

Explainable Boosting Machine Prediction of Emotional Numbness from Trauma Exposure, Dissociation, and Alexithymia

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Article Info

Article type:

Original Research

How to cite this article:

Krivina, E., Sowell, K., & Gill, S. (2026). Explainable Boosting Machine Prediction of Emotional Numbness from Trauma Exposure, Dissociation, and Alexithymia. *Journal of Assessment and Research in Applied Counseling*, 8(4), 1-15.
<http://dx.doi.org/10.61838/kman.jarac.5843>



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ABSTRACT

Objective: This study aimed to predict emotional numbness from trauma exposure, dissociation, and alexithymia among trauma-exposed adults in Canada using an interpretable Explainable Boosting Machine model.

Methods and Materials: This quantitative cross-sectional predictive study was conducted on 426 trauma-exposed adults residing in Canada. Participants completed standardized self-report measures assessing emotional numbness, lifetime trauma exposure, dissociative experiences, and alexithymia. Emotional numbness was considered the outcome variable, while trauma exposure, dissociation, and alexithymia were entered as predictor variables. Data were screened for missing values, response validity, outliers, and distributional properties. Descriptive statistics, reliability coefficients, and Pearson correlations were calculated before predictive modeling. The dataset was divided into training, validation, and test subsets. An Explainable Boosting Machine regression model was trained and evaluated against a conventional multiple linear regression model using root mean squared error, mean absolute error, and coefficient of determination. Global and local interpretability outputs were examined to determine predictor importance, non-linear effects, and interaction patterns.

Findings: Inferential analyses showed that trauma exposure, dissociation, and alexithymia were all significantly and positively correlated with emotional numbness. Dissociation had the strongest correlation with emotional numbness, followed by alexithymia and trauma exposure. The Explainable Boosting Machine model outperformed multiple linear regression across predictive indices. In the independent test set, the linear regression model explained 44% of the variance in emotional numbness, whereas the Explainable Boosting Machine model explained 56% of the variance. The EBM model also showed lower prediction error, with RMSE = 7.67 and MAE = 5.94. Global importance analysis indicated that dissociation was the strongest predictor, followed by alexithymia and trauma

exposure. Interaction analysis showed that the dissociation by alexithymia interaction was the most influential interaction effect.

Conclusion: The findings indicate that emotional numbness is best predicted by psychological processing variables, particularly dissociation and alexithymia, rather than trauma exposure alone. The Explainable Boosting Machine model provided both stronger predictive accuracy and clinically interpretable results, suggesting that emotional numbness may emerge through non-linear and interactive pathways involving trauma burden, dissociative detachment, and impaired emotional awareness.

Keywords: *Emotional numbness; trauma exposure; dissociation; alexithymia; Explainable Boosting Machine; interpretable machine learning.*

1. Introduction

Emotional numbness is a clinically important but often under-specified psychological outcome that refers to a diminished capacity to experience, recognize, respond to, or express emotions with normal intensity. It is commonly observed in trauma-exposed individuals and is frequently described as a subjective sense of emotional deadness, detachment, restricted affect, loss of emotional vitality, and reduced responsiveness to both negative and positive stimuli. Although emotional numbness is often discussed within the broader domain of posttraumatic stress symptoms, it is not merely the absence of distress; rather, it reflects a distinctive alteration in affective processing in which emotional systems become constrained, blunted, or disconnected from conscious experience. Trauma theory has long emphasized that exposure to overwhelming events may disrupt the integration of affect, memory, embodiment, and interpersonal meaning, thereby producing symptoms that extend beyond fear and hyperarousal to include avoidance, dissociation, alexithymic processing, somatic expression, and affective constriction (Paivio & Pascual-Leone, 2023). In this regard, emotional numbness is particularly significant because it may represent both a protective defensive response to intolerable emotional activation and a maladaptive psychological pattern that interferes with recovery, intimacy, self-understanding, and engagement with daily life.

Trauma exposure is one of the most important antecedents of emotional numbness, but its effects are complex and heterogeneous. Individuals exposed to traumatic events do not respond uniformly; some develop intrusive memories and hyperarousal, whereas others primarily show emotional detachment, dissociation, somatization, impaired emotion differentiation, or difficulty accessing internal states. Research on early life stress and trauma has shown that adverse experiences may continue to shape psychological functioning in adulthood, influencing

emotional awareness, mindfulness, stress sensitivity, and regulation of internal experience (Gibson, 2024). Similarly, family violence exposure has been associated with intergenerational patterns of somatization, suggesting that traumatic environments may influence how psychological distress is encoded, communicated, and embodied across developmental and relational contexts (Glaus et al., 2022). Trauma may also impair positive affective engagement, as studies of reward processing in posttraumatic stress disorder indicate that trauma can alter the way individuals interact with positive stimuli, pleasure, and motivational reward systems (Seidemann et al., 2021). Therefore, emotional numbness may be understood not only as avoidance of painful affect but also as a broader reduction in the capacity to respond emotionally to meaningful, rewarding, or relationally significant experiences.

The association between trauma exposure and emotional disturbance is further complicated by individual differences in emotion differentiation, emotional clarity, and emotion regulation. Trauma-exposed individuals who have difficulty differentiating negative emotions may experience greater posttraumatic symptoms in daily life, because poorly differentiated affective states may be experienced as diffuse, overwhelming, and difficult to regulate (Pugach et al., 2023). Studies of women exposed to physical intimate partner violence have similarly highlighted the clinical relevance of emotional clarity, showing that difficulty understanding one's emotional states is closely tied to psychopathology in trauma-exposed populations (Joseph et al., 2024). In adolescents, emotional dysregulation and trauma symptoms have been shown to mediate the relationship between childhood abuse and nonsuicidal self-injury, indicating that trauma-related harm may be transmitted through disruptions in affective regulation and symptom organization (Andersson et al., 2022). More recent research has also connected childhood trauma to maladaptive outcomes through alexithymia and rumination, suggesting that impaired emotional identification and repetitive cognitive

processing may form a chain through which trauma increases psychological risk (Wang, 2024). These findings support the view that trauma exposure alone may be insufficient to explain emotional numbness unless the affective, cognitive, and self-regulatory processes that organize trauma responses are also examined.

