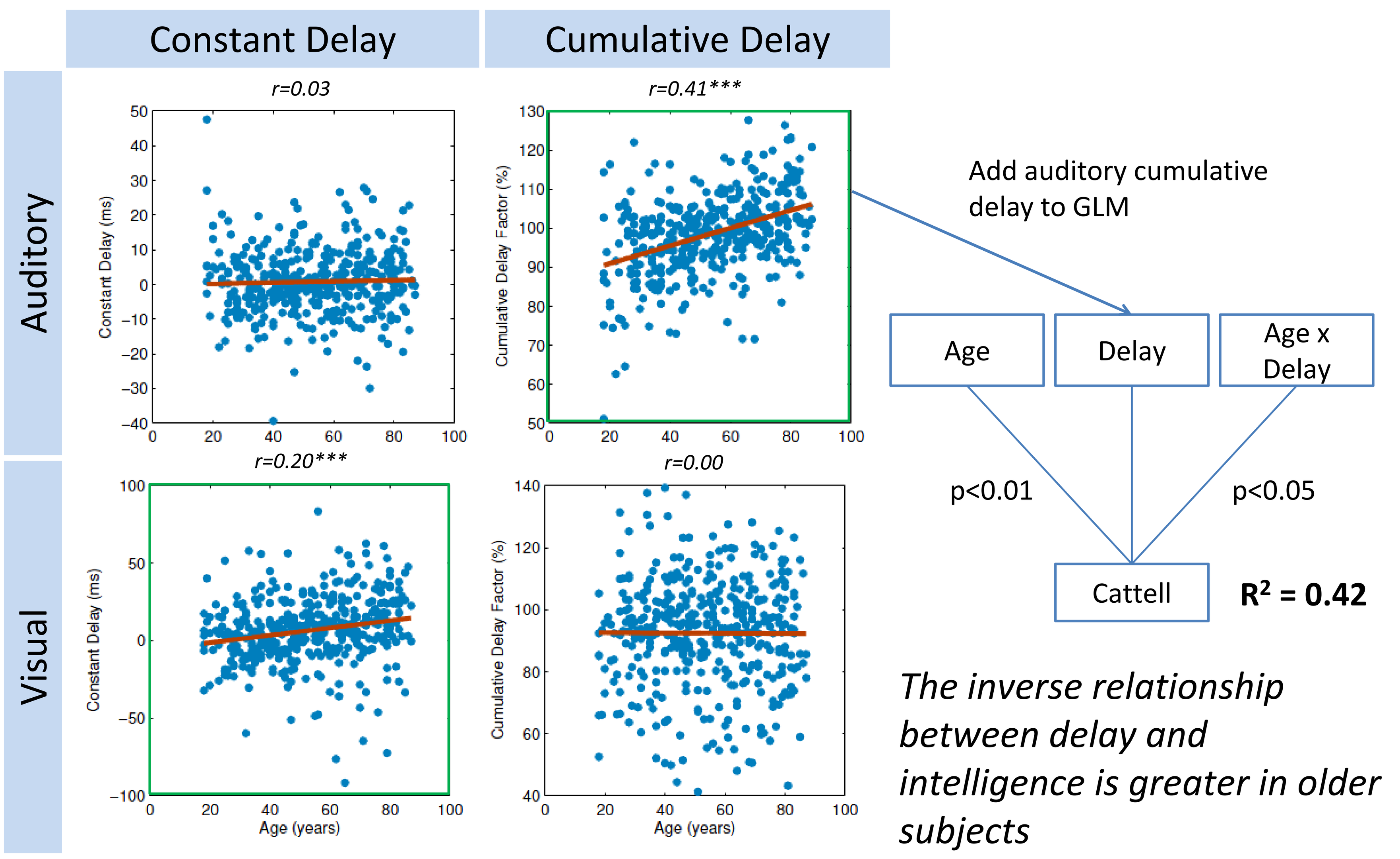

Fig 4*. ERF fitting results. Cumulative delay in the auditory evoked response is strongly correlated with age (r=0.41***). Constant delay in the visual response is moderately correlated with age (r=0.2***).*

Discussion

- Two distinct types of age-related neural delay were derived from the same subjects using the passive audio / visual task
- Cumulative delay in the auditory evoked response was related to fluid intelligence and the linear model revealed an Age x Delay interaction ($p<0.05$)
- Previous work has shown cumulative delay may indicate attentional / inhibitory deficits[5] and these deficits may underlie cognitive decline in ageing

Preliminary results (not shown) reveal that a reduction in post stimulus induced alpha frequency explains cumulative delay in the evoked response.

References

1) Salthouse, T. A., & Ferrer-Caja, E. (2003). What needs to be explained to account for age-related effects on multiple cognitive variables?. Psychology and ageing, 18(1), 91. **2)** Bieniek, M. M., Frei, L. S., & Rousselet, G. A. (2013). Early ERPs to faces: ageing, luminance, and individual differences. Frontiers in psychology, 4. **3)** Portin, R., et al. (2000). Does P3 reflect attentional or memory performances, or cognition more generally?. Scandinavian Journal of Psychology, 41(1), 31-40. **4)** Friston, K. et al. (2008). Multiple sparse priors for the M/EEG inverse problem. NeuroImage, 39(3), 1104-1120. **5)** Chao, L. L., & Knight, R. T. (1997). Prefrontal deficits in attention and inhibitory control with ageing. Cerebral Cortex, 7(1), 63-69.

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