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Effect of Positive Mental Imagery Stimuli on Anhedonic Depressive Symptoms

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This study aimed to investigate the effect of the intervention of positive mental imagery on anhedonia and the underlying reward mechanism in depression, and to explore the sustainability of the impact of the intervention following stress induction. Participants reporting anhedonic depressive symptoms ($N = 54$) were randomly assigned to either a positive mental imagery condition or a verbalization condition, the former utilizing positive imagery stimuli only, and the latter utilizing language-based on meaning. Participants in both the conditions completed a computerized picture-word task for imagery generation and mental arithmetic stress task for stress induction. The results showed that both intervention conditions significantly reduced anhedonia and negative affect and that the mental imagery intervention was not superior to verbalization intervention. After stress induction, there was no significant difference between the two conditions in terms of the sustainability of the impact of the intervention on mood, reward subcomponents, and anhedonia. These findings provide preliminary evidence of the effectiveness of positive mental imagery in improving anhedonia. Furthermore, this study emphasizes the importance of repetitive imagery intervention due to the unsustainable impact of brief interventions after stress induction.

Keywords: positive mental imagery, anhedonic depressive symptoms, stress induction

Anhedonia, a reduced capacity to experience or pursue pleasure, is one of the core symptoms of major depressive disorder (American Psychiatric Association, 2013). Traditionally, anhedonia is considered as a phenomenon related to "loss of pleasure", operationalized as blunted positive affect (PA). However, since previous studies have posited that the level of PA alone may not predict anhedonic symptoms (Bryant, Winer, Salem, & Nardoff, 2017), recent neuropsychological studies have reconceptualized the concept of anhedonia by emphasizing not only mood states but also a multifaceted stage related to reward processing (Rizvi, Pizzagalli, Sproule, & Kennedy, 2016). Several studies have revealed that deficits in subcomponents of reward processing, such as anticipatory pleasure (Da Silva et al., 2017; Treadway & Zald, 2011), pleasure derived from predicted future rewards (Geaney, Treadway, & Smillie, 2015) or motivation (Bryant et al., 2017; Sherdell, Waugh, & Gotlib, 2012) may serve as potential precursors of anhedonic depression (Thomsen, 2015).

Difficulties in reward processing in anhedonic depression are likely caused by dysfunctional interactions between the stress and brain reward systems. According to Pizzagalli (2014), stress reduces activation in the reward-related brain regions, known for their association with reinforcement learning, through the inhibition of the mesocorticolimbic dopaminergic pathways. Consequently, anhedonia may occur as a consequence of blunted reward encoding caused by the negative effects of stressors on the dopamine pathway in depression. Since several studies have upheld the abnormal processing of reward-related stimulus in anhedonic depression (Atchley et al., 2012; Winer & Salem, 2016), identifying the means that facilitate reward processing may hold important therapeutic value in treating anhedonic depressive symptoms.

Given the mechanism of anhedonia, mental imagery may be a

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promising tool for psychological interventions. Mental imagery refers to the experience of accompanying representation of sensory information without a direct external stimulus (Pearson, Naselaris, Holmes, & Kosslyn, 2015). Research evidence suggests that mental imagery can elicit powerful affective responses by helping effective reward encoding. Unlike verbal processing, imagery-based processing may exert a stronger effect on emotion by constructing images that use relevant sensory autobiographical memories (Holmes, Mathews, Mackintosh, & Dalgleish, 2008). Because mental imagery and visual perception rely on similar neural mechanisms (Dijkstra, Bosch, & Van Gerven, 2019), mental imagery may aid the representation of relevant personal memories with their associated emotional tone (Conway, 2001; Holmes, Lang, & Shah, 2009). As a result, it induces "as-if real" emotional responses (Ji, Heyse, MacLeod, & Holmes, 2016).

Based on prior studies, it is plausible that mental imagery contributes to the improvement of the anhedonic depressive symptoms by affecting reward-encoding. This has been confirmed in several studies that reported that the generation of positive mental imagery induces changes in depressed mood states (Blackwell et al., 2015; Heyes et al., 2017). However, only a limited number of studies have investigated the effect of positive mental imagery on anhedonic depressive symptoms focusing specifically on reward processing. While several studies have reported the effect of mental imagery on improving anhedonic symptoms (Blackwell et al., 2015; Min, Kwon, & Lee, 2019), few studies have investigated the relationship between mental imagery and reward processing in anhedonic depression. Moreover, it is important to investigate whether the potentially positive effects of mental imagery are sustained after stress induction. Given the mechanism of anhedonia which may be specifically induced through its interaction with stress (Pizzagalli, 2014), investigating the change in the mental imagery effect after stress induction may be useful for examining the clear effect of mental imagery on anhedonic symptom. However, few studies have investigated the changes of the impact of mental imagery after stress induction. While some prior studies have reported that the effects of mental imagery are maintained in two-week follow-up (Lang, Blackwell, Harmer, Davison, & Holmes, 2012; Torkan et al, 2014), studies that have directly investigated the interaction between the impact of mental imagery and stress are scarce.

Thus, the purpose of the present study was to explore the effect of positive mental imagery intervention on anhedonia and the underlying reward mechanism in depression and to investigate the durability of the impact of the intervention following laboratory stress induction. For this purpose, participants reporting anhedonic depressive symptoms were randomly allocated to one of two conditions: mental imagery or verbalization, which is another mode of representing information according to the dual-coding theory (Paivio, 1991). The present study hypothesized that 1) compared to individuals assigned to the verbalization condition, individuals in the mental imagery condition show higher self-rated mood states, reward subcomponents (anticipated pleasure, consummatory pleasure, and motivation), and less significant anhedonic symptoms after the intervention and that 2) individuals in the mental imagery condition show lower levels of changes in self-ratings of their mood, reward subcomponents, and anhedonic symptoms after a stress induction task.

Methods

Participants

Individuals between aged between 19 and 29 years were recruited through online advertisements posted on internet communities. They were screened for anhedonic depressive symptoms using the Anhedonic Depression subscale of the Mood and Anxiety Symptoms Questionnaire (MASQ-AD) (Clark & Watson, 1991). Specifically, individuals who exceeded the cutoff score of 23 on the MASQ-AD scale were selected and rewarded with 10,000 Korean won to participate for taking part in the study. Individuals taking prescribed antipsychotic medications or receiving psychological treatment were excluded from the study. Finally, a total of 54 adults comprising of 36 females and 18 males, with a mean age of 23.02 ($SD = 3.06$), were selected. The present study was approved by the institutional review board of the university and informed consent was obtained from all the participants.

Questionnaire Measures

The Anhedonic Depression Scale from the Mood and Anxiety Symptoms Questionnaire (MASQ–AD; Clark & Watson, 1991)

The MASQ-AD (Clark & Watson, 1991) is a 22-item scale that as-

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sesses anhedonic depressive symptoms using a 5-point Likert scale ranging from 1 (not at all true) to 5 (very true), with a higher score indicating more severe symptoms. In the present study, the 8-item subscale from the K-MASQ-AD, translated and validated by H. Lee and Kim (2014), was used to screen participants who scored 23 and higher. The 8-item subscale of the MASQ-AD has been identified as outperforming the total scale in predicting current major depressive episode related to anhedonia (Bredemeier et al., 2010). Internal consistency measured by Cronbach's α was .94 in H. Lee and Kim (2014) and was .72 in this study.

Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988)

The PANAS is a 20-item self-report measure of PA and negative affect (NA) using a 5-point Likert scale ranging from 1 (not at all true) to 5 (very true). It included 10 items measuring PA and 10 items measuring NA. The Korean version of the PANAS (H. H. Lee, Kim & Lee, 2003), was used in the present study. Internal consistency was .84 in H. H. Lee et al. (2003) and Cronbach's α was .86 in the present study.

