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# Beyond Impulsivity: Behavioral Disinhibition in ADHD

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## Abstract

There is a general behavioral disinhibition beyond impulsivity in ADHD that leads to risk taking behaviors such as careless driving, substance use, and many other negative consequences or complications. Behavioral disinihibtion (BD) as a frontal and specifically prefrontal cortex pathology, has been seen long in injuries and pathologies to this area of the brain, leading to uncontrolled behavior, is a centerpiece of symptoms cluster in ADHD-HI (Hyper-Impulsive) subtype. The first aim of this paper is to confirm the existence of a general behavioral disinhibition beyond the already recognized one in cognitive domain. The second goal of the study is to identify if there is a link between this phenotype and risk taking, misconduct behaviors and substance use. Lastly we have sought to determine whether there is a correlation between major symptom clusters of ADHD, -i.e. hyperactivity and impulsivity to behavioral disinhibition.

The result of this original study confirms the common presence of behavioral disinhibition as a major symptom cluster in ADHD-HI. We were also able to show a positive correlation exists between the symptoms of hyperactivity and impulsivity with behavioral disinhibition. Furthermore, there is an even stronger link between behavioral disinhibition and risk taking, misconduct behaviors, and substance use, than with hyperactivity and impulsivity. In conclusion, behavioral disinhibition in untreated ADHD demands recognition, treatment, and prevention.

## Introduction

Impulsivity, considered a cardinal symptom of Attention Deficit Hyperactivity Disorder (ADHD) of the hyperactive-impulsive subtype (ADHD-HI) in DSM5, has been ill-defined. Behavioral illustrations that apply more to verbal's such as "blurting out answers before questions have been finished" and "interrupting or intruding on others, e.g., butting into conversations or games" **[1]** are limited in scope. Here we redefine impulsivity as "acting on impulses without considering the consequences of the actions" that we believe to be more proper definition and applicable in the assessment and more understandable clinically by the patients. Beyond the impulsivity, we draw attention to a general "behavioral disinhibition" or lack of control over one's actions and behaviors in ADHD-HI.

Impulsivity and behavioral disinhibition (BD) have been discussed in the literature interchangeably at times and at others, impulsivity has been over-generalized **[2-4]**. BD has been discussed mostly in dementia, intoxication by alcohol and other illicit and licit substances, and brain injuries **[5-8]**, while impulsivity has been observed and reported across several psychiatric disorders such as ADHD, substance use disorders, depression, mania, antisocial and borderline personality disorders among others **[9-11]**. Therefore impulsivity has been recognized as a heterogenic behavioral trait with diverse underpinning neuro-pathophysiologic mechanisms and pathways, mostly limbic-cortico-striatal with the involvement of Dopamine and Serotonin **[9]**. Impulsivity has been mostly defined as "poor self-control", "quick and wrong decision making without forethought or regard for potential consequences". Impulsivity seems mostly require a

"cue" predictive of reward that is measured in labs by SSRT (Stop Signal Reaction Time). That is how impulsivity has also been associated with binge eating and drinking where the food and alcohol are cues and immediate gratification instead of delaying rewards are sought **[9, 11]**.

Since both impulsivity and BD co-exist in ADHD-HI, we distinguish between the two, as our subjects related different behaviors to each phenotypes, though they seem to be very closely associated. Behavioral disinhibition in ADHD has been reported as early as 1972 by Douglas **[12]**, then Quay **[13]** and Barkley **[14]**, and has been considered an inherent component of ADHD. BD by these authors and others later on has been perceived as a phenomenon of "poor impulse control", "poor self-regulation", and "response inhibition", and considered to be a deficiency of "executive function" rather than a general behavioral disinhibition. It has also been included in the inattentive ADHD subtype (ADHD-I), while it may apply only to the ADHD-HI subtype. Our hypothesis is that behavioral disinhibition underpins post-morbidities (a new term that we coin to denote cause-and-effect or a secondary complication of a primary condition, opposed to co-morbidities that occur in parallel) such as risk taking, misconduct behaviors and substance use disorders that are secondary consequences of untreated ADHD.