Dissociation is one of the most theoretically and clinically relevant mechanisms linking trauma exposure with emotional numbness. Dissociation broadly involves disruptions in the normal integration of consciousness, memory, identity, perception, emotion, and bodily experience. Contemporary perspectives emphasize that dissociation should not be reduced to a single explanatory model; rather, it may emerge through trauma-related, cognitive, developmental, interpersonal, and sociocultural pathways (Lynn et al., 2022). In trauma-exposed individuals, dissociation may function as a defensive psychological process that reduces access to overwhelming emotional material, but this protective function may later contribute to chronic detachment and emotional blunting. The mediating role of dissociative symptomatology has been demonstrated in trauma-related problems, including evidence that dissociative symptoms mediate the relationship between posttraumatic stress severity and alcohol-related problems (Patel et al., 2022). Dissociation has also been identified as a key pathway in more complex clinical presentations, including psychosis-related negative symptoms, where trauma, attachment, dissociation, and alexithymia appear to form interrelated routes to diminished emotional and motivational expression (Grady et al., 2025). The clinical importance of dissociation is further reflected in emerging efforts to assess specific dissociative domains, such as dissociation of intimacy, which highlights the role of detachment and disconnection in relational and emotional functioning (Caretti, 2025). In this framework, emotional numbness may represent a subjective and behavioral manifestation of dissociative disengagement from internal emotional experience.

Alexithymia is another central construct in understanding emotional numbness because it directly concerns difficulty identifying, describing, and cognitively processing emotions. Unlike emotional numbness, which refers to reduced emotional responsiveness or felt emotional absence, alexithymia refers to deficits in emotional awareness and symbolic representation. However, these two constructs may overlap clinically, because individuals who cannot identify or describe emotions may experience their internal states as vague, inaccessible, muted, or absent. Meta-analytic

evidence has shown a robust association between child maltreatment and alexithymia, supporting the argument that early adverse experiences can impair the development of emotional awareness and emotional language (Ditzer et al., 2023). Alexithymia is also strongly linked to posttraumatic stress, with evidence indicating that it is associated with both the presentation and severity of posttraumatic symptoms (Edwards, 2022). In the context of posttraumatic stress, the assessment of alexithymia adds explanatory value beyond coping alone, because it captures a fundamental difficulty in emotional processing that may shape symptom expression, adaptation, and treatment needs (Bowen et al., 2022). Clinical reports further suggest that alexithymia and emotional deficits in posttraumatic stress may involve both content disturbances, such as limited emotional vocabulary, and process disturbances, such as impaired access to emotional meaning (Ogłodek, 2022). Neuropsychiatric perspectives also indicate that alexithymia can be understood as a disturbance in systems involved in socioemotional awareness and self-referential emotional processing, as illustrated by work examining frontotemporal dementia as a window into alexithymic functioning (Mendez, 2021).

Recent studies increasingly show that alexithymia is not a peripheral symptom but a transdiagnostic vulnerability that interacts with trauma, dissociation, loneliness, uncertainty, and maladaptive behavior. Alexithymia has been found to mediate or moderate associations between adverse experience and multiple forms of psychological impairment. For example, alexithymia has been identified as a mediator in the relationship between childhood emotional abuse and nomophobia, indicating that impaired emotional processing may contribute to problematic dependency on digital reassurance or attachment-like technological behaviors (Saladino, 2025). Alexithymia has also been studied in relation to problematic sexual behavior through dissociative patterns, suggesting that dissociation and impaired emotional awareness may jointly contribute to maladaptive behavioral regulation (Topino et al., 2025). In reproductive trauma contexts, alexithymia has been associated with posttraumatic stress among patients with early pregnancy loss, with intolerance of uncertainty acting as a mediating mechanism (Xu et al., 2025). Among Black adults, alexithymia has been shown to moderate the relationship between racial trauma and negative emotionality, emphasizing that alexithymic processing may shape emotional consequences of trauma in socially and culturally specific contexts (Phillips et al., 2026). Alexithymia may

also influence awareness of trauma-related memories, as maladaptive cognitive processes and alexithymia can affect meta-awareness of trauma-related memory experiences (Sun et al., 2025). These findings suggest that alexithymia may amplify the consequences of trauma exposure by limiting the individual's capacity to recognize, interpret, and regulate emotional states.

The combined study of trauma exposure, dissociation, and alexithymia is especially important because these variables may not operate independently. Rather, trauma may increase dissociative detachment, dissociation may reduce access to emotional experience, and alexithymia may impair the cognitive labeling and communication of emotions that remain partially accessible. Such processes can create a pathway in which emotional life becomes fragmented, muted, and difficult to integrate. This pattern is consistent with studies showing that trauma and loss may mediate associations between neurodevelopmental traits and eating disorder symptoms in patients with borderline personality disorder, indicating that traumatic experience may interact with broader personality, developmental, and affective vulnerabilities (Carpita et al., 2025). Mechanistic reviews of borderline personality disorder based on electroencephalogram evidence also suggest that disturbances in neural and affective regulation are central to complex emotional instability and dysregulation, which may coexist with dissociative or emotionally restricted states (Chmiel & Kurpas, 2025). Research on autism and functional neurological disorder similarly underscores the value of biopsychosocial, neuropsychological, and computational models for understanding complex symptom formation across boundaries of emotional, bodily, and cognitive processing (Cole et al., 2025). In asylum seekers with posttraumatic stress disorder, mentalization difficulties further illustrate how trauma may disrupt the capacity to understand internal states in oneself and others, thereby deepening emotional disconnection and interpersonal impairment (Aragona et al., 2025). Therefore, emotional numbness should be studied as a multidimensional psychological outcome shaped by trauma burden, dissociative organization, and impaired emotional mentalization.