Dimensional Anhedonia Rating Scale (DARS; Rizvi et al., 2015)

The DARS is a self-report scale measuring the different types of reward deficits across four domains (hobbies, food/drinks, social activities, and sensory experience) using a 5-point Likert scale ranging from 1 (not at all true) to 5 (very true), which is specifically developed for the assessment of anhedonic symptoms in depression. In this study, the modified DARS scale, translated by Park (2018) and revised and validated by E. J. Kim (2018), was used to measure consummatory pleasure, anticipatory pleasure, and motivation. Internal consistency was .95 for total items, .82 for consummatory pleasure, .88 for anticipatory pleasure and .95 for motivation. In this study, the internal consistency was .95 for the total items, .74 for consummatory pleasure, .89 for anticipatory pleasure, and .89 for motivation.

Center for Epidemiological Studies–Depression Scale (CES–D; Radloff, 1977)

The CES-D is a 20-item scale that measures depressive symptoms experienced by the participants in the past week using a 4-point Likert scale ranging from 0 (rarely or none of the time) to 3 (most or all of the time). The K-CES-D, translated and validated by Chon, Choi, and Yang (2001), was used in this study. Internal consistency was .92 in the original validation study (Chon et al., 2001), and was .72 in this study.

Questionnaire upon Mental Imagery (QMI; Sheehan, 1967)

The QMI is a 35-item scale assessing vividness of imagery in seven sensory modalities (e.g., audition) using a 7-point Likert scale ranging from 1 (no imagery) to 7 (imagery as vivid as real). In the current study, the Korean version of the QMI, translated and validated by J. H. Kim (1995), was used to exclude the confounding effects of the imagery ability. Cronbach's α was .92 in Min et al.'s (2019) study and was .95 in this study.

Picture Word Task

The participants of the present study took part in a computerized Picture Word (PW) task adapted from a previous study (Holmes et al., 2008), which was programmed using Psychopy3 version 3.0. and was administered using an Intel Core i3-6100U CPU laptop. In the PW task, the participants were repeatedly instructed to generate images or a single sentence by combining ambiguous pictures and positive verbal captions. Specifically, the participants in the mental imagery condition were instructed "Imagine the situation vividly combining the word and the picture" for 1,500 ms, while participants in the verbalization condition were given the direction "Make a single concrete sentence combining the word and the picture". Then, as Table 1 indicates, all the participants were presented with ambiguous/neutral pictures with positive word captions for 3,500 ms. Ambiguous/neutral pictures were downloaded from the Internet (non-copyrighted). Each picture was an ambiguous photo of daily objects and scenes, as in previous studies (Blackwell et al.,

Table 1. *Example of Picture-word Stimuli used in the Intervention*

Picture	Accompanying caption
Smartphone	"Fun"
Alarm clock	"Relaxation"
Night	"Peace"
Blackboard	"Achievement"
Box	"Gift"
Tree	"Refreshing"

2015; Holmes et al., 2008; Pictet, Coughtrey, Mathews, & Holmes, 2011). Positive words were selected from the Korean Affective Words List (Hong, Nam, & Lee, 2016), with positive valences ranging from 6 to 8 ($M = 7.36$, $SD = .52$), together with a variety of arousal levels ($M = 4.57$, $SD = 1.35$). Subsequently, a beep sounded, and the participants were asked to respond about the vividness of their imagination or concreteness of sentence construction using a 5-point Likert scale ranging from 1 (very hard to imagine/make a sentence) to 5 (very easy to imagine/make a sentence). After the rating, the participants were guided to continue the remaining trials. The task consisted of one training block which contained 4 trials, followed by 4 test blocks, each containing 16 trials.

Mental Arithmetic Stress Task

Mental Arithmetic Stress Task (MAST) is a computer-based mental calculation task designed to induce stress (Sawai et al., 2019). Because of its strong stress component, many previous studies, including depressive disorder studies, have used the MAST to elicit stress (Jonassaint et al., 2009; A. Y. Kim et al., 2019). In this study, all participants were instructed to perform serial subtraction of 17 from 8,500 mentally (e.g., 8,500-17, 8,483-17). After 5 min, a beep sounded and the participants were asked to rate the stress load using a 5-point Likert scale ranging from 1 (not at all) to 5 (completely).

Manipulation Checks

Manipulation check measures were used at the end of the experiment to identify task compliance. The participants were asked to rate the degree of the use of each strategy (mental imagery vs. verbalization) using a 10-point Likert scale ranging from 1 (never) to 10 (always) and check the predominant strategy they used during the PW task. The questionnaire items were obtained from Lim (2018).

Procedure

The participants provided written informed consent after being briefed on the study. They were randomly allocated to one of the two conditions (mental imagery or verbalization). The experimental session began with self-reported measurements of anhedonic depressive symptoms, current mood, and reward deficits, as pre-intervention measures. After the baseline assessment, the PW task was completed, which included either trial-by-trial ratings of the vividness of picture-word combinations in the mental imagery condition or a rating of verbalization concreteness of the association in the verbalization condition. Following the PW task, the participants completed a self-report questionnaire using the same scale used in the previous measurement. MAST was then implemented to induce stress in the participants. The participants assessed their mood, reward-related symptom, and anhedonia again. Additionally, all the participants were guided to rate the predominant strategy they used while engaging in the PW task at the end of the experiment. Finally, the participants were debriefed and compensated for their participation.

Data Analysis

SPSS 25.0 was used for all statistical data analysis. A chi-square test of homogeneity was conducted to determine whether the participants complied with the experimental instruction, and to rule out the possibility of heterogeneity between the two groups. To investigate between-group differences in the variables of interest, an independent sample *t*-test was used. A two-way mixed-model ANOVA was then applied to examine the efficacy of mental imagery on mood, reward subcomponents, and anhedonic symptoms, as well as the sustainability of the impact of the intervention. Finally, a paired samples *t*-test was used to further investigate the pre- and post-intervention differences in both the conditions.

Results

Baseline Measures

Table 2 shows the outcomes of the baseline measures. Neither condition (mental imagery condition vs. verbalization condition) showed significant differences in the current anhedonic depression score, baseline PANAS mood magnitude, anticipatory pleasure, consummatory pleasure, and motivation.

Manipulation Checks

To examine instructional compliance, the chi-square and independent *t*-tests were used. Regarding the prevalent usage of strategy, the two groups showed significant differences in the use of

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Table 2. *Baseline Measures*

	Mental Imagery (n = 31)		Verbalization (n = 23)		*t*	*p*
	M	*SD*	*M*	*SD*		
MASQ-AD	73.35	8.89	73.04	10.29	.12	.906
CES-D	27.35	7.47	25.35	8.47	.92	.361
QMI	186.58	33.59	192.48	21.26	-.74	.464
PANAS						
Positive Affect	19.16	5.02	20.74	5.66	-1.08	.284
Negative Affect	17.94	5.77	19.96	7.74	-1.05	.276
DARS						
Consummatory Pleasure	4.31	.57	4.22	.52	.59	.561
Anticipatory Pleasure	4.22	.74	4.22	.63	.00	.999
Motivation	3.88	.90	3.84	.74	.18	.860

Note. MASQ-AD = Mood and Anxiety Symptom Questionnaire-Anhedonic Depression; CES-D = Center for Epidemiological Studies-Depression Scale; QMI = Questionnaire upon Mental Imagery; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.

prevalent strategy during the PW task ($\chi^2(1) = 6.400$, $p = .011$), indicating that a substantial proportion of the participants followed instructions corresponding to the allocated condition. Regarding the degree of the usage of each strategy, there was a significant difference in the degree of verbalization ($t(52) = -2.64$, $p = .011$), whereas there was no significant difference in the degree of mental imagery usage between the two groups ($t(52) = .99$, $p = .328$). These results indicate that the participants in both the conditions used similar levels of mental imagery and that, while the mental imagery group depended more on imagery processing, the verbalization group relied more on verbal processing.

