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Comparing the Working Memory Capacity with Cognitive Flexibility, Cognitive Emotion Regulation, and Learning Styles of University Students: A Domain General View

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Keywords
Working memory capacity · Cognitive emotion regulation · Cognitive flexibility · Learning styles

Abstract
Introduction: The goal of this study was to investigate the relationship of working memory capacity with the use of cognitive emotion regulation strategies, cognitive flexibility level, and learning styles of university students. ***Methods:*** In the present study (N = 39), the participants completed the Emotion Regulation Questionnaire, Cognitive Flexibility Scale, Kolb Learning Styles Inventory, and Vermunt Learning Styles Inventory and three WM capacity (WMC) tasks that are Rotation Span Task, Operation Span Task, and Symmetry Span Task. Their WMCs were assessed, and the relationship of it was compared with cognitive emotion regulation, cognitive flexibility, and learning styles. ***Results:*** The results indicated that there is a significant difference and negative correlation (r= –0.341) between Operation Span Task and refocus on planning. Findings of the research indicated correlations between emotion regulation strategies and between cognitive flexibility and two emotion regulation strategies that are refocus on planning (r = 0.528) and positive reappraisal (r = 0.574). Only one learning style that is Processing Strategies in Vermunt Learning Style Inventory was found significantly different in terms of the cognitive flexibility level of the participants. The results also indicated a positive correlation between verbal and spatial WM tasks which support the domain general view for WMC. ***Conclusions:*** Further studies are advised to be conducted between cognitive emotion regulation strategies and working memory capacity as these findings may have significant implications for understanding the correlation between memory and emotion.

Introduction

The tendency of developing strategies for managing less familiar situations is a human-specific feature that can be capsuled within executive function set in prefrontal cortex. The learning environment of individuals is one of those places in which unfamiliar or less familiar information is most likely to encounter, and both executive functions and strategies are necessitated. Strategies for managing cognitive tasks can be needed in memory for recalling the necessary information and using it even when it is manipulated and also in cognitive emotion regulation for regulating negative emotions as in reappraisal. The necessity for using strategies is also of great impor-

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tance during the encoding of information, internalization, and learning of it. The common grounds of all these different components necessary for managing cognitive tasks are that they are related to executive functions. WM capacity (WMC), for instance, refers to the manipulation of information during cognitive activity [1], and it, as an intellectual functioning, refers to a limited capacity in which necessary information are temporarily stored and manipulated at the same time [2]. A large body of research has focused on the WMC of individuals, and recent research in this vein suggests that individuals with high WMC are more accurate in cognitive tasks [3], and it is related with fluid intelligence [4], information compression [5], attention [6, 7], cognitive flexibility [8, 9] all of which are executive functions of human cognition.

The WMC and Cognitive Emotion Regulation

According to McRae and Gross [10], emotion regulation is required when people feel the need for using strategies against discrepancies between their emotional state and realities. Managed unconsciously, cognitive emotion regulation is an ability to balance emotions of the limbic system at the cognitive level which is enacted by the prefrontal cortex. Studies indicate that people who are high in WMC tend to use more emotion regulation strategies [11], and WM training improves emotion regulation ability [12–14]. The relationship between these two components must be a subject to more studies as these studies indicated.

The WMC and Cognitive Flexibility

Cognitive flexibility, the ability to engage in two or more cognitive processes simultaneously, is an important executive function of human cognition [15]. This ability can be associated with complex cognitive functions which are possible to decrease with aging and is highly associated with the use of strategies from the cognitive perspective [16]. WMC and cognitive flexibility were found to predict creative thinking processes [17], and studies comparing these two components of executive functions can be conducted more in order to understand the relation between them in the cognitive level. Considering that someone who is assumed to have a high level of cognitive flexibility uses the transition between information or the cognitive control of information effectively, it can be concluded that these individuals may have the capacity to use the information in their WMC effectively.

Current Aims

The current study aimed to find out the relationship among various executive functions necessary for cognitive tasks that are WMC, cognitive emotion regulation, cognitive flexibility, and the relation of those components with learning styles of individuals which are another basic strategy that individuals develop for the learning environment. To that end, the participants were determined as individuals with high or low WMC after taking three complex span tasks in order to assess their WM abilities.

Materials and Methods

Participants

The participants were 39 young undergraduates from Istanbul Gelisim University. All participants received a detailed information about the process and gave a written consent before participation. Students completed one questionnaire, one scale, two inventories, and three memory tasks details of which are shared in the relevant subtitle. All measurements were provided in their native language, Turkish.

Materials

Emotion Regulation Questionnaire

Developed by Garnefski, Kraaij ve Spinhoven [18], the Emotion Regulation Questionnaire is a 5-point Likert scale consisting of 36 questions. The Cronbach alpha coefficients range between 0.67 and 0.81. The subdimensions of scales are self-blame, acceptance, rumination, positive refocusing, refocus on planning, positive reappraisal, putting into perspective, catastrophizing, and other-blame.

Cognitive Flexibility Scale

The scale was developed by Martin and Rubin [19], and it is a one-factor scale consisting of 12 questions, internal consistency of which is 0.74, and its Cronbach alpha coefficient is 0.77.

Kolb Learning Styles Inventory and Vermunt Learning Styles Inventory

Kolb Learning Style Inventory: This short inventory was developed by Kolb [20] in which 4 learning styles are designated. The learners are defined as Diverger, Converger, Assimilator, and Accommodator which are determined by 12 questions.

Vermunt Learning Styles Inventory: Developed by Vermunt [21], the Vermunt Learning Styles Inventory consists of 120 questions with 20 subscales and four factors that are Processing Strategies, Regulation Strategies (metacognition), Mental Models of Learning, and Learning Orientations.

WM Complex Span Tasks

WM capacities of participants were measured with complex span tasks short version of which was reorganized by Foster and his colleagues [22]. These tasks are Rotation Span Task, Operation Span Task, and Symmetry Span Task, and all three tasks take almost 1 h to complete depending on the speed of students.

Table 1. One-way ANOVA results for the comparisons of Kolb Learning Style results with the results of Cognitive Flexibility Scale and Cognitive Emotion Regulation

	N	$\bar{X}$	Ss.	Sum of square	SD	Mean of square	*F*	*p* value
Cognitive Flexibility Scale								
Accommodator	5	59.00	8.00	17.20	2	8.60	0.15	0.857
Diverger	29	58.41	7.59	2,000.23	36	55.56		
Assimilator	5	56.60	5.68	2,017.44	38			
Total	39	58.26	7.29					
Acceptance								
Accommodator	5	13.20	5.40	7.69	2	3.85	0.37	0.693
Diverger	29	14.31	2.98	374.21	36	10.39		
Assimilator	5	13.40	1.52	381.90	38			
Total	39	14.05	3.17					
Positive refocusing								
Accommodator	5	10.80	3.96	27.77	2	13.88	0.88	0.425
Diverger	29	12.28	3.65	570.59	36	15.85		
Assimilator	5	10.00	5.79	598.36	38			
Total	39	11.79	3.97					
Refocus on planning								
Accommodator	5	14.60	3.97	0.77	2	0.38	0.04	0.963
Diverger	29	15.00	3.09	370.00	36	10.28		
Assimilator	5	14.80	3.11	370.77	38			
Total	39	14.92	3.12					
Positive reappraisal								
Accommodator	5	14.00	3.16	41.53	2	20.76	2.72	0.079
Diverger	29	16.55	2.80	274.37	36	7.62		
Assimilator	5	14.40	1.95	315.90	38			
Total	39	15.95	2.88					
Putting into perspective								
Accommodator	5	12.40	2.30	30.45	2	15.22	1.36	0.269
Diverger	29	15.07	3.54	401.86	36	11.16		
Assimilator	5	14.80	2.68	432.31	38			
Total	39	14.69	3.37					
Rumination								
Accommodator	5	14.40	5.13	7.08	2	3.54	0.36	0.700
Diverger	29	14.90	2.77	353.89	36	9.83		
Assimilator	5	16.00	2.92	360.97	38			
Total	39	14.97	3.08					
Self-blame								
Accommodator	5	13.40	4.98	17.21	2	8.60	0.84	0.440
Diverger	29	11.90	2.79	368.69	36	10.24		
Assimilator	5	10.80	3.56	385.90	38			
Total	39	11.95	3.19					
Catastrophizing								
Accommodator	5	10.00	4.90	41.60	2	20.80	1.67	0.203
Diverger	29	8.21	3.44	448.76	36	12.47		
Assimilator	5	11.00	2.35	490.36	38			
Total	39	8.79	3.59					
Other-blame								
Accommodator	5	10.20	6.06	16.84	2	8.42	0.39	0.680
Diverger	29	10.83	4.35	778.14	36	21.61		
Assimilator	5	12.60	5.03	794.97	38			
Total	39	10.97	4.57					

Results did not indicate any significant difference between the subscales of Cognitive Flexibility or Cognitive Emotion Regulation when they were compared with the Kolb Learning Styles of the participants ($p > 0.05$). * $p < 0.05$: one-way ANOVA.

