Beyond the Interview: Using Electroencephalography (EEG) to Evaluate Suicide Risk

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Introduction

According to recent data from the World Health Organization, over 700,000 people die by suicide every year [1]. More specifically, suicide may occur throughout the lifespan in the general population and is the fourth leading cause of death among 15-29 year-olds globally [1].

While impulse may generally play a role in suicide attempts [2], mental states and behavior that eventually culminate in suicide usually start manifesting years before suicidal ideation or acts of deliberate self-harm are displayed. In this regard, suicide risk is typically assessed by mental health professionals utilizing self-administered questionnaires and interviews, which mainly focus on cognitive theories [3-5]. However, several studies suggest that **thoughts or cognitions only play a minor role in the generation of suicidal intent** and that assessments should instead focus on exploring emotions, mood, or affect [6, 7]. Moreover, in day-to-day clinical settings, patients referred to services for suicide prevention are often found to be unable or reluctant to explain how they feel, as a result of shame, fear of being misunderstood, and confusion [8, 9]. On the other hand, suicidal patients typically display a range of highly distressing and rapidly evolving emotional states that mental health professionals most often fail to describe using objective methods [8, 10]. Therefore, while questionnaire- and interview-based assessments can be useful in describing behaviors, this approach is often prone to bias and lacks the accuracy to systematically identify suicide risk factors [11-14].

Resting-state EEG correlates of suicidal behavior

It is well established that suicide attempters are more likely to exhibit both structural and functional abnormalities in the brain [15-18].

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Interestingly, in patients with **greater psychological pain** - a risk factor for suicide, [19]- studies employing electroencephalography (EEG) found that **lower frontal delta power** was linked to the disruption of emotion regulation, including greater rumination as well as the inability to determine the causes and the consequences of suffering [20]. This has been recently confirmed by research showing that the desire for suicide is modulated by the relationship between psychological pain and frontal delta power[21].

Importantly, while there is common agreement among mental health professionals that severe depression increases the risk for self-harm and suicide [22], studies indicate electrophysiological differences between suicide attempters and non-attempters with depression [23, 24]. For example, while **increased theta activity** has been found to be associated with depressive disorder [25-27] and to reflect brain dysfunction in patients with depression or anxiety disorders [28, 29], **increased fronto-central theta power** has also been found to strongly correlate with behaviorally assessed **suicide ideation in young healthy persons** [30], remarking the clinical importance of activity changes within this EEG frequency range in the general population, **even in the absence of diagnosed high-risk mental states.**

From suicide intent to suicide attempt

While a plethora of studies have focused on the link between distinct structural/functional brain anomalies and suicide intent, other research has attempted to unveil the imbalances that are more likely to lead from suicide intention to suicide attempt. For example, a study with female adolescents found a difference in **frontal alpha asymmetry** between suicide attempters and controls with similar age, socio-economic status, cultural background, and locale. In particular, normal controls showed greater alpha power (less activation) over the right hemisphere of the brain, whereas suicidal adolescents showed a trend in the opposite direction [24].
Interestingly, in the same study, while the subsample of attempters with a diagnosis of major depression showed abnormal alpha asymmetry at anterior sites, the non-depressed subgroup of attempters showed abnormal alpha asymmetry at posterior sites. In non-depressed suicide attempters, the posterior alpha asymmetry correlated with suicide lethality but not depression scores. These EEG differences between depressed and non-depressed attempters may again suggest **distinct functional correlates of suicidal behavior,** which questions once again the general belief among mental health professionals that the risk for suicide increases with depression severity [22].

Interestingly, electrophysiological findings indicate that both adolescents and adult psychopaths may exhibit reduced left hemisphere lateralization during the performance of verbal dichotic listening tasks [31, 32]. Also, an EEG study by Davidson and Hugdahl [33] found that higher performance in a verbal dichotic task strongly correlated with EEG alpha power in the left posterior region of the brain. If suicidal behavior can be conceptualized as inwardly directed aggression, suicide attempters might be expected to resemble psychopaths in showing both reduced left hemisphere activation during verbal dichotic listening and also reduced left posterior EEG power in the alpha frequency band. This would be in line with the assumption that abnormal posterior asymmetry in suicidal persons reflects not depression, but rather suicidal or aggressive behavior. Of note, recent research that explored the range of negative emotions in persons with suicide intent found greater anger in this clinical sample [34], which might support the hypothesis that greater tendency for aggression increases the risk for suicide.

Negative self-referencing as a suicide risk factor: Evidence from event-related potentials

Cognitive models of suicide propose that negative views of the self play an important role in shaping suicidal thoughts and related behaviors. In particular, when stress levels exceed a tolerable threshold (i.e., threshold of tolerance), negative beliefs about the self, the world, and the future become increasingly stronger [35] and negative self-evaluations become the main focus. The self then starts being viewed as unlovable, worthless, and helpless [35, 36].

Within this framework, recent research employing event-related potentials (ERPs) has found that, compared with suicide ideators, persons who attempted suicide were characterized by **enhanced P200 amplitudes** in response to the presentation of negative information, which may reflect early semantic monitoring of depressogenic information. This could suggest that, among suicide attempters, enhanced attendance to negative information may facilitate, at least in some cases, the **transition from ideation to action.** In other words, attendance to negative stimuli may trigger more impulsive behaviors that eventually lead to attempting suicide, which is consistent with previous research that suggests a role of negative urgency in suicidal behavior [37]. The greater attendance to negative versus positive stimuli shown by suicide attempters offers some insight on how psychotherapeutic approaches, including cognitive-behavioral therapy, should be structured in suicide attempters to challenge beliefs about the self. Also, complementary approaches to standard therapeutic interventions—e.g., real-time neurofeedback-based modulation of the default mode network (DMN), which is implicated in self-referential processing [38] could contribute to improving clinical outcomes among suicidal persons.

Conclusions

Suicide risk assessments based on self-administered questionnaires and interviews often fail to detect crucial cues in the patient's profile, which can potentially lead to catastrophic consequences. While there is a general understanding among researchers and mental health professionals that suicidal thoughts and behaviors are strongly modulated by emotional imbalances, evidence from EEG and ERP studies have unveiled electrophysiological activity in the brain that can feasibly increase suicide risk, even in the absence of affective disorders.

Thus, it is recommended that basic clinical assessments be complemented with more advanced multimodal investigations such as EEG evaluation, which could offer the opportunity to gain a deeper **objective insight** into the patient's profile and also to detect key neurobehavioral imbalances to consider when formulating ad hoc interventions. Furthermore, in the absence of supportive EEG data, providers may direct examinations towards external influences such as social, behavioral, trauma, or medical-based studies.

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