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To go or not to go: Personality, behaviour and neurophysiology of impulse control in men and women



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ABSTRACT

Population-based studies show that men tend to be more aggressive, commit more violent crimes, and use drugs more often than women. Men are also more likely to suffer from disorders that are characterized by impulsive behaviour. However, surprisingly little is known about sex-related similarities or differences in non-clinical populations in impulse control. The aim of this study was to use multiple assessment methods (self-report questionnaires, behavioural task and electrophysiological recording) in order to better characterize inhibitory processes in a sample of healthy adult men and women ($N = 126$). While women rated themselves as more neurotic and impulsive, men exhibited this behaviour through more commission errors and more premature, impulsive responses. These impulsive behavioural tendencies were reflected in reduced P2 and enhanced N2 amplitudes in men compared to women. The absence of correlations between personality questionnaires, behavioural performance and ERPs suggest that these measures do not assess the same underlying construct. It seems that differences between men and women in impulse control are the result of a combination of social factors and biological determinants that are often difficult to disentangle, but may influence different aspects of behaviour and possibly the susceptibility to develop various psychiatric or neurological disorders.

1. Introduction

There has been much progress in recent years in our understanding of sex differences across a variety of cognitive domains, especially in clinical populations (Fattore & Melis, 2016; McHenry, Carrier, Hull, & Kabbaj, 2014). One of the fundamental cognitive domains is impulse control. The ability to successfully control our impulses by inhibiting unwanted actions or behaviour is essential for the performance in everyday tasks. Inhibition enables us to stop the execution of purposeless or unproductive acts and to hinder irrelevant thoughts or inappropriate emotions (Bari & Robbins, 2013; Cross, Copping, & Campbell, 2011). Without inhibition we would not be able to voluntarily control our behaviour.

A large body of knowledge about sex differences in inhibitory control comes from studies of substance users or patients suffering from various psychiatric or neurological disorders. They show that men tend to be more aggressive, commit more violent crimes, and use drugs more than women including alcohol, tobacco, marijuana, cocaine and hallucinogens (McHenry et al., 2014). Men are also more likely to suffer from disorders that are characterized by impulsive behaviour, such as antisocial personality disorder or attention deficit hyperactivity disorder (Bangasser & Valentino, 2014). However, population-based studies can fail to capture subtle differences in the presentation of

disorders. For example, opioid-dependent women demonstrate more severe clinical profiles, higher rates of cravings, and more comorbid psychiatric conditions than men, and both binge and heavy drinking women have poorer inhibition compared to binge and heavy drinking men (Fattore & Melis, 2016; Weafer & Wit, 2014).

In a non-clinical population it is generally assumed that women display greater ability to inhibit undesirable behaviours and control unwanted impulses than men (Weafer & Wit, 2014). Research on healthy younger age groups – children and adolescents – has shown that overall girls exhibit higher levels of inhibitory control than boys, but this difference is more pronounced in childhood while later during development it becomes minimal (Chapple & Johnson, 2007). Investigations of sex differences in typically developed adult men and women have not revealed consistent evidence for or against sex-related differences in inhibitory performance (Weafer & Wit, 2014). Some report higher percentage of inhibitory failures in men (Saunders et al., 2008), others report higher percentage of inhibitory errors in women (Morgan, Gray, & Snowden, 2011), while others report no sex differences in performance (Ferne, Cole, Goudie, & Field, 2010; Huster, Westerhausen, & Herrmann, 2011). To date, only a few neuroimaging studies have tested for sex differences in inhibition and they did not reveal consistent findings. Some found increased activation in several task-related brain regions (Lee, Huang, Constable, & Sinha, 2006) or a

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strong degree of functional lateralization (Huster et al., 2011) in men compared to women, and others found greater activation in women compared to men (Garavan, Hester, Murphy, Fassbender, & Kelly, 2006; Rubia et al., 2013).

In sum, the evidence for sex similarities or differences in inhibitory control using self-reporting questionnaires and objective behavioural measures is mixed, and using neurophysiological measures almost non-existent, revealing several clear gaps in the literature. Only a handful of studies so far have directly investigated sex differences in inhibitory control in healthy adults using both behavioural and neurophysiological measures. Majority of the *post-hoc* comparisons are made with unequal number of men and women or are limited by small sample sizes and usually without balancing across other demographic variables, e.g., age and education (Weaver & Wit, 2014). The aim of this study was to use multiple assessment methods in order to better characterize inhibitory processes in a sample of healthy adult men and women.

