

# Neurocognitive Function in High Risk Adolescents Participating in a Drug Abuse Preventive Intervention

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## Introduction

Several programs for adolescent substance abuse are reportedly "effective" for a significant number of participants; however, there is invariably a substantial subgroup that does not respond favorably. It is critical that underlying mechanisms for these differences are identified in order to improve prevention efficacy. Integrity of executive cognitive function (ECF) and its modulation of emotional arousal levels may represent significant dimensions of regulatory processes related to risk for substance abuse and may play a principle role in differential responses to programming. ECF is subserved by the brain's prefrontal cortex and its limbic circuitry to regulate behavioral inhibition, sensitivity to rewards and penalties, and decision-making. Deficits in ECF have been associated with both liability to substance abuse and relapse. The premise behind the present study is that differences in these neurocognitive-emotive processes also contribute to differential responses to preventive interventions.

## Subjects

Children in the Baltimore City Public Schools, part of an ongoing preventive intervention study at the Johns Hopkins University Prevention Intervention Research Center (JHU PIRC).

Longitudinal data are available on school achievement, family background, and risk behaviors over a 10 year period.

Two groups of adolescents from this project were selected for the present study (N=93 so far), one with a diagnosis of conduct disorder (CD) (N=43) and the other with an absence of any diagnosis and risk behavior (N=50).

All participants are male, ages 14 through 16 years.

Mean IQ CD group=82; Mean IQ Control group=84.

## Method

During the first of two sessions, subjects receive an IQ test, three developmentally appropriate ECF tasks (i.e., Children's Dice Task, the Logan Change Task, the Choice Delay Task), a test of emotional perception, and simultaneous monitoring of heart rate and skin conductance. The ECF tasks measure risky decision-making, sensitivity to consequences, impulsivity, and delay of gratification. In the second session, half of the subjects are presented with a portion of the curriculum from a model preventive intervention, Positive Adolescent Choices Training (PACT), developed for high-risk, minority, inner-city adolescents. During the first and second session (after the PACT video is viewed), participants actively interact with a virtual character who attempts to engage them in risky behavior (Figure 1). The 3 vignettes include keeping stolen goods (exercise 1), going to a party where there is alcohol (exercise 2), and a fight (exercise 3).

Figure 1: Talk-It-Out Virtual Reality Character



## Results

### Child's Dice Task (adapted from Rogers Decision Making Task):

- Adolescents with CD selected more risky choices than controls during the trials offering the highest reward but with the least likely outcome ( $t=2.364, p=0.021, df=91$ ) (Figure 2).
- Adolescents with CD were slower to make decisions during the high risk trials ( $t=2.181, p=0.032, df=91$ ).
- Repeated measures analysis (Risk (3) x Group (2)) revealed that both groups selected fewer risky choices as risk level increased ( $F=285.680, p<0.0005, df=2,1$ ) (Figure 2).
- The interaction effect, Risk x Group, indicated that the two groups modulated their responses to risk differently (statistical trend,  $F=2.893, p=0.058, df=2,2$ ).

### The Logan Change Task:

- Adolescents with CD made significantly more errors on the first tone block ( $F=7.947, p=0.001$ ) and the second tone block ( $F=5.385, p=0.006$ ) (Figure 3).

### The Sonuga-Barke Choice Delay Task:

- The groups were not significantly different in "larger later" choices ( $t=6.04, p=0.547$ ).

### Extra Presses on All Tasks:

- The CD group made more extra presses for the Child's Dice Task ( $t=2.172, p=0.034, df=91$ ), and for the first ( $F=7.590, p=0.001$ ), and the second ( $F=5.467, p=0.006$ ) block of the Change Task, and the first block ( $t=1.773, p=0.082$ ) of the Delay Choice Task (Figure 4).

### Correlations:

- Deficits in performance on the Dice Task and Logan Change Task were correlated with teacher ratings of impulsivity, hyperactivity and oppositionality as well as parental report of symptoms of CD (Table 1).
- Performance on the Dice Task and Logan Change Task was weakly related to early drug use, as measured when the adolescents were 14. (Table 1).

### Virtual Reality Vignettes:

- Almost all key vignette performance measures loaded strongly on two distinct factors: emotional control and social-cognitive interpersonal skills (e.g., negotiation). This suggests that performance measures have convergent and discriminant validity. The internal reliability of the multi-item factors was high (Cronbach alphas > .90) (Table 2).
- Factor scores were associated with measures of risky or problem behavior in the expected direction, as adolescents who had lower levels of emotional control and social-cognitive interpersonal skills were more likely than those with higher factor scores to report lifetime substance use, and their 8th grade teachers were more likely to report that they had behavioral problems and/or were expelled from school for behavioral misconduct. These findings provide preliminary support for the criterion-related validity of vignette performance measures (Table 2).

