

# Is Impulsivity a Male Trait Rather than Female Trait? Exploring the Sex Difference in Impulsivity

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**Abstract** Impulsivity is raising major interest clinically because it is associated with various clinical conditions such as delinquency, antisocial behavior, suicide attempts, aggression, and criminal activity. The evolutionary perspective argued that impulsivity relates to self-regulation and it has predicted that female individuals should have evolved a greater ability to inhibit pre-potent responses. There is supportive evidence showing that female individuals have better performance on cognitive tasks measuring impulsivity such as delay in gratification and delayed discounting mainly in childhood. During adolescence, brain imaging studies using diffusion tensor imaging on white matter architecture indicated contrary to the evolutionary perspective hypothesis, that young adolescent male individuals may be less vulnerable than age-matched female individuals to risk- and reward- related maladaptive behaviors. In adults, the results are mixed presumably owing to hormonal effects on neuro-biological mechanisms of reward. Consequently, female individuals were less impulsive than male individuals only during fertile stages of the menstrual cycle. Finally, there is evidence the serotonin (5-HT) system is more involved in the impulsivity of men than in that of women. Overall, there seem to be sex differences in impulsivity but these differences are more pronounced in childhood and they are later subject to maturational and hormonal changes during adolescence and adulthood and their effects on the brain, cognition, and behavior.

**Keywords** Impulsivity · Sex differences · Response inhibition · Reward

## Introduction

Impulsivity generally refers to acting without forethought [1, 2]. It can be seen as a set of heterogeneous suboptimal behaviors along two dimensions. One component of impulsivity reflects impulsive action, which is the inability to inhibit a pre-potent response and another component is impulsive choice, which is the difficulty in delaying gratification [3]. A third component reflects impulsive decision making, such as making sub-optimal risky decisions without sufficient consideration [4, 5]. Research on impulsivity has important implications, as impulsive behaviors greatly influence an individual's social life; its adverse outcomes can include delinquency, antisocial behaviors, addiction, suicide attempts, aggression, crimes and pathological gambling [6–10]. Theoretically, impulsivity is closely related to other personality constructs such as sensation seeking [11], failure to plan [12], lack of perseverance [13], venturesomeness [14], poor self-discipline [15], and novelty seeking [16]. For a recent review see Cross et al. [17]. This review searched articles published between 2000 and 2014 in PubMed, Ovid, and Google scholar using the key words “Impulsivity”, “gender”, “female impulsive behavior”, and “sex differences”.

## Neuro-biological Theories of Impulsivity

Neuro-biological theories of personality suggest that impulsivity results from interplay between sensation and novelty seeking and harm avoidance or inhibition [18–20]. Dopamine

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is involved in reward and approach behavior, whereas serotonin mediates restraint or inhibition. Dopamine accelerates risky behavior because, when faced with danger, high-sensation seekers experience stronger attraction than low-sensation seekers. Men's greater sensation seeking chiefly results from a more reactive dopaminergic system [21]. Cloninger [16] suggested three genetically mediated, independent dimensions of personality: novelty seeking, harm avoidance, and reward dependence. Cloninger used the term *novelty seeking* as an alternative to impulsivity, an appetitive motivation that is associated with activity in the dopaminergic reward system and is expressed as a tendency to respond to novel stimuli with excitement [22]. Novelty seeking is highly correlated with Zuckerman's sensation seeking but unlike sensation seeking, no sex difference was found for novelty seeking in a recent meta-analysis [23].

### The Evolutionary Perspective

The topic of impulsivity relates to a broader area of self-regulation that has an evolutionary perspective. Self-regulation is the capacity to select actions that lead to favorable outcomes and avoid actions that lead to unfavorable outcomes. Bjorklund and Kipp [24] hypothesized that because of the different selection pressures placed on male and female individuals, female individuals should have evolved a greater ability to inhibit pre-potent responses. They have argued that overall, the evidence shows a moderate female advantage in behavioral inhibition and a strong female advantage in social inhibition [24]. Hosseini-Kamkar and Morton [25] after evaluating the behavioral, neural, and hormonal evidence for the evolutionary hypothesis have concluded that sex differences in self-regulation are more consistently reported in children prior to the onset of puberty. In adult cohorts, the results of studies examining sex differences in self-regulation were mixed.

### The Cognitive Assessment of Impulsivity and Sex Differences

In the 1970s, Mischel created the delay of gratification paradigm to test children's ability to resist temptation and forgo a small immediate reward to obtain a larger delayed reward [26]. Mischel and Underwood [26] were the first to report that female preschoolers were able to wait for significantly longer periods of time to obtain the larger reward in comparison to their male counterparts. More recently, a meta-analysis was conducted on 33 experiments using the delay of gratification paradigm by Silverman [27]. The meta-analysis revealed a female advantage in the capacity to delay gratification although the effect size of the female advantage in

delay of gratification is relatively small; however, this may be owing to instruments that lack precision and small sample sizes. Based on these findings, it appears as though female individuals are better suited to delay gratification and resist temptation in comparison to male individuals and that this sex difference emerges early in development.