Table 2. One-way ANOVA results for the comparisons of Vermunt Learning Style results with the results of Cognitive Flexibility Scale and cognitive emotion regulation

	N	$\bar{X}$	Ss.	Sum of squares	SD	Mean of squares	*F*	*p* value
Cognitive Flexibility Scale								
Processing Strategies	12	62.75	6.03	501.11	2	250.56	5.95	0.006*
Learning Orientations	6	51.83	6.88	1,516.32	36	42.12		
Mental Models of Learning	21	57.52	6.63	2,017.44	38			
Total	39	58.26	7.29					
Acceptance								
Processing Strategies	12	13.92	2.84	4.34	2	2.17	0.21	0.814
Learning Orientations	6	14.83	3.06	377.56	36	10.49		
Mental Models of Learning	21	13.90	3.48	381.90	38			
Total	39	14.05	3.17					
Positive refocusing								
Processing Strategies	12	12.75	4.16	25.66	2	12.83	0.81	0.454
Learning Orientations	6	12.50	3.73	572.70	36	15.91		
Mental Models of Learning	21	11.05	3.96	598.36	38			
Total	39	11.79	3.97					
Refocus on planning								
Processing Strategies	12	16.58	2.15	49.57	2	24.78	2.78	0.076
Learning Orientations	6	14.67	3.08	321.20	36	8.92		
Mental Models of Learning	21	14.05	3.34	370.77	38			
Total	39	14.92	3.12					
Positive reappraisal								
Processing Strategies	12	16.75	1.96	11.65	2	5.82	0.69	0.509
Learning Orientations	6	15.33	3.39	304.25	36	8.45		
Mental Models of Learning	21	15.67	3.20	315.90	38			
Total	39	15.95	2.88					
Putting into perspective								
Processing Strategies	12	13.25	2.67	46.56	2	23.28	2.17	0.129
Learning Orientations	6	14.17	3.37	385.75	36	10.72		
Mental Models of Learning	21	15.67	3.54	432.31	38			
Total	39	14.69	3.37					
Rumination								
Processing Strategies	12	15.33	2.90	15.57	2	7.78	0.81	0.452
Learning Orientations	6	13.50	4.09	345.40	36	9.59		
Mental Models of Learning	21	15.19	2.91	360.97	38			
Total	39	14.97	3.08					
Self-blame								
Processing Strategies	12	12.17	3.04	27.28	2	13.64	1.37	0.267
Learning Orientations	6	10.00	2.53	358.62	36	9.96		
Mental Models of Learning	21	12.38	3.35	385.90	38			
Total	39	11.95	3.19					
Catastrophizing								
Processing Strategies	12	8.42	3.65	2.61	2	1.30	0.10	0.908
Learning Orientations	6	8.83	3.82	487.75	36	13.55		
Mental Models of Learning	21	9.00	3.66	490.36	38			
Total	39	8.79	3.59					
Other-blame								
Processing Strategies	12	11.00	4.99	56.40	2	28.20	1.37	0.266
Learning Orientations	6	13.67	5.43	738.57	36	20.52		
Mental Models of Learning	21	10.19	3.98	794.97	38			
Total	39	10.97	4.57					

Results did not indicate any significant difference between the subscales of cognitive emotion regulation when they were compared with the Vermunt Learning Styles of the participants ($p > 0.05$). However, the means obtained from the Cognitive Flexibility Scale ($F(2, 36) = 5.95$, $p < 0.05$) were significant in terms of the educational status of the participants, and a comparative analysis was conducted. Levene's test was conducted afterward which indicated that the variations were homogenous ($p > 0.05$). The data obtained from the Scheffe test indicated that the participants having Processing Strategies as a learning style scored higher in cognitive flexibility when it is compared with the ones having learning orientations as a learning style. * $p < 0.05$: one-way ANOVA.

Table 3. One-way ANOVA results for the comparisons of Kolb Learning Style results with the Operation Span, Rotation Span and Symmetry Span Task scores

Kolb learning style	N	X̄	Ss.	Sum of square	SD	Mean of squares	*F*	*p* value
Operation Span Task partial score								
Accommodator	5	28.60	8.56	574.16	2	287.08	1.09	0.348
Diverger	29	36.31	17.14	9,518.61	36	264.41		
Assimilator	5	26.60	15.77	10,092.77	38			
Total	39	34.08	16.30					
Rotation Span Task partial score								
Accommodator	5	12.00	3.94	56.27	2	28.13	0.79	0.463
Diverger	29	15.38	6.29	1,285.63	36	35.71		
Assimilator	5	16.20	5.40	1,341.90	38			
Total	39	15.05	5.94					
Symmetry Span Task partial score								
Accommodator	5	13.80	6.61	88.87	2	44.44	0.58	0.567
Diverger	29	17.97	9.10	2,772.57	36	77.02		
Assimilator	5	19.20	8.38	2,861.44	38			
Total	39	17.59	8.68					

The scores obtained from the Operation Span, Rotation Span, and Symmetry Span Tasks indicate no significance result according to the Kolb Learning Styles of the participants ($p > 0.05$). * $p < 0.05$: one-way ANOVA.

Operation Span Task: In Operation Span Task, participants are given some letters to remember, and mathematical operations are used for distraction. Participants answer the maths questions, click on the button on the screen, and decide if the answer on the screen is true or false for the previous question. Following this, a letter appears on the screen, and it is expected from the participants to keep it in their minds. Participants experience 5 mathematical operations and letters in each block with an 0.5 s interval, and depending on the performance of the student, the number of mathematical operations and letters change, in the range of 3–7. After this process is completed, participants are asked to pick the letter on the letter table set in the correct sequence.

Rotation Span Task: In Rotation Span Task, participants are expected to remember 16 arrays given in 2 sizes with 8 directions. The participants are expected to remember the direction of the arrays and their sizes. As a distractor of memory, they are given a letter in various dimensions and expected to decide if the letter is rotated correctly which necessitates a visualization of it in mind. The process starts with arrays that are expected to be remembered and is followed with letters which are to be rotated in mind. Participants need to click on the screen and tick off the correct arrays out of the array set. In each block of the task, there are 4 sets, and the array sets differ between 2 and 5.

Symmetry Span Task: Symmetry Span Task expects participants to keep red squares in their mind as a part of the memory test. Following this stage, they are also expected to decide if the line appearing on their screen is symmetrical which is a distractor for the squares in memory. The process includes squares to memorize and lines to decide as symmetrical. At the end of each block before reaching the whole process, participants are given a set of squares to choose the red squares given before. The whole process includes 3 blocks and 12 sets, and the squares to remember differs between 2 and 5.

Procedure

This study includes both face-to-face interaction and a distance participation process. The participants first attended 3 WM tasks, completing time of which was almost 1 h. During these complex span tasks, the participants were left alone in the class after the process was detailed on a white board. The absolute scores of the complex span tasks were used in the analysis. Following this face-to-face process, the learning styles inventories were shared with them online via Google Forms. As these inventories included more than a hundred questions, other tests were not assigned to them on the same day. Within the same week, the data for Cognitive Emotion Regulation Scale and Cognitive Flexibility were obtained via a Google Forms link. The survey was terminated after completing the online processes.

Results

The normal distribution was determined with the Skewness-Kurtosis coefficient values, and all values of all variations were found between −2 and +2. This result indicated that the distribution was normal. The confidence interval used for all analyses was determined as 95%. In the Operation Span Task, 51.3% of the participants scored low in their WMC, and 48.7% of them scored high in their WMC. In the Rotation Span Task, 51.3% of the participants scored low in their WMC, and 48.7% of them scored high in their WMC. In the Symmetry Span Task, 53.8%

Table 4. One-way ANOVA results for the comparisons of Vermunt Learning Style results with the Operation Span - Rotation Span - Symmetry Span Task scores

Vermunt learning style	N	$\bar{X}$	Ss.	Sum of square	SD	Mean of squares	*F*	*p* value
Operation Span Task partial score								
Processing Strategies	12	29.25	15.37	641.95	2	320.97	1.22	0.306
Learning Orientations	6	30.67	22.54	9,450.82	36	262.52		
Mental Models of Learning	21	37.81	14.68	10,092.77	38			
Total	39	34.08	16.30					
Rotation Span Task partial score								
Processing Strategies	12	16.17	6.53	22.73	2	11.37	0.31	0.735
Learning Orientations	6	14.17	5.38	1,319.17	36	36.64		
Mental Models of Learning	21	14.67	5.94	1,341.90	38			
Total	39	15.05	5.94					
Symmetry Span Task partial score								
Processing Strategies	12	16.58	9.08	19.78	2	9.89	0.13	0.883
Learning Orientations	6	17.50	11.40	2,841.65	36	78.93		
Mental Models of learning	21	18.19	8.02	2,861.44	38			
Total	39	17.59	8.68					

The scores obtained from the Operation Span, Rotation Span, and Symmetry Span Tasks indicate no significance result according to the Vermunt Learning Styles of the participants ($p > 0.05$). * $p < 0.05$: one-way ANOVA.

Table 5. Correlations of WM complex span tasks

	Operation Span	Rotation Span	Symmetry Span
Operation Span			
Pearson correlation	1	0.175	0.090
Sig. (2-tailed)		0.287	0.584
N	39	39	39
Rotation Span			
Pearson correlation	0.175	1	0.521**
Sig. (2-tailed)	0.287		0.001
N	39	39	39
Symmetry Span			
Pearson correlation	0.090	0.521**	1
Sig. (2-tailed)	0.584	0.001	
N	39	39	39

When the scores obtained from the Operation Span, Rotation Span, and Symmetry Span Tasks were compared with each other, the result indicated that there is a significant correlation between Rotation Span and Symmetry Span Tasks. Results did not indicate any significant correlation between other complex span tasks. ** Correlation is significant at the 0.01 level (2-tailed).

of the participants scored low in their WMC, and 46.2% of them scored high in their WMC. The Kolb Learning Styles of the participants indicated that 12.8% of the participants were Accommodator, 74.4% of them were Diverger, and 12.8% of them were Assimilator. The Vermunt Learning Styles of the participants indicated that 30.8% of the participants had Processing Strategies, 15.4% of them had Learning Orientations, while 53.8% of them had Mental Models of Learning (Tables 1–7).