The broader literature also indicates that emotional numbness is embedded in social, cultural, and relational contexts. Psychological suffering is not always expressed through direct symptom language; it may also be represented through narratives of marginalization, social exclusion, historical suffering, and collective trauma. The analysis of

Dalit psychological suffering in literary and cultural discourse demonstrates that trauma-related distress can be shaped by social position, oppression, and the language available for articulating pain (Cherechés, 2024). This perspective is important because emotional numbness may be experienced not only as an intrapsychic symptom but also as a response to repeated invalidation, silencing, or relational disconnection. In voice-hearers, emotion processes such as emotional reactivity, emotion regulation, and alexithymia have been shown to differentiate psychological functioning, supporting the broader relevance of emotional processing variables across clinical phenomena (Cusworth et al., 2024). Addictive behaviors have also been conceptualized through integrated models of vulnerability and maintenance factors, where emotional dysregulation, dissociation, and related vulnerabilities contribute to maladaptive patterns of coping and self-regulation (Gori et al., 2023). These findings converge with the view that emotional numbness may be maintained by overlapping vulnerabilities in affective awareness, self-regulation, dissociative detachment, and relational functioning.

Although trauma-focused treatments can reduce posttraumatic symptoms and may also improve affective and structural regulation, not all trauma-exposed individuals respond similarly, and individual differences in alexithymia may influence treatment processes and outcomes (Stingl et al., 2021). Evidence on alexithymia and prolonged exposure therapy suggests that alexithymic characteristics may be relevant to treatment response and mechanisms of change, because emotional engagement and emotional learning are central to trauma-focused interventions (Putica et al., 2024). This has direct implications for predictive research: if emotional numbness is shaped by non-linear and interacting contributions of trauma exposure, dissociation, and alexithymia, then traditional linear models may not fully capture the structure of risk. Self-regulatory models also highlight that psychological functioning is organized through complex profiles rather than isolated symptoms, and the development of self-regulatory profile measures reflects the growing need to assess patterns of emotional and behavioral regulation in a more integrated way (Vail et al., 2025). Therefore, an explainable machine learning approach is particularly suitable for this topic because it can model non-linear associations while preserving interpretability. Explainable Boosting Machine modeling allows researchers to estimate the unique contribution of each predictor, identify threshold effects, detect interaction patterns, and present results in a transparent form that can be interpreted

clinically. In the context of emotional numbness, such an approach may clarify whether dissociation is the strongest predictor, whether alexithymia has a threshold-based effect, and whether trauma exposure becomes more influential when combined with elevated dissociative or alexithymic tendencies.

Despite the growing literature on trauma, dissociation, alexithymia, and emotional dysfunction, several gaps remain. First, emotional numbness is often treated as a secondary symptom of posttraumatic stress rather than as an independent outcome worthy of direct predictive modeling. Second, many studies examine trauma exposure, dissociation, or alexithymia separately, even though these constructs are theoretically interdependent and may jointly shape emotional restriction. Third, conventional statistical models may underestimate complex non-linear patterns, such as the possibility that emotional numbness increases sharply only after dissociation or alexithymia reaches a clinically meaningful level. Fourth, much of the literature emphasizes explanation at the group level without providing interpretable prediction structures that can identify which predictors most strongly contribute to individual emotional numbness risk. Addressing these gaps is important for both research and clinical practice because emotional numbness can interfere with help-seeking, therapeutic alliance, exposure-based emotional processing, relational intimacy, and recovery of positive affect. Therefore, the aim of this study was to use an Explainable Boosting Machine model to predict emotional numbness from trauma exposure, dissociation, and alexithymia among trauma-exposed adults in Canada.

2. Methods and Materials

2.1. Study Design and Participants

This study was designed as a quantitative, cross-sectional, predictive study aimed at developing and interpreting an Explainable Boosting Machine model for predicting emotional numbness based on trauma exposure, dissociation, and alexithymia. The target population consisted of adults living in Canada who had experienced at least one potentially traumatic event during their lifetime. The study was conducted using an online data collection procedure in order to reach participants from different Canadian provinces and to increase geographical diversity within the sample. Participants were recruited through online research panels, university announcement systems, community mental health networks, and social media

advertisements related to psychological well-being and trauma research. The final analytic sample consisted of 426 Canadian adults aged 18 to 65 years. Inclusion criteria were being at least 18 years old, currently residing in Canada, having adequate English-language comprehension to complete self-report questionnaires, providing informed consent, and reporting exposure to at least one potentially traumatic life event. Participants were excluded if they submitted incomplete questionnaires, failed embedded attention-check items, provided inconsistent demographic responses, or completed the survey in an unrealistically short time, suggesting insufficient engagement with the items. Before participation, all respondents received information about the purpose of the study, voluntary participation, anonymity, confidentiality, and their right to withdraw from the study at any stage before final submission of the questionnaire. Because the study addressed trauma-related experiences, participants were also provided with information about psychological support services and crisis resources available in Canada. All procedures were conducted in accordance with ethical principles for research with human participants, and electronic informed consent was obtained before access to the questionnaires was granted.

2.2. Measures

A demographic and background information form was used to collect participants' basic characteristics, including age, gender, province of residence, educational level, employment status, marital status, history of psychological treatment, and history of psychiatric medication use. This form also included general questions about whether participants had previously received trauma-focused psychological services, because such information could be relevant for describing the sample and interpreting the psychological profile of participants. The demographic form was not used as a main predictive instrument in the primary model; rather, it was used to describe the study sample and to evaluate whether the recruited participants represented a broad adult Canadian community sample.

Emotional numbness was assessed using the Emotional Reactivity and Numbing Scale, developed by Orsillo, Theodore-Oklot, Luterek, and Plumb in 2007. This self-report instrument was designed to evaluate individual differences in emotional reactivity and emotional numbing, particularly in trauma-exposed populations. In the present study, the emotional numbness-related score was considered

the outcome variable. The items assess restricted emotional experience, reduced responsiveness to positive and negative emotions, and difficulty experiencing emotions with normal intensity. Participants responded to the items using a Likert-type response format reflecting the extent to which each statement was typical of their emotional experience. Higher scores indicated greater emotional numbness and more severe restriction in emotional responsiveness. The scale has been used in previous trauma-related studies, and its validity and reliability have been supported in earlier psychometric research. In the present study, internal consistency reliability was examined using Cronbach's alpha and McDonald's omega before the emotional numbness score was entered into the predictive model.

