Neurocognitive Deficits Underlie Adolescents' Response to a Model Preventive Intervention

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1. Introduction and Aims

Several prevention 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 responsible for these differences are identified so that prevention efficacy can be improved. Executive cognitive functioning (ECF) and its modulation of emotional arousal may represent significant dimensions of regulatory processes related to substance use and response to programming.

The purpose of the present study was threefold:

- To determine the extent to which ECF and emotional perception (e.g., impulse control, risk taking, recognition of social cues, ability to delay gratification) moderate response to a model preventive intervention curriculum (PACT). Hypothetically, deficits in ECF and emotional perception will impede ability to process and apply preventive intervention materials.
- To assess relationships between neurocognitive deficits and longitudinal data (10 years) collected from the child, parent, and teachers, such as early drug use, aggression, impulsivity, shyness, Conduct Disorder and related psychopathology.
- To apply a novel virtual reality interactive tool to evaluate differential decision making responses to the preventive intervention.

2. Subjects

Subgroup recruited from the larger longitudinal study conducted by Johns Hopkins University Prevention Intervention Research Center (JHU PIRC) Program who are registered in the Baltimore City Public Schools. Ten years of longitudinal data have been collected on these subjects, including school achievement, family functioning, well being, psychological status, psychiatric diagnoses, and more. Data reflect reports from child, parent, teachers, and peers and were used to select a subgroup for the present study on the following basis:

Group Recruitment Strategy (subsample = 120) – only males

- Control group: no previous or current diagnosis of Conduct Disorder or other high risk behavior
- Conduct Disorder (CD) group: previous and current diagnosis of Conduct Disorder and other high risk behavior

Demographics

Item	Control Group	CD Group
Sample size	N=63	N=57
Mean Age	16.07	16.08
Ethnicity	54 black; 9 white	51 black; 6 white
Mean IQ	84.92 (sd=12.20)	81.10 (sd=15.02)

3. Design and Methods

Baseline Protocol:

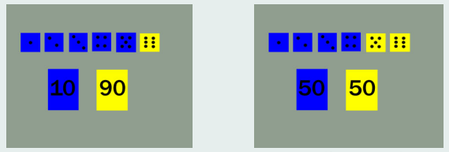
- Estimated IQ (WISC-III: Block Design and Vocabulary)
- Three Neurocognitive Tasks
  - Rogers Decision Making Task (adapted for children) (Fig 1.)
  - Logan Stop Signal Task (impulsivity) (Fig 2.)
  - Sonuga-Burke Choice Delay Task (delay of gratification)
- Ekman 60 Facial Recognition Task (emotional perception)
- Three Virtual Realty Vignettes assessing negotiation and conflict resolution skills (Fig 3.)
- Questionnaire presenting scenarios to assess negotiation and conflict resolution skills
- Interviewer ratings

Experimental Design (six to eight weeks after Baseline):

- Intervention: Random assignment of adolescents from both groups to facilitated exposure to Positive Adolescent Choices Training (PACT) video that presents role modeling curriculum to teach negotiation and conflict resolution
- Posttest Measures:
  - Three different virtual reality vignettes assessing negotiation and conflict resolution skills
  - Questionnaire assessing negotiation and conflict resolution skills
- Debriefing and interviewer ratings

Executive Cognitive Function (ECF) Tasks and Virtual Reality Vignettes

Figure 1. Rogers Decision Making Task (RDMT)



Scenarios:

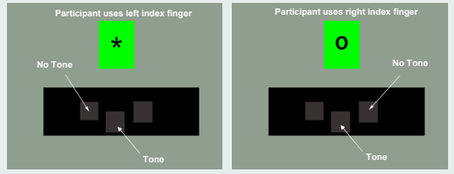
- Highest Risk – 5 blue faces: 1 yellow face
- Moderate Risk – 4 blue faces: 2 yellow faces
- Low Risk – 3 blue faces: 3 yellow faces

Blue bet amount is always less (i.e., safer) except when the bet amounts are 50/50.