Discussion and Conclusion

The results of the present study indicated that scores obtained from the Symmetry Span Task which is a *spatial* WM task are correlated with the scores of Rotation Span Task which is a *verbal* and nonspatial task (shown in Fig. 1). The correlation between a *spatial and verbal task* indicates that individuals who get a high WM score in Symmetry Span Task also scores high in the Rotation Span Task. Studies conducted with individuals with psychological or neurological disorders mostly highlight the difference between spatial and verbal WMC. Taking an earlier study conducted with patients with Parkinson disease having mild clinical symptoms as an example, it indicated that their spatial WMC was weaker when compared to verbal and visual WMC [23]. Also, a very recent study investigated the difference between verbal and visual WMC with depressive individuals and found that only spatial WMC of individuals with unipolar depression and bipolar II depression was impaired [24]. There are some other researches indicating the difference between verbal and spatial WMC in healthy children. A

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Table 6. Correlations of WM complex span tasks and cognitive emotion regulation strategies

	WM – Operation Span Task – partial score	WM – Symmetry Span Task – partial score	WM – Rotation Span Task – partial score	Accep-tance	Positive refocusing	Refocus on planning	Positive reappraisal	Putting into perspective	Rumination	Self blame	Catastrophizing	Other-blame
WM – Operation Span Task – partial score												
Pearson correlation	1	0.090	0.175	0.159	–0.073	–0.341*	0.028	0.032	0.072	0.186	0.045	–0.213
Sig. (2-tailed)		0.584	0.287	0.333	0.661	0.034	0.865	0.849	0.662	0.257	0.785	0.193
N	39	39	39	39	39	39	39	39	39	39	39	39
WM – Symmetry Span Task – partial score												
Pearson correlation	0.090	1	0.521**	0.223	0.124	0.036	0.184	0.301	0.056	–0.085	–0.069	–0.122
Sig. (2-tailed)	0.584		0.001	0.173	0.451	0.829	0.261	0.062	0.736	0.605	0.674	0.458
N	39	39	39	39	39	39	39	39	39	39	39	39
WM – Rotation Span Task – partial score												
Pearson correlation	0.175	0.521**	1	0.137	0.061	0.081	0.109	0.120	0.290	0.093	0.066	–0.112
Sig. (2-tailed)	0.287	0.001		0.406	0.713	0.624	0.508	0.466	0.073	0.572	0.690	0.496
N	39	39	39	39	39	39	39	39	39	39	39	39
Accepteance												
Pearson correlation	0.159	0.223	0.137	1	–0.020	–0.039	–0.049	0.208	0.558**	0.414**	0.331*	0.227
Sig. (2-tailed)	0.333	0.173	0.406		0.904	0.812	0.769	0.203	0.000	0.009	0.039	0.165
N	39	39	39	39	39	39	39	39	39	39	39	39
Positive refocusing												
Pearson correlation	–0.073	0.124	0.061	–0.020	1	0.674**	0.408**	0.196	–0.093	–0.294	–0.273	–0.122
Sig. (2-tailed)	0.661	0.451	0.713	0.904		0.000	0.010	0.232	0.574	0.069	0.093	0.459
N	39	39	39	39	39	39	39	39	39	39	39	39
Refocus on planning												
Pearson correlation	–0.341*	0.036	0.081	–0.039	0.674**	1	0.613**	0.320*	–0.019	–0.162	–0.337*	–0.031
Sig. (2-tailed)	0.034	0.829	0.624	0.812	0.000		0.000	0.047	0.907	0.325	0.036	0.849
N	39	39	39	39	39	39	39	39	39	39	39	39
Positive reappraisal												
Pearson correlation	0.028	0.184	0.109	–0.049	0.408**	0.613**	1	0.396*	–0.169	–0.201	–0.474**	–0.258
Sig. (2-tailed)	0.865	0.261	0.508	0.769	0.010	0.000		0.013	0.304	0.220	0.002	0.113
N	39	39	39	39	39	39	39	39	39	39	39	39
Putting into perspective												
Pearson correlation	0.032		0.120	0.208	0.196	0.320*	0.396*	1	0.184	0.023	0.019	–0.002
Sig. (2-tailed)	0.849	0.062	0.466	0.203	0.232	0.047	0.013		0.262	0.890	0.911	0.989
N	39	39	39	39	39	39	39	39	39	39	39	39
Rumination												
Pearson correlation	0.072	0.056	0.290	0.558**	–0.093	–0.019	–0.169	0.184	1	0.536**	0.506**	0.106
Sig. (2-tailed)	0.662	0.736	0.073	0.000	0.574	0.907	0.304	0.262		0.000	0.001	0.519
N	39	39	39	39	39	39	39	39	39	39	39	39
Self-blame												
Pearson correlation	0.186	–0.085	0.093	0.414**	–0.294	–0.162	–0.201	0.023	0.536**	1	0.440**	0.157
Sig. (2-tailed)	0.257	0.605	0.572	0.009	0.069	0.325	0.220	0.890	0.000		0.005	0.340
N	39	39	39	39	39	39	39	39	39	39	39	39
Catastrophizing												
Pearson correlation	0.045	–0.069	0.066	0.331*	–0.273	–0.337*	–0.474**	0.019	0.506**	0.440 +	1	0.506**
Sig. (2-tailed)	0.785	0.674	0.690	0.039	0.093	0.036	0.002	0.911	0.001	0.005		0.001
N	39	39	39	39	39	39	39	39	39	39	39	39
Other-blame												
Pearson correlation	–0.213	–0.122	–0.112	0.227	–0.122	–0.031	–0.258	–0.002	0.106	0.157	0.506**	1
Sig. (2-tailed)	0.193	0.458	0.496	0.165	0.459	0.849	0.113	0.989	0.519	0.340	0.001	
N	39	39	39	39	39	39	39	39	39	39	39	39

As indicated in the table, the results of the study pointed out that there is a positive strong correlation between Rotation Span Task and Symmetry Span Task ($r = 0.521$); a negative correlation between Operation Span Task and refocus on planning ($r = –0.341$); a positive correlation between acceptance and rumination ($r = 0.558$), self–blame ($r = 0.414$), catastrophizing ($r = 0.331$), positive refocusing, and refocus on planning ($r = 0.674$); a positive correlation between positive reappraisal and refocus on planning ($r = 0.408$); a positive correlation between putting into perspective and refocus on planning ($r = 0.320$), positive reappraisal ($r = 0.396$); a negative correlation between catastrophizing and positive reappraisal ($r = –474$); a positive correlation between self–blame and rumination ($r = 0.536$); a positive correlation between catastrophizing and self-blame ($r = 0.440$), other-blame ($r = 506$). Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

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Table 7. Correlations of Cognitive Flexibility Scale with cognitive emotion regulation strategies

	Cognitive Flexibility Scale	Acceptance	Positive refocusing	Refocus on planning	Positive reappraisal	Putting into perspective	Rumination	Self-blame	Catastrophizing	Other-blame
Cognitive Flexibility Scale										
Pearson correlation	1	–0.055	0.122	0.528**	0.574**	0.308	0.055	0.054	–0.258	–0.134
Sig. (2-tailed)		0.738	0.459	0.001	0.000	0.056	0.738	0.745	0.112	0.416
N	39	39	39	39	39	39	39	39	39	39
Acceptance										
Pearson correlation	–0.055	1	–0.020	–0.039	–0.049	0.208	0.558**	0.414**	0.331*	0.227
Sig. (2-tailed)	0.738		0.904	0.812	0.769	0.203	0.000	0.009	0.039	0.165
N	39	39	39	39	39	39	39	39	39	39
Positive refocusing										
Pearson correlation	0.122	–0.020	1	0.674**	0.408**	0.196	–0.093	–0.294	–0.273	–0.122
Sig. (2-tailed)	0.459	0.904		0.000	0.010	0.232	0.574	0.069	0.093	0.459
N	39	39	39	39	39	39	39	39	39	39
Refocus on planning										
Pearson correlation	0.528**	–0.039	0.674**	1	0.613**	0.320*	–0.019	–0.162	–0.337*	–0.031
Sig. (2-tailed)	0.001	0.812	0.000		0.000	0.047	0.907	0.325	0.036	0.849
N	39	39	39	39	39	39	39	39	39	39
Positive reappraisal										
Pearson correlation	0.574**	–0.049	0.408**	0.613**	1	0.396*	–0.169	–0.201	–0.474**	–0.258
Sig. (2-tailed)	0.000	0.769	0.010	0.000		0.013	0.304	0.220	0.002	0.113
N	39	39	39	39	39	39	39	39	39	39
Putting into perspective										
Pearson correlation	0.308	0.208	0.196	0.320*	0.396*	1	0.184	0.023	0.019	–0.002
Sig. (2-tailed)	0.056	0.203	0.232	0.047	0.013		0.262	0.890	0.911	0.989
N	39	39	39	39	39	39	39	39	39	39
Rumination										
Pearson correlation	0.055	0.558**	–0.093	–0.019	–0.169	0.184	1	0.536**	0.506**	0.106
Sig. (2-tailed)	0.738	0.000	0.574	0.907	0.304	0.262		0.000	0.001	0.519
N	39	39	39	39	39	39	39	39	39	39
Self-blame										
Pearson correlation	0.054	0.414**	–0.294	–0.162	–0.201	0.023	0.536**	1	0.440**	0.157
Sig. (2-tailed)	0.745	0.009	0.069	0.325	0.220	0.890	0.000		0.005	0.340
N	39	39	39	39	39	39	39	39	39	39
Catastrophizing										
Pearson correlation	–0.258	0.331*	–0.273	–0.337*	–0.474**	0.019	0.506**	0.440**	1	0.506**
Sig. (2-tailed)	0.112	0.039	0.093	0.036	0.002	0.911	0.001	0.005		0.001
N	39	39	39	39	39	39	39	39	39	39
Other-blame										
Pearson correlation	–0.134	0.227	–0.122	–0.031	–0.258	–0.002	0.106	0.157	0.506**	1
Sig. (2-tailed)	0.416	0.165	0.459	0.849	0.113	0.989	0.519	0.340	0.001	
N	39	39	39	39	39	39	39	39	39	39

The results of the study indicated that there is a positive strong correlation between cognitive flexibility and refocus on planning (r = 0.528) and positive reappraisal (r = 574). ** Correlation is significant at the 0.01 level (2-tailed).

