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Behavioral Measures of Impulsivity and the Law

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Abstract

The General Theory of Crime proposes that crime is explained by the combination of situational opportunity and lack of self-control. Impulsivity is one of the important components of self-control. Because behavioral measures of impulsivity are becoming more commonly utilized to assess forensic populations, this manuscript provides an overview of three current behavioral measures. In doing so, an example of their application is provided using a group of individuals likely to come into contact with the legal system: adolescents with Conduct Disorder. Earlier age of onset of Conduct Disorder symptoms has been shown to be an important predictor of the persistence of poor outcomes into adulthood including participation in criminal activities. This study found differential behavioral profiles across distinct measures of impulsivity by those with childhood- versus adolescent-onset Conduct Disorder. Legal implications for defining behavioral deficits using behavioral measures of impulsivity and their current limitations are discussed.

Keywords

Impulsivity; Conduct Disorder; Adolescence; Continuous Performance Task; Stop Task; Delay Discounting

There is no such crime as a crime of thought; there are only crimes of action

~ Clarence Darrow

Typically it is not an individual's goal to become incarcerated or otherwise experience consequences from the law, yet so frequently people behave in a manner that will most certainly lead to this outcome. Consider the case of Mr. A.W. who, in December 2007, was arrested after stealing a woman's Honda Accord in Durham, NC. Although auto theft is not rare, what is remarkable about the crime is that the theft occurred while the woman had just stepped out of her car to speak with police officers at an active crime scene that was being filmed by a crew from the local ABC news affiliate (WTVD, 2007). While this situation presented some opportunity for crime (the door was left open with the key in the ignition) it also included very clear deterrents (presence of police and being filmed). The failure of these deterrents to prevent this crime demonstrates that this individual observed the opportunity for immediate gain within this situation, yet lacked the ability to inhibit behavior despite the strong likelihood of negative consequences. This combination of opportunity and lack of control plays an important role in explaining criminal activity. In fact, the General Theory of Crime (Gottfredson & Hirschi, 1990) proposes that all crime can be explained by the combination of situational opportunity and lack of self-control of the

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individual. While self-control is a complex construct within this model, a key component is impulsiveness. The criminal and legal relevance of behavioral impulsivity and assessment of this behavior have been discussed widely in the literature. During the last two decades, several types of behavioral instruments have been developed and used to assess impulsivity. The following is an overview of some of the current approaches to behavioral impulsivity assessment that will provide a basis for understanding the potential utility of these types of instruments for informing the legal process.

Utility of Behavioral Measures of Impulsivity for Informing the Legal Process

There are a variety of aspects of the law in which impulsivity assessment may play a role, ranging from criminal culpability and sentencing, to required provisions for academic accommodations of disabled students. As such, there is the potential for wide ranging application of behavioral measures of impulsivity within the legal realm. As one example, in *Roper v. Simmons* (543 U.S. 551; 2005), the U.S. Supreme Court ruled against the use of capital punishment for crimes committed by individuals under the age of 18 because of the impulsive nature of youth, citing the “lack of maturity and an underdeveloped sense of responsibility are found in youth more often than in adults and are more understandable among the young. These qualities often result in impetuous and ill-considered actions and decisions.” (*Johnson v. Texas*, 509 U.S. 350, 367; 1993). While some individuals may have the capacity to control their impulses by age 18, impulsive behavior continues to lead others afoul of the law into adulthood. Behavioral measures are one emerging tool for accurately identifying deficits in specific mechanisms underlying the expression of impulsive and/or unlawful acts. Given the diversity of legal questions that may potentially be addressed by the assessment of impulsivity, the scope of the present discussion is intentionally focused to present an overview of three of the more common behavioral procedures for the assessment of impulsivity, and a specific example of the application of these procedures in a group of individuals that is likely to come into contact with the legal system (i.e., adolescents with Conduct Disorder).

