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Investigating the Effect of Thinking Styles on Forgiveness with the Mediating Role of Executive Functions in Recovered and Unrecovered Adolescents with Self-Injury

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A B S T R A C T

Purpose: This study aimed to explore how different thinking styles affect self-forgiveness in adolescents who self-injure, taking into account the role of executive functions in recovery compared to non-recovery.

Methodology: A descriptive-correlational approach was used for this cross-sectional study, employing structural modeling and multi-group analysis (MGA). The study included all adolescents in Tehran with a history of self-harm between September and November 2023, with a sample of 111 adolescents selected through purposive sampling. Instruments utilized were the Thinking Styles Inventory (TSI), Executive Functions Questionnaire (EFQ), and Enright Forgiveness Inventory–30 (EFI-30). Statistical analysis was conducted using SPSS version 27 for descriptive statistics and Independent Samples T-Test, as well as SmartPLS version 4 for path analysis and Multi-group Analysis (MGA), with a significance level set at 0.05.

Findings: The study found that Inhibition, Organizing, and Planning decision-making functions did not significantly impact self-forgiveness in the Recovered Adolescents group, while the Planning decision-making function had a positive and significant influence on self-forgiveness in the Unrecovered Adolescents group ($p = 0.043$). Similarly, the Type 1 Thinking Style had a positive and significant effect on self-forgiveness in the Recovered Adolescents group ($B = 0.872$, $p = 0.000$).

Conclusion: The results indicated that recovered adolescents exhibited a Type 1 thinking style and higher executive functions, correlating with greater levels of self-forgiveness. Conversely, non-recovered adolescents tended to have a Type II thinking style, with only the planning function contributing to increased self-forgiveness in this group. These findings highlight the significance of cognitive and psychological factors in the recovery process from self-injury.

Keywords: *self-injury, self-forgiveness, thinking styles, executive functions*

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1. Introduction

Self-harm is characterized as the intentional act of harming oneself or ingesting harmful substances, regardless of the underlying motives, which can result in significant physical, mental, and social repercussions and is a strong indicator of suicidal tendencies (Cliffe et al., 2021). Among adolescents, self-harm has a lifetime prevalence of 16.9%, with potential risk factors including unique personality traits, depression, eating disorders, borderline personality disorders, exposure to media, internet addiction, and neurobiological influences (Wang et al., 2022). Adolescents with traumatic childhood experiences are more vulnerable to persistent and escalating self-harm behaviors, with cortisol secretion and stress response mechanisms potentially contributing to the development or worsening of such behaviors (Reichl et al., 2023; Reichl et al., 2024). Studies have demonstrated a link between depressive symptoms and the onset of self-harm behaviors (Hu et al., 2024). While most adolescents show notable improvement in reducing the frequency of self-harm following treatment, the rate of complete recovery (cessation of self-harm) is relatively low, with only 25% achieving full recovery and 41% experiencing relapse within a year (Reichl et al., 2023).

In adolescents who engage in self-harm, events are unconsciously and distortedly interpreted, with distorted interpretations of reality leading to emotional and cognitive difficulties rather than a single event causing distress. These issues stem from how information is interpreted, which is influenced by their thinking styles (Sabz Chamani, 2020). Thinking styles are the consistent and preferred methods of approaching tasks and activities over time. This concept encompasses cognitive and educational preferences, as well as evidence-based reasoning, categorized into three types: creative, structured, and complex; standard-oriented and structured; and a blend of both types (Hammad & Awed, 2023). One study found that the first type of thinking style is associated with adaptive coping strategies, while the second type is linked to maladaptive coping strategies (Chen, 2022). Another study showed that thinking styles can predict the subjective well-being of teenagers (Kuan, 2023).