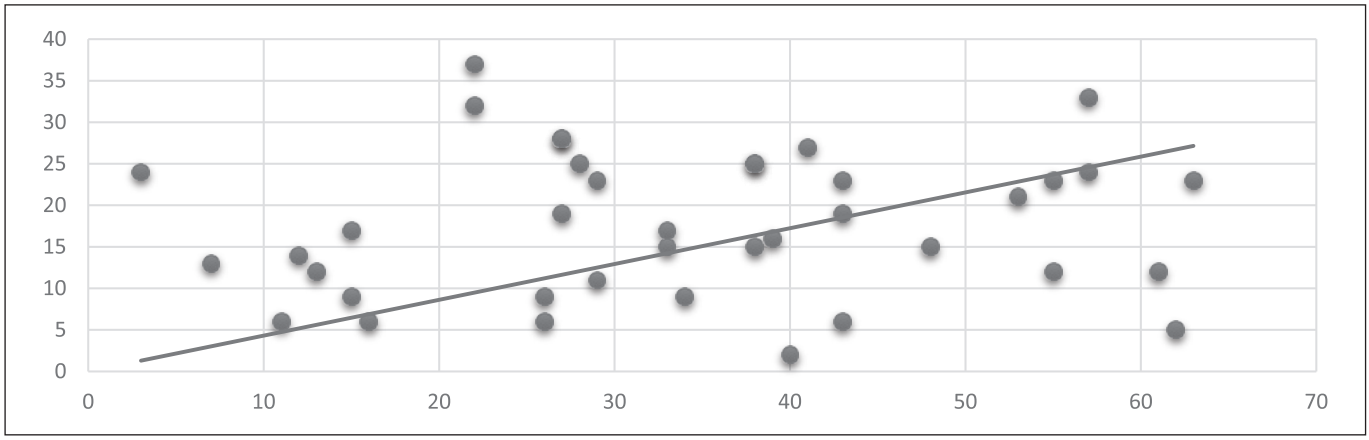

Fig. 1. Rotation span versus symmetry span ($r = 0.521$).

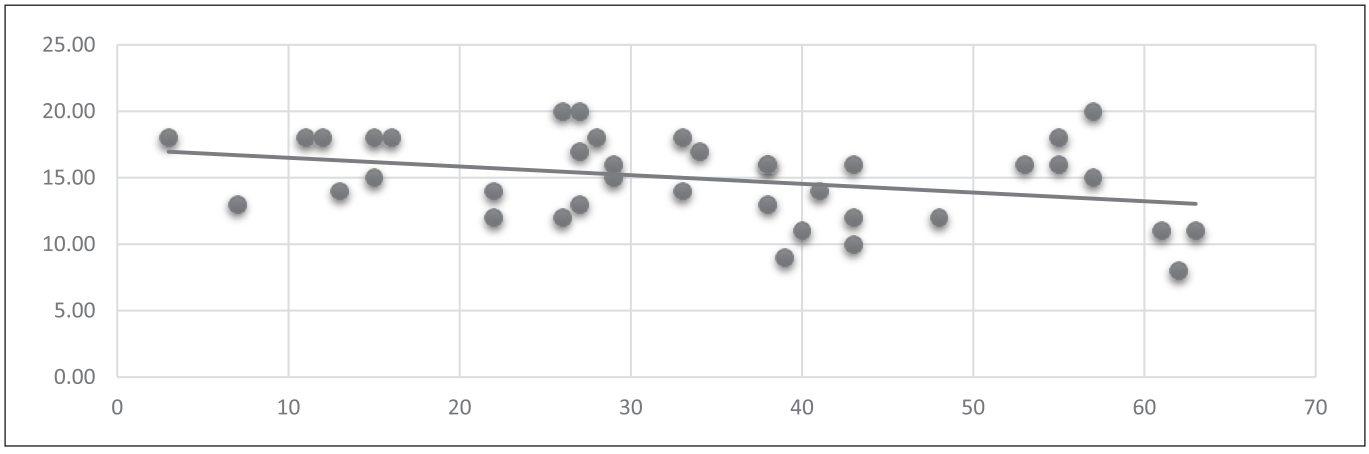

Fig. 2. Operation span versus refocus on planning ($r = -0.341$).

study conducted with children indicated that verbal and spatial WMC have different neural bases in children [25]. Additionally, verbal WMC was found in a study as a good predictor for reading comprehension in children rather than the spatial WM [26]. There are also other studies indicating the relationship between reading skill and verbal WMC [27, 28]. Another study questioning the role of age for WMC found that while verbal WMC is protected across years, the capacity for visual-spatial WM declines in time [29]. Results of the abovementioned studies support the domain specific view in the field of working memory. On top of all these studies pointing the difference between verbal and spatial WM and supporting the domain specific view, the present study conducted with healthy university students indicate a positive correlation between the visual and verbal WMC of individuals. Our study is in contrast to other research and supports the domain general view. There are also similar research suggesting a common storage for verbal, spatial, or visuospatial WM as indicated in the present study [30–32]. When evaluated in terms of multitasking, the result of a very recent study researching the verbal and visuospatial WMC within a multitasking concept in which a Bayesian state-trace analysis was used indicated that while dealing with more than one task at the same time a common pool for verbal and visuospatial data are used which supports the domain general view [33]. Considering all of these studies, it can be speculated that domain general and domain specific *tendencies* may differ with regard to the scenario, cognitive load, age, psychological state, and other

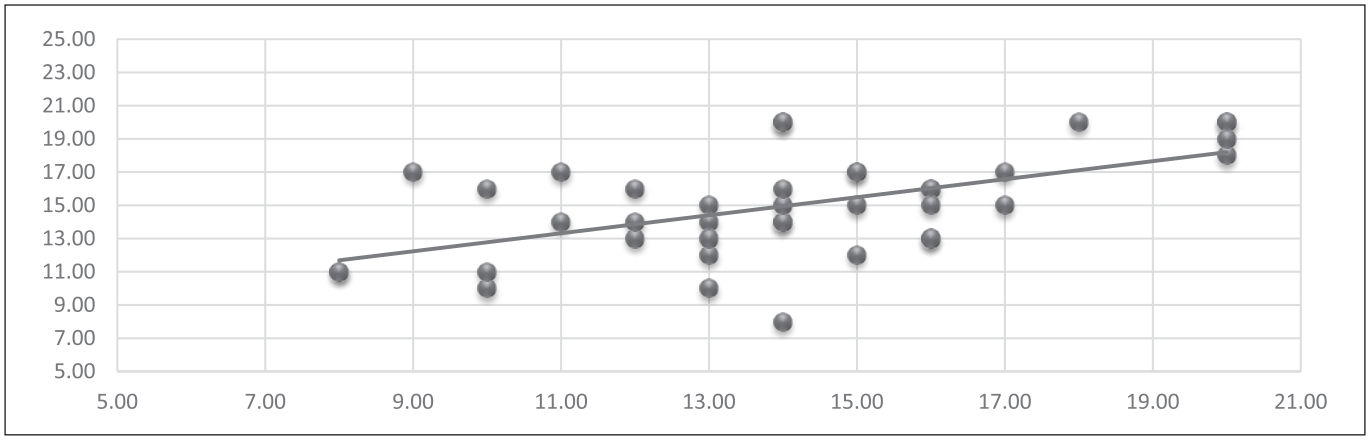

Fig. 3. Acceptance versus rumination ($r = 0.558$).

