Title: An EEG Investigation of the Alpha and Beta Frequency Bands during Resting States in Adults with Williams Syndrome

Authors: Joanna Greer, Colin Hamilton, Mhairi McMullon, Deborah Riby, & Leigh Riby

Introduction: Williams syndrome (WS) is a rare genetic developmental disorder, with distinctive behavioural, social, and cognitive profiles widely documented in the literature (e.g. Bellugi et al., 2007; Martens et al., 2008). Research links these profiles with wider cognitive processes, specifically deficits in executive functioning of attention and inhibition (e.g. Jones et al., 2000; Riby et al., 2011). Behavioural research paradigms highlighting deficits in attentional lapse and inhibitory control (Greer et al., 2013), and social approach behaviours (Little et al., 2013) in WS emphasise the link between these deficits and the known atypicalities in frontal lobe function (Mobbs et al., 2007; Ng et al., 2015). In light of the limited research using neuroimaging techniques, the current study adopted electroencephalography (EEG) methodology, measuring baseline cortical activity to investigate the mechanisms which underpin attentional and inhibitory processes in the absence of goal-directed cognitive processing. Cortical electrical activity was recorded from adults with WS aged 35+ years during Eyes Closed (EC) and Eyes Open (EO) resting states, and compared to that of typically developing adults matched for chronological age (CA) and typically developing children matched for verbal mental ability (MA). Analyses focused on the full alpha (8-12.5 Hz), low-alpha (8–10 Hz), upper-alpha (10–12.5 Hz), and beta (13–29.5 Hz) bands, as these are thought to have functional significance with attentional and inhibitory processes.

Method: Participants were 11 adults with WS (means age 42yrs 7mths, SD 48mths), and two comparison groups consisting of a group of typically developing adults matched for chronologically age (CA; n=16, mean age 42yrs 10mths, SD 50mths), and typically developing children matched for verbal mental ability (MA; n=13, mean age 12 yrs 2 mths, SD 32mths). The MA and WS groups were matched for receptive vocabulary using the raw scores from the British Picture Vocabulary Scale (BPVS-II: Dunn, Dunn, Whetten, & Burley, 1997). The EEG was recorded from 32 channels using an electrode cap (Biosemi, Amsterdam, The Netherlands). Power estimates were derived from the average for full-alpha (8-12.5 Hz), low-alpha (8–10 Hz), upper-alpha (10–12.5 Hz), and beta (13–29.5 Hz) frequency bands at frontal (F3, FZ, F4), central (C3, CZ, C4), and parietal (P3, PZ, P4), and occipital (O1, OZ, O2) sites. The participants were asked to sit still with their eyes closed for 2 minutes, then sit still with their eyes open for a further 2 minutes. During both conditions, the participants were asked to remain relaxed and silent, avoid head and body movements, and refrain from blinking if possible.

Results: A 3 (group: WS / CA / MA) x 4 (location: frontal / central / parietal / occipital) x 3 (hemisphere: left / midline / right) mixed design Analysis of Variance (ANOVA) was applied to the data; with location and hemisphere as the within subjects factors, and groups as the between subjects factor. The ANOVA was applied to the following frequencies a: alpha (α-full), 8–12.5 Hz, b: lower-alpha (α-low), 8–10 Hz, c: upper-alpha (α-high), 10–12.5 Hz, and d: beta (β), 13–29.5 Hz. Numerically (but non-significant) lower power in the alpha bands was observed in the WS group, and comparable beta power with the CA group during both EC / EO conditions (all p values >.05). The MA group’s EEG power was numerically greater across all frequency bands compared to both the WS and CA groups, indicative of a state of neuronal maturation. Analyses also revealed an unusual trend for low variability in the EEG signature of the WS group compared to both control groups, which contradicts the heterogeneity typically observed behaviourally.

Discussion: Whilst non-significant, the WS group’s trend for numerically lower power in the alpha bands during resting states is consistent with other developmental disorders characterised by attentional / inhibitory deficits such as ADHD, and may be indicative of inefficient inhibitory processing due to a state of cortical hyper-arousal (cf. Loo et al., 2009). In contrast, comparable beta power between WS and CA groups during both EC / EO conditions suggests that their baseline EEG signature is commensurate with successful attentional processing, though all analyses need to be interpreted with caution due to the small sample size. The inclusion of the MA group demonstrates that the EEG profile observed in the WS group is not reflective of delayed development but rather is indicative of their developmental disorder. Notably, the unusual trend for low variability in
the EEG signature of the WS group compared to both control groups is of importance for further research. Low EEG variability is associated with impaired behavioural performance (Woltering et al., 2012), whilst high EEG variability observed in typically developing children is important for neuronal development (MacIntosh et al., 2008). The results here further emphasise the need for more detailed research into the EEG characteristics in WS to further inform its role in the behavioural, social, and cognitive profiles of these individuals.

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