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The Evolutionary View and a A Research Review of The Sex Difference in ADHD

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Abstract:

This article introduces ADHD and gender differences and reviews relevant evolutionary psychology theories. Specifically, the hunter-gatherer theory which explains the higher prevalence in males and less disruptive symptoms in females, has been expanded from the perspectives of foraging and navigation. Due to the different navigation strategies, males with ADHD are more likely to be selected by nature for their adaptation to hunting, meanwhile, females with ADHD tend to be eliminated by natural selection.

Keywords: ADHD; sex difference; hunter-gatherer theory; navigation; landmark.

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common disorders globally and has implications for various aspects of everyday life. So far, it has been clarified as a developmental neurological condition through multiple further experiments. To date, ADHD is affecting 8% or 9% of school-aged children and 4.4–5.2% of adults in the US, and the universal estimation for people who are suffering from ADHD is 5.3%[1]. Historically, ADHD was considered a childhood disorder, where the negative effects, including difficulty paying attention or focusing, being easily distracted by things, and poor listening skills, were believed to disappear in adulthood[1]. However, this mistaken understanding of ADHD is disputed by later studies, which found that ADHD persists in a large percentage of adult cases with an incident rate of around 4-5%[2,3].

To improve the overall understanding of ADHD disorder, gender difference is an important concept to be introduced. The ratio of boys to girls diagnosed with ADHD in childhood ranges from 2:1 to 10:1, with a higher prevalence rate in women rather than men in

an adult sample found in studies[4,5], which makes the issue unclear.

This review aims to summarize the gender differences in ADHD and explain them by using evolutionary psychology theories, including the ADHD evolutionary model, Hunting Farming theory, and Mating and parental investment.

2. Literature Review

2.1 . ADHD Evolutionary Theories

2.1.1 . Hunter vs. Farmer Theory

Thom Hartmann developed this theory in his book Attention Deficit Disorder: A Different Perception[6]. The Hunter-farmer theory tries to explain the hyperfocus aspect of ADHD by using the evolutionary history of human beings. During this evolution stage, most or all food is obtained through foraging, gathering food from local and natural sources. This predation requires humans to concentrate on their target for a long time, to complete the predation. Therefore, hyperfocus ADHD might be an advantageous gene that helps individuals to live longer and reproduce more offspring, which humans developed during natural selection. In contrast, individuals without hyperfocus ADHD were described as the consequence of the farming period, where people do not need to have high concentration. Due to this changed selection pressure, most individuals developed other advantageous genes and eliminated the gene code for hyperfocus ADHD[6].

2.1.2 . The response-readiness theory

This theory suggests that ADHD was developed to adapt to resource-depleted, rapidly changing, novel and time-critical environments by introducing three ADHD evolutionary models about the three traits (hyperactivity, inattention and impulsiveness) noted as "response ready"[7]. Increased motor activity (hyperactivity) is proposed as an adaptation mechanism for fitting resource-depleted environments. Hyperactivity may stimulate engagement in proactive activities like foraging, which is essential for animals' living and reproduction. The second model explains the adaptive advantage of the attentional process (inattention). The scanning and rapidly shifting attention support animals to identify threats with hypervigilance, and to cope with changing and novel environments. Even in a relatively low-threat and stable environment, the scanning activity is conducive to future planning and threat anticipation. Nonetheless, there may also be disadvantages of hyperactivity and inattention in those activities which are affected by other factors, thus the argument about the above two traits may be incomprehensive. Lastly, the theory indicates that impulsivity (acting immediately without considering other alternative cues) is an adaptation response to time-critical circumstances. Animals or species face options in hunting and avoiding natural enemies within an extremely short time, where impulsiveness could elevate their survival rate.