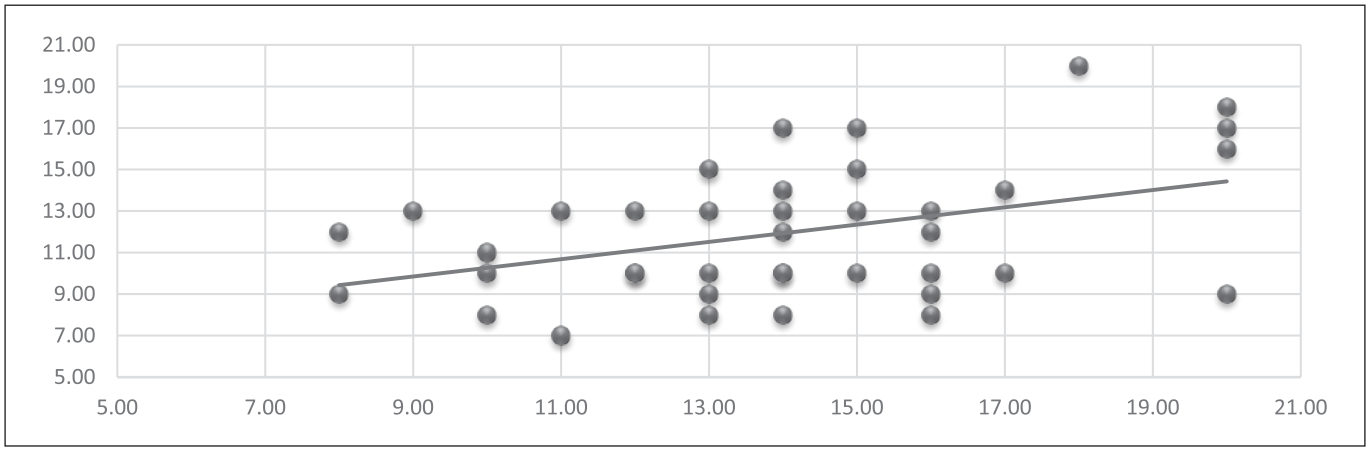

Fig. 4. Acceptance versus self-blame ($r = 0.414$).

relevant indicators. The present study supports the domain general view with its analysis made between verbal and spatial WMC with a continuous correlation, and it is suggested to conduct the complex span tasks with larger groups.

Apart from the domain general view regarding the complex working memory span tasks, the present study also aimed to make a comparison between working memory capacity and use of cognitive emotion regulation strategies. Operation Span Task is another nonspatial and verbal task measuring the WMC of an individual. The result indicates that the WMC of individuals measured with a verbal task that is the Operation Span Task is significantly different from one of the adaptive cognitive emotion regulation strategies of individuals that is the refocus on planning strategy ($t(37) = 2.46$, $p < 0.05$) (shown in Fig. 2) and is strongly correlated with it ($r = -0.341$). This strategy refers to focusing on possible steps to take to manage emotions [34]. There is a negative correlation between WMC and an emotion regulation strategy which indicates that as the WMC of individuals decreases the possibility of individuals use refocus on planning increases. Being strongly related to fluid intelligence [35–38], executive functions [39–41], and executive attention [42], WMC has been an important concern of cognitive studies in recent years. This result contributes to the field in terms of comparing the working memory capacity with a cognitive strategy developed against emotions. Refocus on planning is an adaptive strategy, and an earlier study showed that refocus on planning contributes to resilience

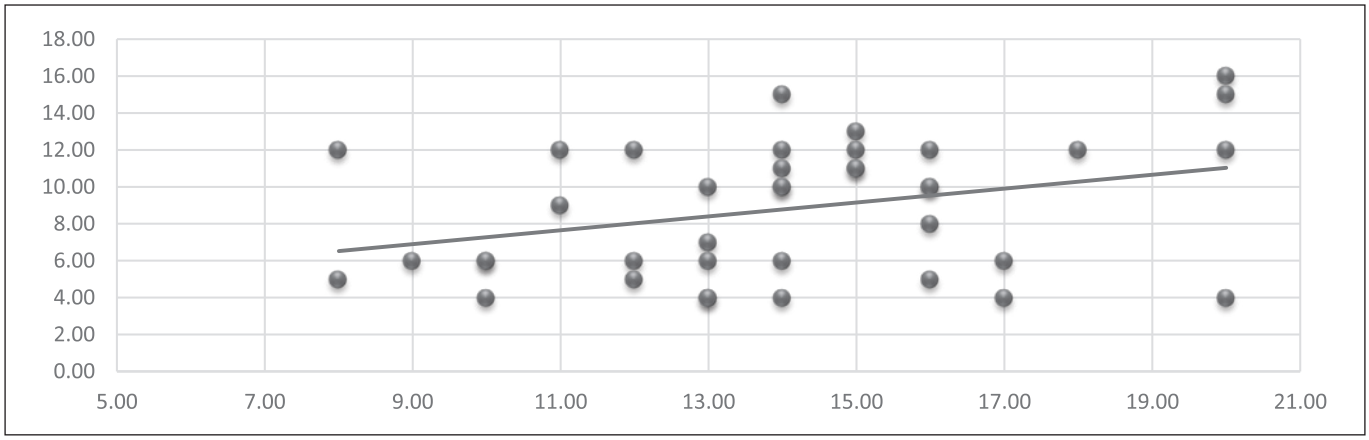

Fig. 5. Acceptance versus catastrophizing ($r = 0.331$).

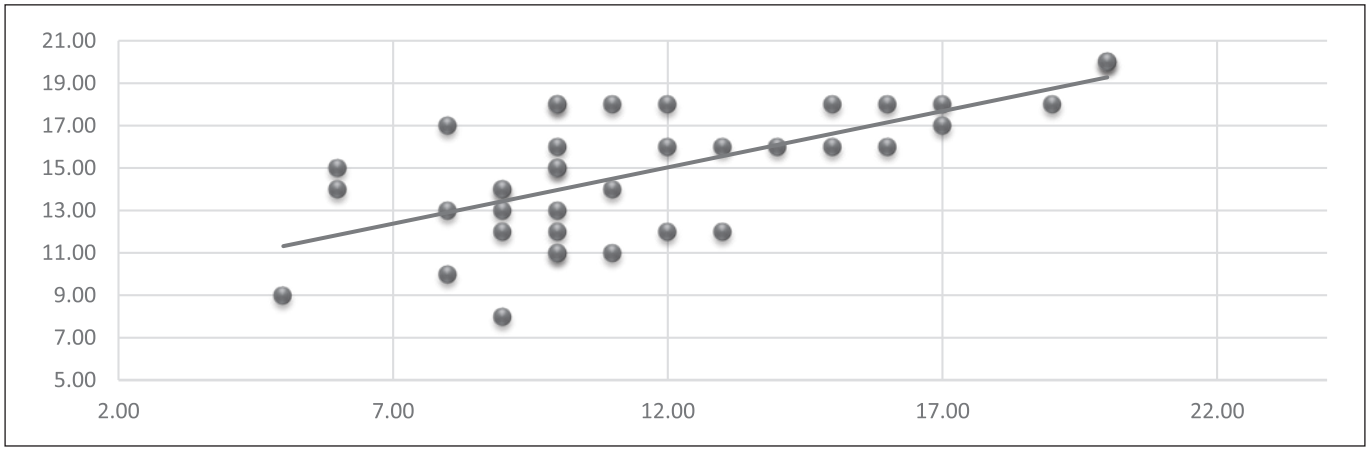

Fig. 6. Positive refocusing versus refocus on planning ($r = 0.674$).

in patients with depression and anxiety disorders [43]. A study conducted more recently also indicated that higher use of refocus on planning strategy is associated with more positive emotions and anxiety symptoms are lower only when more planning is adopted [44]. The finding of this study demonstrates that as the WMC gets lower, a refocus on planning strategy is used more against emotions which might be interpreted as being more in need of using a strategy when being low in terms of memory capacity. As WM is strongly and positively correlated with the fluid intelligence and executive functions, individuals with low WMC who have problems with executive functions might need more strategies for managing their emotions and need to refocus on planning and vice versa. This study highlights the need to find the relationship between cognitive strategies against emotions and WMC. On top of that, as far as we know, no studies had been performed before about the comparison of WMC to cognitive emotion regulation strategies. The present study also aimed to fill this gap and highlights the relation between WM and cognitive emotion regulation.

The study also revealed strong correlations among cognitive emotion regulation strategies. For instance, acceptance is the allowance of emotional experience and feelings as they are [45], and it is associated with positive outcomes [46]. It is a helping strategy for managing emotions when compared to nonacceptance which ends up with psychopathology [47, 48] and anxiety disorders [48, 49]. As a cognitive emotion regulation strategy, acceptance contributes to reducing anxiety or depression [50]. Another study indicated that when patients with functional dyspepsia are compared to healthy people, the

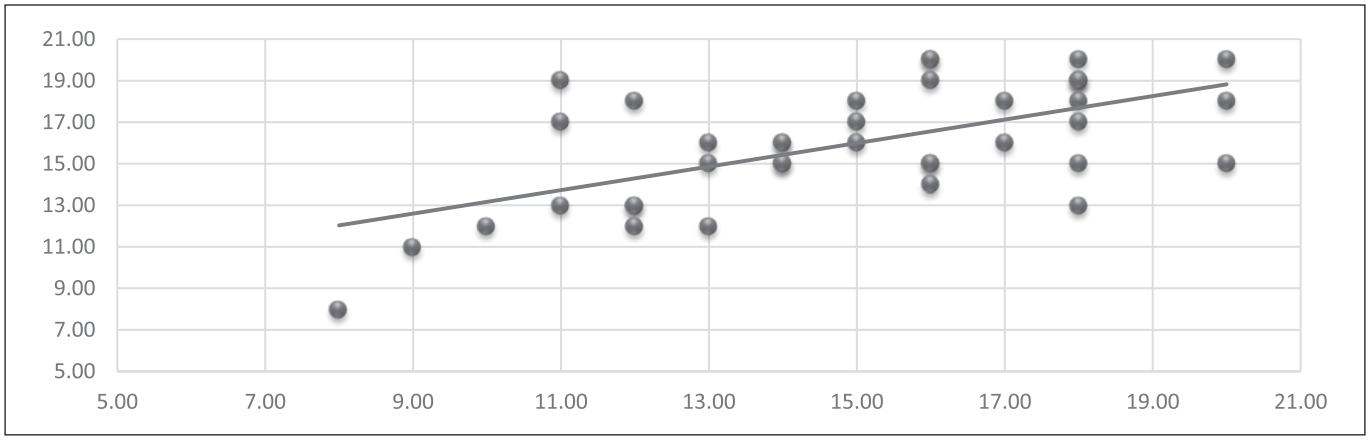

Fig. 7. Positive reappraisal versus refocus on planning ($r = 0.408$).

