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The potential addictive mechanism involved in repetitive nonsuicidal self-injury: The roles of emotion dysregulation and impulsivity in adolescents

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FULL-LENGTH REPORT



ABSTRACT

Background and aims: Nonsuicidal self-injury (NSSI) is highly prevalent in adolescents and is associated with various mental health problems. Repetitive NSSI (R-NSSI), as an extreme manifestation of NSSI, is a growing concern and has been proposed as a behavioral addiction. However, little is known about the potential addictive mechanisms of NSSI. This study aimed to examine the mediating effect of emotion dysregulation and the moderating effect of impulsivity using the Interaction of Person-Affect-Cognition-Execution (I-PACE) model in adolescents who repeatedly engage in NSSI. **Methods:** A total of 3,915 adolescents (mean age = 13.21 years, SD = 0.87, 57.6% male) were recruited from three middle schools. Relevant questionnaires were used to evaluate childhood maltreatment, emotion dysregulation, impulsivity, and NSSI. Mediation and moderated mediation analyses were conducted separately for adolescents with occasional NSSI (O-NSSI) and R-NSSI to assess the relationship between childhood maltreatment, emotion dysregulation, impulsivity, and NSSI frequency. **Results:** Our study found that childhood maltreatment was directly related to NSSI and indirectly related to NSSI through emotion dysregulation in both the R-NSSI and O-NSSI groups. Furthermore, impulsivity played a moderating role in the relationship between emotion dysregulation and NSSI in the R-NSSI group but not in the O-NSSI group. **Discussion and conclusions:** The findings suggest that a high level of impulsivity and a high level of emotion dysregulation may be important risk addictive factors of NSSI through childhood maltreatment. Strengthening the emotion regulation skills and inhibitory control of adolescents with NSSI would be helpful to reduce their self-injury behaviors and maintain their mental health. This finding also supports the validity of the I-PACE model for evaluating R-NSSI.

KEYWORDS

childhood maltreatment, emotion dysregulation, addictive behaviors, impulsivity, repetitive nonsuicidal self-injury

INTRODUCTION

Nonsuicidal self-injury (NSSI) refers to the direct and deliberate destruction of body tissue in the absence of any observable intent to die (Nock, 2010) and is especially prevalent in adolescence. Approximately one in five adolescents in the community (22%) engage in NSSI, and half of those who experience NSSI hurt themselves repeatedly (Gillies et al., 2018; Klonsky & Olino, 2008). Previous studies have found that adolescents with repetitive NSSI have a variety of psychological disorders (e.g., anxiety and depressive symptoms) and are at high risk of future suicide attempts and behaviors (Guan, Fox, & Prinstein, 2012; Spitz et al., 2020). This makes repetitive NSSI a substantial public health concern.

Repetitive NSSI as a behavioral addiction

Among adolescents with NSSI, there are two different subpopulations of NSSI, those engaging in repetitive NSSI (R-NSSI) and those engaging in occasional NSSI (O-NSSI),

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which differ in frequency, motivation, and psychological and psychopathological correlates (Brunner et al., 2007; Manca, Presaghi, & Cerutti, 2014). Brunner et al. (2014) examined differences in adolescent occasional and repetitive NSSI in a large community and found high levels of depression, anxiety, and suicidality in both the R–NSSI and O–NSSI groups; however, the relative risk ratios were higher for the R–NSSI group. A 10-year follow-up study also found that individuals with R–NSSI in adolescence showed a substantially increased risk for mental health problems in young adulthood (Daukantaitė et al., 2021). These findings suggest that R–NSSI is associated with more severe psychopathology, and greater attention should be given to R–NSSI in adolescence.

Researchers have recognized the addictive elements of repetitive engagement in NSSI and conceptualized R–NSSI as a potential addictive behavior (Nixon, Cloutier, & Aggarwal, 2002; Pritchard, Fedchenko, & Lewis, 2021; Worley, 2020). For example, Nixon et al. (2002) found that many addictive features, such as strong urges to self-injure that cannot be stopped, chronic and relapsing tendencies, and an escalation of frequency and severity over time, are displayed in adolescents with R–NSSI. Other studies also found that individuals report repeatedly engaging in NSSI to achieve feelings of relaxation, excitement, or exhilaration (Klonsky, 2007) and a drug-like “high” (Guérin-Marion, Martin, Deneault, Lafontaine, & Bureau, 2018), which suggests a strong association between frequent acts of NSSI and an increased risk for NSSI addiction (Davis & Lewis, 2019). However, previous studies have mainly focused on the addictive features of R–NSSI, and little is known about the underlying mechanisms. Illuminating the potential addictive pathways of R–NSSI may help us gain a better understanding of NSSI and offer important insights into leverage points for early prevention and targeting interventions for NSSI.