When people engage in harmful actions towards themselves or others, they might feel guilt, shame, and self-blame, in which forgiveness plays a crucial role in halting the detrimental cycle and restoring a sense of self-value. Forgiveness entails an internal process that changes an individual's cognitive, emotional, and behavioral aspects in response to mistakes, resulting in a decrease in negative emotions (Moradi et al., 2023). The journey of forgiveness begins when a person decides to alter their behavior in response to negative feelings arising from their mistakes. This process includes taking responsibility for errors and positive changes in one's self-relationship, ultimately leading to reconciliation and self-acceptance (Webb & Boye, 2024). Studies have indicated that self-forgiveness is linked to a lower incidence of suicide attempts, suicidal thoughts, and future suicide attempts, as well as an increased likelihood of forgiving others and a decreased risk of suicide (Hirsch et al., 2017). Additionally, research suggests that enhancing self-forgiveness as a psychological tool could be beneficial in addressing and preventing self-harm and promoting the overall quality of life for individuals facing similar challenges (Hasri et al., 2023).

Self-harm is a behavior that is often seen in adolescents, particularly those in the age range of 14 to 16. As individuals approach the age of 18, the frequency of self-injury tends to diminish. This decline might be linked to alterations in brain activity and improvements in executive functioning. Executive functioning refers to a set of cognitive processes that aid in managing thoughts and actions, including abilities like controlling impulses and maintaining focus (Nilsson et al., 2021). Adolescents who self-harm and have thoughts of suicide might have decreased structural connections in the frontal-subcortical circuits, especially in regions related to executive function. This lack of executive function can result in misinterpretation and inadequate reactions to challenges in their surroundings. Adolescents could be easily influenced and resort to self-harm, possibly due to their deficits in executive function (Li et al., 2023). Research indicates that deficiencies in executive functions, inadequate emotional regulation, and disturbance of behavioral systems can significantly contribute to the persistence of self-harming behaviors. Mozafari and colleagues (2022) revealed that teenagers engaging in self-injury exhibit notable deficiencies in executive functions, particularly in inhibitory control and planning (Mozafari et al., 2022). It was also stated in a study that depressed adolescents with self-injury have more executive dysfunctions and metabolic abnormalities than individuals without self-injury and healthy individuals (Zhang et al., 2022).

Due to the widespread occurrence of non-fatal self-harm among teenagers, there has been a focus in psychological studies on determining the factors that impact these behaviors. One area of interest is the role of executive functions in psychological issues like self-harm. Additionally, concepts such as cognitive styles and self-

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acceptance could be significant in minimizing these behaviors. However, previous research has mainly concentrated on individual factors related to self-harm and has overlooked cognitive and psychological elements such as cognitive styles and self-acceptance. Further research that examines the differences between recovered and non-recovered teenage self-harmers and explores the influence of executive functions as a mediating factor is still lacking. Therefore, the goal of this study is to explore how cognitive styles influence self-acceptance with the mediating impact of executive functions in recovered and non-recovered teenage self-harmers. This study could contribute to the development of cognitive and psychological frameworks for effective therapeutic interventions in teenage self-harmers and offer new approaches to reduce these behaviors.

2. Methods and Materials

2.1. Study Design and Participants

This research utilized a descriptive-correlational approach and a cross-sectional research design, employing a structural model and multi-group analysis (MGA) method. The independent variable in this study was the concept of thinking styles, while self-forgiveness was the dependent variable, and executive functions served as a mediator. The study's target population consisted of adolescents who had engaged in self-injurious behaviors in Tehran from September to November 2023. The study involved 111 teenagers chosen through purposeful sampling for the statistical analysis. The sample size was determined using Cohen's formula from 2013, numerous factors such as observed and latent variables in the model, expected effect size, and desired levels of probability and statistical power (Cohen, 2013). According to this calculation method, the sample size was determined using the following parameters: Expected effect size = 0.25, Target level of statistical power = 0.8, Number of latent variables = 3, Number of observed variables = 114, and Significance level = 0.01. Based on these inputs, the researcher arrived at a sample size of 119 individuals. To account for potential dropouts, the researcher decided to include 150 individuals in the study. The eligibility criteria for participation in the study included being at least 13 years old, possessing adequate literacy and comprehension skills to respond to questions, having engaged in self-harming behaviors within the past year, having visited the clinics where the study was being conducted, and having a history of counseling. The criteria for exclusion also involved individuals who did not complete the questionnaire with more than ten questions and those who had any physical or mental conditions that hindered their participation in the study.