PW Task Outcome

To examine the efficacy of mental imagery, a two-way mixed-model ANOVA was used with the group (mental imagery condition vs. verbalization condition) as the between-subjects factor and time (pre- vs. post-intervention) as the within-subjects factor (Table 3). As indicated in Table 3, time had a statistically significant main effect on anhedonic depression ($F(1, 52) = 25.69$, $p < .001$). However, there was no significant interaction effect between the group and time on anhedonia, indicating that both the conditions showed a reduction in anhedonic symptoms; however, the difference between the two groups was not significant ($F(1, 52) = .37$, $p = .543$). In addition, there was also a significant main effect of time on NA ($F(1, 52) = 38.33$, $p < .001$), despite the lack of evidence supporting a statistically significant interaction between the group and time ($F(1, 52) = 2.41$, $p = .127$). Contrary to our research hypothesis, neither a significant main effect nor an interaction effect on PA was found. In addition, no statistically significant main effect or interaction effect on consummatory pleasure, anticipatory pleasure, or motivation was found.

MAST Outcome

Regarding the rating of the stress load, moderate stress levels were observed in all the participants ($M = 3.15$, $SD = .91$). As indicated in Table 4, time had a significant main effect on anhedonic depression ($F(1, 52) = 5.54$, $p = .022$), NA ($F(1, 52) = 36.90$, $p = .000$), consummatory pleasure ($F(1, 52) = 4.57$, $p = .037$), and anticipatory pleasure ($F(1, 52) = 8.42$, $p = .005$) after inducing stress. However, the interaction effect between the group and time was not statistically significant. Hence, a paired-samples *t*-test and Cohen's *d* coefficient were used to further assess the effect size of each intervention after stress induction. As indicated in Table 5, in the mental imagery condition, there were significant differences between pre- and post-MAST in anhedonia ($t(30) = -2.36$, $p = .025$) and NA ($t(30) = -5.09$, $p = .001$), indicating that anhedonic symptoms and NA increased significantly after stress was induced in mental imagery condition. However, there were no significant differences in PA, anticipatory pleasure, consummatory pleasure, or motivation. In the verbalization condition, significant differences were observed in NA ($t(22) = -3.67$, $p = .001$), consummatory pleasure ($t(22) = 2.07$, $p = .050$), and anticipatory pleasure ($t(30) = 2.16$, $p = .042$), indicating that there was a significant increase in NA and decrease in consummatory and anticipatory pleasure in the verbalization condi-

Table 3. *Pre- and Post-intervention Outcome*

	Groups	Pre-		Post-		Time	Time*Group
		M	*SD*	*M*	*SD*		
MASQ-AD	Imagery	28.13	3.19	23.81	6.08	25.69**	.37
	Verbal	28.26	3.65	24.87	4.65		
PANAS							
Positive Affect	Imagery	19.16	5.02	19.84	6.15	.52	2.69
	Verbal	20.74	5.66	19.00	6.84		
Negative Affect	Imagery	17.94	5.77	15.10	5.19	38.33**	2.41
	Verbal	19.96	7.74	15.22	5.66		
DARS							
Consummatory Pleasure	Imagery	4.31	.74	4.24	.64	.04	1.69
	Verbal	4.22	.52	4.30	.62		
Anticipatory Pleasure	Imagery	4.22	.66	4.25	.68	.74	.07
	Verbal	4.22	.63	4.28	.64		
Motivation	Imagery	3.88	.90	3.92	.81	3.16	.33
	Verbal	3.84	.74	4.04	.74		

Note. MASQ-AD = Mood and Anxiety Symptom Questionnaire-Anhedonic Depression; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.
**$p < .01$.

Table 4. *MAST Outcome*

	Groups	Pre-		Post-		Time	Time*Group
		M	*SD*	*M*	*SD*		
MASQ-AD	Imagery	23.81	6.08	25.97	5.49	5.54*	.43
	Verbal	24.87	4.65	26.09	6.01		
PANAS							
Positive Affect	Imagery	19.84	6.15	19.77	6.65	.99	.84
	Verbal	19.00	6.84	17.48	6.50		
Negative Affect	Imagery	15.10	5.19	19.48	5.57	36.90**	.30
	Verbal	15.22	5.66	20.48	8.46		
DARS							
Consummatory Pleasure	Imagery	4.24	.64	4.17	.64	4.57*	.47
	Verbal	4.30	.62	4.16	.62		
Anticipatory Pleasure	Imagery	4.25	.68	4.13	.76	8.42**	.21
	Verbal	4.28	.64	4.10	.68		
Motivation	Imagery	3.92	.81	3.88	.87	3.16	.33
	Verbal	4.04	.74	3.92	.73		

Note. MASQ-AD = Mood and Anxiety Symptom Questionnaire-Anhedonic Depression; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.
*$p < .05$, **$p < .01$.

tion after completing the stress-induction task. However, no significant differences were found in anhedonia, PA, or motivation.

Discussion

This study aimed to investigate the efficacy of the intervention of positive mental imagery on anhedonic depressive symptoms and to examine the sustainability of the impact of the intervention following the stress induction. Several major findings were obtained in this study. First, contrary to our hypothesis, the expected superiority of mental imagery over the verbalization was not found to improve anhedonic symptoms, mood, anticipatory pleasure, con-

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Table 5. *Effect Size of the Intervention after MAST*

	Groups	Pre-		Post-		*t*	*p*	Cohen's *d*
		M	*SD*	*M*	*SD*			
MASQ-AD	Imagery	23.81	6.08	25.97	5.49	-2.36	.025**	.36
	Verbal	24.87	4.65	26.09	6.01	-1.09	.289	.23
PANAS								
Positive Affect	Imagery	19.84	6.15	19.77	6.65	.07	.948	.01
	Verbal	19.00	6.84	17.48	6.50	1.19	.248	.23
Negative Affect	Imagery	15.10	5.19	19.48	5.57	-5.09	.000**	.81
	Verbal	15.22	5.66	20.48	8.46	-3.67	.001**	.73
DARS								
Consummatory Pleasure	Imagery	4.24	.64	4.17	.64	1.04	.306	.11
	Verbal	4.30	.62	4.16	.62	2.07	.050*	.23
Anticipatory Pleasure	Imagery	4.25	.68	4.13	.76	1.89	.068	.17
	Verbal	4.28	.64	4.10	.68	2.16	.042*	.27
Motivation	Imagery	3.92	.81	3.88	.87	.46	.648	.05
	Verbal	4.04	.74	3.92	.73	1.22	.235	.16

Note. MASQ-AD = Mood and Anxiety Symptom Questionnaire-Anhedonic Depression; PANAS = Positive and Negative Affect Schedule; DARS = Dimensional Anhedonia Rating Scale.
*$p < .05$, **$p < .01$.

summatory pleasure, and motivation. However, there was a significant main effect of time on anhedonia and NA, with a larger effect size in the mental imagery condition.

While no significant difference was found between the two conditions in reducing anhedonia, the result could be interpreted as an effect of mental imagery comparable to that of verbalization on anhedonia. Previous investigations have shown that cognitive therapy, which is mainly tuned to treating verbal forms of cognition (Saulsman, Ji, & McEvoy, 2019), has a beneficial effect in treating depression (Dobson, 1989; Rupke, Blecke, & Renfrow, 2006) as well as severe anhedonia (Khazanov et al., 2020). Based on the prior studies, the impact of mental imagery comparable to that of verbalization seems notable in that it reduces anhedonia, which is known for poor treatment responses (Craske, Meuret, Ritz, Treanor, & Dour, 2016), with only one session. Thus, the marginal difference between the two conditions may indicate the potential role of mental imagery in the treatment of anhedonic symptoms.