Childhood maltreatment and repetitive NSSI

Childhood maltreatment, in the form of abuse and neglect, has been found to be a salient risk factor for NSSI (Ford & Gómez, 2015; Kaplan et al., 2016; Serafini et al., 2017). Nock’s (2009) integrated model of NSSI emphasizes that the risk for NSSI is increased by the presence of distal risk factors (e.g., childhood maltreatment). Evidence from cross-sectional and longitudinal studies has also established the detrimental effect of child maltreatment experiences on NSSI among adolescents (Baetens et al., 2015; He & Xiang, 2022). Moreover, childhood maltreatment is robustly associated with the risk of addictive behaviors in youth, such as gambling problems, internet addiction, and substance-related addiction problems (Felsher, Derevensky, & Gupta, 2010; Lo et al., 2021; Oshri, Liu, Duprey, & MacKillop, 2018). In one study, Martin et al. (2016) also pointed out that childhood maltreatment is uniquely related to the addictive features of NSSI in undergraduate students. It is not yet clear, however, whether childhood maltreatment may influence R–NSSI in adolescents.

The Interaction of Person-Affect-Cognition-Execution (I-PACE) model provides an integrative theoretical framework for the basic process of developing and maintaining addictive behaviors (Brand et al., 2019). In the I-PACE model, childhood maltreatment plays a pivotal role in the onset of several types of addictive behaviors. Several studies have also indicated that individuals with adverse childhood experiences have the potential to experience increased sensitivity to stress and that these individuals are associated with functional and structural abnormalities in cortico-striatal-limbic brain regions (Briand & Blendy, 2010; Elsey et al., 2015), which may increase the risk of developing specific addictive disorders. Thus, based on previous studies, we expected that childhood maltreatment would be positively associated with R–NSSI.

The mediating role of emotion dysregulation

The I-PACE model shows that individuals with a history of childhood maltreatment tend to exhibit affective responses such as emotion dysregulation, which may lead to specific addictive behaviors (Brand et al., 2019). Additionally, Nock’s (2009) integrated model posits that early distal risk factors, such as childhood maltreatment, can undermine an individual’s ability to adaptively regulate their emotions, which in turn can lead to NSSI as a form of emotional coping behavior (Nock, 2010). According to these theories, emotion dysregulation may serve as an important mediator of the relationship between maltreatment and NSSI frequency among individuals with R–NSSI.

Emotion regulation refers to “an individual’s ability to modify an emotional state to promote adaptive, goal-oriented behaviors” (Thompson, 1994). Empirical findings have shown a strong association among childhood maltreatment, emotion dysregulation and NSSI in adolescents (Ghaderi, Ahi, & Shahabizadeh, 2020; Peh et al., 2017; Titelius et al., 2018). On the one hand, researchers have shown that childhood maltreatment is strongly associated with adolescents’ emotion dysregulation (Dvir, Ford, Hill, & Frazier, 2014; Weissman et al., 2019). For example, a recent meta-analysis of thirty-five studies ($N = 11,344$) found childhood maltreatment to be significantly related to increased emotion dysregulation (Gruhn & Compas, 2020). On the other hand, several longitudinal studies have also found that emotion dysregulation predicts greater engagement in NSSI among adolescents (Duggan, Heath, & Hu, 2015; Heffer & Willoughby, 2018). Moreover, in one study, emotion dysregulation was linked to NSSI addictive features, such as increased frequency, and emotion dysregulation may promote an intensification of the use of NSSI over time (Nixon et al., 2002). Although previous studies have indicated the potential mediating role of emotion dysregulation in NSSI, no research has explicitly addressed whether emotion dysregulation plays a mediating role in the relationship between childhood maltreatment and NSSI frequency among individuals with O–NSSI and R–NSSI. Considering the distinctions between R–NSSI and O–NSSI, it is necessary to further explore the mediating role of



emotion dysregulation between childhood maltreatment and NSSI frequency among adolescents with R–NSSI and O–NSSI.