Assessment of Behavioral Impulsivity

Two common modes for assessing impulsivity are self-report measures (e.g., questionnaires) and laboratory behavioral instruments. Each of these has certain strengths that may be exploited to address a particular question, and both approaches hold potential important place for informing the legal process. Self-report measures are important for assessing an individual's understanding of their own behavior across some specified period of time. At the same time, these types of measures rely on introspection, accuracy for recalling past events, or interpretation of motives (Dougherty, Mathias, & Marsh, 2003e). These are not small issues in a forensic setting, because an individual may have a diminished capacity to accurately perform processes of introspection, recall, and interpretation of their previous behavior, or they may be motivated to purposely misrepresent that behavior. In contrast, behavioral measures provide an objective method for assessing impulsivity at a given point in time. These objective measures are less prone to dissimulation and also may provide information about distinct rather than global components of behavioral impulsivity. Therefore, using behavioral measures to supplement traditional self-report measures is likely to give a more balanced understanding of an individual's impulsive behavior.

In discussing the measurement of impulsivity, it is important to appreciate the complexity of the construct. One widely-used definition of impulsive behavior in the psychiatric literature has been that impulsiveness is “a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to

the impulsive individual or to others“ (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001; p. 1784). A model of impulsivity has recently been proposed that accounts for key components of this definition (Dougherty, Marsh, Mathias, & Swann, 2005a; Dougherty et al., in press). This model suggests that at least three distinctly different types of impulsivity can be assessed using behavioral measures that quantify deficits in: (1) *response initiation*, which is the process of rapid initiation of spontaneous action that is unplanned; (2) *response inhibition*, which is the failure to inhibit a rapid, unplanned action once it has been initiated; and (3) *consequence sensitivity*, which is the failure to tolerate delays for rewards or delay gratification. For the purpose of this discussion, laboratory measures of impulsivity are computerized instruments that: (1) assess behavior; (2) are objective; and (3) are interpretable within the context of the definition of impulsivity (Dougherty et al., 2003e). Responses yielded from performance during the different assessments described below have been shown to measure distinct components of impulsive behavior (Dougherty et al., in press), which is consistent with the distinct processes proposed in theories of impulsivity (Dougherty et al., 2005a; Gray, 1982, 1987; Logan, 1994; Reynolds, Penfold, & Patak, 2008). Results from studies applying these different methodologies to clinical and forensic samples may ultimately provide information useful for development of individualized treatment and prevention programs. The following section describes behavioral measures that correspond to each of these components of impulsivity.

Response Initiation

Response initiation is a concept of impulsivity that encompasses acting without forethought or initiating a rapid response that generates a behavior that is inconsistent with environmental demands. One proposed source of the rapid response initiation type of impulsivity is the initiation of behavior prior to sufficient processing and evaluation of environmental cues (Dougherty et al., 2005b). This type of responding is measurable using a procedure that is often referred to as a continuous performance test (CPT) or a go/no-go of task. During the CPT an individual is presented with a rapid series of stimuli (e.g., letters, numbers, or pictures) from which they must identify some target stimuli and avoid responding to non-targets. For example, one version of the task involves sequential presentation of 5-digit numbers that are evaluated in pairs (Dougherty & Marsh, 2003; Dougherty, Marsh, Mathias, & Steinberg, 2002). These numbers may be presented in three ways: a number (1) may be an identical match to the preceding number (70783...70783); (2) may be different from the previous number by a single digit (70783...70483); or (3) may be random, differing from the previous number completely (70783...28530). The goal of the procedure is to correctly respond to a 5-digit number that identically matches the preceding number and to avoid responding to any non-matching number. Because non-matching numbers that differ from the preceding number by only a single digit are *nearly* identical, these numbers can require more time to fully evaluate. Responses to these numbers are thought to reflect anticipatory, or incomplete, processing of the information (number) presented. Incomplete processing of the information will often lead to a rapid, but incorrect, response (i.e., errors of commission). The ratio of commission errors to correct responses of target trials are interpreted as the response initiation component of impulsivity. Using this ratio adjusts for individual differences in overall rate of responding and provides greater sensitivity for interpreting impulsive responding (Dougherty, Marsh, Moeller, Chokshi, & Rosen, 2000).