## Method

Our sample consists of 134 adults (19 years old and over, 82 males, 52 females) (For age and sex distribution, see **Table 4**), who conducted on online test from our website www.adhdrevisited.com from December 2015 to May 2018 and their diagnoses were confirmed by clinical interviews, based on DSM5 ADHD criteria. We subdivided the ADHD symptoms into three clusters of inattention (**Table 1**), hyperactivity (**Table 2**), impulsivity and behavioral disinhibition (**Table 3**).

| | |
|---|---|
| 1 | Are you often inattentive, easily distracted, not able to sustain attention? |
| 2 | Are you often not able to give close attention to details or makes careless mistakes in schoolwork, work, or other activities? |
| 3 | Do you often seem not to listen when spoken to directly? |
| 4 | Do you often not follow through instructions and fail to finish schoolwork, chores, or duties (not due to oppositional behavior or failure to understand instructions)? |
| 5 | Do you often have trouble organizing tasks and activities? |
| 6 | Do often avoid, dislike, or don't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework)? |
| 7 | Do you often lose things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools)? |
| 8 | Are you often forgetful in daily activities? |

**Table 1:** Inattentive symptoms cluster.

| | |
|---|---|
| **1** | Are you or when younger have been hyperactive, restless, could not sit still, fidget a lot, running around and climbing things? |
| **2** | Are you having or when younger had often trouble playing or doing leisure activities quietly? |
| **3** | Are you or when younger were often "on the go" or often acts as if "driven by a motor"? |
| **4** | Do you or when younger used to often talk excessively? |
| **5** | Do you often having trouble waiting one's turn? |
| **6** | Are you impatient, easily getting bored, cannot wait for things? |

**Table 2:** Hyperactivity symptoms cluster.

| | |
|---|---|
| **1** | Do you often blurt out answers before questions have been finished? |
| **2** | Do you often interrupt or intrude on others (e.g., butts into conversations or games)? |
| **3** | Are you impulsive (acting on impulses and not considering the consequences of actions)? |
| **4** | Have you been behaviourally disinhibited, such as being out of control, destroying things and annoying others? |
| **5** | Have you been risk taking such as cycling or driving carelessly? |
| **6** | Do you or have used any illicit substances? |

**Table 3:** Impulsivity & Behavioral Disinhibition symptoms cluster.

| Age Group | Number of Subjects | # of Males | # of Females | Age Range | Age Mean | Age Median | Age Mode |
|---|---|---|---|---|---|---|---|
| Adults (>18) | 134 | 82 (61.19%) | 52 (38.81%) | 58-19 (39) | 29.09774 | 26 | 22 |

**Table 4:** Subjects age and sex statistics.

We merged the two DSM5 questions for the inattentive subgroup of "often has difficulty sustaining attention in task or play activities" and "is often easily distracted" into one question "Are you often inattentive, easily distracted, not able to sustain attention?", but gave it a 2 point value while other questions had a 1 point value. In the hyperactivity symptoms cluster, we merged the DSM questions of "often fidgets", "often leaves seat in situations when remaining seated is expected", and "often runs about or climbs in situations where it is inappropriate" into one question "Are you or when younger have been hyperactive, restless, could not sit still, fidget a lot, running around and climbing things?" and gave it a 3 point value. The DSM criteria of "often has difficulty

waiting for his or her turn" that implies "impatience" and "boredom" and based on our clinical observation are cardinal symptoms of ADHD; we re-phrased to the question "Are you impatient, easily getting bored, cannot wait for things?" and gave it a 2 point value. Although it is not clear in DSM5 whether impatience and boredom are part of the hyperactivity or impulsivity symptom cluster, we included them in the hyperactivity section.