The moderating role of impulsivity

Impulsivity refers to “a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions for the impulsive individual or others” (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Prior studies have emphasized that impulsivity is significantly related to NSSI; specifically, adolescents with high levels of impulsivity are associated with a higher likelihood of engaging in NSSI (Berg, Latzman, Bliwise, & Lilienfeld, 2015; Greenberg, Zhai, Hoff, Krishnan-Sarin, & Potenza, 2021). Impulsivity is also known to play a crucial role in addictive behaviors (Potenza, 2013). In line with the I-PACE model, impulsivity may serve as an important moderator of the relationship between emotion dysregulation caused by childhood maltreatment and engagement in repetitive NSSI (Brand et al., 2019). This model provides insights into the conditional mechanisms underlying the role of impulsivity in R–NSSI. Indeed, impulsivity has been proposed as the moderator between mood disorders and a number of addictive behaviors (Blasco-Fontecilla et al., 2016; Swann, Dougherty, Pazzaglia, Pham, & Moeller, 2004). Evidence from prior studies suggests an interactive effect of impulsivity and emotion dysregulation on maladaptive addiction behaviors. For instance, emotion dysregulation was found to be more strongly related to food addiction for individuals with more, as opposed to less, impulsivity (Pivarunas & Conner, 2015).

Some studies have demonstrated the moderating role of impulsivity in addictive behaviors, while little is known about how impulsivity plays a moderating role in the potential addictive pathway from emotion dysregulation to NSSI frequency within individuals with R–NSSI. Given the prevalence and consequences of R–NSSI, it is critical to explore the role of impulsivity in the relationship between emotion dysregulation and NSSI frequency among adolescents with R–NSSI, which could provide further intervention information for R–NSSI in adolescents.

The current study

Using the I-PACE model as a conceptual framework, we examined the explanatory processes leading to increased NSSI that are involved in the association between childhood maltreatment and NSSI frequency by testing a moderated mediation model among adolescents included in R–NSSI and O–NSSI groups. Our primary hypotheses were as follows: (1) childhood maltreatment would be positively associated with NSSI frequency in both the O–NSSI and R–NSSI groups; (2) emotion dysregulation would mediate the association between maltreatment exposure and NSSI frequency in the O–NSSI and R–NSSI groups; and (3) impulsivity would have a differential role in the moderation of emotion dysregulation and NSSI frequency in the R–NSSI and O–NSSI groups.

METHODS

Participants and procedures

A total of 3,915 healthy adolescents in Grades 7 to 8 were recruited from three middle schools located in North China. Among these adolescents, 270 were excluded because they did not fully complete the survey, so the final sample consisted of 3,645 adolescents (2,059 males, 56.5%) aged 10–16 years old ($M_{age} = 13.21$, $SD = 0.86$). The median household income of the participating families was ¥6,000–¥10,000 per month (approximately \$950–\$1,582). The median education level was a middle school education among both fathers and mothers. Among the participants ($n = 3,645$), 23.5% ($n = 857$; 49.9% female) reported having engaged in NSSI at least once in the past six months, and the most common self-injury methods reported included biting (9.9%; $n = 360$), preventing wounds from healing (9.9%; $n = 360$), and hitting (9.2%; $n = 299$). Given the aim of our research, the final sample included 857 adolescents who had engaged in NSSI at least once.

Written informed consent was obtained from the participants and their parent(s)/caregivers prior to the study. Participants were informed that participation was voluntary, that all the collected data would be kept confidential and that they were free to withdraw from the study at any time during data collection. The questionnaires took approximately 30–35 min to complete. Trained researchers administered the self-report questionnaires to the students in class during regular school hours. After the survey, each participant received a gift of pens and notebooks.

Measures

A demographic questionnaire was created for the purpose of the study to assess demographic characteristics such as sex, age, subjective socioeconomic status, family income, parental education levels, and parental occupation.

Childhood maltreatment was measured using the translated version of the Childhood Trauma Questionnaire-Short Form (CTQ-SF, Bernstein et al., 2003). Twenty-eight items (e.g., Family members have hit me hard enough to leave bruises or marks) were measured on a 5-point Likert scale ranging from 1 (never) to 5 (very often). The sum score of all items was calculated as the final score, with higher scores reflecting more severe maltreatment in childhood. The questionnaire asked subjects about their upbringing prior to the age of 12 with questions relating to four main domains of childhood abuse and neglect (emotional abuse, physical abuse, emotional neglect, and physical neglect). To evaluate the prevalence of childhood maltreatment, we used the standard cutoff scores of the CTQ to determine if a participant had been exposed to a specific form of maltreatment. The cutoff criteria, which were examined in Chinese samples, were as follows (Li et al., 2014): physical abuse scores ≥ 8 , physical neglect scores ≥ 8 , emotional abuse scores ≥ 9 , and emotional neglect scores ≥ 10 . In the present study, the Cronbach's α coefficient was 0.87.