Trauma exposure was measured using the Life Events Checklist for DSM-5. The LEC-5 is a self-report instrument developed by the National Center for PTSD to assess exposure to potentially traumatic events across the lifespan. It includes a range of traumatic experiences, such as natural disasters, accidents, physical assault, sexual assault, combat-related exposure, sudden violent death, sudden accidental death, serious injury, and other highly stressful events. For each event, participants indicated whether the event happened to them directly, whether they witnessed it, whether they learned about it happening to someone close to them, whether it was part of their occupational exposure, whether they were unsure, or whether it did not apply. In the present study, trauma exposure was operationalized as a cumulative trauma exposure score based on the number of event categories endorsed as directly experienced, witnessed, learned about, or encountered through occupational exposure. Higher scores represented broader lifetime exposure to potentially traumatic events. The LEC-5 has been widely used in trauma research and has demonstrated acceptable validity as a screening measure for lifetime trauma exposure.

Dissociation was assessed using the Dissociative Experiences Scale-II, developed as a revised version of the original Dissociative Experiences Scale by Carlson and Putnam. The DES-II is a 28-item self-report measure designed to assess dissociative experiences in daily life, including absorption, depersonalization, derealization, amnesia, and disruptions in the normal integration of consciousness, memory, identity, emotion, perception, and behavior. Participants rated the percentage of time they experienced each dissociative phenomenon, typically from 0% to 100%. The total DES-II score was calculated by averaging the item scores, with higher scores indicating

greater dissociative experience. In the present study, the total dissociation score was used as one of the main predictor variables in the Explainable Boosting Machine model. The DES-II has been widely used in clinical and non-clinical samples, especially in trauma-related research, and previous studies have supported its reliability and validity. Internal consistency was also examined in the current sample before statistical modeling.

Alexithymia was measured using the Twenty-Item Toronto Alexithymia Scale, developed by Bagby, Parker, and Taylor in 1994. The TAS-20 is one of the most widely used self-report instruments for assessing alexithymia and consists of 20 items rated on a five-point Likert scale. The instrument includes three major dimensions: difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Difficulty identifying feelings reflects problems in recognizing and distinguishing emotions from bodily sensations; difficulty describing feelings reflects limitations in verbally communicating emotional states; and externally oriented thinking reflects a cognitive style focused more on external facts and events than on internal emotional experience. Total scores are obtained by summing the items after applying the required reverse scoring, with higher scores indicating greater alexithymia. In this study, the total TAS-20 score was used as the alexithymia predictor in the main model, while subscale scores were examined descriptively to provide a clearer psychological profile of the sample. Previous studies have confirmed the validity and reliability of the TAS-20 across diverse populations, and the internal consistency of the total scale and its subscales was evaluated in the current sample.

2.3. Data analysis

Data analysis was conducted in several sequential stages. First, the dataset was screened for missing values, duplicate responses, careless responding, outliers, and logical inconsistencies. Participants with excessive missing data or failed attention-check items were removed before analysis. For participants with minor missing responses, missing values were handled using appropriate imputation procedures when the proportion of missingness was low and appeared to be random. Descriptive statistics, including mean, standard deviation, minimum, maximum, skewness, and kurtosis, were calculated for emotional numbness, trauma exposure, dissociation, and alexithymia. The internal consistency reliability of the self-report measures was

examined using Cronbach's alpha and McDonald's omega. Pearson correlation coefficients were then calculated to examine the bivariate relationships among trauma exposure, dissociation, alexithymia, and emotional numbness before machine learning modeling.

The main predictive analysis was performed using the Explainable Boosting Machine algorithm. Because the dependent variable, emotional numbness, was measured as a continuous psychological score, the EBM was specified as a regression model. The three main predictors entered into the model were trauma exposure, dissociation, and alexithymia. The dataset was randomly divided into training, validation, and test subsets, with 70% of the data used for model training, 15% used for validation and hyperparameter tuning, and 15% retained as an independent test set for final model evaluation. The training process used cyclic gradient boosting to estimate separate shape functions for each predictor, allowing the model to capture non-linear associations between each psychological predictor and emotional numbness while preserving interpretability. Automatic pairwise interaction detection was also examined to determine whether the joint effects of trauma exposure, dissociation, and alexithymia improved predictive performance beyond the main effects.

Model performance was evaluated using root mean squared error, mean absolute error, and the coefficient of determination. Root mean squared error was used to assess the average magnitude of prediction error with greater sensitivity to larger errors, mean absolute error was used to provide a more direct estimate of average prediction deviation, and the coefficient of determination was used to determine the proportion of variance in emotional numbness explained by the model. To strengthen interpretation, the EBM model was compared with conventional multiple linear regression as a baseline model. This comparison allowed evaluation of whether the non-linear and interaction-sensitive structure of EBM provided superior predictive accuracy compared with a traditional linear approach. Model overfitting was assessed by comparing training, validation, and test performance indices.

The interpretability of the final EBM model was examined through global and local explanations. Global explanations were used to identify the relative contribution of trauma exposure, dissociation, and alexithymia to the prediction of emotional numbness. Predictor importance values were inspected to determine which variable

contributed most strongly to prediction accuracy. Shape functions were then examined to identify the direction and form of each predictor's relationship with emotional numbness, including whether the association was linear, threshold-based, or curvilinear. Local explanations were used to show how each predictor contributed to individual predicted scores, thereby allowing the model to provide case-level interpretability. These explanations were particularly important because the purpose of the study was not only to predict emotional numbness but also to clarify how trauma exposure, dissociation, and alexithymia jointly contributed to emotional restriction in a trauma-exposed adult sample. All analyses were conducted using contemporary statistical and machine learning software, and statistical significance was interpreted at the conventional alpha level of .05 for inferential analyses.

3. Findings and Results

The final sample consisted of 426 trauma-exposed adults residing in Canada. Participants ranged in age from 18 to 65 years, with a mean age of 34.82 years and a standard deviation of 10.76 years. In terms of gender distribution, 268 participants were women, representing 62.91% of the sample, 145 participants were men, representing 34.04%, and 13 participants identified as non-binary, another gender identity, or preferred not to disclose their gender, representing 3.05% of the sample. Regarding province or region of residence, 158 participants lived in Ontario, 82 in Quebec, 61 in British Columbia, 54 in Alberta, 37 in Manitoba or Saskatchewan, 26 in Atlantic Canada, and 8 in northern territories. Educationally, 47 participants had completed high school or less, 116 had completed a college diploma or equivalent postsecondary certificate, 181 held a bachelor's degree, and 82 held a graduate or professional degree. With regard to employment status, 249 participants were employed full-time or part-time, 72 were students, 49 were unemployed or looking for work, 34 were self-employed, and 22 were retired or unable to work. A total of 187 participants reported having previously received psychological counseling or psychotherapy, and 96 reported current or previous use of psychiatric medication. All participants reported exposure to at least one potentially traumatic event, which was required for inclusion in the study.