Moreover, there was neither a significant main effect nor an interaction effect of the intervention on the PA and reward subcomponents, including consummatory pleasure, anticipatory pleasure, and motivation. Considering prior studies that have reported the effect of mental imagery on PA and reward subcomponents (Renner, Murphy, Ji, Manly, & Holmes, 2019), such unexpected findings from the present study need further explanation. One possible explanation may be related to the arousal levels of the stimuli used in the PW task. In the PW task, the mean arousal level of the positive word stimuli were 4.57 ($M = 4.57$, $SD = 1.35$), indicating a medium level of arousal. However, reward subcomponents such as anticipatory pleasure, are likely to have a stronger relationship with high-aroused pleasant states (Geaney et al., 2015). Moreover, PA induced by medium-arousal stimuli could not be properly evaluated because of the limitation of the PANAS, which is suitable only for capturing high-arousal PA states (McManus, Siegel, & Nakamura, 2019). Therefore, it is likely that the impact of mental imagery on PA or reward subcomponents was not actually reflected.

Second, there was no significant difference between the two groups in terms of the durability of the impact of the intervention on mood, reward subcomponents, and anhedonia. However, the degree of the change varies depending on the condition. After performing the MAST, anhedonia and NA increased in the mental imagery condition while in the verbalization condition, NA increased and consummatory and anticipatory pleasure decreased. Regarding anhedonia, the impact of the intervention was not sustained only in the mental imagery condition perhaps due to the increased sensitivity to emotional state after performing mental imagery (Mitchell & Cusack, 2016). Consequently, it is likely that

the participants reported lower levels of anhedonia after the intervention, causing larger changes in anhedonic symptoms following the stress induction task. Thus, a significant change in anhedonia score was found only in the mental imagery condition even though anhedonia symptoms were higher in the verbalization condition than in the mental imagery condition.

Moreover, as for anticipatory pleasure, we may explain the results by considering the characteristics of the reward subcomponents and the mechanism of mental imagery. Anticipatory pleasure, a prospect-based emotion, seems to be drawn from positive past experiences that induce a stronger sense of pleasure (Painter & Kring, 2016). Thus, mental imagery may have an impact on anticipatory pleasure by representing an image related to sensory personal memories (Holmes et al., 2009). However, the stress induced in this study was related to cognitive load rather than personal real-life stressors. As a result, it may be possible that the impact of mental imagery on anticipatory pleasure after stress induction was preserved in the mental imagery condition because of the discrepancy between the reward subcomponent-related stress and MAST-induced stress. In contrast, it seems that the impact of stress was stronger in the verbalization condition because they relied more on semantic processing.

This study contributes to our understanding of anhedonic depression by revealing the effects of mental imagery on anhedonic symptoms. While the results did not show a clear superiority of imagery intervention on anhedonic symptoms, mental imagery intervention was found to improve anhedonia. This implies that positive mental imagery can be used as an add-on therapy to an existing treatment considering that extant treatments are relatively ineffective for anhedonia. Another strength is that unlike previous studies that only identified the direct effects of imagery intervention, the current study investigated whether the impact of mental imagery on anhedonia is sustainable following stress induction. Although a more elaborate stress induction task is called for in future research, it is noteworthy that this study emphasizes the necessity of repetitive imagery intervention because of the unsustainability of the impact of a brief intervention after stress induction. However, the present findings must be considered in light of the following limitations. First, the sample size was not large enough to detect any differences between the two conditions. Second, even though there were insignificant changes in reward subcomponents after the imagery intervention, we could not confirm the efficacy due to usage of stimuli with a medium arousal range. In future studies, stimuli eliciting a higher arousal level are required considering the relevance between arousal level and reward subcomponents. Third, minute differences between the two conditions in the usage of mental imagery may render the comparison between the two interventions difficult. To make a clear comparison, more frequent monitoring of manipulation is required in future studies. Finally, given the mechanism of mental imagery, the stress induction task used in the present study may not induce stress relevant to reward subcomponents. We encourage future research to adopt stress-induction task related to daily life stress to identify the impact of stress more precisely on reward subcomponents after the intervention.

Author contributions statement

MJP, a graduate student at Yonsei University, collected and analyzed the data, and prepared the manuscript. SHP, an associate professor at Yonsei University, served as the principal investigator of the research grant and supervised the research process. All the authors provided critical feedback, participated in revision of the manuscript, and approved the final submission.

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Original Article

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The Relationship Between Prescription Patterns and Symptom-Based Subtypes of Depression Using Minnesota Multiphasic Personality Inventory-2 Restructured Form (MMPI-2-RF) Specific Problems Scales in Korean Clinical Sample

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We derived five heterogeneous subtypes for 473 Korean depressive disorder patients through a latent profile analysis using the specific problems scale of the Minnesota Multiphasic Personality Inventory-2 Restructured Form (MMPI-2-RF), which we used in a previous study (Choi, 2019). In this study, we attempted to confirm the clinical usefulness of specific problem scales by comparing the drug prescription patterns of the five derived subtypes: mild, helpless, somatic, avoidant with anxiety, and irritable with anxiety. Through retrospective medical records of 473 patients with depressive disorder, we investigated their demographic variables, hospitalizations, and prescriptions during the initial, third, and sixth months of treatment. There was a significant difference among the groups in the number of antidepressants prescribed initially and in the third months of treatment. Additionally, we noted differences in antipsychotics prescription in months three and six and sedative/hypnotics prescription in month six. The study results confirmed that the subtypes of depressive disorder based on specific problem scales of the MMPI-2-RF were associated with prescription patterns and clinical course. This finding suggests that subtyping based on multidimensional symptoms, not just the main symptoms of depression, may be useful in establishing a focused treatment plan tailored to the individual characteristics of patients in the initial phase of treatment.

Keywords: depression, symptom-based subtypes, specific problems scale of MMPI-2-RF, latent profile analysis, prescription patterns

Depressive disorders, which include multiple heterogeneous clinical features, are classified into subtypes based on various criteria. Historically, researchers and clinicians have attempted to classify the subtypes based on the heterogeneous aspects of depressive disorder, such as the specifier of the disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM), severity, family history, and age of onset (American Psychiatric Association, 2013; Savitz & Drevets, 2009; Sharpley & Bitsika 2013). In recent years, subtypes classification has included data-driven approaches because of the advantages of using various indicators to explore real and heterogeneous subgroups within depressive disorders (Ten Have et al.,2016; Van Loo, De Jonge, Romeijn, Kessler, & Schoevers, 2012). Latent cluster analysis or latent profile analysis using various symptom dimensions as indicators is also referred to as a person-centered approach rather than a variable-centered approach because it subtypes based on the similarities and differences within

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patients with depressive disorder.

Previous studies that analyzed symptom patterns through a person-centered approach mainly derived latent clusters based on diagnostic criteria or depression scales, such as the Beck Depression Inventory (BDI), Hamilton Depression Rating Scale (HAM-D), and Center for Epidemiologic Studies-Depression Scale (CES-D) (Van Loo et al., 2012; Ten Have et al., 2016; You et al., 2011). These studies had the advantage of classifying subgroups based on the typical symptoms of depressive disorder. However, the limitation was that they did not reflect the patterns of various atypical symptoms of depressive disorder. Patients with depressive disorder also often have anxiety or somatic symptoms, irritability, or aggression, which are not included in the DSM specifiers.