Emotion dysregulation was measured using the short form of the Difficulties in Emotion Regulation Scale (DERS-SF, Kaufman et al., 2016), which consists of 18 items with answers ranging from 1 (almost never) to 5 (almost always). To assess difficulties regulating emotions in times of distress, many items begin with “When I’m upset.” Respondents are asked to indicate how often the items applied to themselves (e.g., When I’m upset, I have difficulty focusing on other things). Higher scores represent greater difficulty regulating emotions. In the present study, the Cronbach’s alpha coefficient was 0.86.

Impulsivity was assessed using the Chinese version of the Barratt Impulsiveness Scale (BIS-11) (Li et al., 2011; Patton, Stanford, & Barratt, 1995), a widely used self-reported measure of impulsiveness. Twenty items (e.g., I make up my mind quickly; I often have extraneous thoughts when thinking) are measured on a 5-point Likert scale ranging from 1 (never) to 5 (always). The sum score of all items was calculated as the final score, with higher scores reflecting higher levels of impulsivity. In the present study, the Cronbach’s alpha coefficient was 0.87.

Nonsuicidal self-injury was measured using a shortened and modified version of the Deliberate Self-Harm Inventory (DSHI) developed and validated by Gratz (2001). The scale includes nine items (hitting, scratching, piercing, burning, biting, and cutting to bleed). Each of the items is rated on a seven-point scale of 0 (never) to 6 (more than five times), reflecting participants’ frequency of self-injury behaviors over the past six months. Scores are calculated by averaging all the responses; higher scores indicate higher levels of NSSI. The scale has been successfully used among Chinese adolescents and has exhibited good reliability and validity (Huang, Zhao, & Li, 2021). In the present study, the Cronbach’s alpha coefficient was 0.87.

Statistical analysis

All statistical analyses were conducted using SPSS 19.0. First, Pearson’s correlation analysis was used to examine the relationship among childhood maltreatment, emotion dysregulation, impulsivity and NSSI. Second, we divided the participants into two groups according to the frequency of NSSI (participants with NSSI scores of ≥ 4 were included in the R–NSSI group and those with NSSI scores of < 4 were included in the O–NSSI group) (Brunner et al., 2007; Lutz et al., 2021). We tested the hypothesized conceptual models in the R–NSSI group and O–NSSI group separately and used the PROCESS macro for SPSS (Model 4 & Model 14) developed by Hayes (2013), which is able to test mediating, moderating, and moderated mediating effects. Specifically, to examine the mediating effect of emotion dysregulation, Model 4 in SPSS was used, with childhood maltreatment as the independent variable, emotion dysregulation as the mediating variable, and NSSI frequency as the dependent variable. To examine the moderating effect of impulsivity, Model 14 in SPSS was used, with childhood maltreatment as the independent variable, emotion dysregulation as the mediating variable, impulsivity as the moderating variable,

and NSSI frequency as the dependent variable. According to Model 14 (Hayes & Matthes, 2009), the moderated mediating effect was computed using bias-corrected bootstrapping with 5,000 samples; a 95% confidence interval (CI) that did not include zero indicated a significant effect. If the moderated mediating effect was significant, slope tests were conducted. Three values of impulsivity, including low (one standard deviation below the mean), moderate, and high (one standard deviation above the mean) levels, were defined to acquire detailed information.

In addition, previous studies have found that some sociodemographic variables, such as sex, age, and perceptions of one’s family’s socioeconomic status (SSES), account for individual differences relating to the main variables (Nock, 2010; Plener, Schumacher, Munz, & Groschwitz, 2015); therefore, as these were not the primary concerns for the current study, sex, age, and subjective socioeconomic status were controlled in all subsequent analyses.

Ethics

Approval was obtained from the ethics committee of Institutional Review Board of the Faculty of Psychology, Beijing Normal University (IRB Number 202112100080). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

RESULTS

Descriptive statistics

Among the participants ($n = 3,645$), 38.3% ($n = 1,396$) reported having experienced at least one form of maltreatment in childhood: 772 subjects (21.2%) reported emotional abuse, 350 subjects (9.6%) reported physical abuse, 605 subjects (16.6%) reported emotional neglect, and 282 subjects (7.7%) reported physical neglect.