We added our definition of impulsivity, "acting on impulses without considering the consequences of the actions" to the two questions in DSM5 "blurting out, or butting into conversations or games" and "often interrupting or intruding on others". We also added a question relating to behavioral disinhibition (BD), "Have you been behaviorally disinhibited, such as being out of control, destroying things and annoying others?" and a question about risk taking to this category "have you been risk taking such as cycling or driving carelessly" and a question on substance use, "do you or have you used any illicit substance" (**Table 5**).

| | |
|---|---|
| **1** | Don't think before speak and got into trouble for saying inappropriate things before thinking |
| **2** | Very impulsive and react very quickly and emotionally rather than rationally |
| **3** | Still get into troubles for bad decision makings without thinking and considering the consequences at work and in personal life |
| **4** | Have thrown people off for acting on impulses |
| **5** | Now regret aftermath of my impulsive behaviors but not when younger |
| **6** | Being ridiculed by peers and punished by parents for being impulsive |

**Table 5:** Examples of Impulsivity (acting on impulses without thinking).

Examples of impulsivity (such as acting on impulses), BD, and risk taking behaviors recorded by some individuals in the comment box in their tests are shown in (**Table 6, 7 & 8**). We also included two questions to measure "Novelty Seeking" and "Reward Seeking" in ADHD, "Are you novelty seeker (getting bored easily with old things and looking for new things or changing things?" and "Are you reward seeker (seeking reward when doing things/tasks, or driven by rewards?" We matched the 66% positive response diagnostic criterion of DSM5 for inattentive and hyperactivity symptom clusters. When >66% or 2/3 of the questions in each symptom cluster was positive, we summarized them into one under "inattention" and "hyperactivity" in our data (Appendix 1). Since impulsivity is a cardinal diagnostic symptom of ADHD-HI and is captured by three questions in our symptoms cluster **(Table 6)**, we put them all under one column whenever 2 out of three received a positive response (Appendix 1).

| | |
|---|---|
| **1** | Used to scream and say bad words for no good reasons to others or just to the air |
| **2** | Annoying others and destroying |
| **3** | Has been told to be out of control |
| **4** | Breaking and damaging things |
| **5** | Drawing all over the walls |
| **6** | Being punished often for being out of control |
| **7** | Still out of control and do things out of logic |
| **8** | Would dance on the desks in school |
| **9** | Often was in trouble as a child |
| **10** | Was aggressive and combative |
| **11** | Throwing knives into the couch and around |
| **12** | Take apart things like electronics without putting them back together |
| **13** | Broke all the doors and walls in the house |

**Table 6:** Examples of Behavioral Disinhibition.

## Results

First we tested the validity rate of each definition of impulsivity by DSM5, "blurting out, or butting into conversations or games" and "often interrupting or intruding on others" with our re-definition of "acting on impulses without considering the consequences of the actions" through correlation analysis (using Correlation Coefficient calculation) of these with the cardinal symptom clusters of ADHD, inattention, hyperactivity, and also BD, risk taking behaviors and substance use (Table 8). Each definition of DSM5 correlated with the inattention 0.0725 (7.25%) and 0.0697 (6.97%), while our re-definition correlated 0.0731 (7.31%), but with hyperactivity, the DSM definitions correlated 0.2080 (20.80%) and 0.0756 (7.56%), while our impulsivity re-definition was correlated higher (0.2248 or 22.48%) (**Table 7**).

| | |
|---|---|
| 1 | Has been told not realizing risk and often being in trouble |
| 2 | Doing stunts on bicycle or roller blades and jungle gym was my home |
| 3 | More as a child but still do things that cross the line as an adult |
| 4 | Often took risks and was regarded as odd by peers |
| 5 | When playing video games, take risks and go out of control and get more angry than peers |
| 6 | Careless driving, getting into accidents and being yelled at by other drivers |

