

# An application of eye tracking technology to detect attention bias for suicide related stimuli

Steven Vannoy, Samuel Gable, Madeline Brodt, Melanie Cadet,  
Bonnie Andrews, Meredith Maloney  
University of Massachusetts Boston  
Department of Counseling & School Psychology,  
Boston, MA, USA  
steven.vannoy@umb.edu

## ABSTRACT

Suicide is a leading cause of mortality world-wide, accounting for 1.4% of annual deaths. Traditional risk factors, self-report questionnaires, and clinical interviews have limited predictive validity for short-term suicide attempts. Studies using behavioral measures like the Suicide Implicit Association Test (S-IAT) to detect automatic and unconscious preference towards suicide related stimuli have demonstrated unique positive predictive value in high-risk psychiatric inpatients. While the S-IAT is a major step forward in suicide risk assessment, there are still significant limitations in our ability to predict short-term suicide attempts. We have developed a multi-modal behavioral assessment protocol to assess risk with high predictive value using eye tracking technology intended to augment the S-IAT and traditional assessment tools. Results from our pilot study indicate eye-tracking may be a feasible and valid technology for suicide risk prediction.

## Author Keywords

Suicide; Eye Tracking; Attention; Prevention.

## ACM Classification Keywords

J.4. Computer Applications: Social and Behavioral Sciences

## INTRODUCTION

It is well known that traditional risk factors, including self-reported suicide ideation (SI) are not highly accurate predictors of future attempts (SA) [17, 5, 11, 21, 22, 23, 35]. The use of computer-based tasks to measure information processing biases have emerged as significant improvements in risk measurement. Specifically, studies using the Suicide Implicit Association Test (S-IAT) to detect automatic and unconscious attitudes towards suicide have demonstrated positive predictive value in high-risk psychiatric inpatients [24, 9, 10, 28, 30, 36]. While the ability of the S-IAT to predict SA is a major improvement over traditional risk factors and clinician ratings, the properties of the procedure are unknown in less severe psychiatric populations and the predictive value is too low to fulfill the needs of suicide risk assessment in general practice. The IAT was designed to measure “up-stream”

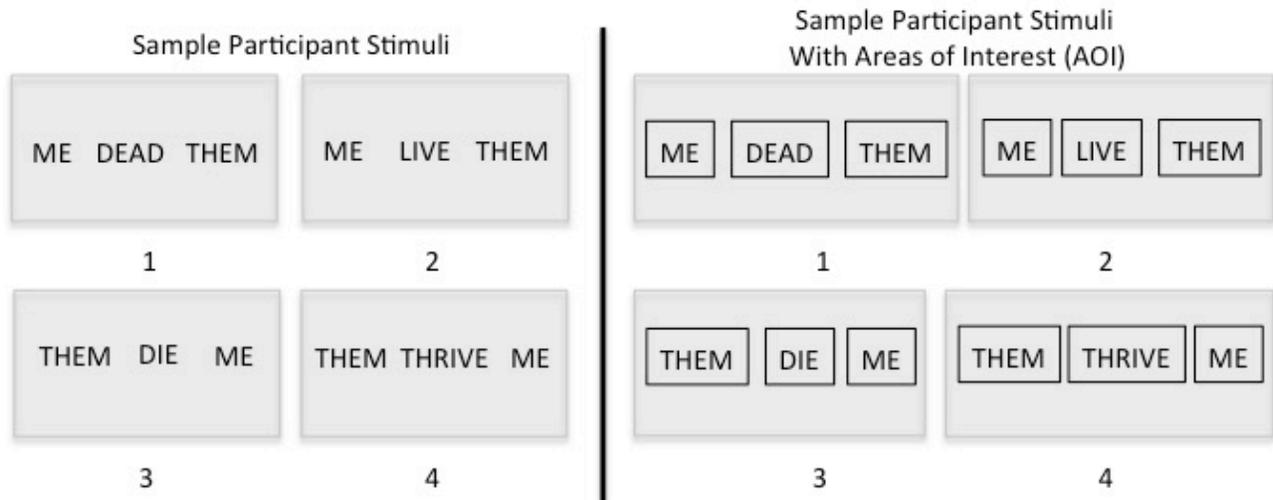
cognitive information processing (attitudes) [12, 13, 25]. Several technologies exist to measure “down-stream” information processing (attention) and emotional response to stimuli (affect). Specifically, infrared eye tracking is a non-invasive method capable of tracking gaze and serves as a cognitive measure of visual attention [15]. It has been used in a wide range of mental health research [1, 4, 9, 15, 31, 32, 33]. To assess attention bias for suicide related stimuli, we applied eye tracking technology in what we call the Eye Tracking Suicide Assessment Measure (ETSAM). We report the results of a pilot study and propose that the ETSAM demonstrates that eye tracking is a promising technology for enhancing suicide risk assessment.