The methodology used for the research was as follows: initially, the required authorizations were secured from the university where the researcher was enrolled to carry out the study. Subsequently, the researcher was connected with three psychology clinics by his professors. Once in contact with the psychology and counseling clinics, parents of teenagers who had a history of self-harm behavior and had sought counseling at the centers were reached out to. Information regarding the objectives and permissions of the research was shared with the parents, and arrangements were made with those who expressed interest. Parents and adolescents were reassured that they could opt out of the research process if they chose not to participate. Due to limited cooperation from all parties involved, the research process and questionnaire completion, both in person and online, lasted for three months. The participants were intentionally split into two categories: teenagers who showed improvement in self-injurious behavior and those who did not. Out of the 150 completed questionnaires, only 121 were utilized, with 10 disregarded due to anomalies. Additionally, 29 questionnaires were excluded from the study due to incomplete responses or intentional inaccuracies in the surveys. The surveys were given to participants through self-reporting in person or sometimes online. To adhere to the ethical standards of the study, participants were informed that the questionnaires did not ask for any personal information and that adolescents had the option to opt out of the research process if they chose not to participate.

2.2. Measures

2.2.1. Thinking Styles

In 1992, Sternberg and Wagner created a questionnaire with the intention of assessing the thinking style of individuals (Sternberg & Wagner, 1992). The questionnaire consists of 65 questions, each rated on a five-point Likert scale ranging from completely disagree to completely agree. The scale evaluates thirteen different thinking styles, categorized into three main types of thinking styles. The first type (comprising 25 items) includes the Legislative style, which pertains to individuals who are highly interested in creativity and design and tend to approach tasks in their unique manner. Judicial style: Individuals primarily focus on assessing and judging people and activities. Hierarchical

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style: These individuals are capable of multitasking and arranging tasks based on priority, method, location, energy allocation, and resources while also dividing their attention among multiple tasks. Free-thinking style: Individuals with a free-thinking approach gravitate towards new and uncertain activities, preferring to tackle tasks in unconventional and innovative ways that challenge conventional norms and practices. The combined scores of these styles encompass the initial thinking style. The second type of thinking style (consisting of 20 items) is characterized by the following styles: Executive style: Individuals who prefer to adhere to relevant instructions and rules and are drawn to activities with clear and straightforward guidelines. Conservative style: Individuals who use established rules and methods in various tasks and execute them using tried and true approaches. Monarchic style: Individuals who focus on one task at a time. The third type of thinking style (consisting of 25 items) includes the following: Anarchic style: Individuals who enjoy activities where they have the freedom to use unconventional methods to solve problems and do not feel constrained by rules, instructions, or systems. Internal style: Individuals who prefer to work independently and are self-reliant with no particular dependencies. External orientation: Individuals who engage in activities that involve interaction with others. These activities are influenced by the external world and rely on other people. Oligarchic orientation: Individuals engage in multiple activities at once without prioritizing between them. A study conducted in Iran found the scale to have a high internal consistency rating of 0.88 (Ahanchian & Hassanian, 2013). The researcher also found Cronbach's alpha values to be 0.746, 0.740, and 0.723. Additionally, the questionnaire showed good convergent validity with scores of 0.586, 0.560, and 0.548.

2.2.2. Executive Functions

Coolidge (2005) created this survey to evaluate the executive functions of individuals (Coolidge & Wynn, 2005). The developer has confirmed the validity and reliability of the questionnaire. The test was developed and standardized according to the criteria of the American Psychiatric Association (APA). The questionnaire includes 19 items, each scored on a four-point scale from 1 (never) to 4 (always). The individual's scores on the scale are totaled to calculate a final score. Questions 1 to 8 assess decision-making and planning, questions 9 to 16 evaluate organization, and questions 17 to 19 focus on inhibition. Scores on the test range from 19 to 75, with higher scores indicating stronger executive functions. The reliability of the questionnaire was tested using Cronbach's alpha, resulting in scores of 0.81 to 0.82 for organization and decision-making, planning, and inhibition (Jabarzadeh et al., 2022). In this study, Cronbach's alpha values for organization, decision-making, planning, and inhibition were 0.887, 0.804, and 0.816, respectively.