The Minnesota Multiphasic Personality Inventory-2 (MMPI-2), widely used in clinical settings as an assessment tool, covers various psychopathologies (Butcher et al., 2001). A reconstructed version with improved psychometric stability and construct validity has been launched, thereby increasing its usefulness in research and clinical evaluation (Ben-Porath & Tellegen, 2008; Han, Moon, Lee, & Kim, 2011). Among the subscales of the reconstructed version that can be used directly with the 338-item Minnesota Multiphasic Personality Inventory-2 Restructured Form (MMPI-2-RF) or converted from MMPI-2, the 23 specific problem scales have the advantage of allowing the identification of detailed symptoms in various dimensions. Because the 23 specific problem scales measure detailed symptoms without overlapping each other in various dimensions, they have the advantage of identifying symptom patterns of a wide range of dimensions in addition to the severe level of accompanying symptoms indicated by the comorbid diagnosis. It includes somatic/cognitive, internalizing, externalizing, and interpersonal scales; therefore, it can be a useful tool for grouping patients with a depressive disorder based on the patterns of various symptom dimensions.

To classify patients with a depressive disorder based on multi-dimensional symptoms, we conducted a latent profile analysis (LPA) of 473 patients with depressive disorders using the MMPI-2-RF specific problems scales as indicators in a previous study (Choi, 2019[1]). As a result, we adopted a classification model with five classes (or groups): "mild group", "helpless group", "somatic group", "avoidant group with anxiety", and "irritable group with anxiety". The mild group (22.6%) showed a low level of symptoms in all dimensions and had lower comorbidity. The helplessness group (23.9%) had high hopelessness and self-doubt but a lower level of other somatic/cognitive symptoms or externalizing symptoms. This group is similar to the group classified as having typical depression (Rodgers et al., 2014a) or moderate depression without anxiety (Ten Have et al., 2016). In the somatic group (27.9%), we observed elevated somatic/cognitive domain symptoms, whereas passivity and social avoidance on interpersonal scales were not as high as those of the helplessness group. It is understood as a group showing a tendency to experience depression as somatic symptoms, a subtype frequently reported in previous studies (Carragher, Adamson, Bunting, & McCann, 2009; Lee et al, 2014). The avoidance group with anxiety (19.0%) showed high overall symptoms on all internalizing scales, especially high passivity and social avoidance on interpersonal scales. There was also a high rate of co-occurrence of anxiety disorders in this group. The irritable group with anxiety (6.6%) showed high externalizing symptoms such as aggression and activation, in addition to overall high internalizing symptoms, and had a high rate of alcohol use disorder. Both groups were similar to depression with anxiety reported in previous studies (Ten Have et al., 2016; You et al., 2011). However, since the MMPI-2-RF-specific problem scales, including externalizing problems, were used as indicators, it was possible to divide the anxious group into avoidant and irritable groups. Figure 1 shows the plot of the five-class model. Appendix 1 illustrates the fit indices of the competing latent class models in this study and Appendix 2 summarizes the comorbid diagnoses of the four classes. The five-class model contained one mild group, two moderate groups, and two severe groups in terms of criticality. It also derived groups of heterogeneous patterns with similar severity levels but with symptoms in different domains. In other words, we suggest that subtyping using the specific problem scales of the MMPI-2-RF effectively captures heterogeneous the aspects of depression.

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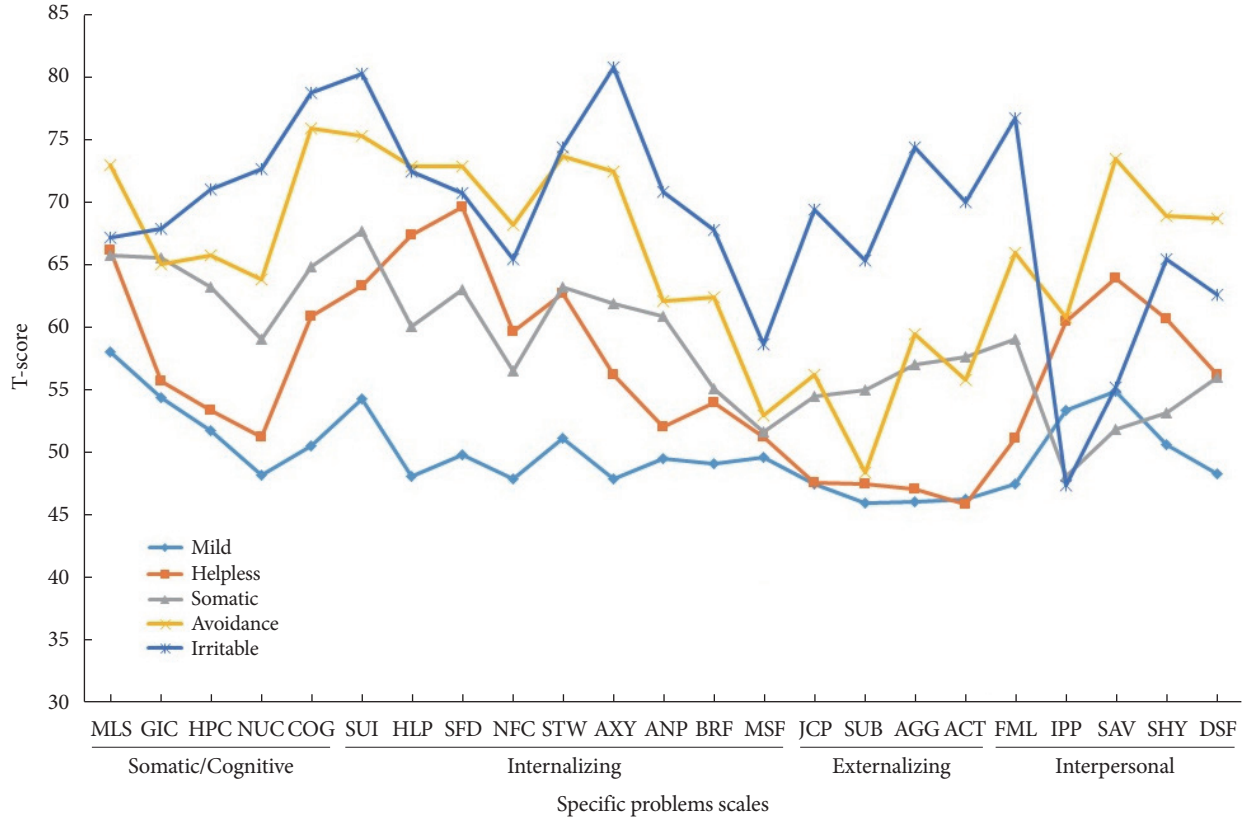

Figure 1. *Latent profiles plot of the 5-class model.*
Note. MLS = Malaise; GIC = Gastrointestinal Complaints; HPC = Head Pain Complaints; NUC = Neurological Complaints; COG = Cognitive Complaints; SUI = Suicidal/Death Ideation; HLP = Helplessness; SFD = Self-Doubt; NFC = Inefficacy; STW = Stress/Worry; AXY = Anxiety; ANP = Anger Proneness; BRF = Behavior-Restricting Fears; MSF = Multiple Specific Fears; JCP = Juvenile Conduct Problems; SUB = Substance Abuse; AGG = Aggression; ACT = Activation; FML = Family Problems; IPP = Interpersonal Passivity; SAV = Social Avoidance; SHY = Shyness; DSF = Disaffiliativeness.

Comparing the prescription patterns according to subtypes is expected to support the clinical usefulness of the classification using the specific problem scales of the MMPI-2-RF as indicators. A few previous studies classified depressive disorder into subtypes based on symptoms and compared the clinical course of the disease, but most of them analyzed subtypes based on typical symptoms of depression using criteria for depressive disorder or depression scales (Alexandrino-Silva et al., 2013; Lamers et al., 2010; You et al., 2011; Ulbricht, Rothschild, & Lapane, 2015). Few studies have compared drug prescription patterns to data-driven subtypes of depressive disorder based on personality characteristics rather than symptoms (Hori et al., 2017).