Among the participants ($n = 857$) who reported having engaged in NSSI at least once in the past six months, based on their frequency of NSSI (Brunner et al., 2007), adolescents reported a half-year prevalence of 11.85% for O–NSSI (NSSI scores < 4 ; $N = 432$, $M_{\text{age}} = 13.16$; 46.8% female) and 11.65% for R–NSSI (NSSI scores ≥ 4 ; $N = 425$, $M_{\text{age}} = 13.28$; 53.2% female).

Mean, standard deviation and correlations for all study variables

The mean, standard deviation and correlation matrix of the variables are shown in Table 1. According to the correlation analyses, all main variables’ correlations were significant in both the R–NSSI group and the O–NSSI group. Childhood maltreatment was significantly positively correlated with emotion dysregulation, impulsivity and NSSI frequency. Emotion dysregulation was significantly positively correlated with both impulsivity and NSSI frequency. In addition, impulsivity was significantly positively correlated with NSSI frequency.



Table 1. Means, standard deviations, and correlations among the study variables

Variables	M	SD	1	2	3	4	5	6	7
Repetitive NSSI Group									
1. Sex (0 = male)	-	-	1						
2. Age	13.28	0.83	-0.04	1					
3. SSES	5.02	1.47	-0.01	-0.19**	1				
4. Childhood maltreatment	33.15	11.41	0.07	0.05	-0.14**	1			
5. Emotion dysregulation	55.52	12.02	0.11*	0.02	-0.08	0.28***	1		
6. Impulsivity	55.59	12.59	0.10*	0.05	-0.16**	0.31***	0.53***	1	
7. NSSI	12.54	10.56	0.08	0.11*	-0.09*	0.41***	0.38***	0.36***	1
Occasional NSSI Group									
1. Sex (0 = male)	-	-	1						
2. Age	13.16	0.86	-0.03	1					
3. SSES	5.09	1.36	-0.00	-0.05	1				
4. Childhood maltreatment	28.21	7.24	0.01	0.03	-0.17***	1			
5. Emotion dysregulation	48.20	10.76	0.05	0.10*	-0.08	0.26***	1		
6. Impulsivity	50.29	10.29	0.04	0.06	-0.16**	0.38***	0.50***	1	
7. NSSI	1.75	0.80	0.04	0.01	-0.09	0.13**	0.18***	0.10*	1

Note: SSES = subjective socioeconomic status; NSSI = nonsuicidal self-injury. * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

Test of the proposed mediation model

Hypothesis 1 assumed that childhood maltreatment would be positively associated with NSSI frequency. The results revealed that childhood maltreatment was directly associated with NSSI frequency both in the R–NSSI ($\beta = 0.39$, $P < 0.001$) and O–NSSI groups ($\beta = 0.12$, $P < 0.005$).

Hypothesis 2 assumed that emotion dysregulation would mediate the relationship between childhood maltreatment and NSSI frequency. As shown in Fig. 1a, in the R–NSSI group, childhood maltreatment was positively related to emotion dysregulation (a path, $\beta = 0.17$, $P < 0.001$), emotion dysregulation was positively related to NSSI frequency (b path, $\beta = 0.55$, $P < 0.001$), and childhood maltreatment was positively related to NSSI frequency (c' path, $\beta = 0.38$, $P < 0.001$). Emotion dysregulation partially mediated the relationship between childhood maltreatment and NSSI frequency ($a*b$, indirect effect = 0.09), and the mediating effect model accounted for 23.08% of the total effect. As shown in Fig. 1b, in the O–NSSI group, childhood maltreatment was positively related to emotion dysregulation (a path, $\beta = 0.22$, $P < 0.001$), emotion dysregulation was positively related to NSSI frequency (b path, $\beta = 0.03$, $P < 0.01$), and a significant indirect effect of childhood

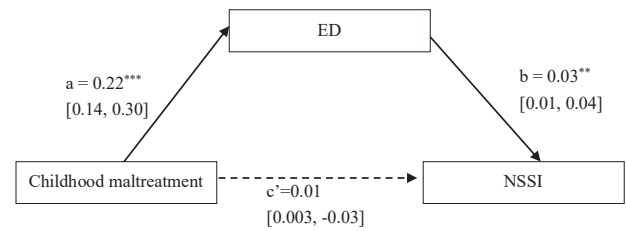


Fig. 1b. Influence of childhood maltreatment on NSSI, mediated by emotion dysregulation in the O–NSSI group

Note: 1) Numbers are standardized regression coefficients. 2) ED = emotion dysregulation, NSSI = nonsuicidal self-injury. 3) * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

maltreatment on NSSI frequency through emotion dysregulation was found ($a*b$, indirect effect = 0.01). The total effect (c path, $\beta = 0.02$, $P < 0.005$) between childhood maltreatment and NSSI frequency was also significant. However, after introducing emotion dysregulation, the relationship between childhood maltreatment and NSSI frequency was not significant (c' path, $\beta = 0.01$, $P > 0.05$), revealing a full mediation effect.