**Table 7:** Examples of Risk taking behaviors.

The DSM5's "blurting out, or butting into conversations or games" correlated with BD, risk taking and substance use, 0.2537 (25.37%), 0.2799 (27.99%), and 0.0873 (8.73%), respectively, and "often interrupting or intruding on others" correlated 0.0938 (9.38%), 0.0841 (8.41%) and 0.1369 (13.69%) respectively. Our re-definition of impulsivity correlated with BD, risk taking and substance use much higher (0.4765 or 47.65%; 0.5004 or 50.042%; and 0.2878 or 28.78%) **(Table 8)**.

| | Inattention | Hyperactivity | BD | Risk taking | Substance use | Novelty seeking | Reward seeking |
|---|---|---|---|---|---|---|---|
| Blurting out | .0725 | .2080 | .2537 | .2799 | .0873 | .2013 | .0813 |
| Interrupting | .0697 | .0756 | .0938 | .0841 | .1369 | .0608 | .0056 |
| Acting on impulses | .0731 | .2248 | .4765 | .5004 | .2878 | .3526 | .1319 |

**Table 8:** Correlation between three impulsivity symptom clusters and Inattention, Hyperactivity, Behavioral Disinhibition (BD), risk taking and substance use in total subjects-N 134.

Among all the subjects of the three subtypes, the rates of each symptom clusters were as following: Inattention 98.50%; Hyperactivity 76.86%; Impulsivity 74.63%; Behavioral Disinhibition 67.16%; Risk taking behaviors 65.67%, Substance use 52.98%, Novelty seeking 80.60%, and Reward seeking 70.15% (Appendix 1). There were only 13 subjects with ADHD-I (Inattentive subtype, with no hyperactivity or impulsivity) comprising 9.7% of the total subjects (Appendix 2), and 81 subjects with ADHD-HI (Hyperactive & Impulsive) comprising 60.45% of the total subjects (Appendix 3), and 121 subjects with ADHD mixed subtype (Hyperactive or Impulsive) comprising 90.30% of the total subjects (Appendix 4). A statistic summary and comparison between the subtypes and symptom clusters is seen in (**Table 9**).

| | |
|---|---|
| ADHD-I | 9.7% |
| ADHD-HI | 60.45% |
| ADHD-Mixed | 90.30% |
| Inattention | 98.50% |
| Hyperactivity | 76.86% |
| Impulsivity | 74.63% |
| Behavioral Disinhibition | 67.16% |
| Risk Taking Behavior | 65.67% |
| Substance Use | 52.98% |
| Novelty seeking | 80.60% |
| Reward Seeking | 70.15% |

**Table 9:** Subtypes and symptom Cluster Statistics.

Finally a correlation analysis between each cardinal symptom clusters of Inattention, Hyperactivity, Impulsivity and Behavioral Disinhibition (BD) were made with each other and risk taking behaviors, substance use, novelty and reward seeking among all the total 134 subjects (Table 10). Inattention showed a higher positive correlation with hyperactivity (0.0754 or 7.54%), then with impulsivity (0.0731 or 7.31%) and the lowest with BD (0.0428 or 4.28%). Hyperactivity correlated higher with BD (0.5282 or 52.83%) than with impulsivity (0.2248 or 22.48%). BD correlated the highest respectively with hyperactivity (0.5283 or 52.83%), with impulsivity (0.4765 or 47.65%), with risk taking behavior (0.9502 or 95.02%), with substance use (0.32.15 or 32.15%), with novelty seeking (.04103 or 41.03%), and with reward seeking (0.1922 or 19.22%) than any other symptom clusters including impulsivity (**Table 10**).

| | Inattention | Hyperactivity | Impulsivity | BD |
|---|---|---|---|---|
| Inattention | .1000 | .0754 | .0731 | .0428 |
| Hyperactivity | .0754 | .1000 | .2248 | .5283 |
| Impulsivity | .0731 | .2248 | .1000 | .4765 |
| BD | .0428 | .5283 | .4765 | .1000 |
| Risk Taking | .0032 | .5717 | .5008 | .9502 |
| Substance use | .0415 | .2261 | .2878 | .3215 |
| Novelty Seeking | .0952 | .4333 | .3526 | .4103 |
| Reward Seeking | .0803 | .0936 | .1319 | .1922 |

**Table 10:** Correlation between Risk taking and substance use with Inattention, Hyperactivity, Impulsivity and Behavioral Disinhibition (BD) in total subjects-N 134.