While the results of delay of gratification measures and teacher/parent reports of self-regulation indicate that there is a female advantage in self-control (at least early in development), the results on a related measure (delay discounting) are contradictory. Delay discounting is a task used to measure impulsive choice by asking participants to select between a large reward delivered at variable delays (1 day, 7 days, 30 days) and a smaller immediate reward. As the length of the delayed reward increases, participants are more inclined to select the smaller immediate reward. Evolutionary theorists such as MacDonald [28] argued that male individuals are more likely to score higher on behavioral approach measures (sensation seeking, impulsivity, reward seeking, and aggression) and are thus less likely to control pre-potent approach tendencies. Dittrich and Leipold [29] reported supporting evidence that male individuals preferred a smaller immediate payment rather than a larger delayed payment thus suggesting that female individuals are better able to delay gratification in comparison to male individuals. There is contradictory evidence showing the opposite pattern of sex differences in relation to delay discounting with female individuals discounting more steeply than male individuals [30, 31]. A review article investigating sex differences in impulsive choice (which refers to the tendency to prefer small immediate rewards rather than large delayed rewards) and impulsive action (a lack of behavioral inhibition) showed that many of these inconsistent findings may be due to variations in the subjects under study and the tasks used [3]. Weafer and de Wit [3] reviewed the literature and argued that sex differences appear to exist on these measures, but the direction and magnitude of the differences vary. In humans and some other species, female individuals tend to discount more steeply than male individuals on measures of delay discounting (impulsive choice), whereas sex differences in impulsive action depend on the task administered. Male individuals commit more inhibitory errors on the Go/No-Go task (failing to inhibit a pre-potent response) than female individuals, whereas female individuals commit more inhibitory errors than male individuals on the Stop Signal Task. Based on these findings and others it appears that female individuals have an advantage in terms of delay of gratification but not necessarily on impulsive action. However, the sex difference in delay of gratification and inhibitory control more generally is more evident in childhood, whereas in adults there are inconsistent results. Hosseini-Kamkar and Morton [25] argued that one potential reason for these mixed findings in adult cohorts could be because

of the activation effects of hormones. Sex hormones may modulate the neural circuitry underlying self-regulation and result in differential patterns of behavior across different phases of the menstrual cycle. They have suggested that the mixed findings in self-regulation in adult cohorts could potentially be due to variations in levels of hormones exerting their influence on the meso-cortico-limbic dopamine reward pathway. It is therefore being suggested that individuals who have increased neural responses to rewards and/or are more sensitive to the prospect of obtaining rewards would have greater difficulty inhibiting pre-potent responses and delaying gratification.

### Impulsivity, Reward and Hormonal Changes

Structural studies using autoradiography and functional studies using positron emission tomography showed that male individuals had higher  $D_1$  receptor density in the nucleus accumbens [32]; women may have lower  $D_2$  receptor occupancy compared with men [33], and this reduced  $D_2$  receptor occupancy may result in higher striatal dopamine synthesis capacity in women relative to men [34]. These sexual differences in the structure and subsequent function of the dopamine reward pathway may make men and women differentially susceptible to the reinforcing properties of reward. Munro et al. [35] revealed that men had greater dopamine release in the ventral striatum in response to amphetamines. Perhaps under baseline conditions, female individuals have greater dopamine synthesis capacity; however, when administered a rewarding substance, male individuals have greater dopamine release in the ventral striatum. Furthermore, Munro et al. [35] reported that the baseline binding potential of  $D_2$  receptors varies as a function of the menstrual cycle: women in the luteal phase had lower baseline binding potential in the putamen relative to women in the follicular phase. In the light of these findings, an investigation of hormonal influences on the dopamine reward pathway is warranted.

Recent experiments suggested that female individuals are less impulsive than male individuals only during fertile stages of the menstrual cycle. Dreher et al. [36] obtained functional magnetic resonance imaging (fMRI) scans from healthy women during the luteal and mid-follicular phases of their menstrual cycle. The fMRI paradigm included an event-related reward task; the results provided evidence of enhanced blood-oxygen-level-dependent responses associated with rewards during the phase of their menstrual cycle directly preceding ovulation. Because of the fluctuating levels of estrogen and progesterone across the menstrual cycle, female individuals may adopt differential strategies to facilitate reproduction and mate selection during different phases of their menstrual cycle. For example, being impulsive might not incur

enormous risks during phases of the menstrual cycle when female individuals are not fertile any risk incurred would only apply to the female individual herself and not to a developing embryo. In accordance with this hypothesis, Pine and Fletcher [37] demonstrated that women in their luteal phase (non-fertile phase) are more impulsive than women in other phases of the menstrual cycle. However, according to parental investment theory, female individuals must be selective in securing an appropriate mate and therefore, they may exhibit less impulsivity during periods of their menstrual cycle when they have the capacity to reproduce [38–40]. These fluctuations as a result of hormonal changes during the menstrual cycle may help explain the mixed findings in delay discounting in adult cohorts that might be influenced by the phases of fertility (i.e., women discount more steeply in non-fertile phases of the menstrual cycle and discount less steeply in the fertile phase of their menstrual cycle).