Table 1

Descriptive statistics, reliability coefficients, and intercorrelations among the study variables

Variable	M	SD	Min	Max	Skewness	Kurtosis	Cronbach's alpha	McDonald's omega	1	2	3	4
Trauma exposure	4.28	2.34	1.00	13.00	0.91	0.74	—	—	1.00			
Dissociation	21.64	14.82	0.00	72.86	0.83	0.46	0.94	0.95	0.41***	1.00		
Alexithymia	58.37	12.06	23.00	92.00	0.22	-0.31	0.86	0.87	0.34***	0.52***	1.00	
Emotional numbness	42.18	11.47	16.00	70.00	0.18	-0.42	0.91	0.92	0.43***			

Table 1 presents the descriptive statistics, internal consistency coefficients, and correlations among trauma exposure, dissociation, alexithymia, and emotional numbness. The mean trauma exposure score indicated that participants had experienced multiple forms of potentially traumatic events across the lifespan. Dissociation showed moderate variability, suggesting that the sample included individuals with both low and clinically meaningful levels of dissociative experience. Alexithymia scores were also elevated in a considerable portion of the sample, reflecting difficulties in identifying and describing emotional states. Emotional numbness scores showed adequate dispersion and no severe departure from normality, supporting the suitability of the variable for regression-based machine learning analysis. Reliability coefficients were strong for

dissociation, alexithymia, and emotional numbness, with Cronbach's alpha and McDonald's omega values exceeding the conventional threshold of acceptable internal consistency. The correlation matrix showed that all three predictor variables were significantly and positively associated with emotional numbness. Dissociation had the strongest bivariate relationship with emotional numbness, followed by alexithymia and trauma exposure. Trauma exposure was also positively correlated with dissociation and alexithymia, indicating that broader traumatic event exposure was associated with higher dissociative symptoms and greater difficulty processing emotional states. These preliminary findings supported the theoretical and statistical rationale for entering trauma exposure, dissociation, and alexithymia into the Explainable Boosting Machine model.

Table 2

Predictive performance of the baseline regression model and Explainable Boosting Machine model

Model	Dataset	RMSE	MAE	R ²	Explained variance
Multiple linear regression	Training set	8.31	6.48	0.47	47.00%
Multiple linear regression	Validation set	8.74	6.83	0.42	42.00%
Multiple linear regression	Test set	8.55	6.71	0.44	44.00%
Explainable Boosting Machine	Training set	7.23	5.62	0.60	60.00%
Explainable Boosting Machine	Validation set	7.81	6.08	0.54	54.00%
Explainable Boosting Machine	Test set	7.67	5.94	0.56	56.00%

Table 2 compares the predictive performance of the conventional multiple linear regression model and the Explainable Boosting Machine model across the training, validation, and independent test datasets. The baseline multiple linear regression model explained 44.00% of the variance in emotional numbness in the independent test set, indicating that trauma exposure, dissociation, and alexithymia had meaningful linear predictive value. However, the Explainable Boosting Machine model showed stronger performance across all evaluation indices. In the test set, the EBM model explained 56.00% of the variance in emotional numbness, showing a 12-percentage-point improvement over the linear regression model. The EBM

model also produced lower prediction errors, with a test RMSE of 7.67 and a test MAE of 5.94, compared with an RMSE of 8.55 and an MAE of 6.71 in the linear regression model. The relatively small difference between the training, validation, and test performance of the EBM model indicated that the model did not show substantial overfitting and that its predictive accuracy generalized adequately to unseen cases. These findings suggest that the associations between the predictors and emotional numbness were not fully linear and that the interpretable non-linear structure of the EBM model provided a more accurate representation of the psychological pattern underlying emotional numbness.

Table 3

Global importance of predictors and detected interaction effects in the Explainable Boosting Machine model

Predictor or interaction term	Importance score	Normalized importance	Direction of association with emotional numbness	Interpretation
Dissociation	0.312	100.00	Positive, non-linear	Strongest predictor; higher dissociation was associated with higher predicted emotional numbness, especially at moderate-to-high dissociation levels
Alexithymia	0.247	79.17	Positive, threshold-based	Higher alexithymia predicted higher emotional numbness, with a marked increase after the mid-range of the scale
Trauma exposure	0.164	52.56	Positive, stepped	Greater cumulative trauma exposure was associated with higher emotional numbness, particularly after exposure to multiple event categories
Dissociation × Alexithymia	0.056	17.95	Amplifying interaction	Emotional numbness was highest when both dissociation and alexithymia were elevated
Trauma exposure × Dissociation	0.041	13.14	Conditional interaction	The effect of trauma exposure was stronger among participants with higher dissociation
Trauma exposure × Alexithymia	0.022	7.05	Weak interaction	Trauma exposure contributed slightly more to emotional numbness when alexithymia was elevated

Table 3 presents the global interpretability results of the Explainable Boosting Machine model. Among the three main predictors, dissociation had the highest normalized importance score and was therefore the strongest predictor of emotional numbness. This finding indicates that disruptions in awareness, memory, identity, perception, and emotional integration were central to the prediction of reduced emotional responsiveness. Alexithymia was the second most important predictor, showing that difficulty identifying and describing emotions substantially contributed to emotional numbness beyond the effect of dissociation. Trauma exposure was also an important predictor, although its relative contribution was smaller than those of dissociation and alexithymia. This pattern suggests

that emotional numbness was not predicted merely by the amount of trauma exposure but also by the individual's psychological processing of trauma-related experience. The interaction results further clarified this pattern. The strongest interaction was observed between dissociation and alexithymia, indicating that participants with both elevated dissociative experiences and high alexithymia had the highest predicted emotional numbness scores. The trauma exposure by dissociation interaction also showed that cumulative trauma exposure became more predictive of emotional numbness when dissociation was elevated. The weakest interaction was observed between trauma exposure and alexithymia, suggesting a modest conditional effect.