## Discussion

According to Grafman et al. **[15]** in their handbook of neuropsychology, "disinhibition" is a lack of restraint manifested in several ways, affecting motor, emotional and cognitive domains with signs and symptoms e.g. impulsivity, disregard for others and social norms, aggressive outbursts, misconduct, oppositional and risk taking behaviors. Disinhibition is a common symptom following brain injury, or lesions, and dementia particularly of the frontal lobe and orbitofrontal cortex **[16-18]**. Behavioral disinhibition (BD) as a result of damage to the frontal lobe could also be seen as a result of consumption of alcohol and central nervous system depressants drugs, e.g. benzodiazepines that disinhibit the frontal cortex from self-regulation and control, particularly in the young and aged brains **[6-8]**. Therefore BD seems to be a general umbrella that covers a wide range of behaviors,

including but not limited to impulsivity or in the cognitive domain.

It is widely believed that the prefrontal cortex (PFC) with its frontal-subcortical circuits serves as a source of inhibitory control over other brain areas. The three principal behaviorally relevant circuits originate in the 1) dorsolateral prefrontal cortex, 2) orbitofrontal cortex, and 3) anterior cingulate cortex. Circuit-specific marker behaviors associated with each circuit are executive dysfunction (dorsolateral prefrontal-subcortical circuit), motoric disinhibition (orbitofrontal-subcortical circuit), and apathy or emotional inhibition (medial frontalsubcortical circuit) **[19-20]**. The basal ganglia forms one of the most complicated systems in the brain, with extensive connectivity to other subcortical regions, e.g. limbic system and the higher cortical regions, specially frontal cortex, composed almost entirely of inhibitory GABAergic neurons and affected by dopamine. This extensive neural network controls the initiation and continuation of motoric, emotional, behavioral and cognitive functions at a relatively selective, fine-grained level **[21-24]**.

There is evidence from animals and human brains imaging studies that not only frontal lobe, but also a sophisticated neural network from subcortical to higher cortex are actively in dynamic concert to control our thoughts, emotions and behaviors or otherwise we lose the control and being impulsive and disinhibited **[25-27]**. There is also ample evidence that the modulation of dopamine (DA) levels as well as dopaminergic areas in the brain affect impulsive choice behavior, seeking immediate vs. delayed reward and perhaps general disinhibtion. **[27,28]** Moreover dopamine has a significant role in the development of prefrontal cortex during early development and its impact on behavioral inhibition and cognition **[29]**.

ADHD since when it was labeled "Minimal Brain Dysfunction" and "Hyperkinetic Disorders" to the recent years has been known as a generalized disinhibition in domain of cognition, manifested as executive dysfunction or inattention; also in the motoric domain as hyperactivity, restlessness; and behaviorally as impulsivity, risk taking behavior, conduct disorder, and drug seeking; as well emotionally as aggression, anger, temper tantrum and irritability, due to PFC pathology causing disinhibition across these different domains **[30-39]**. Some authorities have even suggested heterogeneity in ADHD, and separated the ADHD-HI and ADHD-I s two separate pathological entities due to BD being a centerpiece in the pathophysiology of ADHD-HI as a disinhibitory disorder **[40-41]**.