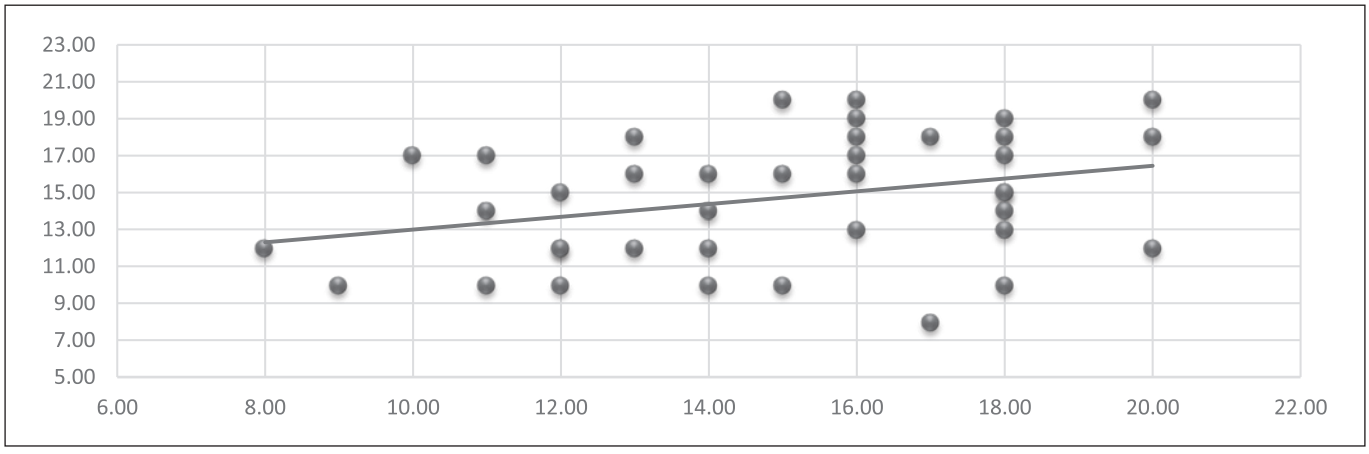

Fig. 8. Putting into perspective versus refocus on planning ($r = 0.320$).

healthy ones tend to use more acceptance which is an adaptive cognitive emotion regulation strategy [51]. However, in an earlier study, acceptance was found positively correlated with depressive symptoms in major depressive disorder outpatients [52]. Another study with high school students having nonsuicidal self-injury reported higher levels of acceptance [53]. There are various studies on acceptance as a cognitive emotion regulation strategy most of which point both to positive and negative aspects of it. In this study, results obtained from the scores of college students showed that as the use of acceptance decreases, the use of rumination also decreases and vice versa (shown in Fig. 3). Rumination is a maladaptive cognitive emotion regulation strategy which is about thinking continually on feelings resulted from negative situations. For instance, euthymic bipolar disorder and major depressive disorder individuals reported increased use of rumination [54]. Besides this, a study conducted with adolescents showed that individuals with internalizing problems scored significantly higher on the cognitive emotion regulation strategies of rumination [55]. Another study with children showed that rumination mediated the relationship between anxiety problems and their consequent interference [56]. Being a quite negative strategy, rumination is mostly related with negative results of emotion. The result of this study shows that acceptance and rumination are positively correlated which supports the studies proving the relation of acceptance with depression and anxiety despite being an adaptive one. In an earlier study conducted with college students [57], other-blame, rumination, acceptance, and reduced positive reappraisal were found related to maladaptive anger

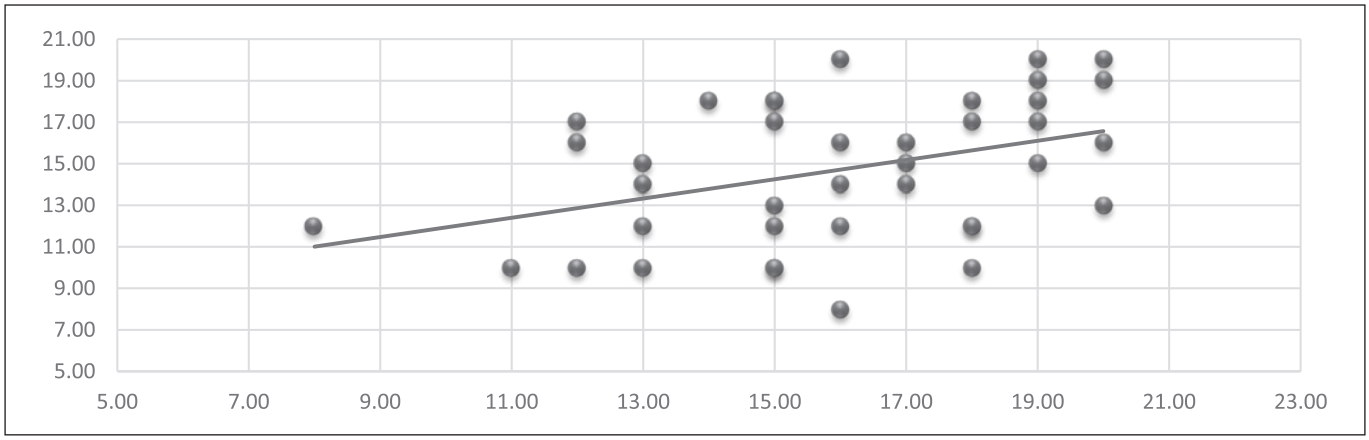

Fig. 9. Putting into perspective versus positive reappraisal ($r = 0.396$).

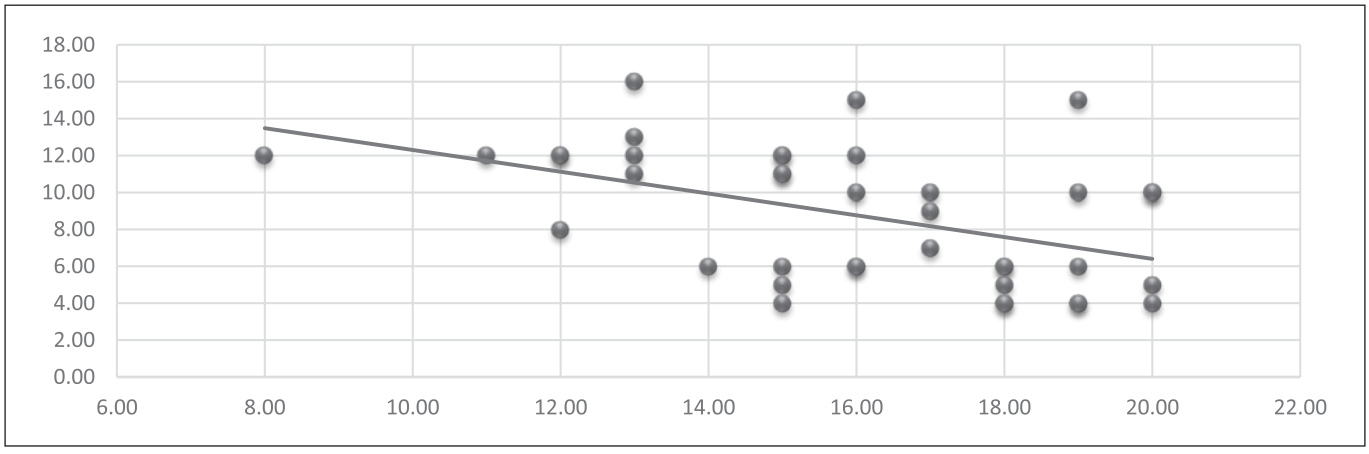

Fig. 10. Catastrophizing versus positive reappraisal ($r = -0.474$).

suppression, and the authors also advised to reevaluate the place of acceptance as an adaptive strategy. Acceptance was also found positively correlated in the present study with self-blame which is a maladaptive strategy (shown in Fig. 4). Self-blame is also a maladaptive cognitive emotion regulation strategy. An earlier study also indicated that self-blame, acceptance, and catastrophizing are positively correlated with depressive symptoms in major depressive disorder outpatients [52] which is consistent with the results of this study pointing to the negative aspects of acceptance. The result of the study shows that as the use of acceptance as a strategy increases the use of catastrophizing also increases (shown in Fig. 5). In a study conducted with adolescents, catastrophizing was found strongly related to all forms of violent behavior [58]. In another study, somatic complaints were significantly related to a more frequent use of maladaptive cognitive coping strategies, such as catastrophizing about negative life events [59]. Also, individuals with euthymic bipolar disorder and major depressive disorder reported increased use catastrophizing [54]. Another study with children showed that catastrophizing mediated the relationship between anxiety problems and their consequent interference [56]. Thus, the result of the study is consistent with the results of the whole study which might necessitate putting the strategy of acceptance into a negative place