## METHODS

Our study was conducted with a diverse sample of college students attending a large, East Coast public university. All procedures were approved by our Institutional Review Board. Participants were recruited through offering extra credit in introductory psychology courses or through campus-wide emails offering \$20 pre-paid food service cards. Participants had a wide age range (18 to 82,  $m = 23$ ), and gender heterogeneity (60% female). Additionally, 85.2% of participants identified as heterosexual and 12.5% as homosexual, bisexual, or queer. The sample was highly diverse in terms of race/ethnicity; 51.1% identified as White, 13.6% as Hispanic, 12.5% as Asian or Asian-American, 9.1% as Black or African American, 5.7% as multiracial, and 8% identified as Other.

## Description of instruments

*Eye Tracking Suicide Attention Measure (ETSAM)*: The ETSAM was developed considering research on the relationship between attentional bias and suicidality [8, 24]. Given the dynamic process by which current goals, past experiences and reward history influence attentional processing, tracking attentional bias may offer a unique marker for suicide risk complementary to the S-IAT and existent self-report measures. Indeed, the presence of persistent, suicide-relevant cognitions and, often, history of previous attempts in those at higher risk of suicide, can be



**Figure 1: Participant-view and analysis-view of example stimuli. The left side of the diagram represents four distinct screen shots presented to participants. The right side of the diagram contains the same four slides, but illustrates the AOI used for analysis. Fixations that fall within the AOI are coded to be either ‘self’ or ‘other’ as well as ‘self-life’, ‘self-death’, ‘self-life’, and ‘self-death’.**

understood cognitively to facilitate the loading of both internal and external suicide-oriented stimuli into working memory and perpetuating an orientation towards suicidality [1, 3, 18]. For the ETSAM, we developed a computer-based attention-bias measurement procedure using an eye-tracking device (Tobii Pro X2-60, tobii.com), custom experimental design software (iMotions, iMotions.com), and statistical analysis code developed in our lab [29]. The ETSAM models the bias a participant has for visual fixations on self-death stimuli compared to self-life stimuli. The attention bias is operationalized using the fixation time spent on ‘self’, ‘others’, ‘life’, and ‘death’. Figure 1 illustrates examples of what a participant might view on the screen and the areas of interest (AOI) used to calculate the ETSAM score.

Fixations were operationalized as eye movements that remained within a radius of  $\sim 0.43$  cm for 100 milliseconds or longer. The iMotions software facilitates the creation of stimuli “slides” (e.g. text, graphics, photos, videos) and synchronizes eye-tracking input with the “presentation”. Basic fixation metrics can be extracted, including start-time, duration, and location. We created ten slides, each containing a “life” or “death” related word in the center with a “self” or “other” word on either side (Figure 1). We used the ten life and death related words that are used in the S-IAT (death, dead, die, suicide, gone, live, life, thrive, breathe, alive, future). We fixed the self versus other stimuli with the words ‘ME’ and ‘THEM’, alternating left and right position. Each slide was presented for 8 seconds. Participants were told they would be viewing a sequence of slides for about 2 minutes, and that they should maintain their gaze on the computer screen attending to whatever captures their attention.