Behavioral disinhibition has been also associated with the externalizing disorders or behaviors, such as conduct disorder, substance use, and novelty seeking **[42]**. BD has also been shown to be a hereditary phenotype of ADHD linked with its underlying pathology of PFC **[43-44]**. In a large study on 16,099 children and adolescents, ages 6 to 18 years, the individuals with greater ADHD trait scores had worse response inhibition, slower response latency, and the ADHD traits and inhibition were shown to be co-heritable **[45]**. Disordered dopamine neurotransmission is implicated in mediating impulsiveness and disinhibition across a range of behaviors and disorders including addiction, compulsive gambling, ADHD, and dopamine dysregulation syndrome. It has been shown that pharmacologically enhancing dopamine activity increases impulsivity by enhancing the diminutive influence of increasing delay on reward value (temporal discounting) and its corresponding neural representation in the striatum **[46]**. The lesions in the ventromedial part of the prefrontal cortex (VMPFC), which is part of the orbitofrontal cortex (OFC), has been shown to cause the individuals to discount, or neglect, the future consequences of their decisions, leading to behavioral disinhibition and risk taking **[47]**.

In this study, we have shown that first of all the impulsivity in DSM5 is ill-defined and insufficient, but our re-definition of impulsivity as "acting on impulses without considering the consequences of the actions" correlates more with the other cardinal symptoms of ADHD. Our impulsivity definition of "Acting on impulses" correlated higher with the inattention (7.31%), and more so with hyperactivity (22.48%), BD (47.65%), risk taking (50.04%) substance use (28.78%), novelty seeking (35.26%) and reward seeking (13.19%) than with DSM5 symptom definition of impulsivity as "Blurting out" 7.25%, 20.80%, 27.99%, 8.73%, 20.13% & 8.13%. Interrupting and intruding into others fared the least, correlating with inattention 6.97%, with hyperactivity 7.56%, with BD 9.38%, with risk taking 8.41%, with substance use 28.78%, with novelty seeking 6.08% & with reward seeking 5.6% (Table 8). In summary while "blurting out" scored better than "interrupting and intruding on others" for impulsivity, our re-definition of impulsivity as "acting on impulses" fared much higher with inattention, hyperactivity, BD, risk taking, substance use, novelty & reward seeking.

Lastly we showed that BD correlated much higher with hyperactivity than impulsivity (52.83% Vs. 22.48%), with impulsivity than hyperactivity (47.65% Vs. 22.48%), and higher with risk taking than hyperactivity and impulsivity even to our re-definition (95.02% Vs. 52.83% & 50.08% respectively). BD correlated higher with substance use than with hyperactivity and impulsivity (32.15% Vs. 22.61% & 28.28%). While only hyperactivity correlated marginally higher with novelty seeking than BD (43.33% Vs. 41.03%), BD correlated higher with novelty seeking than impulsivity (41.03%Vs.35.26%), and much higher than hyperactivity and impulsivity with reward seeking (19.22% Vs. 9.36% & 13.19%) (**Table 10**).

As it was discussed in the introduction, impulsivity and BD have been used interchangeably and not differentiated sufficiently at a phenomenonologic or symptomatic descriptive level, though it is more so at an underlying neruo-pathophysiologic level **[47,48]**. A look at some examples that our sample reported about their impulsive vs. disinhibitory

behaviors demonstrate this differentiation at a symptomatic level better. "not thinking before speaking and getting into trouble for saying inappropriate things before thinking"; "react very quickly and emotionally rather than rationally"; "get into troubles for bad decision makings without thinking and considering the consequences at work and in personal life" seem to be different with the following examples of BD by the subjects. "Screaming and saying bad words for no good reasons to others or just to the air"; "Annoying others and destroying"; "Being told to be out of control"; "Breaking and damaging things"; "Dancing on the desks in school"; "Being aggressive and combative"; "Taking apart things such as electronics without putting them back together"; "Breaking all the doors and walls in the house" seem to be general disinhibitory problems and not impulsive behaviors in response to a cue or for immediate gratification and reward seeking.