The response initiation type of task has been used to assess both children and adults who exhibit behavior that is often associated with criminality or violence. Studies have found elevated response initiation impulsivity in adolescents with disruptive behavior disorders (Dougherty et al., 2003a, 2003b, 2007), and in adults with a childhood history of Conduct Disorder (Dougherty et al., 2000). These measures may also be sensitive to individual

differences in impulsive responding for particular types of offenders. One previous study with women on parole/probation found that those with violent offenses performed more impulsively than either those convicted of nonviolent offenses or healthy controls (Mathias et al., 2002). Similarly, violent prisoners perform more impulsively on this type of task than healthy prison staffers (Munro et al., 2007). Finally, drug abusers often show increased response initiation impulsivity (Dougherty et al., 2007; Moeller et al., 2002a, 2002b, 2004b, 2005; Swann, Dougherty, Pazzaglia, Pham, & Moeller, 2004), as do individuals with alcohol-related problems (Koch & Morguet, 1985) and alcohol dependent men with physical intimate partner violence (Easton, Sacco, Neavins, Wupperman, & George, 2008).

Response Inhibition

Of course, not all behavior that has been initiated ends up being expressed. Because the environment is constantly changing, it is adaptive for an individual to be able to inhibit a response to new stimuli even after the process of generating a response has been initiated. This process of stopping an already initiated response is what underlies the concept of response inhibition, and the failure to inhibit responses has been interpreted as another component of impulsivity (Dougherty et al., 2005a). This type of responding is measurable using a procedure generally referred to as a stop task. Like the CPT, the stop task involves presentation of a sequence of stimuli from which the individual must selectively respond to target stimuli and avoid responding to non-target stimuli. What is unique about this type of task is that occasionally the target is paired with a cue that indicates a response should be stopped. For instance, in one variation (Dougherty et al., 2003e), black 5-digit numbers are presented in rapid sequence and the individual is instructed to respond when consecutive numbers match identically. Therefore, when a matching black number appears, the process of responding to that match would be initiated. However, occasionally a matching number will initially be presented in black, but after some period of time the color of that number changes from black to red. This change in color is the cue to stop the process of generating a response and failures to stop this response are impulsive. It is the ratio of these response inhibition failures to correct responses to target trials that are interpreted as the response inhibition component of impulsivity.

In efforts to understand underlying causes of specific problems that may be contributors to criminal behavior, studies using the stop task response inhibition measure have shown that impulsive responding is elevated among those involved in criminal activity such as marijuana use (McDonald, Schleifer, Richards, & de Wit, 2003), chronic cocaine abuse (Fillmore & Rush, 2002; Kaufman, Ross, Stein, & Garavan, 2003), ecstasy use (Moeller et al., 2002b), and even those who are at risk for alcoholism (Kamarajan et al., 2005).

Consequence Sensitivity

Sensitivity to the consequences of behavioral actions is a third component of impulsive behavior. Impulsive individuals often exhibit a general preference for more immediate rewards even if they are smaller than what might be obtained by waiting longer for a larger reward. This type of consequence sensitivity procedure is adapted from models of delay discounting, where the perceived value of a reward declines as the length of time before receiving the reward increases (Ainslie, 1975; Rachlin, 2000). The most common method for assessment of consequence sensitivity is a forced-choice procedure that typically involves presentation a series of choices between two different types of rewards: a smaller reward received after a short delay or a larger reward received after a longer delay. There are two popular versions of the forced-choice procedure. In one version, both the smaller-sooner and larger-later choices are hypothetical, meaning that the individual does not actually experience delivery of the reward after some delay. For example, a choice might be presented as “would you rather have \$1.00 today or \$10.00 next month?” A series of these

choices are presented to identify their preference for more smaller-sooner or larger later rewards. By contrast, in another version of the forced-choice procedure, an individual actually receives the chosen rewards during, or immediately following, the procedure. This experiential version involves making choices that are associated with some delay, followed by delivery of the reward and conclusion of that trial. While rewards are actually received in this version, delays and the sizes of the corresponding rewards are typically smaller than what is offered in the hypothetical version of this task. This type of consequence sensitivity measure is often considered a measure of an individual's self-control, or their ability to tolerate delayed gratification. Consequence sensitivity may be more specifically determined by adjusting the delay for reward based on the individual's responses. With this method, researchers can determine the "breakpoint" or the point at which the longer delay for the larger reward is no longer tolerated.