Test of the proposed moderated mediation model

As shown in Table 2 and Fig. 2, in the R–NSSI group, impulsivity moderated the relationship between emotion dysregulation and NSSI frequency ($\beta = 0.25$, $P < 0.01$). However, in the O–NSSI group, impulsivity did not moderate the relationship between emotion dysregulation and NSSI frequency ($\beta = 0.001$, $SE = 0.008$, 95% $CI = -0.01, 0.01$).

To clearly demonstrate patterns of impulsivity’s moderation effects in the R–NSSI group, a further simple slope analysis was conducted. As revealed in Fig. 3, there was a significant positive relationship between emotion dysregulation and NSSI frequency in adolescents with average ($\beta = 0.68$, $SE = 0.12$, $t = 5.43$, $P < 0.001$, 95% $CI = 0.43, 0.92$) and high ($\beta = 0.43$, $SE = 0.10$, $t = 4.50$, $P < 0.001$, 95% $CI = 0.24, 0.62$) levels of

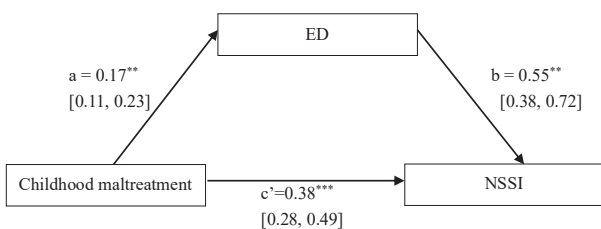


Fig. 1a. Influence of childhood maltreatment on NSSI, mediated by emotion dysregulation in the R–NSSI group

Note: 1) Numbers are standardized regression coefficients. 2) ED = emotion dysregulation, NSSI = nonsuicidal self-injury. 3) * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.



Table 2. Results of the moderated mediation model for the R–NSSI group

Independent variables	Emotion dysregulation (Mediating variable)			NSSI (Dependent variable)		
	β	SE	95% CI	β	SE	95% CI
Childhood maltreatment	0.17***	0.03	[0.11, 0.23]	0.34***	0.05	[0.24, 0.45]
Emotion dysregulation				0.23*	0.11	[0.01, 0.44]
Impulsivity				–0.001	0.13	[–0.25, 0.25]
Impulsivity \times Emotion dysregulation				0.25***	0.07	[0.10, 0.39]
Age	0.003	0.06	[–0.11, 0.12]	0.19	0.10	[–0.004, 0.39]
Sex (0 = male)	0.19*	0.10	[0.00, 0.37]	0.15	0.16	[–0.18, 0.47]
SSES	–0.03	0.03	[–0.09, 0.04]	0.02	0.06	[–0.10, 0.13]
R^2	0.09			0.29		
F	10.31***			23.90***		

Note: 1) Standardized regression coefficients are reported. 2) * $P < 0.05$. ** $P < 0.01$. *** $P < 0.001$.

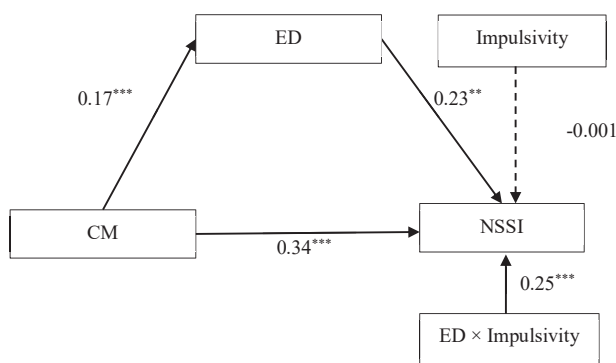


Fig. 2. The moderated mediation model for the R–NSSI group

Note: 1) The dotted line is not significant; 2) CM = Childhood Maltreatment, ED = Emotion Dysregulation, NSSI = nonsuicidal self-injury. 3) * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