Moreover the underlying reward seeking of impulsivity that is seen in other psychiatric disorders such as substance use, binge eating and drinking **[49]** correlated higher with substance use (25.50%) and with impulsivity (13.19%) than novelty seeking that seems to be more associated with ADHD-HI (23.53%). Novelty seeking fared higher in our data with BD and risk taking (41.03% & (40.04%) than reward seeking (19.22% & 18.10%) (**Table 11**).

| | Novelty Seeking | Reward Seeking |
|---|---|---|
| Impulsivity | .03526 | .1319 |
| BD | .4103 | .1922 |
| Risk Taking | .4004 | .1810 |
| Substance use | .2353 | .2550 |

**Table 11:** Correlation between Impulsivity, BD, Risk Taking, Substance use and Novelty and Reward Seeking in total subjects-N 134.

Novelty and reward seeking also like impulsivity and BD have been used interchangeably in the literature and linked to dopamine and striatal-prefrontal circuit function. Novelty or sensation seeking has also been thought to be linked psycho-pathologically to reward seeking **[32, 50]**. But despite this misconception, novelty-seeking has been shown to be positively correlated with Substantial Nigra/Ventral Tegmental Area (SN/VTA) activation of striatum elicited by novel cues that did not predict reward, whereas reward-dependence was related to activations elicited by novel cues that predicted reward. The positive correlation between SN/VTA responses to novelty and novelty-seeking scores has been associated with a negative correlation with reward-related SN/VTA activation and memory enhancement. In a better word, novelty-seekers tend to show generally up regulated, novelty-induced exploratory behavior, even when novelty does not predict reward **[51]**.

Our results here confirm previous reports that ADHD is associated with higher novelty-seeking scores and a decreased reward anticipation response. Along this line adults with ADHD have also shown decreased activation in the ventral striatum during the anticipation of gain, but increased activation of the orbitofrontal cortex in response to gain outcomes. Ventral striatal activation in adults with ADHD during gain anticipation has been negatively correlated with self-rated symptoms of hyperactivity and impulsivity **[52,53]**. This aligns with our result that reward seeking is more in line with impulsivity and substance use than novelty or sensation seeking that is more in line with BD, risk taking (**Table 11**)

It has been extensively and for long shown in the literature that the negative consequences of untreated ADHD being mostly due to its impulsivity component that now behavioral disinhibition needs to be added to. The Cambridge Study in Delinquent Development **[54]**, a prospective longitudinal survey of males from ages 8 to 32 years old have reported the prediction of adolescent aggression, teenage and later on adult violence and convictions for violence in untreated ADHD. Another longitudinal analytic study of a cohort of 435 boys has found strong connection between juvenile delinquency and ADHD, starting even as early as preschool age, escalated at school entry, and persisted into adolescence **[55]**. Genetic studies have also reported association between ADHD and risk of aggressive behaviors **[56]**.

A review of the outcomes of 351 ADHD studies has also demonstrated complications of untreated ADHD in academic, antisocial behavior, careless driving and accidents, substance use/addictive behavior, self-esteem, and social function domains, that improved with treatment **[57]** ADHD has also been shown to be associated with earlier onset of poly-substance use disorders independently of psychiatric comorbidity. The substance use among ADHD is so high that at least one out of 4-5 substance users may have undiagnosed and untreated ADHD as early as age 10 that in turn could increase the risk of conduct and oppositional defiant disorders in childhood and adolescents that in turn could increase the risk of anti-social and other delinquent behaviors and even personality disorders in adulthood **[58, 59]**. Impulsivity and more so behavioral disinhibition as we showed in our studies are the leading phenotypes to these ADHD post-morbidities.

Adults with ADHD are also at increased risk of accidents, trauma and workplace injuries, particularly traffic accidents, increased rates of substance abuse and criminality, that all could improve with treatment **[60]**. A large national sample of the United States population **[61]** adults aged 18 years and older during the 2004-2005 has shown that impulsivity is quite high in general population (about 17%), particularly among males and younger individuals, and associated with a broad range of psychiatric disorders, particularly drug dependence, personality disorders, bipolar disorder and ADHD. This report asserts that impulsivity is associated with behavioral disinhibition, attention deficits, and lack of planning, risk taking and dangerous behaviors to the individuals and others, including driving recklessly, starting fights, shoplifting,

perpetrating domestic violence and trying to hurt or kill with higher risk of lifetime trauma and substantial physical and psychosocial impairments **[61].**