Therefore, this study aimed to confirm any significant differences in the pattern of actual prescribing by clinical judgement according to these multipledimensional symptom-based subtypes using MMPI-2-RF specific scales. It is expected that patients in the mild group, with the lowest severity of depression, are more likely not to receive an antidepressant in the initial treatment, and the two high-severity groups, the avoidant and irritable groups, would likely receive more antidepressants in combination with antipsychotics. In addition, even at the same severity level, it is expected that the prescription patterns of the helpless and somatic symptom groups were different and that the prescription rates of antipsychotic drugs were different between the avoidant and irritable groups. We also examined whether the medications corresponded to the Korean Medication Algorithm for Depressive Disorders revised in 2017 by the Korean Society for Affective Disorders and the Korean College of Neuropsychopharmacology (Seo et al., 2017). In the Korean Medication Algorithm for Depressive Disorders, antidepressant monotherapies are recommended as first-line treatment for non-

psychotic depression. The combination of antidepressants and atypical antipsychotics is recommended for psychotic depression, mixed feature, and anxious distress. In addition, when the initial treatment is ineffective, the method of adding antidepressants and antipsychotics is selected rather than changing antidepressants as the severity increases.

For this study, we retrospectively analyzed medical records to identify the medications prescribed to patients with each of the five subtypes of depression. The analysis of medical records included a comparison of differences in medication selection (e.g., antidepressants, antipsychotics, mood stabilizers, augmentation drugs, anxiolytics, and sedative/hypnotics) across the subtypes in the initial and the secondary treatment strategies, and an assessment of any differences in the duration of treatment.

Methods

Participants and Procedure

For this study, we collected medical records from the same sample reported by Choi (2019). The medical records retrospectively include psychological assessment data, types of medication, and maintenance periods of drug treatment for outpatients and inpatients who visited the Department of Mental Health and Medicine at the University Hospital from March 2014 to December 2016, and those who provided informed consent and responded to a series of questionnaires. Additionally, we collected data on demographic variables, including sex, age, and years of education. Psychological assessments, including the MMPI-2-RF and BDI, were usually conducted within 1 to 4 weeks after the first consultation with a psychiatrist. During the follow-up, the psychiatrist recorded the diagnosis after psychological assessment. Data on medication prescriptions were collected during initial treatment. On December 31, 2019, when we collected the study data, the rate of treatment maintenance was 19.5%, and the average follow-up period was 640.45 days.

We studied 473 patients, excluding cases of suspected involvement in the brain's organic damage and medical condition, or those diagnosed with intellectual disability, past mania or hypomania, or suspected schizoaffective disorder. The age range of the participants was 18–80 years, with an average age of 39.56 years (standard deviation, 16.79), among whom 217 were men (45.9%) and 256 were women (54.1%). A total of 395 patients (83.5%) were diagnosed with major depressive disorder, 30 (6.3%) with persistent depressive disorder, and 40 (8.5%) with unspecified depressive disorders.

We conducted this study as a retrospective medical record analysis of patients who had provided written informed consent after reading the manual for usage of research data. This study was approved by the Institutional Review Board (IRB) of the hospital.

Lists of Drugs used by Patients

We divided the drug list proposed by the Korean Medication Algorithm for Depressive Disorders into initial, three-month, and six-month periods of treatment. The list of drugs is presented in Table 1.

Table 1. *List of Prescribed Drugs*

Antidepressant	Escitalopram, fluoxetine, fluvoxamine, paroxetine, sertraline
	Desvenlafaxine, duloxetine, milnacipran, venlafaxine
	Bupropion
	Mirtazapine
	Moclobemide
	Tianeptine
	Agomelatine
	TCA (amitriptyline, clomipramine, imipramine, etc)
Antipsychotics	Amisulpiride, aripiprazole, blonanserin, clozapine, olanzapine, paliperidone, quetiapine, risperidone, ziprasidone, typical antipychotics
Mood stabilizers	Carbamazepine, lamotrigine, lithium, valproate
Augmentation drugs	Buspirone, gabapentin, ketamine, pindolol, psychostimulant, thyroid hormone, topiramate
Anxiolytics & hypnotics	Alprazolam, Clonazepam, Lorazepam, Diazepam, Clobazam, Bromazepam
	Stilnox, triazolam, etc.

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Measures

Specific Problems Scales in the Minnesota Multiphasic Personality Inventory–2 Restructured Form (MMPI–2–RF)

Clinicians have developed the MMPI-2-RF to improve the overall psychometric properties of the MMPI-2, which assesses symptoms and diagnostic possibilities in clinical populations (Ben-Porath & Tellegen, 2008). The published MMPI-2-RF Korean version has acceptable reliability and validity (Han et al., 2011). The MMPI-2-RF consists of nine validity scales, three higher-order (H-O) scales, nine restructured clinical (RC) scales, 23 specific problems (SP) scales, two interest scales, and the revised Personality Psychopathology-Five (PSY-5) scales. In this study, we used 23 specific problem scales as indicators for latent profile analysis (LPA). The somatic and cognitive sets of specific problem scales include malaise (MLS), gastrointestinal complaint (GIC), head pain complaint (HPC), neurological (NUC), and cognitive complaint (COG). Internalizing scales included suicidal/death ideation (SUI), helplessness (HLP), self-doubt (SFD), inefficacy (NFD), stress/worry (STW), anxiety (AXY), anger proneness (ANP), behavior-restricting fear (BRF), and multiple specific fear (MSF). Externalizing scales included juvenile conduct problems (JCP), substance abuse (SUB), aggression (AGG), and activation (ACT). Interpersonal problem scales included family problems (FML), interpersonal passivity (IPP), social avoidance (SAV), shyness (SHY), and disaffiliativeness (DSF). The validation study in the Korean clinical sample indicated an adequate internal consistency of .63-.80 for the specific problem scales (Han et al., 2011).

Beck Depression Inventory

This scale was originally developed by Beck, Steer, and Brown (1996) to assess the degree of depression and was standardized in Korea by Lee and Song (1991). The scale consists of 21 items measured on a three-point Likert scale. The internal consistency of the Korean version was .78, and the test-retest reliability was .75. The internal consistency in the present study was .92. We used the BDI score to compare the degree of depression among subtypes.

Data Analyses

First, to compare the demographic characteristics between the five subtypes derived from LPA, we used the MMPI-2-RF specific problems scale as an indicator, as in the previous study (Choi, 2019). We used the chi-square test, ANOVA, and Bonferroni post-test to analyze the severity of depression measured by BDI, hospitalization rate, duration of hospitalization, and rate of follow-up maintenance after three months, six months, and at the time of analysis. We performed a chi-square test to assess drug prescription patterns according to the period for each depression subtype, antidepressant prescription rates, combined treatment, and types of drugs divided into initial, three-month, and six-month periods. SPSS 25.0 (IBM Corp., Armonk, NY, USA) was used for the analysis

Results

Demographic and Clinical Course of the Subtypes

Analysis of the demographic data revealed a statistically significant difference in age and sex between the groups according to the clinical type of depression, but no significant difference in years of education. The proportion of women in the mild group (66.4%), helpless group (55.8%), and somatic group (59.8%) was high but low in the avoidant group with anxiety (33.3%) and irritable group with anxiety (41.9%). The mean age of the groups was as follow: mild (47.27), helpless (41.60), somatic (39.93), irritable group with anxiety (32.94), and avoidant group with anxiety (29.58). There were no significant differences in hospitalization rates or duration between the groups at the three-month follow-up, six-month follow-up, and overall follow-up periods. At the three-month follow-up, 66.44% ($n = 319$) of the total patients ($N = 473$) continued treatment, and at the six-month follow-up, 50.3% ($n = 238$) of the total patients continued treatment. The demographic and clinical characteristics of the subtypes are presented in Table 2.