2.2.3. Forgiveness

Enright et al. developed a questionnaire in 2021 to evaluate self-forgiveness, with reliability and validity confirmed by the creators (Enright et al., 2021). It includes 30 items rated on a six-point scale and divided into emotional, behavioral, and cognitive subscales. Total scores are calculated by summing individual item scores, with higher scores indicating stronger self-forgiveness. Internal consistency was high for emotional ($\alpha = 0.97$), behavioral ($\alpha = 0.85$), and cognitive ($\alpha = 0.94$) scales, with overall questionnaire reliability measured at 0.78 using Cronbach's alpha (Lavafpour Nouri et al., 2014). In this study, Cronbach's alpha for the questionnaire was determined to be 0.795.

2.3. Data Analysis

The study utilized SPSS version 27 software for descriptive statistics, while SmartPLS version 4 software was employed to analyze the relationships between variables and perform Multi-group Analysis (MGA). The normality of the distribution of research variables was assessed using the Shapiro-Wilk test, which indicated that the research variables did not have a normal distribution. Therefore, SmartPLS was utilized for further analysis. Additionally, an Independent Samples T-Test was conducted to evaluate differences between groups with a significance level set at 0.05.

3. Findings and Results

The researcher analyzed the descriptive statistics related to the research variables. The participants were categorized into three age groups: 15-16 years old (21.6%), 16-17 years old (27.0%), and 18-19 years old (51.4%). Likewise, the participants were grouped into boys (61.3%) and girls (38.7%) based on gender. They were also categorized based on the type of self-harm they engaged in, including cutting, burning skin, hitting or biting, plucking hair, engaging in

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physically dangerous behaviors, punching oneself or a wall, and other reasons. At first, the researcher investigated the descriptive statistics of the research variables. Table 1 shows the mean and standard deviation of the research variables.

Table 1

Descriptive statistics and t-test results

Variable	Groups	Mean	SD	Min	Max	t	df	p	Mean Difference
Type 1 Thinking Style	Recovered Adolescents	83.544	6.921	73	95	5.153	109	< .001	6.007
	Unrecovered Adolescents	77.537	5.186	73	94				
Type 2 Thinking Style	Recovered Adolescents	52.509	4.852	47	62	-3.960	109	< .001	-3.732
	Unrecovered Adolescents	56.241	5.077	47	62				
Type 3 Thinking Style	Recovered Adolescents	80.860	6.269	73	90	-0.175	109	0.861	-0.214
	Unrecovered Adolescents	81.074	6.613	73	91				
Enright Forgiveness	Recovered Adolescents	106.26	11.22	91	123	4.438	109	< .001	7.374
	Unrecovered Adolescents	98.889	4.928	93	106				
Planning decision-making function	Recovered Adolescents	15.509	2.667	12	20	2.175	109	0.032	1.120
	Unrecovered Adolescents	14.389	2.757	11	20				
Organizing	Recovered Adolescents	14.333	2.881	10	21	2.092	109	0.039	0.981
	Unrecovered Adolescents	13.352	1.944	10	17				
Inhibition	Recovered Adolescents	5.649	0.876	4	7	2.004	109	0.048	0.371
	Unrecovered Adolescents	5.278	1.071	4	7				

An analysis of the data from Table 1 using the Independent Samples T-Test showed a significant difference between Recovered Adolescents and Unrecovered Adolescents in various variables such as Type 1 Thinking Style, Type 2 Thinking Style, Self-giving, planning decision-making function, Organizing, and Inhibition ($P<0.05$). When comparing the mean values of these variables between the two groups, it is evident that Recovered Adolescents had higher levels of Type 1 Thinking Style, Self-giving, planning decision-making function, Organizing, and Inhibition compared to Unrecovered Adolescents, while Unrecovered Adolescents had higher levels of Type 2 Thinking Style. The researcher also assessed the assumptions of the test. The Shapiro-Wilk test was used to check the normality of the distribution of the research variables, and since the test results were significant for all research variables ($P<0.001$), it indicates that the variables did not follow a normal distribution. As the researcher employed a random sampling method, this assumption was met.