While there are extensive reports in the literature of the post-morbidities or complications of untreated ADHD, there is lack of pathophysiologic explanations or association of which elements or phenotypes of ADHD being causal. In this paper for the first time to our knowledge, we expanded the earlier reports of behavioral disinhibition (BD) that have been more studied in the cognitive domain and termed more as "response inhibition" to a general behavioral domain. We showed that the general BD in ADHD-HI is associated more than other phenotypes or symptom clusters of inattention, hyperactivity and impulsivity to risk taking behaviors, substance use, and novelty or sensation seeking. Therefore we hypothesize that BD could be the underpinning endophenotype leading to any misconduct, careless and reckless behaviors without considering the negative consequences onto the individual, others, and the society at large.

As discussed impulsivity is a multi-faceted behavior associated with many psychiatric conditions, including mood disorders, particularly suicidality, personality disorders, substance use, and in connection with the serotonergic in addition to the dopaminergic functions of the brain and is not limited to ADHD **[62-65]**. But ADHD-HI could be a unique disorder to have both impulsivity and behavioral disinhibition in connection with the pre-frontal lobe pathology and dopaminergic deficiency, leading to risk taking, careless, reckless and misconduct behaviors, not only on a impulse and cue-based, but in general and not much reward-conditioned like other impulsive disorders. Further replication studies to reconfirm our results and also to directly bridge between BD and all risk and careless behaviors of untreated ADHD are required to prevent these costly post-morbidities of this condition.

## Limitations

We limited our data to adult age group, as we are working on the collected data on children and adolescents to be published soon as well. The collected sample were self-referred and tested, with the option of being anonymous, unless those who referred to our clinic as well for clinical assessment and treatment. The questions on our re-definition of impulsivity and BD have not previously been validated by others, and our finding of positive correlation with other symptom clusters of ADHD, i.e. hyperactivity and impulsivity is the first validation of these parts of questionnaire.

## Conclusion

Behavioral disinhibition (BD) has been recognized in ADHD at least since 1973 by Pontius **[30]** when the condition was labeled as MBD (Minimal Brain Dysfunction) and known to be associated with Frontal lobe pathology. In later years since the understanding of ADHD from a "hyperkinetic" or hyperactive condition moved to a more cognitive deficiency condition with emphasis on difficulties in sustain attention, working memory and executive function, BD was recognized as a cognitive deficit and labeled mostly as "response inhibition". But since ADHD-HI is a pathophysiological condition of the brain striatum in connection with the frontal, particularly the prefrontal cortex, so BD like hyperactivity and impulsivity is not only a cognitive deficit endophenotype, but a general symptoms cluster, affecting motoric, emotional and behavioral domains as well.

Therefore in the present research through our collected data in a group of adult ADHD, we showed the presence and significant correlation of BD in ADHD-HI along with hyperactivity and impulsivity. We demonstrated that BD is not only a cognitive deficit and issue, but a general behavioral problem leading to many post-morbidities or complications of untreated ADHD, involving risk taking, substance use and other misconduct behaviors. BD in fact was more associated with risk taking behavior, substance use than impulsivity that needs re-defining in DSM. We also showed that our new definition of impulsivity has more validity and stronger correlation with other cardinal symptom clusters of ADHD. Furthermore there was a differentiation between impulsivity and BD, in behavioral disinhibition being more associated with novelty than reward seeking that impulsivity is linked with.

In closing remarks, behavioral disinhibition needs to be recognized as a general behavioral symptoms cluster, a centerpiece and cardinal diagnostic symptom of ADHD-HI, due to its significance in leading to many costly consequences or post-morbidities such as risk taking, misconduct behaviors and substance use. In fact the screening of ADHD should not be only on academic under-achievements, but also on individuals with risk taking, such as driving carelessly and uncontrolled behaviors leading to many irreversible consequences.

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