Prescription Patterns of the Subtypes

First, a significant difference in the initial antidepressant prescription was observed between the groups in the initial antidepressant prescription. In the mild (31.8%), somatic (34.8%), and avoidant group with anxiety (32.2%), the rate of not prescribing antidepressants was high from the initial visit. In contrast, in the irritable group with anxiety, the prescription rate of two or more antidepressants from the initial visit was 19.4%. The initial prescriptions of the subtypes are presented Table 3.

Table 2. *Comparison of Subtypes on Demographic and Clinical Characteristics (N = 473)*

	Class 1 Mild group	Class 2 Helpless group	Class 3 Somatic group	Class 4 Avoidant group with anxiety	Class 5 Irritable group with anxiety	χ^2/F	Bonferroni
Component ratio	107 (22.6)	113 (23.9)	132 (27.9)	90 (19.03)	31 (6.6)		
Age[a]	47.27 (15.54)	41.6 (18.30)	39.93 (15.42)	29.58 (13.44)	32.94 (13.50)	17.36***	1 > 3, 4.5/2 > 4/ 3 > 4
Sex: women[b]	71 (66.4)	63 (55.8)	79 (59.8)	30 (33.3)	13 (41.9)	25.83***	
Education (yr)[a]	12.14 (3.41)	12.32 (3.19)	14.6 (4.88)	13.17 (3.01)	13.16 (2.69)	1.34	
BDI : *M* (*SD*)[a]	19.98 (10.06)	30.30 (9.44)	29.14 (10.21)	38.62 (11.12)	42.17 (9.27)	48.36***	1 < 2, 3, 4, 5/ 2 < 4, 5/3 < 4,5
Admission (%)[b]	31.00 (29.00)	26.00 (23.00)	27.00 (20.50)	14.00 (15.60)	7.00 (22.60)	4.45	
Admission (day)[a]	20.90	26.23	20.07	25.21	25.71	0.96	
at 3rd month treatment retention rate[b]	68.00 (63.60)	75.00 (66.40)	87.00 (65.90)	68.00 (75.60)	21.00 (67.70)	3.64	
at 6th month treatment retention rate[b]	50.00 (46.70)	57.00 (50.40)	60.00 (45.50)	54.00 (60.00)	17.00 (54.80)	5.43	
Present treatment maintenance[b]	20.00 (18.70)	24.00 (21.20)	20.00 (15.20)	23.00 (25.60)	5.00 (16.10)	4.19	

Values are presented as a mean (standard deviation) or number (%).
[a]By ANOVA, [b]By chi-square test, ***$p < .001$.

Table 3. *Comparison of Subtypes on Initial Prescription Pattern (N = 473)*

	Mild group	Helpless group	Somatic group	Avoidant group with anxiety	Irritable group with anxiety	χ^2
Antidepressant no use	34 (31.80)	26 (23.00)	46 (34.80)	29 (32.20)	7 (22.60)	15.79*
Antidepressant 1 kind	70 (65.40)	78 (69.00)	77 (58.30)	51 (56.70)	18 (58.10)	
Antidepressant 2 kinds	3 (2.80)	9 (8.00)	9 (6.80)	10 (11.10)	6 (19.40)	
Antipsychotics use	1 (0.90)	0	0	1 (1.10)	1 (3.20)	5.35
Mood stabilizer use	0	0	0	0	0	
Adjunctive drug use	1 (0.90)	0	0	0	1 (3.20)	7.87
Anxiolytics Sedative/hypnotics use	53 (49.50)	68 (60.20)	83 (62.90)	55 (61.10)	18 (58.10)	4.97

Values are presented as a number (%).
*$p < .05$.

Second, there were statistically significant differences in the prescriptions of antidepressants and antipsychotics between each clinical group for patients who continued treatment for three months. The mild (16.2%) and somatic (14.9%) groups showed higher rates of not prescribing antidepressants even after three months of treatment. In contrast, the rate of prescription of two or more antidepressants increased in the following order: irritable group with anxiety (38.1%), avoidant group with anxiety (23.5%), and helpless group (22.7%). At treatment initiation, antipsychotics prescriptions comprised 0.6% of the total but increased to 45.5% after three months of treatment. After three months of treatment, the antipsychotics prescription rate was high in the irritable group with anxiety (61.9%) and the avoidant group with anxiety (55.9%), followed by the helpless (48.0%), somatic (40.2%), and mild (33.8%) groups. The 3rd month prescriptions of the subtypes are presented Table 4.

Lastly, there were significant differences in the prescription rates of antipsychotics and anxiolytics combined with sedative/hypnotics in patients after six months. Regarding the prescription of antipsychotics at the six-month follow-up visit, the prescription rate was higher in the avoidant group with anxiety (61.1%) and the irritable group with anxiety (64.7%) than other groups. A moderate rate occurred in the helpless (50.9%) and somatic groups (50.0%), whereas it was low in the mild group (30.0%). Regarding treatment with anxiolytics and sedative/hypnotics at six months of treatment, the prescription rate in the irritable group with anxiety (94.1%) was very high, followed by the avoidant group with anxiety (75.9%) and the somatic group (75.0%). This rate was rela-

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Table 4. *Comparison of Subtypes on 3rd Month Prescription Pattern (N=319)*

	Mild group	Helpless group	Somatic group	Avoidant group with anxiety	Irritable group with anxiety	χ^2
Antidepressant no use	11 (16.20)	4 (5.30)	13 (14.90)	6 (8.80)	1 (4.80)	22.29*
Antidepressant 1 kind	44 (64.70)	54 (72.00)	60 (69.00)	43 (63.20)	12 (57.10)	
Antidepressant 2 kinds	13 (19.10)	17 (22.70)	14 (19.10)	16 (23.50)	8 (38.10)	
Antidepressant 3 kinds	0	0	0	3 (4.40)	0	
Antipsychotics use	23 (33.80)	39 (48.00)	35 (40.20)	38 (55.90)	13 (61.90)	10.14*
Mood stabilizer use	3 (4.40)	3 (4.00)	6 (6.90)	5 (7.40)	2 (9.50)	1.65
Adjunctive drug use	5 (7.40)	4 (5.30)	3 (3.40)	3 (4.40)	1 (4.80)	1.30
Anxiolytics Sedative/hypnotics use	42 (61.80)	48 (64.00)	87 (72.40)	68 (73.50)	21 (85.70)	6.43

Values are presented as a number (%).
*$p < .05$.

Table 5. *Comparison of Subtypes on 6th Month Prescription Pattern (N=238)*

	Mild group	Helpless group	Somatic group	Avoidant group with anxiety	Irritable group with anxiety	χ^2
Antidepressant no use	6 (12.00)	7 (12.30)	7 (11.70)	3 (5.60)	1 (5.90)	11.13
Antidepressant 1 kind	34 (68.00)	33 (57.90)	40 (66.70)	31 (57.40)	10 (58.80)	
Antidepressant 2 kinds	9 (18.00)	17 (29.80)	13 (21.70)	18 (33.30)	5 (29.40)	
Antidepressant 3 kinds	1 (2.00)	0	0	2 (3.70)	1 (5.90)	
Antipsychotics use	15 (30.00)	29 (50.90)	30 (50.00)	33 (61.10)	11 (64.70)	12.14*
Mood stabilizer use	1 (2.00)	4 (7.00)	4 (6.70)	5 (9.30)	1 (5.90)	2.44
Adjunctive drug use	2 (4.00)	1 (1.80)	3 (5.00)	2 (3.70)	0	1.62
Anxiolytics Sedative/hypnotics use	29 (58.00)	34 (59.60)	45 (75.00)	41 (75.90)	16 (94.10)	12.46*

Values are presented as a number (%).
*$p < .05$.

tively low in the helpless (59.6%) and mild (58.0%) groups. The 6th month prescriptions of the subtypes are presented Table 5.