2.2 . The Sex Difference in ADHD

2.2.1 . The higher incident rate and severity in males

In youth, ADHD is 16 times more frequent in males than in females, with the total incident rate in clinical samples larger than the population sample[8]. This research finds the sex differences in the severe range and presentation of ADHD, conduct problems and learning problems in males and females whether they receive treatment. Additionally, the research shows that males have much higher percentages of all the symptoms (distractions, movement and action or study problems) than females[9,10]. However, in clinical studies, males and females are approximately the same proportion, which could be explained by the positive relationship between severity and the possibility of males and females getting treatment for ADHD. According to the predictive analysis, sex-by-symptom has obvious interactions with action problems and treatment conditions. In females, these actions are intense for clinical prognosis and the prescriptions of medical treatment[8,5].

Males tend to display a higher severity of ADHD symptoms than females, possible explanations include genuine etiological differences or human artefact factors. In an experiment, 2332 twins and siblings attended the action and cognitive testing, and the result showed that the average difference and variation difference combination model fully explains the sex difference of the symptoms severity of ADHD[11]. Bidwell et al. (2007) also found the mediating role of cognitive endophenotypes in the effect of different sexes on symptom severity[12]. Besides, the sex differences in ADHD may be attributed to sex differences in dopamine receptor density[13]. The rise in striatal dopamine receptors of males rather than females shows a similarity of the early developmental appearance of motor symptoms of ADHD, and this may explain why male rates are 2–4 times higher than females[14].

2.2.2 . The sex difference in ADHD subtypes

Transient lateralized D2 dopamine receptors (left>right) in the male striatum may increase the vulnerability to ADHD. More persistent attentional problems may be associated with the overproduction and delayed pruning of dopamine receptors in the prefrontal cortex. Differences in D1 receptor density in the nucleus accumbens may have

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implications for increased substance abuse in males[15].
To investigate gender differences in self-reported ADHD symptoms in a group of adults with ADHD and a control group. Methods: A total of 682 adults with ADHD (49.9% females) and 882 controls (59.2% females) completed the Adult ADHD Self-Report Scale (ASRS), listing the 18 symptoms included in the diagnostic criteria of ADHD. Results: Within the ADHD group, females reported more severe symptoms of inattention and hyperactivity/impulsivity than males. This higher symptom report of females was not found in the control group, where the number of severe inattention symptoms was higher in males. Conclusion: The results suggest that childhood symptoms of ADHD may have gone unnoticed in girls, emphasizing the need for longitudinal studies of ADHD symptoms across the lifespan[16].

2.3 . ADHD Sex Difference Evolutionary Theories

2.3.1 . Sex selection strategy—higher impulsiveness/hyperactivity in males

Generally, males are considerably more likely to be diagnosed with ADHD than females. And females affected by hyperactivity/impulsivity may be more likely to be excluded from diagnosis due to the current age of onset criteria[17]. However, previous research still supports that males with ADHD present more hyperactivity/impulsivity than females[18]. Evolutionary explanations suggest that males who can perform more actively provide foundations for a higher frequency of mating. Specifically, the parental investment theory considers positively attending mating activities in males as more likely to inherit the genes from males, which in turn perform advantages in competitions. Hence, ADHD's subtypes I and II, which display more symptoms of impulsiveness and hyperactivities, are more likely to be evolutionary mismatches since they might produce more offspring and advance in natural selection.
This topic seems intricate: impulsiveness can be divided into rapid-response impulsivity and reward-delay impulsivity, and participants differ in age, life stages, gender, and so on. Meanwhile, we must consider the relationship between sex selection strategy and males' advantages formed by hyperactivity, which is not specifically defined in many previous reports.

2.3.2 . Female inattention tendency to cope with multitasks

It might be hard to notice females with ADHD have a higher possibility of obtaining a certain symptom than males with ADHD. Some reports indicate that when girls are diagnosed with ADHD, they are more often diagnosed as predominantly inattentive than boys with ADHD[5]. However, the researchers have not reached a consensus. Some researchers found that females with ADHD had lower ratings on inattention problems in comparison with the corresponding males, which also occurred in symptoms of hyperactivity and impulsivity[18]. Assuming inattention is an adaptation, inattention might fit the requirements of coping with threats, novelty, and changes in humans' ancient environment, based on the social activities of hunting and gathering[7]. Nevertheless, more recent research claims that the female's superiority in multitasking is a stereotype, and its results showed no gender difference in sequential multitasking costs[19]. To conclude, the opinion, that females with ADHD might exhibit more symptoms of inattention caused by the adaptation mismatch formed by the requirement of multitasking, is not solidly proved yet.