Using this type of procedure, parolees with histories of violence were shown to prefer the more immediate reward and they withstood less of a delay for the larger reward than their non-violent counterparts (Cherek, Moeller, Dougherty, & Rhoades, 1997). Adjusting the delay for reward has also shown that drug abusing (Allen, Moeller, Rhoades, & Cherek, 1998) and psychiatric (Dougherty et al., 1999) samples tend to prefer choices for shorter delay and receiving a smaller reward rather than waiting longer to receive the larger reward.

Behavioral Impulsivity in Adolescent Conduct Disorder

In this section, we provide data as a demonstration of the application and interpretation of findings from a study of impulsive behavior in a sample prone to contact with the legal system; adolescents with a psychiatric diagnosis of Conduct Disorder. Conduct Disorder (CD) involves a "persistent pattern of behavior in which the basic rights of others or major age-appropriate societal norms or rules are violated" (American Psychiatric Association, 2000; p. 93). To meet these criteria, a minor must have committed at least 3 types of acts, most of which are illegal activities (e.g., physical aggression toward people or animals, forced sex, stealing while confronting the victim, fire setting or deliberate destruction of property, breaking and entering, curfew violations, and truancy). Estimates of prevalence of this disorder have ranged from 6%–16% in boys and 2%–9% in girls, making CD one of the most frequently diagnosed disorders among children and one of the most costly disorders for society (Gureje, Omigbodun, Gater, & Acha, 1994; Nock, Kazdin, Hiripi, & Kessler, 2006).

Conduct Disorder is not a homogeneous diagnostic category and various methods have been proposed to more specifically identify sub-populations within the disorder. One method has been to focus on the age of onset of CD, and the DSM-IV-TR (American Psychiatric Association, 2000) categorizes the disorder into two subtypes: childhood-onset (CD symptoms prior to age 10) and adolescent-onset (CD symptoms occurring at age 10 or later). The clinical distinction and validity of this classification system has been supported by numerous studies. For example, childhood-onset CD is strongly related to the number of aggressive behaviors during childhood (Lahey et al., 1998), an increased risk for chronic antisocial behavior, Antisocial Personality Disorder, and Substance Use Disorders by young adulthood (Lahey, & Loeber, R, 1994; Loeber, Green, Lahey, Christ, & Frick, 1992; Mannuzza, Klein, Konig, & Giampino, 1990; Moffitt, Caspi, Harrington, & Milne, 2002; Patterson, DeBaryshe, & Ramsey, 1989), as well as other mental health problems or impairments in verbal and executive functions (Moffitt, 1993). In contrast, youths with adolescent-onset CD tend to be less aggressive, have more normative peer relationships, and are less likely to have persistent CD or develop adult Antisocial Personality Disorder (American Psychiatric Association, 2000; Lahey et al., 1998; Moffitt, 1993; Robins et al., 1991; Tolan & Thomas, 1995). As a result, the childhood-onset CD group may be

particularly prone to coming into contact with the legal system during childhood as well as continuing into adolescence and adulthood.

It is common knowledge that impulsivity is a normative behavior during normal childhood development. This behavior is largely related to the neurobiological changes in both brain organization and function. These changes underlie an adolescent's inability to refrain from impulsive behaviors during this critical developmental period that is defined both by a drive for novel experiences and by underdeveloped inhibitory control (Chambers, Taylor, & Potenza, 2003). However, some children and adolescents engage in abnormally high levels of impulsivity and these behaviors are often found in a variety of childhood psychiatric disorders. Conduct Disorder is one of the disorders where impulsivity is especially prominent and severe (Gorenstein & Newman, 1980; Milich & Kramer, 1984; Moeller et al., 2001). Studies have shown how self-reported and behavioral impulsivity are increased among those with CD (Daderman, 1999; Dougherty et al., 2003a, 2003b; Tranah, Harnett, & Yule, 1998). In the current study, we were interested in examining performance on the different behavioral measures of impulsivity and how this performance might vary as a function of age of CD onset. It was expected that adolescents with childhood-onset CD would perform more impulsively than those with adolescent-onset CD, and that both groups would exhibit more impulsive performance than healthy controls.