Figure 1

Explainable Boosting Machine shape functions for predicting emotional numbness from trauma exposure, dissociation, and alexithymia

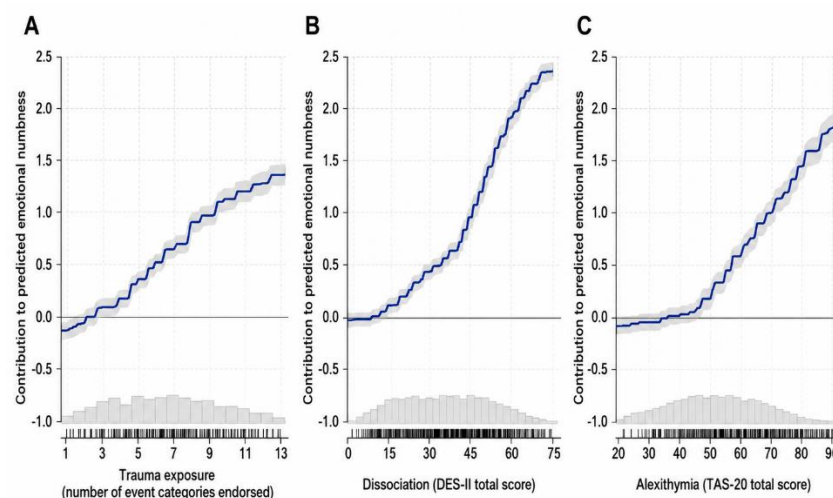


Figure 1 illustrates the shape functions generated by the Explainable Boosting Machine model for the three primary predictors of emotional numbness. The shape function for trauma exposure showed a stepped positive pattern, indicating that predicted emotional numbness increased as the number of endorsed traumatic event categories increased. The increase was relatively gradual at lower levels of exposure but became more pronounced once participants reported exposure to four or more traumatic event categories, suggesting that cumulative trauma burden may have a threshold-like relationship with emotional restriction. The shape function for dissociation showed the clearest and strongest non-linear pattern. Predicted emotional numbness remained comparatively lower at minimal dissociation levels, increased steadily across the moderate range, and rose sharply when dissociation scores moved into the higher range. This pattern suggests that dissociation may be especially important when it exceeds ordinary absorption-like experiences and begins to reflect more disruptive forms of psychological detachment, depersonalization, derealization, or memory discontinuity. The shape function for alexithymia also showed a positive threshold-based pattern, with predicted emotional numbness increasing most clearly after the mid-range of alexithymia scores. This indicates that difficulty recognizing and verbalizing emotions may become particularly predictive of emotional numbness when emotional processing deficits reach a moderate or high level. Taken together, the figure shows that the EBM model did not treat the predictors as having simple linear effects. Instead, it revealed clinically meaningful non-linear patterns, in which emotional numbness was most strongly predicted by elevated dissociation, high alexithymia, and repeated exposure to traumatic events.

4. Discussion

The present study examined the prediction of emotional numbness from trauma exposure, dissociation, and alexithymia among trauma-exposed adults in Canada using an Explainable Boosting Machine model. The findings showed that all three predictor variables were positively associated with emotional numbness, with dissociation showing the strongest bivariate correlation, followed by alexithymia and trauma exposure. In the predictive modeling phase, the EBM model outperformed the conventional multiple linear regression model, explaining 56% of the variance in emotional numbness in the independent test set

compared with 44% explained by the linear regression model. This finding indicates that emotional numbness is not adequately represented as a simple linear outcome of trauma exposure alone; rather, it appears to emerge from a more complex configuration of trauma burden, dissociative processing, and impaired emotional awareness. The global interpretability results further showed that dissociation had the highest importance score, alexithymia was the second most influential predictor, and trauma exposure contributed meaningfully but less strongly than the two psychological processing variables. This pattern supports the view that the psychological organization of trauma-related experience may be more predictive of emotional numbness than the mere number of traumatic events. Trauma theories emphasize that traumatic experiences can disrupt affective integration, memory processing, self-experience, and relational meaning, which may lead not only to distress and hyperarousal but also to restricted emotional responsiveness and detachment (Paivio & Pascual-Leone, 2023). The present findings are therefore consistent with the assumption that emotional numbness reflects a trauma-related alteration in emotional processing rather than a simple reduction in mood or affective intensity.

The strong predictive role of dissociation is one of the most important findings of this study. In the EBM model, dissociation showed the highest global importance and a clear non-linear pattern, with predicted emotional numbness increasing sharply when dissociation reached moderate-to-high levels. This suggests that mild dissociative experiences may not necessarily produce severe emotional restriction, whereas more persistent or disruptive dissociative processes may substantially increase emotional numbness. This result is consistent with contemporary models that conceptualize dissociation as a multidimensional phenomenon involving disruptions in consciousness, memory, identity, perception, emotional integration, and bodily experience (Lynn et al., 2022). The finding also aligns with evidence showing that dissociative symptomatology mediates the relationship between posttraumatic stress severity and alcohol-related problems, suggesting that dissociation may function as a mechanism through which trauma-related distress becomes transformed into maladaptive coping and emotional disengagement (Patel et al., 2022). In addition, studies on pathways to negative symptoms in psychosis have identified trauma, attachment disturbance, dissociation, and alexithymia as interconnected mechanisms contributing to reduced emotional expression and motivational impairment (Grady et al., 2025). The present study extends this line of

evidence by showing that dissociation is not only associated with broad psychopathology but also has a dominant and interpretable role in predicting emotional numbness specifically.