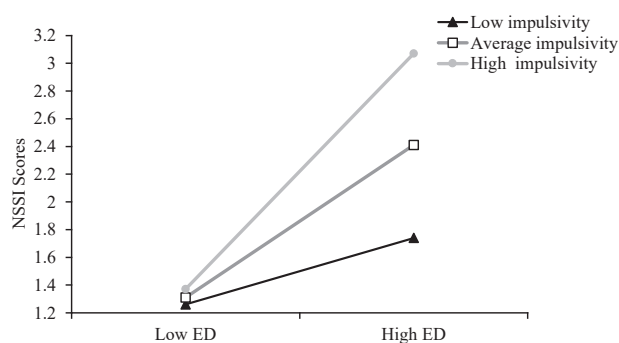


Fig. 3. Moderating effect of impulsivity on the association between emotion dysregulation and NSSI. Numbers are standardized regression coefficients

impulsivity, but there was no significant relationship in adolescents with low levels of impulsivity ($\beta = 0.18$, $SE = 0.12$, $t = 1.53$, $P = 0.13$, $95\% CI = -0.05, 0.41$). This indicates that the association between emotion dysregulation and NSSI frequency was weaker for adolescents in the R–NSSI group with low impulsivity than for those with high impulsivity.

Correspondingly, the mediating effect of emotion dysregulation on the relationship between childhood maltreatment

and NSSI was significant in adolescents with high (with the indirect effect being 0.12, $SE = 0.04$; $95\% CI = 0.06, 0.20$) and average levels of impulsivity (with the indirect effect being 0.07, $SE = 0.02$; $95\% CI = 0.04, 0.13$) but was not significant in those with low levels of impulsivity (with the indirect effect being 0.03, $SE = 0.02$; $95\% CI = -0.003, 0.08$). The index of moderated mediation was 0.04 ($SE = 0.02$; $95\% CI = 0.01, 0.08$), which indicated that the mediation model was different among the levels of impulsivity.

DISCUSSION

NSSI most commonly begins in adolescence, and more severe NSSI has been associated with future suicide risk (Robinson, Garisch, & Wilson, 2021). The current study first elucidated the potential addictive pathway of NSSI by testing a moderated mediation model embedded within the I-PACE theoretical framework, helping us gain a better understanding of behavioral NSSI addictions. Specifically, the current study evaluated how (mediating mechanisms) and when (moderating mechanisms) childhood maltreatment was associated with NSSI frequency in adolescents with O–NSSI and R–NSSI. In the R–NSSI group, childhood maltreatment exerted its effects on NSSI frequency through emotion dysregulation, and impulsivity moderated the mediating effect. In the O–NSSI group, childhood maltreatment exerted its effects on NSSI frequency through emotion dysregulation, while the moderating effect of impulsivity on NSSI frequency was not significant.

Our findings indicate that 11.65% of a Chinese school sample reported engaging in R–NSSI in the past half-year, which is consistent with R–NSSI prevalence rates found in adolescent community samples that were reported to range from 6.3 to 18.4% (Daukantaitė et al., 2021; Lüdtke et al., 2017). The present study adds new evidence regarding the relationship between childhood maltreatment and NSSI frequency in adolescents with R–NSSI. First, the study identified maltreatment as a risk factor for NSSI. This is consistent with previous findings that childhood trauma has a significant impact on NSSI in adolescents (Martin et al., 2016;

Nock, 2010). Exposure to chronic stressors in the childhood environment may alter youths' biological capacity to regulate distress (Gunnar & Quevedo, 2007), thus predisposing them to engage in problem behaviors, such as NSSI, to regulate emotional distress. This finding implies that maltreatment may serve as a predisposing factor that repeatedly contributes to adolescents' NSSI behaviors.

Second, the results indicate that emotion dysregulation is a strong risk factor for R–NSSI among adolescents. The negative reinforcement model proposes that the avoidance of negative affect is the prepotent motive behind NSSI, and reduction of emotional distress thereby increases the likelihood of future NSSI (Nock & Prinstein, 2004). Previous studies have also shown that individuals with emotion dysregulation are motivated to use NSSI as a means of regulating their emotions (Klonsky, 2007; Taylor et al., 2018). This finding lends further support to the potential roles of negative reinforcement and relief from negative emotions as important mechanisms of R–NSSI. Additionally, the results showed that emotion dysregulation mediated the relationship between childhood maltreatment and NSSI frequency within both the O–NSSI and R–NSSI groups, which is consistent with Nock's (2009) integrated model that emotion dysregulation plays an important mediating role in NSSI, considering the frequency of NSSI. It should also be noted that emotion dysregulation partially mediated the relationship between maltreatment and NSSI frequency within the R–NSSI group, which suggests that other mediating mechanisms (e.g., cognitive responses to trigger in the I-PACE model) may exist when interpreting the relationship between maltreatment and NSSI frequency among adolescents with R–NSSI. Future studies need to consider other factors that contribute to R–NSSI, such as inhibitory control, and other forms of negative reinforcement when using the I-PACE framework to examine the addictive features of NSSI.