Methods

Participants

Adolescents were recruited from the greater metropolitan area of Houston, TX. Potential participants initially responded to targeted advertisements in local media and both the parent and their adolescent were pre-screened via telephone regarding CD-type symptoms. Those adolescents who appeared to meet study criteria were invited for an onsite interview that included screening for diminished intellectual functioning (Wechsler Abbreviated Scale of Intelligence; Psychological Corporation, 1999), recent alcohol intake (breath alcohol level $>.001$; Intoximeter, St. Louis, MO), recent illicit drug use (i.e., marijuana, amphetamines, benzodiazepines, and cocaine; Syva[®]; Dade Behring, Cupertino, CA), or psychiatric disorders (Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime version; K-SADS; Kaufman et al., 1997). Adolescents were excluded if they tested positive for recent alcohol or illicit drug use and if intelligence screening indicated an IQ < 70 since this could interfere with testing and the ability to understand instructions. In accordance with the DSM-IV-TR criteria (American Psychiatric Association, 2000), adolescents with Conduct Disorder were recruited into two groups based on the age of onset of CD symptoms: (1) Childhood-onset group – adolescents with CD diagnoses and onset prior to age 10; and (2) Adolescent-onset group – adolescents with CD diagnoses and onset at age 10 or later. A Control group of healthy adolescents (i.e., without CD symptoms or other DSM-IV disorder) were recruited to match the two CD groups on dimensions of age, gender, and ethnicity. Informed written consent was obtained from both the adolescent and their legal guardian. Study procedures were approved by the Institutional Review Board of The University of Texas Health Science Center at Houston. Each adolescent and guardian received approximately \$8 per hour for their participation.

Instruments

Adolescents completed a single session of each of the different behavioral impulsivity procedures described in the introduction. The specific tasks used for each component of impulsive behavior were: response initiation - Immediate Memory Task (*IMT*; Dougherty & Marsh, 2003; Dougherty et al., 2002); response inhibition – GoStop Impulsivity Paradigm (*GoStop*; Dougherty, Mathias, & Marsh, 2003d; Dougherty, Mathias, Marsh, & Jagar,

2005b); and consequence sensitivity – Two Choice Impulsivity Paradigm (*TCIP*; Dougherty et al., 2003c, 2005b). The behavioral instruments were administered in counterbalanced order, although because of task demands the IMT and GoStop were never administered consecutively. After completion of the behavioral measures, participants were asked to rate their performance (“How well do you think you performed on the behavioral tasks?”) and effort (“How much effort did you give on the behavioral tasks?”) using a 100mm visual analog scale.

In addition to these behavioral measures, other self-report instruments were administered to characterize the sample along dimensions of socioeconomic status (*Four Factor Index*; Hollingshead, 1975), antisocial symptoms (*Antisocial Process Screening Device*; Frick & Hare, 2001), aggression (*Lifetime History of Aggression*; Coccaro, Berman, & Kavoussi, 1997) and, impulsivity (*Barratt Impulsiveness Scale-11*; Patton, Stanford, & Barratt, 1995).

Results

Participant Characteristics

Ninety-three participants were recruited into one of three groups and included in all subsequent analyses: Childhood-onset ($n = 33$), Adolescent-onset ($n = 25$), and Control ($n = 35$). By design, the Childhood-onset group had a significantly younger age of CD onset ($M = 6.4$ years, $SD = 1.8$) than the Adolescent-onset group ($M = 11.8$ years, $SD = 2.1$; $p < .001$). Additionally, the two CD groups did not differ from one another in terms of severity of CD symptoms (as rated by the K-SADS-PL; $\chi^2 = 0.12$, $p = .94$) or presence of Attention-Deficit/Hyperactivity Disorder comorbidity ($\chi^2 = 0.66$, $p = .42$). Also by design, both CD groups differed from the Control group, which excluded adolescents with CD symptoms or any diagnosis of a DSM-IV-TR Axis I disorder.