2.3.3 . Hunter-gatherer Theory—Foraging and Navigation

Hunter-gatherer theory argues that the hunter-gatherer society worked with men as hunters and women as gatherers and caregivers, specifically, males were responsible for hunting the food that was difficult to access, while females gathered food outside of time for other tasks (e.g. breastfeeding)[20]. The theory also suggests that the sex difference (a higher incidence rate in males and less disruptive symptoms in females) in ADHD is due to the sex labor division with different requirements for those activities. Exploration, competition, and aggression were requisite in hunting, while the female activities needed attention to detail, emotional regulation, and social cohesion.
Critiques also exist (e.g. the overgeneralization of the ancient labor division pattern) for hunter-gatherer theory. A worldwide survey challenges the view of "Man the Hunter" rooted in the physical fitness gap between genders, arguing that women are more advanced in endurance, allowing them to engage in a tug-of-war chase with their prey[21]. However, a recent study displays that although hunting behavior also sometimes exists in females, the general gendered labor division still dominates in the hunter-gatherer society[22].
However, the foraging and navigation aspect, which is also closely related to ADHD and sexes, has not been discussed in this theory nor the others.
ADHD and Navigation
Human navigation mainly involves locomotion (physical motions to navigate, e.g. walking and running, along with the spatial cognition of surroundings) and wayfinding[23]. Having an intimate correlation with navigation skills, memory is significant in navigation with overlapping sections, including wayfinding, complex path integration and

associative spatial memory[24].

There are multiple strategies for navigation and memory. Egocentric navigation is defined as the navigation strategy from a self-referenced perspective which relies on ample proximal environmental cues, while allocentric navigation strategy forms a third-perspective spatial cognition with remote cues, for instance, relatively static landmarks[25,26]. Memory strategies involve a nucleus-dependent response strategy and a hippocampus-dependent spatial strategy, the former allows navigation along familiar routes by repetition and habit formation, in other words, it requires stimulus-response associations between body movements and environments; the latter relies heavily on space-defining stimuli and reference frame other than the viewer, requiring the formation of the correlation between environmental cues and the change from the body-centered reference to world-centered reference[27]. According to these definitions, egocentric navigation and response strategy could be used as a pair, while allocentric navigation and spatial strategy are usually used simultaneously.

Multiple studies have discussed the association between ADHD and spatial strategies, among which the dependency on landmarks is extensively discussed[27-30]. Robaey et al. (2016) suggest less reliance on landmarks in the navigation activity of children with ADHD[27]. The study conducted a group of comparison experiments to distinguish the applied memory strategies of children with ADHD characteristics from those of typically developing children (TD). Participants were asked twice to complete a navigation task within a virtual radial-arm maze, one has landmarks along the path while the other doesn't. As a result, children with at least one ADHD symptom reveal a higher preference for a response strategy with little reliance on landmarks, and TD tends to navigate by spatial strategy which primarily relies on landmarks. Another study by Del et al. (2021) indicates that the samples in the ADHD group tend to use the egocentric navigation strategy and have allocentric navigation deficits in spatial cognition compared to the control group[28]. The experimenters asked children with ADHD and typical developing children to draw maps of an area with multiple crossings and landmarks and track their motion. As a result, children with ADHD are more likely to repeat their old routes and return to the starting point, which is a signal of applying egocentric navigation.

The navigation of hunter and gatherer

Both hunting and gathering require spatial cognition and navigation capacity, however, there are spatial sex differences due to the different environmental contexts and response mechanisms of these two activities[31]. Females obtain advantages in content-general relational spatial memory, serving the gathering activity by two significant abilities: navigating to and locating resources within patches[32]. A universal male advantage across human societies is shown by a 3D mental rotation test specifically for measuring navigation by orientation, meanwhile the results of an object location memory (landmark-dependent spatial memory) task suggest a female superiority[31,33]. Furthermore, a study illustrates that females obtain an absolute spatial memory advantage over males towards immobile food resources (e.g. fruit trees) for adapting to gathering activity[34].