Notably, our research extends knowledge on the moderating effects of impulsivity on NSSI frequency among adolescents with R–NSSI. According to the I-PACE model, the level of general inhibitory control (used interchangeably here with impulsivity) moderates the relationship between affective and cognitive responses to external or internal triggers and specific addictive behavioral decisions (Brand et al., 2019). In line with this model, our results show that emotion dysregulation typically leads to more frequent NSSI when adolescents exhibit high and moderate levels of impulsivity, providing more detailed and specific explanations for when and under what conditions emotion dysregulation may lead to subsequent NSSI addiction. The results also showed that for adolescents with R–NSSI and high impulsivity, childhood maltreatment was significantly associated with NSSI through emotion dysregulation. It is possible that adolescents with high impulsivity have more difficulty regulating emotions; thus, when maltreatment triggers emotion dysregulation, they may use NSSI as a maladaptive emotional coping strategy (Eisenberg, 2000; Maxfield & Pepper, 2018). Furthermore, individuals with a greater frequency of NSSI may learn that NSSI is a quick way to avoid negative emotional states; they are more likely

to shift the negative affective response caused by maltreatment as the cue to NSSI, resulting in NSSI becoming a habitual behavior in emotion dysregulation (Brand et al., 2019).

Taken together, the present study found that in the R–NSSI group, the results not only showed the mediating effect of emotion dysregulation on the relationship between childhood maltreatment and NSSI frequency but also showed the moderating effect of impulsivity on the relationship between emotion dysregulation and NSSI frequency, while in the O–NSSI group, the results only showed the mediating effect on the relationship between childhood maltreatment and NSSI frequency. The results for the adolescents with R–NSSI showed an integrative model including both emotion dysregulation and impulsivity factors (A and E in the I-PACE model, respectively), which may suggest that the I-PACE model can be helpful in conceptualizing repetitive NSSI.

The present study should be considered in the context of its limitations. First, given the critical role of impulsivity in addictive behaviors, this study illustrates the general role of impulsivity in NSSI addiction for the first time. However, some research has also indicated that subtypes of impulsivity (e.g., emotion-related impulsivity and negative and positive urgency) may have different links to NSSI (Allen & Hooley, 2019; Claes & Muehlenkamp, 2013). Future research may examine how different facets of impulsivity contribute to the maintenance of R–NSSI. In addition, the coefficient of the index of moderated mediation was small due to the sample size of the R–NSSI group; therefore, the findings of this study should be interpreted with caution. Future studies should expand the sample size of adolescents to further validate our findings. Second, the current study used adolescent self-reports to collect data, which could be subject to bias. However, emotion dysregulation and childhood maltreatment experiences are too subjective for valid and reliable assessment by other raters. The same is true for NSSI, which adolescents do not typically discuss with others (Nock, 2010); thus, the self-report approach also seemed appropriate. Nevertheless, the main variables should be further examined using multimethod data (e.g., self-report measures and performance-based assessments). Third, we assessed NSSI habits over the past half year, and given that NSSI patterns may change over time during adolescence (Barrocas, Giletta, Hankin, Prinstein, & Abela, 2015), future studies may benefit from applying longitudinal designs to explore the long-term effects of impulsivity and emotional dysregulation on NSSI addiction development during adolescence. Additionally, the cross-sectional design could not confirm the causal relationships we assumed among the core variables. Thus, longitudinal studies are needed in future studies.

The current study yielded three novel findings. First, this is the first known study to reveal the potential addictive pathway of NSSI among adolescents. The results also demonstrated that the I-PACE framework is valid for analyzing NSSI addiction in a Chinese community adolescent sample. Second, the study identified a distinction

between repetitive NSSI and occasional NSSI with respect to the pathway involved in the association between childhood maltreatment and NSSI. These results suggest that mental health professionals and clinicians should be aware of the essential difference between O–NSSI and R–NSSI, and treatment approaches could be tailored to individuals who engage in O–NSSI and R–NSSI (Blasco-Fontecilla et al., 2016). Third, we found a moderating role of impulsivity in the R–NSSI group but not in the O–NSSI group and that impulsivity contributes to repetitive engagement in NSSI. Therefore, the development of inhibitory control can help adolescents with emotion dysregulation, especially in regard to preventing problems that may lead to NSSI addiction.

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