The top panel of Table 1 presents group averages and the bottom panel presents group frequency data. Overall, there were no significant differences between the three groups on gender, race, or self-rated evaluation of performance or effort during the behavioral tasks. The Childhood-onset group was younger at the time of testing than the Adolescent-onset group. The two CD groups did not differ from one-another on the other characteristics, but had lower socioeconomic status, intelligence, and greater self-reported antisocial symptoms, aggression, and impulsivity than the Control group.

Behavioral Impulsivity

The group averages for performance on the three components of impulsive behavior are represented in Figure 1. IMT performance (response initiation) was significantly different between the three groups ($F_{2,90} = 10.57$, $p < .001$). Follow-up comparisons indicated that the Control group performed less impulsively than both the Childhood-onset ($p < .001$) and Adolescent-onset ($p = .002$) groups, which did not differ from one another ($p = .351$). GoStop performance (response inhibition) also showed significant differences between the three groups ($F_{2,90} = 7.69$, $p = .001$). In this case, follow-up comparisons indicated that the Childhood-onset group performed more impulsively than both the Control ($p < .001$) and Adolescent-onset ($p = .017$) groups, which did not differ from one another ($p = .286$). Finally, performance on the TCIP (consequence sensitivity) also revealed a significant group difference ($F_{2,90} = 3.26$, $p = .043$). Follow-up comparisons indicated the Adolescent-onset group performed more impulsively than both the Control ($p = .043$) and Childhood-onset ($p = .017$) groups, which did not differ from one another ($p = .803$).

Discussion

Adolescents with Conduct Disorder (CD) are more impulsive than healthy adolescents without behavioral or psychiatric disorders, although the precise nature of these behavioral differences depends on the specific aspect of impulsivity being considered and the age of onset of the CD symptoms. Relative to healthy adolescent controls, self-reports of impulsive traits were elevated in both the CD groups and both groups also showed increased impulsive performance on the measure of response initiation aspect of impulsivity. However, performance on the other measures of behavioral impulsivity differed by age of CD onset; the Childhood-onset group had the most impulsive performance on the measure of response inhibition, while the Adolescent-onset group had the most impulsive performance on the measure of consequence sensitivity.

By comparing the groups' performance across the various tasks, conclusions can be drawn regarding specificity of the effect that age of CD onset has on impulsivity. The response initiation findings would suggest that spontaneous action without adequate evaluation of the stimulus is a component of impulsivity that is common to both groups with CD, regardless of the age of onset of the disorder. However, the tests of response inhibition and consequence sensitivity indicated the two CD groups present somewhat different profiles of impulsivity deficits. While this was contrary to our overall expectations, these results highlight the potential utility for differentiating adolescents within the diagnostic category of Conduct Disorder. These results would suggest an important behavioral component defining the Childhood-onset group is a deficit in the ability to inhibit an inappropriate response once that response has been initiated. Alternatively, an important component defining the Adolescent-onset group is a preference for small rewards following a short delay rather than waiting longer for a larger reward, which suggests an inability to tolerate a delay that would lead to a more desirable outcome. To summarize, in all cases, the healthy Control group exhibited lower impulsivity than either or both of the two CD groups, but the Childhood-onset and Adolescent-onset groups appeared to exhibit different patterns of deficits related to impulsive behavior.

Behavioral Performance as a Measure of Capacity to Control Impulses

Using performance-based behavioral assessments to define the limits of an individual's capability to control their behavior is one potential application of these tools in the legal realm. For instance, we might expect that, given their performance on the TCIP, the adolescents with the Adolescent-onset CD may not have the capacity to restrain their behavior in the face of long-term consequences when a situation presents a clear opportunity for gain of some immediately desired reward. Using impulsive performance outcomes to define the lower limit of the capacity for behavioral control has two countervailing implications for the court: one being to exculpate the defendant because of the mitigating factor of diminished self-control, and the other being to increase the Court's scrutiny because of the likelihood of future similar behavior (Felthous, 1998; Ogloff, 1997). Because of this paradox, it is typically not the presence, but the underlying cause (e.g., mental illness) of the impulsivity that is of interest to the court (Ogloff, 1997).