Since inhibition can be estimated by tasks requiring the suppression of a pre-potent response (Bari & Robbins, 2013), in addition to self-report questionnaires, we used a visual Go/No-Go task, registered behavioural responses (accuracy and reaction times) and recorded electroencephalographic (EEG) activity. The Go/No-Go is a reaction time task, which requires a motor response when Go stimuli are presented and inhibition of the response when No-Go stimuli are presented. When a Go response is executed before the stimulus analysis is complete, e.g., in the first 200 ms after stimulus onset, it is considered as a premature response that indexes individual's impulsive tendency to act with less forethought compared to most individuals with equal knowledge and ability (Donkers & Boxtel, 2004; Knežević & Marinković, 2017). The event-related potentials (ERPs) which are extracted from the EEG enable precise determination of processing stages by continuously measuring processing between a stimulus and a response (Luck, 2014). ERP components previously related to the Go/No-Go task are N1 peaking around 100 ms after stimulus onset thought to reflect visual processing, followed by a positive going P2 thought to reflect early attentional processes (Bokura, Yamaguchi, & Kobayashi, 2001). Between 200 and 350 ms N2 arises which is considered as an index of a variety of cognitive control processes, including conflict monitoring and attentional control (Huster, Enriquez-Geppert, Lavalley, Falkenstein, & Herrmann, 2013). A frontally maximal P3 component that arises between 300 and 500 ms is thought to reflect the actual inhibition of the motor response in the premotor cortex (Polich, 2007). We expected that, even in the absence of differences in personality traits or behavioural performance, the ERP analysis will provide important insights about neural underpinnings of inhibition in men and women. To the best of our knowledge, this is the first study that investigated sex differences in response inhibition in a sample of healthy adult men and women using multiple assessment methods, including psychological tests, behavioural task and electrophysiological recordings.

2. Method

2.1. Participants

64 women (average age = 26.14 (\pm 5.75), age range 19–42) and 62 men (average age = 26.32 (\pm 6.67), age range 19–44) were included as volunteers in this study (N = 126). They were recruited via E-mails, social networking (Facebook), word-of-mouth referrals and advertisements at the University of Zagreb. Additional 12 participants took part but were excluded as outliers due to excessive EEG artefacts and/or low number of correct trials (three standard deviations from the mean). None of the participants reported any EEG contraindications, including previous head-injuries or medication use at the time of the study. All were right-handed, with normal or corrected-to-normal vision. The study conformed to the ethical standards of the American Psychological Association (APA) and was approved by the local Ethics Committee.

2.2. Procedure and task

The study was conducted at the Laboratory for Psycholinguistic Research at the University of Zagreb, Croatia. It consisted of two sessions. During the first session, participants were familiarized with the experimental procedure, read and signed an informed consent, and completed a battery of standardized psychological tests and questionnaires which included: Cognitive Nonverbal Test (Sucevic, Momirovic, Fruk, & Augustin, 2004) which estimates non-verbal IQ, Barratt Impulsivity Scale (Patton, Stanford, & Barratt, 1995) which assesses non-planning, attention and motor impulsivity, and Eysenck Personality Questionnaire (Eysenck & Eysenck, 1994) that assesses neuroticism, psychoticism and extraversion. Afterwards each participant underwent two practice runs comprising 300 trials in total.

During the second session after the EEG electrodes were attached, participants were first given 150 practice trials. A visual Go/No-Go task (Knežević & Marinković, 2017) was administered during which a stream of X and Y letters was presented in an alternating order. Participants were instructed to respond as quickly and accurately as possible to each stimulus alternation (X following Y = Go trials) and to withhold their responses whenever the stimuli repeated (X following X or Y following Y = No-Go trials). A total of 520 trials consisted of 75% (388) Go and 25% (132) No-Go trials, divided into three blocks and counterbalanced across participants. Between each No-Go trial there were 2 to 6 Go trials. The letters were presented for 300 ms every 1250 ± 150 ms, in yellow font on a black background within the visual angle of 0.76° . The task was programmed in E-prime 2.0 and the responses were given by pressing a key on the Serial Response Box (Psychology Software Tools, <http://www.pstnet.com/>) with the right index finger.

2.3. EEG recording and data processing

The electroencephalogram (EEG) was continuously recorded using a standard 32-channel actiCAP connected to the Brain Vision (version 1.03) recording system (Brain Products GmbH, Munich, Germany). Blinks were recorded by means of two electrodes placed above and below the right eye (VEOG), while horizontal movements were recorded from electrodes placed at the outer canthus of each eye (HEOG). The electrode impedance was kept below 5 kOhms.

EEG data processing was carried out with Brain Vision Analyser 2.1 software package. Continuous EEG recordings were filtered off-line with a band-pass filter from 0.1 Hz to 30 Hz. VEOG and HEOG artefacts were removed using Independent Component Analysis (ICA) ocular correction algorithm in a semiautomatic manner. The signal was re-referenced to the average of right and left mastoids. Sweeps at any scalp electrode in which the absolute difference between two adjacent sample points of data exceeded $75 \mu\text{V}/\text{ms}$, and the average amplitude exceeded $\pm 100 \mu\text{V}$ were edited out during the averaging procedure (Luck, 2014). The data were additionally visually inspected by the experimenter, and epoched from -200 to 1000 ms with respect to stimulus onset. All trials were baseline-corrected to a 200 ms pre-stimulus period. Only trials with correct responses to Go stimuli between 200 and 1000 ms from stimulus onset and correctly withheld responses to No-Go stimuli were included in the analysis. Artefact-free ERP averages were obtained for $84 \pm 8\%$ trials in the Go condition and for $84 \pm 11\%$ trials in the No-Go condition. The components of interest were determined based on the inspection of the grand average waveforms and in reference to the literature (Huster et al., 2013; Polich, 2007). Amplitudes were measured as the mean voltage for each participant and condition in a given measurement window: N1 from 75 to 125 ms, P2 from 125 to 200 ms, N2 from 200 to 300 ms and P3 from 300 to 500 ms. For statistical analysis, amplitudes at frontal (F3, Fz, F4) electrodes were averaged together. We only report data from the frontal electrodes in order to reduce the number of comparisons since this is where the components of interest have typically been reported as most

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