On the other hand, the present study indicated positive correlations among adaptive cognitive emotion regulation strategies. Positive refocusing is about focusing on

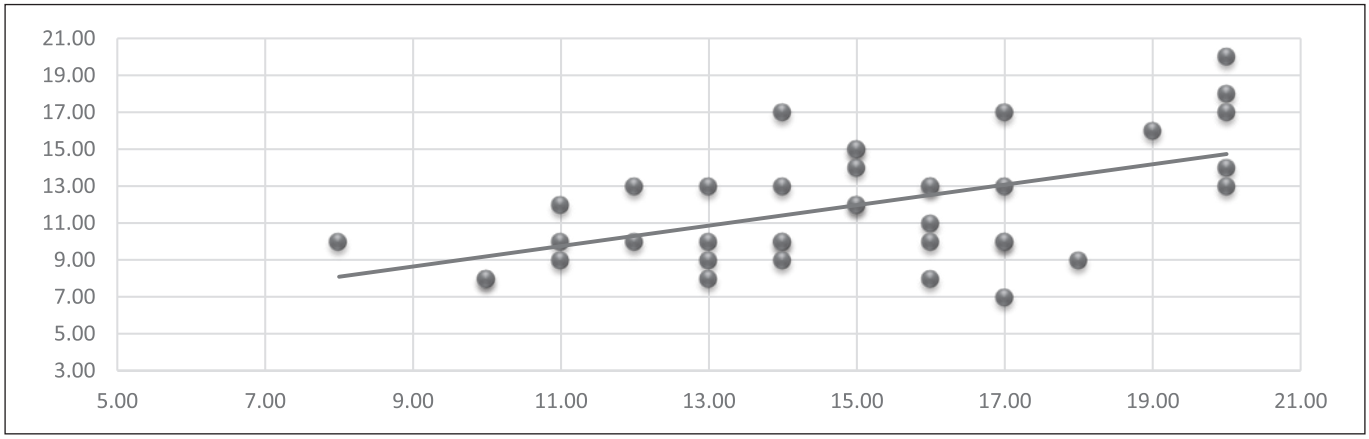

Fig. 11. Self-blame versus rumination ($r = 0.536$).

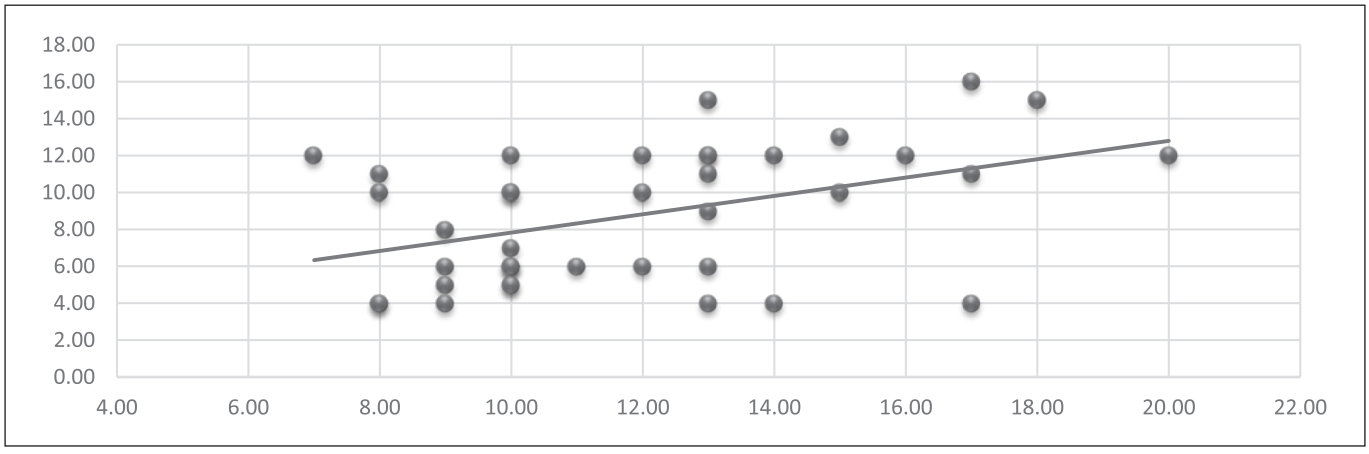

Fig. 12. Catastrophizing versus self-blame ($r = 0.440$).

positive experiences and is an adaptive cognitive emotion regulation strategy. An earlier study found specific relationships between externalizing problems and positive refocusing in adolescents [55]. A recent study also found that positive refocusing contribute to reducing anxiety or depression [50]. Results of this study complies with the results of previous studies and indicates that as positive refocusing increases, the strategy of refocus on planning also increases (shown in Fig. 6). Refocus on planning is an unconscious strategy developed to manage a negative situation at the cognitive level [60]. It is another adaptive cognitive emotion regulation strategy and is mostly related to resilience. Refocus on planning, positive reappraisal, and less rumination were found in a study to contribute to resilience in patients with depression and anxiety disorders [43]. A recent study indicated that high school students with nonsuicidal self-injury reported lower levels of refocus on planning [53]. Another recent research conducted with healthcare professionals indicated that positive refocusing can protect them from the destructive effects of moral distress which is directly and positively associated with burnout and protect their well-being [61]. The result of present study indicates a positive correlation between two adaptive cognitive emotion regulation strategies that are positive refocusing and refocus on planning which complies with previous studies. On the other hand, positive reappraisal, another adaptive coping style, was found inversely related to depression in a study [57] and was found to reduce the effect of bullying on anxiety [62]. The result of present study complies well

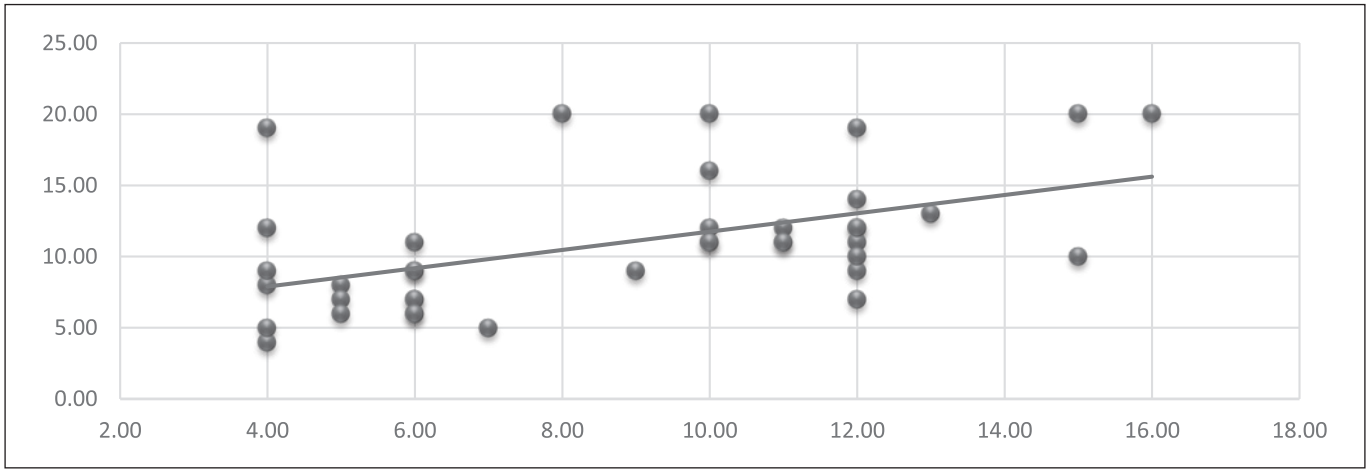

Fig. 13. Catastrophizing versus other-blame ($r = 0.506$).

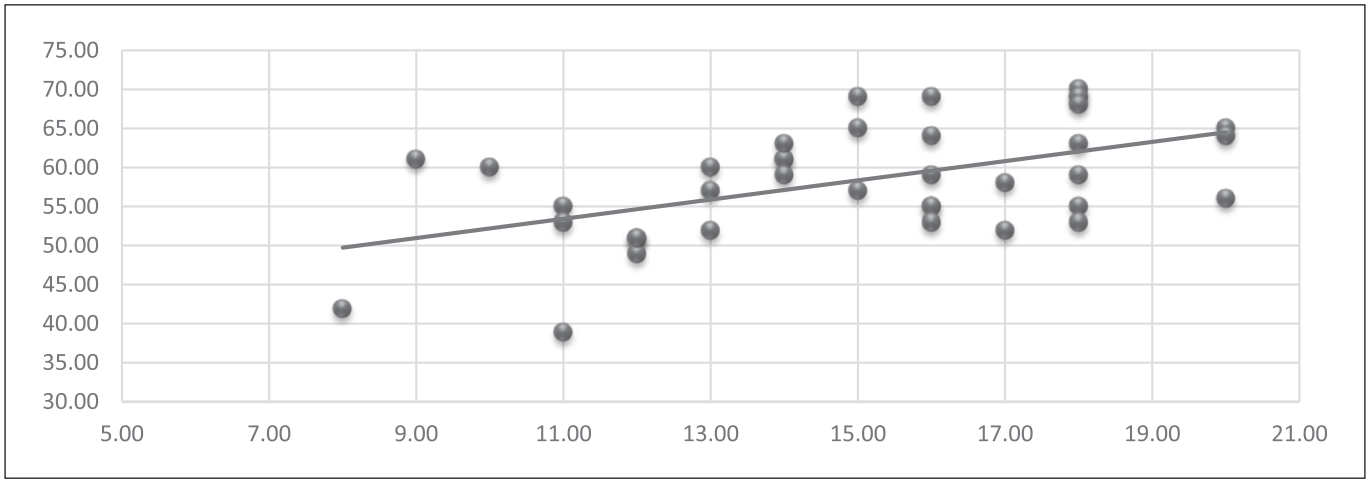

Fig. 14. Cognitive flexibility versus refocus on planning ($r = 0.528$).

with previous research that positive reappraisal and refocus on planning are also positively correlated adaptive cognitive emotion regulation strategies (shown in Fig. 7). The present study again found that refocus on planning is positively correlated with putting into perspective which is another adaptive cognitive emotion regulation strategy (shown in Fig. 8). Putting into perspective is an adaptive coping style and is beneficial in the absence of treatment [63]. Thus, an expected finding of the present study indicated that there is a positive correlation between those adaptive cognitive emotion regulation strategies.