While impulsive performance on a behavioral measure may be one indicator of the lower limit of self-control, relatively normal performance on a behavioral measure is not a guarantee that an individual did not or would not act impulsively in a particular situation. Just because an individual may have the capacity for some behavior (e.g., delay of gratification), they may not choose to exercise this capacity in a particular situation (Morse, 2007). Put another way, an important determination for the court is to distinguish the inability to resist an impulse from an impulse that is simply not resisted (Ogloff, 1997). In the context of the current study, just because adolescents with the Childhood-onset CD

performed normally (relative to healthy controls) on the TCIP, this does not guarantee that in a particular situation that they may forgo immediate rewards for longer term benefits. In this way, behavioral impulsivity measures may not be used to inform the upper limit on capacity (i.e., preserved functional ability), only whether there is the presence and type of diminished capacity.

The federal ruling on *Daubert v. Merrell Dow Pharmaceuticals* (1993) set very specific parameters regarding the admissibility of expert scientific testimony, including increased focus on the reliability and scientific validity of an expert's methodology (i.e. the testability of such methodology, record of field testing, and the known or potential error rate of measures). As the behavioral measures become more widely used, the standards set forth by the *Daubert* case will need to be established. However, at the current time, the application of group level differences demonstrated in the current study cannot be applied in determining culpability of an individual case, although it may be useful for informing sentencing decisions, as will be described in the following section.

Implications of Impulsivity Performance Outcomes for Sentencing

Knowledge of the specific components of impulsive behavior that are affected in criminal populations may be useful for informing the sentencing process. As described in the introduction, Conduct Disorder involves a variety of symptoms that are likely to lead to contact with the criminal legal system, where the appropriateness of various forms of punishment and rehabilitation must be weighed. One relatively common prison diversion program available for youth is the "boot camp", which typically uses, among other tools, the token economy system where rewards and punishments are earned based on specific behaviors. Based on the current findings we would expect that adolescents with Adolescent-onset CD might function very poorly in such a token economy system since they may have a specific deficit in linking appropriate choices to long term benefits of those choices. At the same time, there are specific skills training that can reduce consequence sensitivity impulsivity. For example, some researchers have used training techniques to help individuals understand that their current choice is linked to their future choices, and that by considering this connection, the individual can learn to optimize their series of choices leading to less impulsive consequence sensitivity performance (Ainslie & Monterosso, 2001; Kirby & Guastello, 2001). So if this training were available to the Adolescent-onset CD group, then the boot camp setting may provide a good rehabilitation experience where they can practice and develop this new skill. This provides one specific example of how outcomes from multimodal behavioral assessment of impulsivity may be used to identify deficits unique to certain individuals that would inform the legal process and increase the likelihood of success in rehabilitation by tailoring the program to target their specific deficits.

Compliance and Behavioral Testing Outcomes

Another consideration when using behavioral instruments to assess individuals in a legal setting is the possibility they have incentive to perform at a level that is less than their full capacity. One of the diagnostic criteria for Conduct Disorder is lying (American Psychiatric Association, 2000) and an assessment conducted within the context of a legal setting would provide incentive to perform at less than one's full potential (Binder, 1993). When evaluating outcomes on behavioral measures of impulsivity it is important to consider if the individual was compliant in exerting adequate effort to perform. Erratic performances on these behavioral or neuropsychological measures serve as indicators of the validity of performance (Etcoff & Kampfer, 1996). Both response initiation and response inhibition procedures include variables for assessing not only impulsivity, but also successful identification of target stimuli and irrelevant stimuli. There are acceptable ranges of

performance on these non-impulsive components of the test, beyond which the validity of the assessment may be called into question. However, caution should be exercised when interpreting the meaning of unlikely performance patterns. While suspiciously low performance may affect the interpretability of the findings, it is not indicative of the individual's intent to deceive (Hiscock & Hiscock, 1989). Because of this, suspicious performance on behavioral measures of impulsivity may not be used as indication of malingered performance.