Figure 2: Selection of Riskiest Choice on RDMT by CD Adolescents

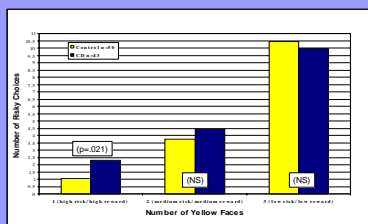


Figure 3: Error Rate for Logan Change Task

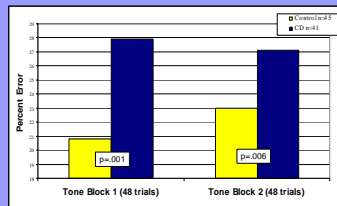


Figure 4: Impulsivity (i.e., Extra Button Presses) for All Tasks

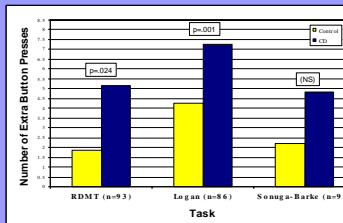


Table 1: Correlations Between ECF Performance and Longitudinal Data

Longitudinal Data	Dice Task		Logan Change Task		Choice Delay Task	
	# Y1 Risky Choice	# Extra Presses	# Correct First Tone Block	# Extra Presses	# smaller sooner choices	# Extra Presses
Hyperactivity	.349***	.291**	-.381***	.311**	.030 (ns)	-.173 (ns)
Impulsivity	.373***	.301**	-.359***	.373**	.027 (ns)	-.165 (t)
Oppositional	.337***	.263*	-.320***	.330***	.060 (ns)	-.113 (ns)
Conduct Disorder	.356***	.066 (ns)	-.493***	.452***	.093 (ns)	.247*
Aggression	.230 (t)	.199 (ns)	.022 (ns)	.128 (ns)	-.213 (t)	.001 (ns)
Marijuana Ever Used	.093 (ns)	-.026 (t)	-.286*	.320**	-.097 (ns)	.015 (ns)
Marijuana First Used	-.344***	-.002 (ns)	.012 (ns)	-.054 (ns)	-.302	.212 (ns)

Hyperactivity, impulsivity, and oppositional behavior based on teacher ratings.  
 Conduct disorder and aggression based on parent report  
 Drug use based on self report.  
 \*p<.05, \*\*p<.01, \*\*\*p<.005, \*\*\*\*p<.0001, t-d,16, ns = not significant

Table 2: Results from Virtual Reality Vignettes

Assessment of the Validity of Vignette Performance Measures: Results of Factor Analysis and Associations Between Factor Scores and Behavioral Measures  
 Factor Loadings of Vignette Performance Measures (Convergent & Discriminant Validity)

Measure	Factor 1	Factor 2
Emotional control, exercise 1	.891	.030
Emotional control, exercise 2	.854	.014
Emotional control, exercise 3	.867	-.006
Being non-provocative, exercise 1	.862	.175
Being non-provocative, exercise 2	.869	.143
Being non-provocative, exercise 3	.713	.188
Negotiation, exercise 1	.555	.536
Negotiation, exercise 2	.550	.591
Engagement level, exercise 1	-.014	.891
Engagement level, exercise 2	.000	.847
Engagement level, exercise 3	-.068	.803
Stating preferences, exercise 1	.213	.865
Stating preferences, exercise 2	.210	.859
Stating preferences, exercise 3	.207	.814
Number of verbalizations, exercise 1	.035	.816
Number of verbalizations, exercise 2	.005	.893
Number of verbalizations, exercise 3	.002	.897

\*Information-seeking measures for all three exercises and the negotiation measure for exercise 3 did not load strongly on any factor.

### Mean Factor Scores for Dichotomous Behavioral Measures (Criterion Validity)

	Ever Used Violence		Ever Used Alcohol		Ever Used Marijuana		Expelled from School	
	Yes	No	Yes	No	Yes	No	Yes	No
Factor 1	.204	-.015	.131	.200	-.002	.013	-.412	.197
Factor 2	-.376	.232	-.082	-.143	-.475	.150	.020	.008

\*p<.05

### Correlations with 8th Grade Teacher Behavioral Ratings (Criterion Validity)

Behavioral Construct	Factor 1	Factor 2
Hyperactivity	.337***	.04
Impulsivity	.320***	-.06
Oppositional/Defiant	.345***	-.16
Proactive Discipline	-.286***	.09

\*p<.05, \*\*p<.01

## Conclusions

- The CD group made more risky decisions, particularly in situations that offer the potential of a large reward for such behavior even though there was a very low probability of this outcome and a greater likelihood of penalty.
- The slower reaction time indicates the possibility that the CD group processes information related to risky decisions less efficiently than the control group.
- The CD group was more impulsive and distractible as reflected in the greater number of errors on the Logan Change Task and the extra button presses on all tasks.
- Measures of executive decision making and impulsivity are related to several risk behaviors to include hyperactivity, impulsivity, oppositional behavior, conduct disorder and early drug use.
- Use of Interactive Virtual Reality Vignettes to gauge actual behaviors, not just reported behaviors, may be an effective and meaningful method to measure behavioral change over time.

### Implications:

- Novel measures of executive cognitive function distinguish between high risk and low risk adolescents.
- Adolescents with Conduct Disorder may benefit from interventions to specifically address deficits in impulsivity and risky decision making.
- Adolescents with executive cognitive deficits may be unable to process materials from preventive interventions that do not target executive cognitive deficits.

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