Positive reappraisal is an adaptive coping style, mostly related to well-being and beneficial for patients suffering from PTSD [63]. The present findings indicated that there is a positive correlation between putting into perspective and positive reappraisal (shown in Fig. 9). Positive reappraisal is defined as reinterpreting the current negative situation in order to see the positive sides of it, and a recent study indicated that high-trait-anxious women use the positive reappraisal strategy inefficiently [64]. Positive reappraisal was also negatively correlated with depressive symptoms in major depressive disorder outpatients in an earlier study [52] (Lei et al., 2014). The same study also indicated that catastrophizing is positively correlated with depressive symptoms in major depressive disorder outpatient. Being a maladaptive strategy, catastrophizing is mostly found relevant with negative

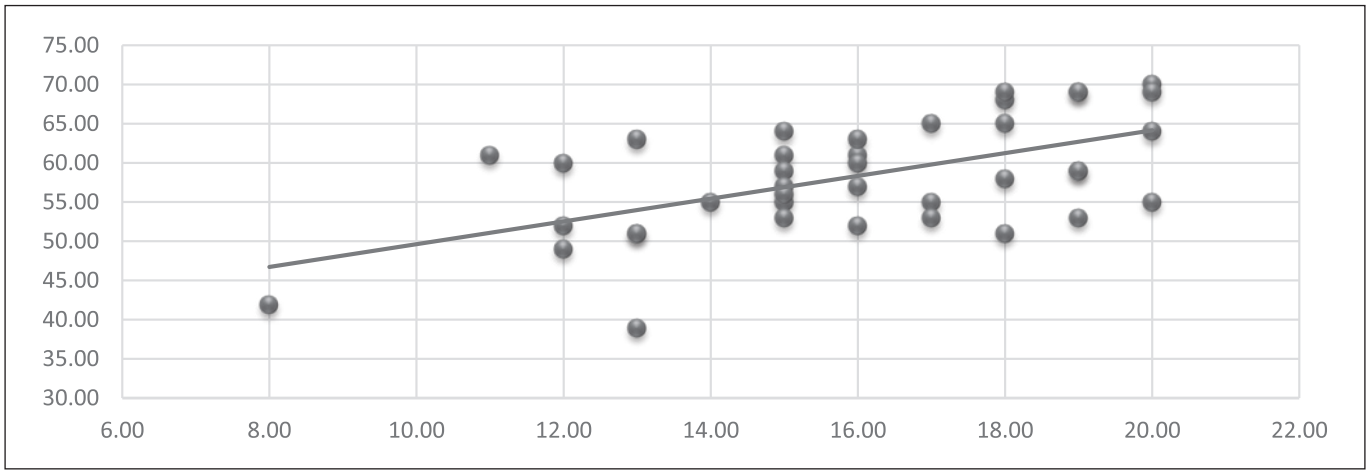

Fig. 15. Cognitive flexibility versus positive reappraisal ($r = 0.574$).

moods. In a study researching the violent behavior, catastrophizing was found strongly related to all forms of violent behavior [58]. In another study, somatic complaints were significantly related to a more frequent use of maladaptive cognitive coping strategies, such as blaming oneself, ruminating, and catastrophizing about negative life events [59]. Also, euthymic bipolar disorder and major depressive disorder individuals reported increased use of rumination, catastrophizing, and self-blame as stated above [54]. Apart from the studies performed by adults, a study with children also showed that catastrophizing, rumination, and other-blame mediated the relationship between anxiety problems and their consequent interference [56]. The present study supports the literature and shows a negative correlation between adaptive and maladaptive cognitive emotion regulation strategies that are catastrophizing and positive reappraisal (shown in Fig. 10).

The results of the present study indicated positive correlations among maladaptive cognitive emotion regulation strategies as well. Self-blame is a maladaptive coping strategy. It is positively correlated with depressive symptoms in major depressive disorder outpatients and somatic complaints [52, 59]. Rumination is also another maladaptive coping strategy that is related to anxiety problems [56]. The present study found that there is a positive correlation between self-blame and rumination which are two maladaptive strategies (shown in Fig. 11). The findings demonstrate a consistency with prior findings in the literature. Self-blame, catastrophizing, and other-blame are also maladaptive coping strategies, and in terms of cognitive emotion regulation, they are not beneficial as shown by most of the studies conducted in this field. Self-blame and catastrophizing are positively correlated with depressive symptoms, and euthymic bipolar disorder and major depressive disorder individuals use catastrophizing and self-blame as a coping strategy [52, 54]. As stated before, self-blame and catastrophizing are two maladaptive cognitive emotion regulation strategies, and catastrophizing is strongly related to violent behavior and somatic complaints [58, 59]. A study conducted with children also showed that catastrophizing, rumination, and other-blame mediated the relationship between anxiety problems and their consequent interference [56]. Another study with a large sample of unemployed people indicated that they go to maladaptive strategies that are self-blame, other-blame, and catastrophizing mostly. In a recent study, it was found that self-blame, other-blame, and catastrophizing are positively related to problematic online gaming [65]. The present study contributes to the existing information about maladaptive strategies and shows that catastrophizing is positively correlated with self-blame as well as other-blame (shown in Fig. 12, 13).

The analysis of cognitive flexibility and cognitive emotion regulation scales also revealed positive correlations in the present study. Refocus on planning, an adaptive strategy, and a coping style which were found in previous research as being highly related to resilience, well-being, and higher use of refocus on planning as a cognitive emotion regulation strategy are associated with more positive emotions while also anxiety symptoms are lower

only when more planning is adopted [44, 53]. On the other hand, cognitive flexibility is defined as being aware of alternatives for a situation and also being willing to adapt to this situation as well as having self-efficacy against this adaptation [19]. In this study, a strong correlation was found for cognitive flexibility and refocus on planning (shown in Fig. 14). A possible interpretation of this result could be that individuals with high cognitive flexibility also use adaptive cognitive emotion regulation strategies. This result is in agreement with another result of this study. Another strong correlation was found for cognitive flexibility and positive reappraisal which is an adaptive cognitive emotion regulation strategy (shown in Fig. 15). It is about seeing the positive sides of negative situations and was found in previous research as correlated with resilience while being beneficial for patients suffering from depression, anxiety, and PTSD [43, 63]. Since refocus on planning and positive reappraisal are adaptive cognitive emotion regulation strategies, they are being correlated with cognitive flexibility levels of individuals. These results indicate that as the cognitive flexibility level of individuals increases, their chance of using adaptive cognitive emotion regulation strategies also increases.

In the present study, one another main concern was to investigate the relations of learning styles with cognitive components regarding cognitive emotion regulation and cognitive flexibility. However, results did not indicate any significant difference or correlation for learning styles measured with Vermunt and Kolb Learning Styles Inventories. In addition to that, only the means obtained from the Cognitive Flexibility Scale ($F(2, 36) = 5.95$, $p < 0.05$) were significant in terms of the educational status of the participants, and a comparative analysis was conducted. The Levene's test was conducted afterward which indicated that the variations were homogenous ($p > 0.05$). The data obtained from the Scheffe test indicated that the participants having Processing Strategies as a learning style scored higher in cognitive flexibility when it is compared with the ones having Learning Orientations as a learning style. Processing Strategies are mainly related to cognitive functions that are knowledge, understanding, and skill [66]. The relationship between cognitive flexibility and a cognitive-based learning style that is processing Strategies is consistent with their main definitions. However, there is no study with regard to the relationship between cognitive flexibility and learning styles. Detailed research is hereby advised for handling a possible relation between cognitive features and learning style dominance.

Limitations

In this study, it was aimed to investigate possible correlations and differences between cognitive emotion regulation strategies, WM tasks, cognitive flexibility, and learning styles. There are important results collected in the present study, and a future study with a larger group would make great contribution to the field of cognitive and educational psychology.

Acknowledgments

We especially thank all our students who volunteered their time to our study.

Statement of Ethics

The study has been approved by the Ethics Committee of Rectorate in Istanbul Gelisim University in Turkey with 2021/21 meeting number. The participants filled out a consent form before attending the sessions of the study.

Conflict of Interest Statement

The authors declare no conflict of interest.

Funding Sources

The authors did not receive support from any organization for the submitted work.

Author Contributions

Kahraman Guler and Aylin Aydin collaboratively formulated the research question, conceptualized the study, analyzed the data, and wrote the manuscript.

Data Availability Statement

All data, analysis code, and research materials are available at (https://osf.io/hf5tc/?view_only=03dde01b7e1149a0ab7b0c019a9b4267).

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