Table 2

Similarity results with Permutation test

Step	Step1. sameness	Step2.Hybrid matching	Step3. Equality of Mean		Step 3. Equality of variance	
Variable		Permutation p value	Permutation mean difference	Permutation p value	Permutation mean difference	Permutation p value
Enright Forgiveness (EFI)	Yes	0.276	0.783	0.000	1.647	0.000
Inhibition	Yes	0.000	0.377	0.067	-0.401	0.055
Organizing	Yes	0.348	0.393	0.041	0.787	0.011
Planning decision-making function	Yes	0.267	0.408	0.034	-0.066	0.756
Type 1 Thinking Style	Yes	0.616	0.885	0.000	0.578	0.022
Type 2 Thinking Style	Yes	0.000	-0.710	0.000	-0.090	0.527
Type 3 Thinking Style	Yes	0.120	-0.034	0.857	-0.106	0.391

Similarly, in Table 2, the researcher investigated the similarity of means and variance among groups to explore the feasibility of conducting a multi-group analysis of the MICOM method using the Permutation test. Initially, the researcher checked if the same indicators were used for both groups, which was confirmed by the test results. Then, a

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Hybrid matching study was conducted to validate the Inhibition and Type 3 Thinking Style variables, although the Permutation p-value did not reach statistical significance. Next, the researcher examined the equality of means and variance among groups for the variables. Some variables showed differences in mean and variance, leading the researcher to utilize the WELCH-SATTERHWAITE TEST in the PLS software for path analysis. The model was then run to evaluate the path coefficients and significance levels among variables in Table 3. Lastly, the researcher specified a bootstrap value of 5000 for this study.

Table 3

Standard research coefficients

Path between variables	Path (Recovered Adolescents)	p value (Recovered Adolescents)	Path (Unrecovered Adolescents)	p value (Unrecovered Adolescents)	Difference (Recovered Adolescents-Unrecovered Adolescents)	p value (Recovered Adolescents vs Unrecovered Adolescents)	Result
Inhibition -> EFI	0.072	0.115	-0.085	0.520	0.157	0.263	rejection
Organizing -> EFI	-0.139	0.074	-0.191	0.192	0.052	0.753	rejection
Planning decision-making function -> EFI	0.035	0.788	0.329	0.043	-0.294	0.160	rejection
Type 1 Thinking Style -> EFI	0.872	0.000	0.189	0.147	0.683	0.005	confirmation
Type 1 Thinking Style -> Inhibition	-0.217	0.540	0.083	0.595	-0.300	0.437	rejection
Type 1 Thinking Style -> Organizing	0.714	0.000	-0.340	0.004	1.053	0.000	confirmation
Type 1 Thinking Style -> Planning decision-making function	0.896	0.000	0.126	0.470	0.771	0.004	confirmation
Type 2 Thinking Style -> EFI	0.040	0.503	-0.054	0.664	0.094	0.493	rejection
Type 2 Thinking Style -> Inhibition	-0.032	0.807	-0.252	0.095	0.220	0.273	rejection
Type 2 Thinking Style -> Organizing	-0.223	0.019	0.083	0.561	-0.306	0.076	rejection
Type 2 Thinking Style -> Planning decision-making function	-0.165	0.042	0.106	0.441	-0.271	0.092	rejection
Type 3 Thinking Style -> EFI	-0.164	0.289	-0.103	0.585	-0.061	0.802	rejection
Type 3 Thinking Style -> Inhibition	0.099	0.764	0.095	0.602	0.004	0.991	rejection
Type 3 Thinking Style -> Organizing	-0.015	0.941	0.123	0.437	-0.138	0.591	rejection
Type 3 Thinking Style -> Planning decision-making function	0.074	0.709	-0.501	0.000	0.575	0.021	confirmation

According to the findings presented in Table 4 and following figures, the variables related to Inhibition, Organizing, and Planning decision-making did not show a significant impact on selflessness in the group of Recovered Adolescents. However, the Planning decision-making variable had a positive and significant influence on selflessness in the group of Unrecovered Adolescents (p = 0.043). Similarly, the Type 1 Thinking Style variable had a positive and significant impact on selflessness in the Recovered Adolescents group (B = 0.872, p = 0.000). Additionally, the Type 1 Thinking Style variable had a positive and significant effect on Organizing in the Recovered Adolescents group (B = 0.714, p = 0.000). The Type 1 Thinking Style variable also had a positive and significant effect on Planning decision-making in the Recovered Adolescents group (B = 0.896, p = 0.000). However, the Type 1 Thinking Style variable had a significant negative impact on Organizing in the Unrecovered Adolescents group (B= -0.340, p = 0.004).

