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Brief report: “Spiders-No, Puppies-Go”, introducing a novel Go NoGo task tested in inner city adolescents at risk for poor impulse control



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Introduction

In adolescents, externalizing disorders and the syndrome of neurobehavioral disinhibition are a broad spectrum of disorders involving poor impulse control as a cardinal feature. These disorders are linked to substance use disorder (SUD), thus possibly representing a vulnerability to addiction (Kuperman et al., 2001; Tarter et al., 2003). With the eventual goal of assessing whether deficits of impulse control predate and/or potentially predispose to drug use, our laboratory studies impulsivity in adolescents who are at high risk for poor impulse control.

The traditional Go NoGo task measures “rapid-response” impulsivity by evaluating the ability of a subject to inhibit a prepotent response when the subject is asked to respond to a series of rapidly presented Go stimuli and to withhold responding to less frequently presented NoGo stimuli (Horn, Dolan, Elliott, Deakin, & Woodruff, 2003). Responding to a NoGo stimulus, an error of commission, represents a failure to suppress the prepotent Go response, i.e. a failure of response inhibition, with more commission errors indicating greater impairment in response inhibition. Poor performance on a Go NoGo task has been demonstrated in populations with SUD (e.g. cocaine, opioids, and cigarette smoking) (Fillmore & Rush, 2002; Forman et al., 2004; Kaufman, Ross, Stein, & Garavan, 2003; Luijten, Littell, & Franken, 2011).

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We observed that the typical Go NoGo task was not engaging to our study populations, who typically have low levels of education and/or attention deficits. We suggest that this is because typical Go NoGo tasks utilize abstract stimuli such as letters of the alphabet (e.g. Go = X and NoGo = Y) or shapes (e.g. Go = circle and NoGo = square) (Mostofsky et al., 2003). Thus, we developed a Go NoGo task that uses approach/avoidance congruent pictures, e.g. appealing/pleasant objects (baby animals) on Go trials, and unappealing/unpleasant objects (spiders) on NoGo trials. These stimuli have inherent ecological validity, as choosing the appropriate response to environmental stimuli is critical for survival (Chen & Bargh, 1999). We hypothesized that the use of approach/avoidance congruent pictures, rather than abstract stimuli (commonly used in the typical Go NoGo task) would facilitate better task engagement in our adolescent ‘at risk’ population.

In this paper, we describe the development, reliability and construct validity of an Approach-Avoidance (A-A) Go NoGo task. The A-A Go NoGo task incorporates three levels of difficulty. This multi-level approach allows us to assess the validity of the task design because the number of commission errors should increase as the level of difficulty increases (de Zubicaray, Andrew, Zelaya, Williams, & Dumanoir, 2000; Durston, Thomas, Worden, Yang, & Casey, 2002). We piloted the A-A Go NoGo task in a cohort of socioeconomically deprived, inner city adolescents with low average IQ, at risk for poor impulse control, and examined whether the novel task correlated with observation based measures of impulsivity.

Methods

Participants

Participants were 19 adolescents (male 53%, age 13.5 ± 1.1 years, 100% African American, mean Wechsler Preschool and Primary Scale of Intelligence-Revised collected at age 6 = 81.9 ± 11.3) drawn from a larger cohort (Hurt, Brodsky, Roth, Malmud, & Giannetta, 2005; Wechsler, 1989). These adolescents are considered to be at elevated risk for SUD due to environmental exposure and family history of substance abuse (Li et al., 2000; Silberg, Rutter, D’Onofrio, & Eaves, 2003). Twenty-four participants of the larger prospective study were available at the time of their regularly scheduled yearly follow-up visit and matched available testing slots for our study. Five participants were excluded from data analysis due to incomplete data acquisition. The demographic data of participants not tested did not significantly differ from tested participants.