Recent brain imaging studies using fMRI have also shown sex differences in impulsivity and its neural correlates. Liu et al. [41] compared male and female performance on the Go/No-Go task and found higher activation of the rostral anterior cingulate cortex (ACC) in male individuals compared with female individuals. Furthermore, male individuals showed strong negative correlations between reaction time in the impulse inhibition task and ACC and a positive correlation with ratings of excitement seeking. Interestingly, this area has been implicated in many behavioral and clinical conditions that are more prevalent in male than in female individuals such as attention-deficit hyperactivity disorder, violence, and aggression.

The ability to resist reward-related impulses was investigated by Diekhof et al. [42] who assessed with fMRI which neural processes enable men and women to successfully control their desire for immediate reward when this is required by a higher-order goal (i.e., during a “desire-reason dilemma”) [43]. Although men and women showed similarities in the general response of reward areas such as the nucleus accumbens and the ventral tegmental area to predictors of immediate reward, they differed in additional brain mechanisms that enabled self-controlled decisions against the preference for immediate reward. First, men exhibited a stronger reduction in activation in the ventral pallidum, putamen, temporal pole, and pregenual ACC during the “desire-reason dilemma”. Second, connectivity analyses revealed a significant change in the direction of the connectivity between the prefrontal cortex and nucleus accumbens during decisions counteracting the reward-related impulse when comparing men and women. Altogether, these studies support the view of sex differences in the recruitment of sex-specific neural resources during the successful deployment of self-control, inhibition, and delayed gratification and merit further investigation.

## Impulsivity, White Matter Architecture and Sex Differences During Adolescence

During adolescence, rapid maturational brain changes occur at a time that is associated with risk-taking behaviors and cognitive development. Studies on sex differences, impulsive behavior, and white matter architecture in adolescents using diffusion tensor imaging were reviewed by Bava et al. [44]. Silveri et al. [45] reported sex differences in fractional anisotropy (FA), a measure of white matter coherence were related to response inhibition measured by the Stroop task. A following study revealed that greater white matter anisotropy in several areas in male individuals was associated with lower impulsivity measured by a delay-discounting task [46]. Finally, maturation of medial frontal cortices in male individuals was implicated in the maturation of rational decision making and avoidance of risky choices [47]. Higher FA measures in male individuals in frontal, fronto-parietal, and fronto-temporal white matter pathways were found and these sex differences in association fibers may be associated with differential vulnerabilities to maladaptive behaviors, considering their link to risk-taking tendencies [44]. Given that risky and sensation-seeking behavior peaks relative to puberty [48, 49], it has been argued that young adolescent male individuals may be less vulnerable than age-matched female individuals to risk- and reward-related maladaptive behaviors [44]. Sex differences in brain structure and impulsivity during adolescence may have implications for risky sexual behavior among adolescent female individuals [50]. Research and treatment should therefore consider gender differences when investigating the role of impulsivity in adolescent sexual risk-taking behavior.

## Impulsivity, Serotonin (5-HT) and Sex Differences

Although dopamine and reward have been widely investigated in the context of impulsivity and sex differences, the brain's serotonin (5-HT) system has a crucial role in impulsivity. 5-HT plays an important role in the modulation of different functions and behaviors including appetite, sleep, memory and learning, mood and sexuality [51, 52]. However, one of the most important roles of 5-HT in the central nervous system is that it might serve as a “modulator” of impulsivity and aggression [53–57]. In a preliminary study, Marazziti et al. [58] explored the relationships between impulsivity, sex and a peripheral serotonergic marker, the platelet serotonin transporter (SERT), in a group of 32 healthy subjects. They found that women had a higher Barratt Impulsivity Scale (BIS-11) total score than men, and also higher scores of two factors of the same scale: the motor impulsivity and the cognitive complexity. Second, the density of the SERT transporter was significantly and positively related to the cognitive complexity factor, but only in men. Furthermore, men showed a

significant and negative correlation with 5-HT binding, and the motor impulsivity factor. These findings suggest that women are generally more impulsive than men, but that the 5-HT system is more involved in the impulsivity of men than in that of women.

## Summary

There are many indicators that from the evolutionary and neuro-biological perspectives men are more impulsive than women who should have evolved a greater ability to inhibit pre-potent responses. There is supporting evidence showing that women perform better on cognitive tasks measuring impulsivity such as delay in gratification and delayed discounting mainly in childhood. During adolescence, brain imaging studies indicated that contrary to the evolutionary perspective hypothesis, young adolescent male individuals may be less vulnerable than age-matched females to risk- and reward-related maladaptive behaviors. During adulthood, there are mixed results on sex differences in impulsivity that could be owing to hormonal changes and their effects on the dopamine reward system. There is evidence that the 5-HT system is more involved in the impulsivity of men than in that of women. The sex difference in impulsivity is therefore subject to maturational, neuro-pharmacological and hormonal changes during adolescence and adulthood. The emerging evidence for the genetic role in impulsivity [2, 59, 60] could also perhaps explain sex differences in impulsivity in the future.

## Compliance with Ethics Guidelines

**Conflict of Interest** Aviv Weinstein and Pinhas Dannon have no conflicts of interest.

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