Game IQ: To control for participant's understanding of and engagement in the game

- 4 blue faces: 2 yellow faces
- 50/50 bet

Figure 2. Stop Signal Task (SST)



3 Conditions:

- Baseline – No tone presented, 36 trials
- Block 1 – Tone distracter presented, 48 trials
- Block 2 – Tone distracter presented, 48 trials

Tone trials consist of "easy" and "hard" tone distracters

- Easy – Tone displayed immediately after visual stimulus is presented
- Hard – Tone displayed a few milliseconds after visual stimulus is presented

Figure 3. Virtual Reality Character

Scenarios:

- Stolen Goods
- Drinking or Drug Use and Girls
- Provocation to Fight

Group Differences in Performance on ECF Tasks and Outcome Measures (Social Cognition)

Figure 4. Group Differences in Emotional Perception (Facial Recognition)

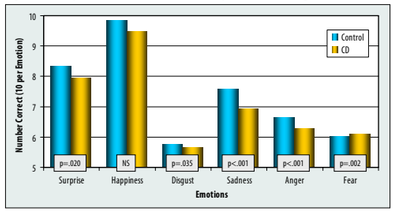


Figure 5. RDMT Performance Differences between Conduct Disorder and Non-CD

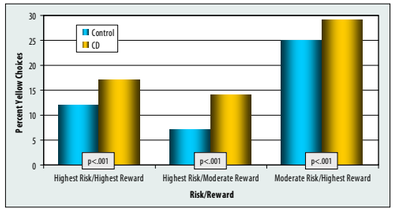


Figure 6. Group Differences in Performance on the SST

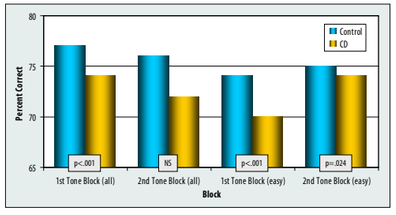
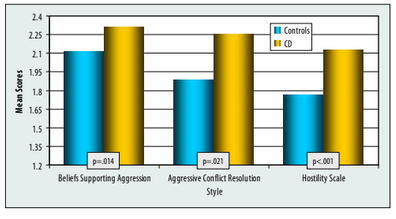


Figure 7. Group Differences on Social Cognition Outcome Measure at Baseline



Correlations Between ECF tasks, Longitudinal Data, and Outcome Measures (Vignettes & Social Cognition)

Table 1. Correlations Between Choices on RDMT and Teacher Rating of Aggression

Teacher Rating	Highest Risk Choices		Moderately High Risk Choices		Highest Reward Choices		Moderate Reward Choices		Highest Risk and High & Moderate Rewards Combined		Moderately High Risk and High & Moderate Rewards Combined	
	R	p=	R	p=	R	p=	R	p=	R	p=	R	p=
Grade 9 Proactive Aggression	.31	.004	.24	.027	.29	.007	.29	.008	.40	.001	.22	.037
Grade 7 Reactive Aggression*	.27	.013							.31	.004		
Grade 6 Reactive Aggression*									.27	.013		

*Measure only taken in grades 6 & 7

Table 2. Correlations Between RDMT Reaction Time (RT) and Outcome Measures

Social Cognition	Moderate Risk Choices - RT		Low Risk Choices - RT		Average Risk Choices - RT	
	R	p=	R	p=	R	p=
Aggressive Conflict Resolution Baseline	-.22	.019	-.30	.001	-.27	.004
Aggressive Conflict Resolution Experimental			-.31	.001	-.22	.019
Hostility Scale Baseline	-.20	.041			-.21	.031

Table 3. Correlations Between Performance [Reaction Time (RT) and Total Correct] on SST and Outcome Measures

Vignette Performance (V) and Social Cognition (SC)	Baseline RT		Block 1 RT		Block 2 RT		Total Correct Block 1		Total Correct Block 2	
	R	p=	R	p=	R	p=	R	p=	R	p=
Communication Skills Experimental (V)	-.24	.012	-.28	.003	-.22	.021				
Beliefs Supporting Aggression Baseline (SC)	-.20	.043	-.20	.038						
Beliefs Supporting Aggression Experimental (SC)									.20	.040
Aggressive Conflict Resolution Baseline (SC)	-.22	.020					.24	.012	.24	.009

Primary Hypothesis

Table 4. ECF and Emotional Perception Predict Differential Response to Model Preventive Intervention Curriculum