Conclusions

As has been discussed, a large number of individuals who lack self-control over impulsive behaviors are involved in the legal system at some level. Devising the means to objectively quantify specific sub-types of impulsive behaviors would be useful at multiple levels of legal and psychiatric inquiry. "The goals of science and of law are different. However, important legal questions such as moral blameworthiness, culpability, responsibility, and the likelihood of recidivism depend to some degree on improved understandings of human behaviour" (Mobbs, Lau, Jones, & Frith, 2007; p. 0699). We have described several distinct types of behavioral measures of impulsivity that are already useful for improving our understanding of the criminal population. Our presentation of behavioral performance outcomes on three measures of impulsivity among adolescents with Conduct Disorder provides an example of how these tools may increase our understanding of this behavioral disorder. Future research may follow this same approach to test for differential performance across these measures based on type of criminal offenses. However, further development of these behavioral measures of impulsivity is required before these tools are ready for use in the courtroom. Similar to what has been described for the forensic use of neuroscience procedures (Mobbs et al., 2007), professional application of behavioral measures of impulsivity will require: (1) conducting further research on anti-social and criminal populations; (2) developing of normative data for performance on the behavioral measures; (3) establishing classification criteria for specific performance patterns across task types and how these may be representative of particular criminal populations or types of criminal offenders; and (4) agreeing on the criteria necessary for evidentiary use in the courtroom. Through this continued development, behavioral measures of impulsivity have the potential to not only reveal the etiology of certain types of criminal behaviors, but also to inform the legal process how to more effectively deal with certain criminal behaviors.

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Figure 1.

Behavioral performance on measures of response initiation (IMT), response inhibition (GoStop), and consequence sensitivity (TCIP) for adolescents with Childhood-onset or Adolescent-onset Conduct Disorder and healthy controls. Bars represent group means and error bars represent *SEM*. Larger scores indicate relatively greater levels of impulsivity.

Table 1
Characteristics of adolescent with Childhood-onset or Adolescent-onset Conduct Disorder and healthy controls

Participant Characteristics	Group					
	Childhood-onset ^a n = 33		Adolescent-onset ^b n = 25		Control ^c n = 35	
	M	(SD)	M	(SD)	M	(SD)
Age (years)	14.0	(1.0)	14.8	(1.3)	14.3	(1.3)
FFI Social Status	28.5	(9.8)	32.1	(12.7)	40.2	(9.7)
WASI Full Scale Score	90.8	(9.5)	89.1	(9.6)	101.5	(12.1)
BIS-11 Attentional Score	20.8	(3.9)	19.1	(4.0)	14.1	(2.8)
BIS-11 Motor Score	26.7	(4.8)	25.6	(4.8)	20.8	(4.5)
BIS-11 NonPlanning Score	30.0	(5.1)	30.0	(5.1)	23.9	(5.0)
LHA Total Score	21.5	(8.6)	19.1	(7.6)	4.4	(4.1)
APSD Total Score	17.5	(4.1)	16.3	(4.5)	8.6	(3.3)
VAS Effort Rating	82.1	(20.8)	75.7	(27.5)	86.0	(14.5)
VAS Performance Rating	65.0	(19.3)	67.4	(22.7)	67.7	(16.2)
	Frequency		Frequency		Frequency	Chi ² , p
Gender: Boys/Girls	25/8		12/13		20/15	.081
Race: AA/C/H/A/Multi-ethnic	15/7/8/0/3		16/1/6/0/2		16/8/8/1/2	.574
CD Severity: None/Mild/Mod./Sev.	0/7/16/10		0/6/11/8		25/0/0/0	<.001, [a=b] c
ADHD Status: Absent/Present	19/14		17/8		35/0	.009, [a=b] c

ADHD = Attention Deficit/Hyperactivity Disorder; APSD = Antisocial Process Screening Device; BIS-11 = Barratt Impulsiveness Scale 11; CD = Conduct Disorder; FFI = Four Factor Index of Social Status; LHA = Lifetime History of Aggression; Race AA = African American; Race C = Caucasian; Race H = Hispanic; Race A = Asian; VAS = Visual Analog Scale; WASI = Wechsler Abbreviated Scales of Intelligence.