The importance of dissociation may be explained by the defensive function it often serves in response to overwhelming emotional states. When traumatic experience exceeds the individual's capacity for integration, dissociative detachment may reduce immediate emotional pain by limiting access to traumatic affect, bodily arousal, and autobiographical meaning. However, this same defensive process may later become generalized, producing chronic restriction in emotional responsiveness. The current EBM shape function supports this interpretation, as emotional numbness increased most strongly at higher dissociation levels, indicating a possible threshold at which dissociation shifts from an occasional coping response to a broader disruption in emotional life. Emerging work on the dissociation of intimacy further supports the idea that dissociation can interfere with closeness, relational presence, and affective connection, thereby linking dissociative processes with emotional and interpersonal detachment (Caretti, 2025). This is also consistent with studies of mentalization among asylum seekers with posttraumatic stress disorder, which suggest that trauma may impair the ability to understand one's own and others' internal states, thereby contributing to emotional disconnection and relational difficulty (Aragona et al., 2025). Therefore, the strong role of dissociation in the present study may reflect a broader impairment in integrating emotion into conscious self-experience.

Alexithymia also emerged as a major predictor of emotional numbness. The EBM results showed that alexithymia had the second highest importance score and followed a threshold-based pattern, with predicted emotional numbness increasing more clearly after the mid-range of alexithymia scores. This indicates that difficulty identifying and describing emotions may become especially consequential when emotional awareness deficits reach a moderate or high level. The finding is highly consistent with meta-analytic evidence showing that alexithymia is strongly associated with posttraumatic stress presentation and severity (Edwards, 2022). It also aligns with findings that assessing alexithymia provides explanatory value in the context of posttraumatic stress beyond coping alone, because alexithymia reflects a core limitation in accessing and symbolizing emotional states (Bowen et al., 2022). Similarly, research on alexithymia and emotional deficits

related to posttraumatic stress disorder has emphasized that trauma-related alexithymia may involve both content disturbances, such as limited emotional vocabulary, and process disturbances, such as impaired emotional access and differentiation (Ogłodek, 2022). In the present study, emotional numbness may therefore be understood partly as the subjective consequence of not being able to identify, interpret, or communicate internal affective states.

The relationship between alexithymia and emotional numbness can also be interpreted developmentally and transdiagnostically. Meta-analytic evidence indicates that child maltreatment is associated with higher alexithymia, suggesting that adverse developmental contexts may impair the acquisition of emotional awareness and language (Ditzer et al., 2023). Other studies similarly show that childhood trauma may contribute to later maladaptive outcomes through alexithymia and rumination, indicating that emotional processing deficits can form part of a pathway from trauma to psychological impairment (Wang, 2024). In addition, alexithymia has been shown to mediate or moderate associations between trauma and multiple psychological outcomes, including nomophobia following childhood emotional abuse (Saladino, 2025), posttraumatic stress after early pregnancy loss through intolerance of uncertainty (Xu et al., 2025), and negative emotionality in the context of racial trauma (Phillips et al., 2026). These studies support the present finding that alexithymia is not a secondary or incidental characteristic but a central emotional-processing vulnerability that may intensify trauma-related emotional numbing. From this perspective, emotional numbness may not indicate that emotion is absent; rather, emotion may be present but poorly differentiated, inaccessible, or disconnected from verbal-symbolic representation.

Trauma exposure was also a significant predictor of emotional numbness, although its contribution was smaller than that of dissociation and alexithymia. This finding is theoretically meaningful. It suggests that cumulative trauma exposure increases vulnerability to emotional numbness, but its predictive power depends substantially on how trauma is psychologically processed. The shape function for trauma exposure showed a stepped positive pattern, with emotional numbness increasing more noticeably after participants endorsed multiple traumatic event categories. This is consistent with evidence that early life stress and trauma have long-term implications for adult psychological functioning, including mindfulness, emotional awareness, and stress regulation (Gibson, 2024). It also corresponds

with research showing that trauma exposure within families may contribute to intergenerational somatization and altered expression of distress (Glaus et al., 2022). Furthermore, trauma can affect not only fear systems but also reward and positive affect systems, as reflected in research showing that posttraumatic stress disorder may alter interaction with positive stimuli and reward-related experience (Seidemann et al., 2021). Therefore, the present finding that trauma exposure predicts emotional numbness supports the idea that repeated or cumulative trauma may progressively reduce emotional responsiveness, especially when traumatic experiences involve chronic threat, helplessness, relational betrayal, or emotional invalidation.

The interaction findings further clarify the psychological structure of emotional numbness. The strongest interaction was between dissociation and alexithymia, indicating that predicted emotional numbness was highest when both dissociative experiences and alexithymic traits were elevated. This result suggests that emotional numbness may be intensified when two forms of emotional disconnection co-occur: dissociation reduces integration of emotional experience, while alexithymia reduces the ability to identify and describe whatever emotional experience remains accessible. The interaction between trauma exposure and dissociation also showed that cumulative trauma was more strongly related to emotional numbness among individuals with higher dissociation. This supports the idea that trauma exposure may be particularly numbing when it is processed through detachment rather than integration. Similar integrated pathways have been observed in research on addictive behaviors, where vulnerability and maintenance factors include emotional dysregulation, dissociative tendencies, and maladaptive regulation strategies (Gori et al., 2023). Studies of problematic sexual behavior have also shown that alexithymia may be linked to maladaptive behavior through dissociative patterns, reinforcing the possibility that alexithymia and dissociation operate together rather than separately (Topino et al., 2025). The present findings therefore suggest that the combined presence of dissociation and alexithymia may represent a particularly high-risk psychological profile for emotional numbness.

The findings also align with broader literature on emotional clarity, emotion differentiation, and emotion regulation. Trauma-exposed individuals with lower negative emotion differentiation have been shown to experience greater posttraumatic stress symptoms in daily life (Pugach et al., 2023). Women exposed to physical intimate partner violence also show links between emotional clarity and

psychopathology, suggesting that the capacity to understand emotional states is essential for adaptation after trauma (Joseph et al., 2024). Similarly, emotion processes among voice-hearers, including emotional reactivity, emotion regulation, and alexithymia, have been shown to meaningfully differentiate psychological functioning (Cusworth et al., 2024). These findings support the present conclusion that emotional numbness is closely tied to the individual's capacity to recognize, differentiate, and regulate emotion. The relevance of self-regulatory functioning is further supported by research on self-regulatory profiles, which highlights the importance of examining patterns of emotional and behavioral regulation rather than isolated symptom dimensions (Vail et al., 2025). Therefore, the EBM results contribute to the field by showing that emotional numbness can be understood as a predictable outcome of dysregulated and poorly integrated emotional systems.