Domain	Mediating Factor	Change from Baseline	F Ratio[1]	Impact of Mediator on Intervention
RDMT (Risky Decision Making)	Extra Presses (impulsivity)	Communication Skills (Virtual Reality Vignettes)	3.01[1]	↓
	Total Points		4.72*	↑
	RT for high risk choices		2.85[1]	↓
	High Risk Choices		4.50*	↓
CDT (Delay of Reward)	Larger Longer		3.99*	↓
	Smaller Shorter		3.99*	↓
Conduct Disorder	CD		4.84*	↓
SST (Impulsivity)	Non Presses (Baseline)	Hostility Scale (Social Cognition)	3.87[1]	↓
CDT (Delay of Reward)	Extra Presses (impulsivity)		5.35*	↓
Emotional Perception	Total Correct		4.26*	↓
RDMT (Risky Decision Making)	Extra Presses (impulsivity)	Beliefs Supporting Aggression (Social Cognition)	5.94*	↓
	RT for high risk choices		3.76[1]	↓
	RT for medium risk choices		7.15**	↓
	RT for lower risk choices		7.47**	↓
	Total Average RT		8.03**	↓
SST (Impulsivity)	Late Presses Baseline		3.69[1]	↓

[1] Adjusted for IQ and race; *p=.05, **p=.01; [1] Borderline statistical significance: p < 0.1

PACT by Group Effects on Outcome Measures

Figure 8. PACT and CD Group Effects on Aggressive Conflict-Resolution Style

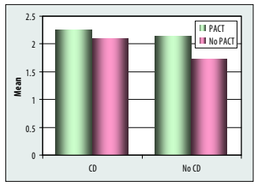
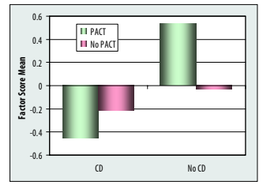


Figure 9. PACT and CD Group Effects on Communication Skills



4. Results

CD Performance on ECF/Emotional Perception and Outcome Measures Relative to NonCD:

- Misinterpreted all facial expressions more often than controls except for happiness (Fig. 4).
- Made riskier choices (less probability of winning) and do so when the rewards associated with such choices are larger (e.g., bet associated with risky choice = 70 or 90) (Fig. 5)
- Were less able to inhibit responses when the tone delay is short (easy) (Fig. 6)
- Had higher scores for supporting aggression, aggressive conflict resolution styles and hostility (Fig. 7)

Correlations between longitudinal data and ECF function:

- Of the longitudinal data collected by JHU-PIRC, teacher ratings of aggression were positively correlated with level of risky decision making on the RDMT (Table 1).

Correlations between ECF function and social cognition:

- Adolescents who reported higher levels of aggressive conflict resolution (pre and post) and higher levels of hostility took less time (reaction time: RT) overall in making choices on the RDMT, during the low and moderate risk conditions of the task (Table 2).
- Adolescents who had lower levels of communication skills during the session 2 vignettes had longer RTs during all three conditions of the SST (with and without tone distracters) (Table 3).
- Adolescents showing higher levels of beliefs supporting aggression in sessions 1 & 2 had longer RTs during both conditions of the SST (with and without tone distracters) (Table 3).
- Adolescents with higher levels of beliefs supporting aggression in session 2 had a higher number of correct responses in Block 2 of the SST (Table 3.)
- Adolescents reporting high levels of aggressive conflict resolution styles in session 1 had a higher number of correct responses in Blocks 1 & 2 of the SST (Table 3.)

Relationship between PACT intervention, group membership, and outcome measures:

- Adolescents with CD respond less favorably to an acute administration of the PACT intervention as measured by Social Cognition (Fig 8.) and Vignettes (Fig 9.)

Primary Hypothesis

- Poor performance on ECF (RDMT, SST, CDT) and Emotional Perception Tasks predicted deficits in ability to process the preventive curriculum based on change in outcome measures (Vignettes & Social Cognition) (Table 4.)

5. Conclusions

Delineating the neurocognitive and emotional regulatory substrates of response to drug abuse prevention programs may provide valuable insights for developing therapeutic interventions for adolescents who tend to be refractory to both conventional and novel treatments. Research on vulnerability and protective factors suggest that tailored, targeted interventions will be most effective when social and environmental manipulations are "matched" to an individual's genotype, thereby reinforcing more adaptive and normative phenotypes. The present study supports that notion that intact ECF and its regulation of emotional perception may, in fact, be a prerequisite for a favorable response to any intervention program. This knowledge should serve to eventually inform the field as to individual characteristics which distinguish between children positively affected by various interventions relative to those least affected, and determine what components are needed to design an effective intervention strategy.

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