Combining Structural and Functional Neuroimaging Techniques to Study Typical Developmental Patterns of Emotion Processing in Adolescents.

William Lloyd, Justin Williams, David Perrett, Gordon Waiter
University of Aberdeen

INTRODUCTION

Development during adolescence has been shown to be a period of extensive change in brain structure [1]. However, the knowledge of the detail of this these changes and their effect on brain function is still limited. The combination a number of imaging techniques will hopefully allow for a more complete picture. Recent years have seen a revolution in MRI techniques of structural brain imaging, with major advances in the quality and variety of imaging sequences available. The various types of contrast that MRI provides has expanded beyond mere morphological parameters. A number of measurable characteristics can act as markers. These range from relatively simple volumetric studies of tissue types, to analysis of chemical composition, and tissue structure and organisation at a microstructural level. A number of techniques now exist, each providing unique measures of brain structure. This research will use a combination of structural scanning techniques alongside an fMRI study. The structural scanning protocol will include standard T1 and T2 weighted imaging, an extended diffusion protocol that allows for tensor imaging, tractography and diffusion kurtosis imaging (DKI) , and T2 relaxographic imaging (T2R). Inclusion of DKI and T2R will represent the first studies of brain development using these methods, therefore proving novel markers with which to assess white matter changes.

METHODS

80 participants will be selected based on sex and age to provide 10 participants in each of eight different sex-balanced groups of typical young people from 8-16yrs of age (8-9yrs, 9-10yrs, 10-11yrs, 11-12yrs, 12-13yrs, 13-14yrs, 14-15yrs,15-16yrs).

Scanning will be performed on a 3T scanner (Philips Achieva X-series 3.0, Philips, Eindhoven). A 30 minute structural scanning protocol includes T1- , T2-, diffusion, and T2R weighted imaging. The fMRI protocol includes two types of stimulus; happy and neutral faces. For each stimulus there will be two 'levels' of emotion; happy/slightly happy and fearful/slightly fearful. For each of these there are two co-variables; the face looking towards camera or face looking clearly away from camera. The image set is shown twice to the participant. The first time the participant is asked 'Is he/she happy?', and the second time 'Is he/she fearful?'. For the null variable, a set of neutral faces are also shown and the participant will be asked 'Is this person male?'.

DISCUSSION

fMRI of facial emotion processing

Facial emotion communication is an important component in social interaction. Better understanding of maturational changes provides a valuable resource for investigating the neural mechanisms that underline deficits in interpreting facial emotion in childhood behavioural and other related disorders [2]. The fMRI protocol allows for study of a number of facets of emotion processing. More prototypic emotional expressions are easier to interpret than subtle ones and demonstrate a stronger response in emotional perception. Important distinctions exist between the processing of direct and averted (relative to the observer) gaze. The impact of facial expression is greater when personally directed than when averted. Expressions of anger and joy are recognized quicker when directed to an observer, whereas fear or sadness are recognized quicker when averted. Different brain areas are thought to be recruited dependent on whether gaze is direct or averted. Face direction has also been hypothesised to have an important distinction [3].

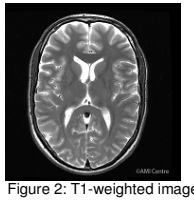

Figure 2: T1-weighted image

Structural Imaging

There are numerous structural MR imaging methods, where different structural measures may be obtained due to the way in which the MR signal, S, is manipulated. Voxel Based Morphometry (VBM) is used to classify tissue as either grey matter, white matter, or CSF. It is used define specific brain structures and can determine morphometric change in these structures with age. VBM studies acquire a signal where:

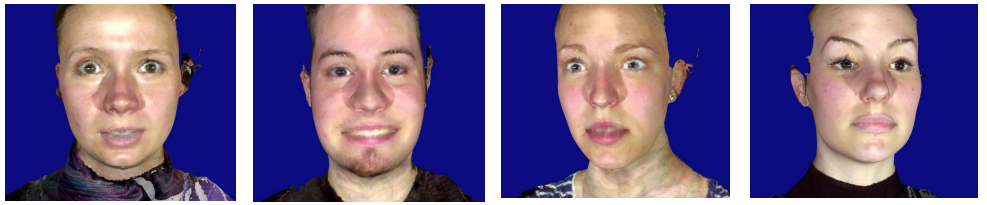

Figure 1. Examples of Facial emotion stimuli.

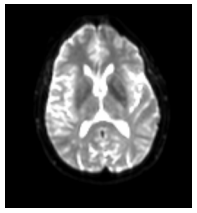

Figure 3: Diffusion-weighted image

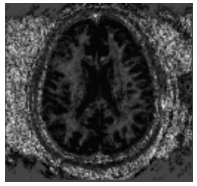

Figure 4: Diffusion kurtosis image

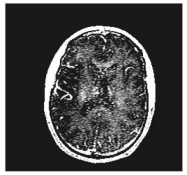

Figure 5: Myelin water fraction T2R image

$$S = \frac{k(PD)[1-e^{-TR/T1}]e^{-TE/T2}\sin(\alpha)}{[1-\cos(\alpha)]e^{-TR/T1}}$$

Diffusion imaging is an indirect method of analysing structure by examining the kinetics of water molecules. A number of calculable parameters are available from diffusion data, such as measures of diffusivity, trace, anisotropy, and apparent diffusion coefficient (ADC). Reduced water motion, and increasingly anisotropic water movement, is a feature of brain maturation, apparent in measures such as reduced ADC values . The diffusion signal is given by:

$$S = S_0 e^{-t/T2} e^{-bD}$$

An extension of diffusion imaging is measuring the kurtosis; the degree to which the water diffusion deviates from the Gaussian distribution assumed in the standard model. Kurtosis has been shown to give novel information and may be a more accurate method of examining structure. The diffusion kurtosis signal is given by:

$$S = S_0 e^{-bD+\frac{1}{6}b^2 D_{app}^2 K_{app}}$$

T2R is a method of separating the full T2 signal into its component parts., i.e. for brain imaging the signal from each of the myelin sheath, extracellular space, or CSF. This allows direct study of myelin development by measuring the myelin water fraction (MWF).

REFERENCES

1. C. Lebel, L. Walker, A. Leemans, L. Phillips, and C. Beaulieu. Microstructural maturation of the human brain from childhood to adulthood. NeuroImage, 40(3):1044–1055, 2008.
2.D.M. Palmer,B.J. Liddell, E. Gordon, L.M. Williams. Facial emotion processing from childhood to adulthood: An event-related potential study of maturational changes.. NeuroImage,31(3):88 - , 2006.
3. JHG Williams; DI Perrett; GD Waiter; S Pechey. Differential Effects of Tryptophan Depletion on Emotion Processing According to Face Direction. Soc Cogn Affect Neurosci. 2007;2(4):264-273.

ACKNOWLEDGEMENTS

This research is jointly funded by SINAPSE and Philips.