The superiority of the EBM model over linear regression is another important finding. The EBM explained a larger proportion of variance and produced lower prediction error, while also preserving interpretability through predictor importance scores and shape functions. This suggests that emotional numbness is characterized by non-linear and threshold effects that conventional linear regression may partially obscure. For example, the effect of dissociation appeared to increase sharply at moderate-to-high scores, and the effect of alexithymia became more pronounced beyond mid-range values. These patterns are consistent with the broader movement toward more complex biopsychosocial, neuropsychological, and computational models in clinical psychology and psychiatry (Cole et al., 2025). They are also compatible with mechanistic approaches to affective and personality-related psychopathology, including work on borderline personality disorder and neural correlates of emotional dysregulation (Chmiel & Kurpas, 2025). In addition, research showing that trauma and loss spectrum factors mediate relationships between autistic traits and eating disorder symptoms among patients with borderline personality disorder supports the need to study complex interrelations among trauma, affective processing, and clinical outcomes (Carpita et al., 2025). In this context, EBM offers a useful analytic framework because it allows clinically interpretable modeling of non-linear associations and interactions.

5. Conclusion

Finally, the results have important implications for trauma-focused assessment and intervention. Trauma-focused treatment may reduce not only core posttraumatic symptoms but also attendant symptoms and broader affective and structural dysregulation (Stingl et al., 2021). However, individual differences in alexithymia may influence response to prolonged exposure therapy and its mechanisms of change, because trauma-focused work often requires emotional engagement, labeling, and processing (Putica et al., 2024). Alexithymia and maladaptive cognitive processes may also affect meta-awareness of trauma-related memories, suggesting that some individuals may have difficulty recognizing and reflecting on trauma-related internal states (Sun et al., 2025). The present findings therefore indicate that emotional numbness should be assessed through multiple domains: trauma exposure, dissociation, and alexithymia. In addition, culturally and socially embedded forms of psychological suffering should not be overlooked, as trauma-related distress can be shaped by social exclusion, marginalization, and available narratives of suffering (Cherechés, 2024). Neuropsychiatric evidence on alexithymia also suggests that emotional awareness depends on broader systems of self-referential and social-emotional processing (Mendez, 2021). Overall, the findings support an integrated interpretation of emotional numbness as a trauma-related outcome most strongly predicted by dissociative detachment and alexithymic emotional-processing deficits, with cumulative trauma exposure contributing through both direct and conditional pathways.

6. Limitations & Suggestions

This study had several limitations that should be considered when interpreting the findings. First, the cross-sectional design prevents causal conclusions about the direction of relationships among trauma exposure, dissociation, alexithymia, and emotional numbness. Although the predictive model identified important associations and non-linear patterns, it cannot determine whether trauma exposure caused dissociation and alexithymia, whether dissociation and alexithymia contributed to emotional numbness over time, or whether emotional numbness itself influenced participants' reporting of internal experiences. Second, all variables were assessed using self-report questionnaires, which may be affected by recall bias, response style, social desirability, and limited

insight, particularly because dissociation and alexithymia involve disruptions in awareness and emotional reporting. Third, the use of an online Canadian adult sample increased accessibility and geographic diversity, but it may have excluded individuals with limited internet access, lower literacy, severe clinical instability, or insufficient English-language comprehension. Fourth, although the EBM model was interpretable and performed better than linear regression, it was developed within a single sample and requires external validation before being generalized to other populations, clinical settings, cultural groups, or trauma types. Fifth, trauma exposure was measured as a cumulative event-count index, which does not fully capture severity, chronicity, age of onset, interpersonal betrayal, perceived threat, or duration of traumatic experiences.

Future studies should use longitudinal designs to examine whether trauma exposure, dissociation, and alexithymia prospectively predict the development or persistence of emotional numbness over time. Such studies would help clarify whether dissociation and alexithymia function as mediators, moderators, maintenance factors, or consequences of emotional numbness. Future research should also validate the present EBM model in independent samples, including clinical PTSD populations, refugees and asylum seekers, survivors of interpersonal violence, military and first-responder populations, and individuals with complex trauma histories. It would also be valuable to include more detailed trauma variables, such as developmental timing, interpersonal nature, chronicity, betrayal, perceived helplessness, and cumulative adversity load. In addition, future studies should combine self-report instruments with clinician-rated assessments, behavioral emotion-recognition tasks, ecological momentary assessment, psychophysiological measures, and neurocognitive indicators of emotional processing. Further research could also compare EBM with other interpretable and non-interpretable machine learning models to determine whether predictive accuracy can be improved while maintaining clinical transparency. Finally, future studies should examine whether specific treatment processes, such as improved emotional labeling, reduced dissociation, increased embodiment, and enhanced affect tolerance, reduce emotional numbness in trauma-exposed individuals.

The findings suggest that clinicians working with trauma-exposed adults should assess emotional numbness as a distinct and clinically meaningful outcome rather than treating it only as a secondary feature of posttraumatic stress. Assessment should include not only the presence and

number of traumatic events but also dissociative experiences and alexithymic difficulties, because these psychological processing variables may provide more precise information about emotional restriction. In clinical practice, individuals with high dissociation may benefit from stabilization, grounding, body-oriented awareness, and gradual integration strategies before intensive trauma processing is introduced. Individuals with elevated alexithymia may require interventions that strengthen emotional vocabulary, emotional differentiation, affect labeling, and reflective awareness before they can fully engage in trauma-focused emotional processing. The results also suggest that treatment planning should be individualized, because emotional numbness may arise from different profiles of trauma burden, dissociative detachment, and impaired emotional awareness. Clinicians should monitor emotional numbness throughout treatment, especially when clients appear behaviorally functional but report limited emotional experience, reduced pleasure, detachment from relationships, or difficulty identifying internal states. In addition, explainable prediction models may eventually support clinical decision-making by helping practitioners identify which mechanisms are most relevant for each client and by guiding targeted intervention planning.

Acknowledgments

We would like to express our appreciation and gratitude to all those who cooperated in carrying out this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

Authors' Contributions

All authors equally contributed in this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

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