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Table 4

The Results of Hypotheses

path between variables	Difference	p value	Result
Type 3 Thinking Style -> Planning decision-making function -> EFI	0.168	0.108	rejection
Type 3 Thinking Style -> Inhibition -> EFI	-0.041	0.510	rejection
Type 2 Thinking Style -> Organizing -> EFI	0.015	0.703	rejection
Type 1 Thinking Style -> Inhibition -> EFI	-0.010	0.945	rejection
Type 2 Thinking Style -> Inhibition -> EFI	0.047	0.291	rejection
Type 1 Thinking Style -> Planning decision-making function -> EFI	-0.009	0.837	rejection
Type 1 Thinking Style -> Organizing -> EFI	-0.024	0.582	rejection
Type 3 Thinking Style -> Organizing -> EFI	-0.164	0.058	rejection
Type 2 Thinking Style -> Planning decision-making function -> EFI	0.026	0.622	rejection

Figure 1

Path coefficients between variables and significance level In Recovered Adolescents group

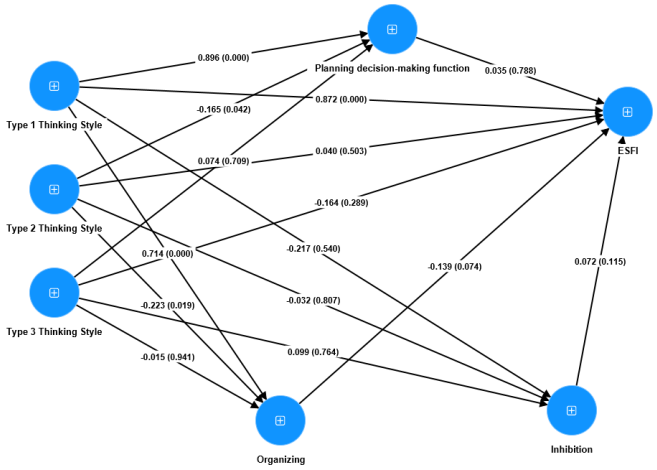
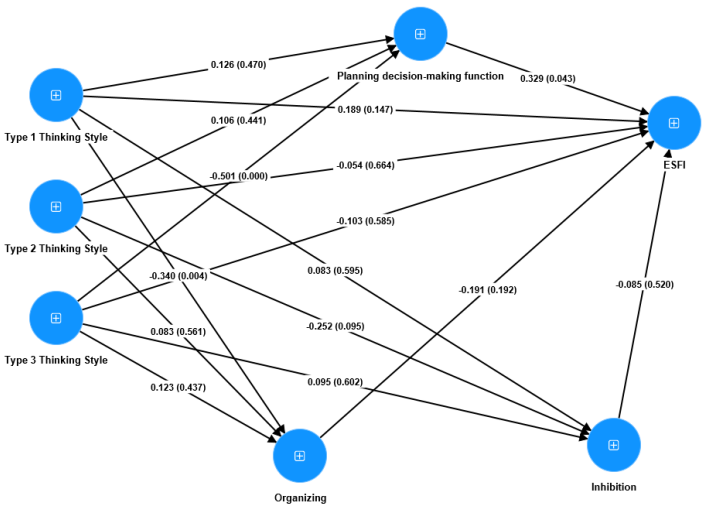


Figure 2

Path coefficients between variables and significance level In Unrecovered Adolescents group



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Furthermore, based on the multi-group analysis, the impact of the Type 1 Thinking Style variable on selflessness was significant between the two groups, with a significant effect on selflessness observed in the Recovered Adolescents group (Recovered Adolescents vs Unrecovered Adolescents (P= 0.005). Therefore, the Type 1 Thinking Style contributes to increased selflessness in the Recovered Adolescents group. The impact of the Type 1 Thinking Style variable on Organizing was also significant between the two groups, with a positive effect on Organizing in the Recovered Adolescents group and a negative influence in the Unrecovered Adolescents group (Recovered Adolescents vs Unrecovered Adolescents (P= 0.000). Similarly, the impact of the Type 1 Thinking Style variable on the Planning decision-making function was significant based on multi-group analysis, with an effect on Planning decision-making function observed in the Recovered Adolescents group (Recovered Adolescents vs Unrecovered Adolescents (P = 0.004). Hence, the Type 1 Thinking Style enhances the Planning decision-making function in the Recovered Adolescents group. Finally, the researcher investigated the indirect impact of the research variables utilizing the bootstrap method.