Measures

The A-A Go NoGo task was administered on a laptop computer, programmed using “E-Prime” (Schneider, Eschman, & Zuccolotto, 2002). Go stimuli were pictures from one of three categories: baby animals, sweets, and flowers; NoGo stimuli were pictures from one of three categories: scorpions, snakes, and spiders. The task consisted of three levels of difficulty: the most difficult condition had 12.5% NoGo’s (with 20 NoGo trials and 140 Go trials; 2.7 min), the moderate condition had 25% NoGo’s (with 20 NoGo trials and 60 Go trials; 1.3 min) and the least difficult condition had 33% NoGo’s (with 20 NoGo trials and 40 Go trials; 1 min). Maintaining the same number of NoGo trials (20) allowed for direct comparison of error rates across the three conditions. To optimize the prepotency load, the Go and NoGo trials were randomly presented with the constraint that 1 NoGo trial would occur within each block of 8 trials in the 12.5% condition, within each block of 4 trials for the 25% condition, and within each block of 3 trials for the 33% condition. To reduce carry-over across conditions we repeated the instruction screens before each condition. Each trial began with a 300msec stimulus presentation followed by a 700msec presentation of a cross-hair fixation point. The participants could respond at any point during the 1 s trial.

We presented the difficulty conditions in two orders (12.5%, 25%, 33% and 33%, 25%, 12.5%). The error scores were compared between the two orders and were found not to be different.

As part of the longitudinal study, the Achenbach System of Empirically Based Assessment Teacher Report Form for ages 6–18 (TRF) was collected at the end of the school year (Achenbach & Rescorla, 2001). This observation based measure assesses five aspects of externalizing spectrum disorders (see Table 1). As a measure of impulsivity for this study, we examined the correlation between the five TRF behavioral scores (collected within the previous year) and errors of commission on the A-A Go NoGo task.

Table 1

Externalizing measures from the Achenbach Teacher report Form.

Achenbach measures	T score (Mean \pm SD)	Normal ($T < 64$)	Borderline ($T = 65–69$)	Clinical ($T > 70$)
Rule Breaking	60.9 \pm 6.4	13	5	1
Attention Deficit/Hyperactivity Problems	59.4 \pm 6.5	15	4	0
Oppositional Defiant Problems	60.3 \pm 7.5	11	7	1
Conduct Problems	60.6 \pm 6.1	16	0	3
Aggressive Behavior	59.5 \pm 7.2	16	2	1

The first column presents the mean T scores (mean normalized scores) and standard deviations for 5 observation based measures of externalizing spectrum disorders from the Achenbach Teacher Report Form (TRF). On these measures, T scores between 65 and 69 represent the borderline clinical range, while scores of 70 and above represent the clinical range. The third column lists the number of our participants falling in the borderline clinical range for each of the five measures. The fourth column lists the number of participants falling in the clinical range for each of the five measures.

Procedure

The A-A Go NoGo task was administered in two experimental sessions separated by 1.5–11.5 months (mean = 6.90 ± 2.67 months). For each participant, the order of the three levels of difficulty and assignment of stimuli by condition across the two sessions were held constant. Following each session, an informal question and answer period assessed participant engagement. Associations between TRF and A-A Go NoGo were examined for each session separately and the average of the two sessions (to provide a better estimate of performance). All participants provided informed consent, and all procedures were approved and monitored by the University Of Pennsylvania School of Medicine Institutional Review Board.

Results

We used a within-subject factorial design with 3×2 (difficulty \times test session) variables. We performed a two-way repeated-measures analysis of variance (ANOVA) with difficulty level (12.5%, 25%, and 33% NoGo) and session number (first and second) as within-subject factors. We found a main effect of test session ($F = 18.46$; $df = 1$; $p < 0.001$), with significantly fewer errors of commission on the second session (6.3 ± 0.38) vs first session (7.8 ± 0.49). The main effect of difficulty level was not statistically significant, though it approached significance ($F = 2.49$; $df = 2$; $p = 0.097$; $\eta_p^2 = 0.12$). Within-subject contrast analysis demonstrated a trend in error scores in the predicted direction. We observed significantly greater errors of commission on the 12.5% condition (7.7 ± 0.56) vs 33% condition (6.4 ± 0.54), ($F = 5.1$; $df = 1$; $p = 0.037$). There were no significant interactions between these factors ($F = 0.126$; $df = 2$; $p = 0.882$).