AOIs were created around each word on the slide and we extracted the individual fixations that occurred for each participant, on each slide, in each of the AOIs. We used this information to estimate the attention bias towards “self” in the presence of “death” stimuli as opposed to bias towards “self” in the presence of “life” stimuli.

Attention can be quantified using a variety of fixation metrics including total fixation time, number of fixations, and time to first fixation. Following sensitivity analyses, we chose to quantify attention using average fixation time spent on “me-death” stimuli compared to average fixation time spent on “me-life” stimuli across all slides.

Two potential confounds include: 1) a general fixation bias for ‘me’ that is unrelated to whether it is a ‘death’ or ‘life’ slide (me-bias), and 2) a general fixation bias for ‘death’ verses ‘life’ (death-bias). To control for these potential confounds, we modeled the difference in average amount of time spent fixating on ‘me-death’ vs ‘me-live’ stimuli using linear regression with the ‘me-bias’ and ‘death-bias’ as predictor variables and average ‘me-death’ time as the criterion. The residuals from this regression are converted to z-scores that represent the ‘me-death’ bias adjusted for our identified confounds.

*Suicide Implicit Me-Death Attitude Bias (S-IAT):* The S-IAT [23] is a behavioral measure intended to reflect implicit biases favoring associations between the constructs of self and death compared to self and life. We implemented the S-IAT using PsychoPy [27].

*Suicide related covariates:* Participants completed on-line questionnaires related to depression (PHQ-9) [19]; anxiety (GAD-7) [34], reasons for living (RFL) [20], history of

	ETSAM	S-IAT	PHQ-9	PHQ-SI	GAD-7	SBQ-R	SCS
ETSAM							
S-IAT	0.068						
PHQ-9	0.339*	0.276					
PHQ-SI	0.335*	-0.076	0.634***				
GAD-7	0.322*	0.343*	0.909***	0.586***			
SBQ-R	0.186	0.268	0.552***	0.393*	0.513***		
SCS	0.297	0.334*	0.778***	0.599***	0.727***	0.694***	
RFL	-0.300	-0.137	-0.589***	-0.485**	-0.547***	-0.650***	-0.609***

**Table 1: Variable Correlations. Values > 0.32 significant at p < .05. N = 43.**

suicide behaviors and beliefs (SBQ-R) [26] and current suicide related cognitions (SCS) [6].

## RESULTS

Our sample was diverse with respect to mental health distress and history of suicide related behaviors. Nearly a quarter (22.7%) of participants screened positive for mild depression and 13.6% for major depression based on the PHQ-9. Similarly, 17.1% of participants met screening criteria for generalized anxiety disorder based on the GAD-7. Suicide ideation as indicated on item 9 of the PHQ-9 was common (20.5%). Lastly, 34.1% of respondents screened positive for elevated suicide risk on the SBQ-R. Based on individual items of the SBQ-R, 11.4% had a lifetime history of suicide attempt and 4.5% reported it likely that they would eventually attempt suicide (no one endorsed 'very likely').

Table 1 presents first order correlations between the ETSAM, S-IAT and our covariates. The ETSAM and S-IAT correlation is very small ( $r = 0.07$ ) whereas both the ETSAM and S-IAT are significantly correlated with more than one covariate. Although our decision to use average fixation time for the ETSAM resulted in reasonable correlation with the covariates, some individuals had very few fixations on me-death stimuli. Sensitivity analyses excluding individuals with small numbers of me-death fixations influenced the correlations significantly. The results in Table 1 reflect a minimum number of fixations threshold of ten. This reduced the number of participants with valid S-IAT and ETSAM scores to  $n = 43$ .

## CONCLUSION

Eye tracking technology provides an opportunity to improve upon behavioral measures of suicide risk, such as the S-IAT. Numerous measurement issues must be addressed before this approach becomes clinically feasible. Future research should focus on identifying the optimal fixation metric and modifying the protocol to reduce noise. The most critical next step is to collect data in a high-risk sample with follow up assessment of suicide attempts in order to determine the potential for positive predictive value of the ETSAM and how it may contribute to a multi-measure, multi-method protocol.

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