4. Discussion and Conclusion

The goal of this study was to examine how different thinking styles impact self-forgiveness in recovered adolescents who engaged in self-injurious behavior while also considering the role of executive functions. This was done by comparing them to non-recovered adolescents.

The findings indicated that recovered adolescents exhibited higher levels of type I thinking style (legislative, judicial, hierarchical, liberal), self-forgiveness, and executive functions such as decision-making, planning, organization, and inhibition compared to non-recovered adolescents. Conversely, non-recovered adolescents displayed a greater prevalence of type II thinking style (executive, conservative, monarchical). In adolescents who had recovered, executive functions like decision-making, inhibition, organization, and planning did not play a main role in self-forgiveness. On the other hand, in adolescents who had not recovered, planning had a positive impact on self-forgiveness. Furthermore, a Type I thinking style enhanced self-forgiveness, organization, decision-making, and planning abilities in recovered adolescents but reduced organization in non-recovered adolescents. The results of this study indicate that recovered adolescents exhibit higher levels of Type I thinking style, self-forgiveness, and executive functions compared to non-recovered adolescents. On the other hand, non-recovered adolescents show higher levels of Type II thinking style. These findings are consistent with previous research (Hasri et al., 2023; Hirsch et al., 2017; Kuan, 2023; Mozafari et al., 2022; Zhang et al., 2022).

One study found that thinking styles can predict the subjective well-being of adolescents (Kuan, 2023). A separate study revealed that adolescents who engage in self-injury exhibit notable deficiencies in executive functions, particularly in areas like inhibitory control and planning (Mozafari et al., 2022). Another study also noted that depressed adolescents with self-injury have more executive dysfunctions and metabolic abnormalities compared to individuals without self-injury and those who are healthy (Zhang et al., 2022). Research indicates that self-forgiveness is linked to an increased likelihood of forgiving others in the future and a decreased risk of suicide (Hirsch et al., 2017). In addition, a different study proposed that enhancing self-forgiveness as a psychological tool could be beneficial in treating and preventing self-harm and enhancing the quality of life for individuals facing similar challenges (Hasri et al., 2023).

This discovery suggests that non-recovered adolescents tend to rely more on Type II thinking, which is characterized by quick but less analytical processing and is typically triggered by stress and emotional challenges. These adolescents react immediately to stress due to a lack of emotional regulation and cognitive control skills. Negative beliefs and unpleasant experiences further limit their ability to develop logical and analytical thinking (Sabz Chamani, 2020). The changes in cognitive structures and emotional regulation resulting from psychological interventions are one of the main reasons for the improvement observed in recovered self-injuring adolescents. These interventions assist adolescents in better managing life's stresses and challenges, as well as enhancing their problem-solving and decision-making skills. Participation in therapy sessions also enhances cognitive flexibility and the development of new mental structures. Positive reinforcement from therapists and the social environment further reinforces these positive changes (Hammad & Awed, 2023). One factor contributing to increased self-forgiveness in recovered adolescents is their improved acceptance of negative experiences and acquisition of emotional regulation skills. Through treatment, these adolescents come to understand that

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persistent self-blame and guilt are counterproductive and can keep them trapped in negative emotions rather than promoting positive change (Moradi et al., 2023). Additionally, executive functions such as cognitive inhibition, planning, and decision-making are enhanced by strengthening brain networks associated with cognitive control and emotional regulation. In recovered adolescents, engagement in mental exercises and behavioral interventions leads to increased activity in the frontal regions of the brain linked to executive functions. These exercises aid in fortifying neural connections and establishing new behavioral patterns, ultimately enhancing their executive skills (Li et al., 2023).