In addition, as mentioned earlier, allocentric navigation depends more on stable environmental cues like landmarks, in the gathering context, fruit trees, hills, rivers, etc. Reversely, hunters with fast and frequent motion face more dynamic and contextual circumstances than gatherers, acquiring higher reliance on proximal and time-sensitive cues other than landmarks, such as animal fur and footprint. Silverman et al. (2000)the present research sought to identify the evolved mechanisms involved in hunting that contribute to the dimorphism. The focus of these studies was the relationship between three-dimensional mental rotations, the spatial test showing the largest and most reliable sex difference favoring males, and wayfinding in the woods. Space constancy was presumed to be the evolved mechanism fundamental to both of these abilities. Measures of wayfinding were derived by leading subjects individually on a circuitous route through a wooded area, during which they were stopped at prescribed places and required to set an arrow pointing in the direction the walk began. As well, subjects were eventually required to lead the experimenters back to the starting point by the most direct route. In support of the hypotheses, males excelled on the various measures of wayfinding, and wayfinding was significantly related across sexes to mental rotations scores but not to nonrotational spatial abilities or general intelligence.","container-title":"Evolution and Human Behavior","DOI":"10.1016/S1090-5138(00 claim that hunters use a combined navigation strategy of egocentric and allocentric navigation, however, although allocentric navigation is also essential for hunting, hunters reveal a more significant tendency to use an egocentric navigation strategy than gatherers[31].

Combining the above theories, we can speculate that the lower incident rate of ADHD in females might be associated with the higher reliance on landmarks of female spatial memory and navigation in gathering behavior. To further explain, males with ADHD are more likely to be selected by nature for their adaptation to hunting, meanwhile, females with ADHD tend to be eliminated by natural selection. This insight supplements the existing explanation based on the hunter-gatherer theory, helping

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us understand the sex difference in ADHD from the navigation aspect.

To test to our theory, a series of verifications are requisite: comparing the navigation ability of individuals with and without ADHD in the hunting and gathering context separately, and that of females and males within the two contexts. If the theory holds, there are four expected results. Firstly, men and women perform better in hunting and gathering, respectively. Secondly, the female control group will show better performance than the female ADHD group in the gathering context. Besides, compared to their respective control groups, males perform better in hunting than females in gathering. Lastly, the control groups will perform worse in both contexts without landmarks than those within.

3. Conclusion

Overall, this paper discusses the ADHD formation and sex differences in ADHD from an evolutionary psychology perspective. ADHD is conceived as a mismatch of modern environments and the traits developed to adapt to the ancestral environments. The response-readiness theory suggests that the three ADHD continuas help organisms be ready to respond to external stimuli, and the hunter-farmer theory points out that ADHD traits obtain better adaptation in hunting. Nonetheless, response readiness and hunting adaptation are no longer appropriate for modern contexts.

Regarding the sex differences in ADHD, males obtain higher incident rates and severity than females, with a bias toward impulsiveness and hyperactivity, which might be due to the higher sex competition and mating pressure. Some studies claim that females have less disruptive symptoms and a bias toward inattention which is harder to diagnose, however, the inattention tendency which might be due to the muti-task requirement remains uncertain. The hunter-gatherer theory explains the differences by the sex labor division, claiming that individuals with ADHD adapt better to hunting which was the responsibility of males in the hunter-gatherer society, and females responsible for gathering and caring demanded less impulsiveness and hyperactivity.

Extending the hunter-gatherer theory from the foraging and navigation aspect, we find that the differences in navigation and memory strategies between children with ADHD and normal children also exist in hunting and gathering. From this association, we could speculate that resulting from the different navigation and memory strategies, males with ADHD are more likely to be selected for their adaptation to hunting, and females with ADHD tend to be eliminated by natural selection.

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ISSN 2959-6122

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