Pearson correlation was used to examine the relationships between errors of commission on repeat administrations. The task demonstrated excellent test re-test reliability for the number of commission errors observed in the first session (23.3 ± 6.3) and the second session (18.8 ± 4.9) (Pearson $r = 0.70$, $p = 0.001$). Additionally, positive associations were observed between A-A Go NoGo task performance and TRF scores for aggressive behavior problems and attention deficit/hyperactivity problems. During the first A-A Go NoGo session, higher errors of commission were significantly correlated with higher aggressive behavior scores. During the second and the average of the two A-A Go NoGo sessions, higher errors of commission were associated with both higher aggressive behavior scores and higher attention deficit/hyperactivity scores (see Table 2). None of the remaining TRF correlates were associated with task performance. Performance on the A-A Go NoGo task was independent of IQ during both sessions ($r = -0.31$, $p = 0.196$). In an informal questionnaire following the experimental session, the participants indicated that the A-A Go NoGo task was engaging.

Discussion

Here we report results from our newly developed A-A Go NoGo task examined in a cohort of socioeconomically deprived, inner city adolescents with low average IQ, and at risk for poor impulse control and associated conditions such as SUD. The A-A Go NoGo task resulted in orderly data: errors of commission increased between the least and most difficult levels. The A-A Go NoGo task also demonstrated excellent test re-test reliability with the strong correlation between task performance across sessions. Additionally, in agreement with the literature, higher errors of commission were associated with both higher aggressive behavior scores and higher attention deficit/hyperactivity scores; a number of prior studies have demonstrated that participants with attention deficit/hyperactivity disorder have impaired performance on the Go NoGo task compared with controls (Schulz et al., 2004) and the Go NoGo task has been used to explore brain correlates of poor impulse inhibition in subjects with pathological aggression (Verona, Sprague, & Sadeh, 2012). These results suggest that the A-A Go NoGo task may represent an alternative method to measure rapid response inhibition that may be useful in individuals who have difficulty processing abstract stimuli such as those with low IQ or attention disorders.

Despite the strengths of this study, there are a number of limitations. Possibly due to our small sample size, we did not observe a main effect for the three difficulty levels, however significant differences were observed between the most and least difficult levels. Alternatively, the middle difficulty level may not be necessary to distinguish task performance differences. The task demonstrated a practice effect on the second administration, however, importantly, this did not affect the primary finding of a strong correlation in task performance across sessions. Our study was underpowered to conduct analysis of sex differences in task performance. Continued study with a larger sample size is necessary. Another limitation of the study is that we were unable to draw conclusions based on clinical diagnoses because all the participants were disadvantaged, inner city, at risk adolescents. In future studies using this task, we plan to have participants rate the valence of the stimuli following the

Table 2

Achenbach Teacher report form correlation with performance on the A-A Go NoGo task.

Achenbach measures	First session A-A Go NoGo	Second session A-A Go NoGo	Average A-A Go NoGo
Attention deficit/Hyperactivity problems	$r = 0.374$, $p = 0.115$	$r = 0.522$, $p = 0.022^*$	$r = 0.474$, $p = 0.040^*$
Aggressive behavior	$r = 0.465$, $p = 0.045^*$	$r = 0.599$, $p = 0.007^*$	$r = 0.567$, $p = 0.011^*$

For two of the five observation based measures of externalizing spectrum disorders from the Achenbach Teacher Report Form (TRF) significant correlations were demonstrated between errors of commission on the Approach-Avoidance (A-A) Go NoGo task and TRF measures (during the first session, during the second session and the average of the two sessions of the A-A Go NoGo task respectively), * indicates statistically significant correlation.

task. Ratings can be used as a covariate to reduce potential confounds associated with individual variability in response to stimuli.

The A-A Go NoGo task produced systematic, reliable data, and demonstrated several advantages: The task was engaging, independent of IQ and correlated with aggression and attention deficit/hyperactivity problems. These several elements encourage its continued testing in varied clinical populations.

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