The study also found that a Type I thinking style in recovered adolescents can enhance self-forgiveness, organization, and decision-making skills, although it does not significantly impact executive functions. On the other hand, non-recovered adolescents who exhibit a Type I thinking style may experience a decrease in organization and planning abilities, leading to an increase in self-forgiveness. Despite the study's originality and the absence of research directly exploring the relationship between thinking styles, self-forgiveness, and the role of executive functions in adolescents with and without a history of self-injurious behaviors, the results are generally in line with findings from similar studies in related areas. This suggests that the results align with previous research findings while offering new perspectives that were previously unexplored (Chen, 2022; Cheng et al., 2024; Cheng & Sin, 2021; Coomes, 2019; Westers et al., 2012).

The study's results showed that Type I thinking styles are predominantly associated with effective coping mechanisms, while Type II thinking styles play a role in ineffective coping strategies (Chen, 2022). Previous research on self-forgiveness has demonstrated that individuals can enhance their decision-making and planning abilities by taking ownership of their errors and creating plans for self-improvement (Coomes, 2019). Additionally, findings from a separate study indicated that individuals who struggle with self-forgiveness are more likely to engage in non-suicidal self-injury as a means of regulating emotions and improving social interactions, such as managing unwanted emotions, combating feelings of numbness or emptiness and seeking connection with others.

One study found that Type I thinking styles are linked to effective coping strategies, while Type II thinking styles are related to ineffective coping strategies (Chen, 2022). Research has found that self-forgiveness can enhance decision-making and planning skills when individuals take responsibility for their errors and work on self-repair skills (Coomes, 2019). Another study found that not forgiving oneself is linked to self-harm for reasons such as managing emotions, seeking connection, and overcoming feelings of emptiness (Westers et al., 2012). Studies have indicated that individuals who exhibit more perseverance and excitement tend to possess cognitive styles that are more analytical and concentrated (Cheng et al., 2024). The Type I thinking style includes characteristics such as processing speed, intuition, and automatic reactions. This thinking style can help increase self-forgiveness by simplifying information about oneself and focusing on acceptance and moving forward rather than self-blame. This simplification can reduce anxiety and guilt, leading to self-acceptance and forgiveness (Vismaya et al., 2024). Type I thinking requires less mental effort for adolescents to focus on tasks such as planning, decision-making, and improving organization skills (Sabz Chamani, 2020). However, the lack of a significant impact of executive functions on self-forgiveness may be due to the substantial difference between the two. Executive functions center on intricate cognitive processes, while self-forgiveness relies on emotional and intuitive elements and less on logical and planned structures. This implies that approaches focusing on emotional acceptance and flexible thinking may be more effective in enhancing self-forgiveness. On the other hand, enhancing executive functions can play a pivotal role in various aspects of individual and social life (Mürner-Lavanchy et al., 2022). In adolescents who are not fully developed, the intuitive and automatic type I thinking style, coupled with negative emotions like anxiety and depression, leads to cognitive disarray and decreased organizational abilities. Instead of aiding in information management, this thinking style reinforces disjointed and unfocused reactions and contributes to psychological instability. In contrast, engaging in planning by establishing logical and purposeful frameworks assists these adolescents in redefining past errors as part of their growth process, reducing negative emotions, and ultimately achieving self-forgiveness (Cheng & Sin, 2021).

The study found that recovered adolescents with a Type I thinking style and higher executive functions showed higher levels of self-forgiveness. In contrast, non-recovered adolescents used a Type II thinking style more, and only the planning function helped increase their self-forgiveness. These results highlight the importance of cognitive and psychological factors in self-harm recovery. It is

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recommended to focus on legislative, judicial, and liberal thinking styles in educational and counseling programs for non-recovered adolescents. Problem-solving, judicial analysis, and critical thinking methods can be beneficial. Special attention to planning and executive functions is suggested for non-recovered adolescents to increase self-forgiveness. Exercises focusing on organizational skills, decision-making, and cognitive games are advised. Workshops or psychotherapy sessions promoting acceptance and forgiveness can enhance psychological conditions in recovered adolescents. Educational and family environments should encourage psychological security and the development of creative thinking styles. Intervention programs should focus on strengthening Type I thinking style and executive functions for adolescents at risk of self-injury.

Authors' Contributions

Authors equally contributed to this article.

Declaration

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

Transparency Statement

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Declaration of Interest

The authors report no conflict of interest.

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The research protocol followed the guidelines set forth in the Helsinki Declaration, which offers ethical standards for research involving human subjects.

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