Discussion

The purpose of this study was to verify the clinical usefulness of the MMPI-2-RF in the initial evaluation of patients with depressive disorder by confirming whether the pattern of medication prescription differed according to the subtype of depression derived based on the MMPI-2-RF specific problem scales. The types of prescribed drugs differed among the five symptom-based subtypes. We found no statistically significant difference between the subtypes of depression in the maintenance of outpatient treatment.

Specifically, among the groups, we observed a difference in the selection of antidepressants for the initial treatment according to the clinical evaluation of the practitioner. In the mild and somatic groups, the proportion of prescribed antidepressants was not high. In contrast, in the irritable group with anxiety, the prescription rate of the two types of antidepressants from the initial treatment onwards was the highest, followed by the avoidant group with anxiety. Considering the differences in the severity of depression measured by BDI and the increasing levels of depression observed in order of the mild, the somatic and helpless, the avoidant and irritable groups, we observed a correlation between the prescription of antidepressants from the initial treatment onward and the severity of depression. In addition, the helpless group, which was characterized by typical depressive symptoms, received more initial antidepressant prescriptions than the somatic group, which showed a similar level of severity, and the avoidant group with higher levels of depression as measured by the BDI. In the initial treatment, the less severe the depression and the less typical depressive symptoms, the fewer antidepressants were prescribed.

At the three-month follow-up visit, there were significant differ-

ences in the prescriptions of antidepressants and antipsychotics for patients among the groups. At three months, although there was no significant difference between the subtypes in the duration of treatment, a large proportion of patients in the mild and somatic groups were not prescribed antidepressants at all. In addition, the rate of prescribing two or more antidepressants was higher in the irritable group with anxiety. Prescriptions included SSRIs, such as escitalopram, serotonin–norepinephrine reuptake inhibitors (SNRIs), such as venlafaxine, and other antidepressants such as bupropion or mirtazapine. The more severe and irritable the depression, the higher the frequency of prescriptions for two or more antidepressants. Practitioners selected and prescribed primary antidepressants (escitalopram and venlafaxine) for severe episodes as recommended by the Korean Medication Algorithm for Depressive Disorders. In particular, the rate of prescription for antipsychotics at the three-month follow-up visit increased overall, with the rate being highest in the irritable group with anxiety and the avoidant group with anxiety. We noted that antipsychotics controlled patients' symptoms in both the irritable and avoidant groups with anxiety, considering that the severity of depression was high and accompanied by anxiety-related symptoms. This finding is consistent with the Korean Medication Algorithm for Depressive Disorders, which in severe episodes, recommends antidepressant treatment alone or in combination with antipsychotics (Seo et al., 2017).

The antidepressant prescription rate for patients receiving treatment for six months did not differ among the types of depression. Rather, there were differences among the subtypes of prescription antipsychotics, anxiolytics, and sedative/hypnotics. In particular, the prescription rate of anxiolytics and sedative/hypnotics was overwhelmingly high (94.1%) in the irritable group with anxiety among patients in treatment for six months. Patients in the irritable group had externalizing problems such as drug abuse, aggression, and a tendency for excitability. These characteristics may be related to the high prescription rates of anxiolytics and sedative/hypnotics in this group. Subtyping with the MMPI-2-RF specific problem scales helped discriminate the irritable group requiring more combination therapy with antipsychotics and sedatives from the depression group accompanying anxiety, which has been considered a typical subtype of depression

Despite experiencing relatively high depression and anxiety-related symptoms, patients in the avoidant group with anxiety did not show externalizing behavior problems. These problems appear primarily as social avoidance and interpersonal passiveness, particularly in men and younger age groups (Choi, 2019). Researchers reported that men have a lower serotonin-based antidepressant response than women (Sramek et al., 2016) and may benefit more from cognitive behavioral therapy (López-López et al., 2019; Health Quality Ontario, 2019; Churchill et al., 2013). In this subtype, psychotherapeutic approaches such as cognitive-behavioral therapy, including exposure in addition to drug treatment, could be more useful. Meanwhile, in the somatic group, it may be helpful to use a physical control method such as respiratory training or a muscle relaxation method in addition to drug treatment (Van Dessel et al., 2014).

In patients with mild depressive symptoms, we expected the rate of discontinuation of treatment at three months or six months to be high, but there was no significant difference between the subtypes of depression. At three months of treatment, 66.4% (319) of the total (473) patients continued treatment, and 33.26% discontinued treatment, which was similar to the discontinuation rate of acute treatment (30–40%) in previous studies (Bull et al., 2002; Lin et al., 1995; Maddox, Levi, & Thompson, 1994; Olfson, Marcus, Tedeschi, & Wan, 2006). At six months of treatment, 50.3% (238) of the total (473) patients continued treatment. This finding is similar to the drug compliance rate for treating depression (49.1%) (Gauthier et al., 2017). Regarding the discontinuation of treatment for each type of depression, clinicians should consider various other variables such as compliance issues, economic or primary support groups, the degree of interest in treatment, side effects of drug treatment, and the patient-therapist relationship. However, the reasons for such treatment discontinuation could not be identified in this study. In future studies, an accurate comparison of progress will be possible only when the reasons for discontinuation between the groups are identified.

Our previous study (Choi, 2019) derived five subtypes with different severity and symptom patterns through a person-centered approach using the MMPI-2-RF specific problems scales for depressive disorder patients. The current research confirmed that the patterns of actual medication prescriptions differed according

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to the derived subtypes through medical record investigation. To summarize, first, the ratio of antidepressant prescription and combination therapy was different depending on the severity of depression. Second, even within the same severity level, the helpless group showing typical depressive patterns had more depression prescriptions from the first treatment to three and six months than the somatic group. Third, among the groups with anxiety, the irritable group with externalizing problems required more antidepressants and a combination of antipsychotics and sedatives than the avoidant group.

These findings suggest that using the profile of the MMPI-2-RF specific problem scales in the initial evaluation of patients with depression may be helpful in medication planning. Clinicians treating patients with a mild profile on the specific problem scales or symptoms in the somatic/cognitive domain may first defer from drug treatment. Both the mild and helpless groups were more likely to have alleviated symptoms with antidepressants alone. On the other hand, avoidant and irritable groups with anxiety may benefit from combining two or more antidepressants, antipsychotics, anxiolytics, and sedative/hypnotics at treatment initiation.

The strengths of this study are as follows; First, to distinguish between the heterogeneous types of depressive disorder, we identified the subtypes through a person-centered approach rather than a variable-centered approach. We retrospectively analyzed the natural clinical course according to this classification. Second, based on the evaluation time point, we divided the treatment into early, middle, and late treatments and continuously reviewed the prescription patterns for each type of drug, as recommended by the Korean Medication Algorithm for Depressive Disorders. Finally, we suggested a more effective drug type and treatment strategy to follow after the initiation of treatment according to the data-driven depression subtype based on the MMPI-2-RF specific problems scales.

The study also has some limitations. First, in some cases, the study participants completed MMPI-2-RF without a drug prescription; however, in other cases, they completed a questionnaire after starting medication. Therefore, the MMPI-2-RF profile may reflect the effect of medication. Second, we considered the natural clinical course of the disease in term of drug prescriptions from the therapist's perspective. Changes in patient symptoms were not considered objective indicator. In future studies, it is necessary to check whether symptoms improve in patients after a certain medication according to the subtype. Furthermore, if it can be confirmed whether there is a change in subtypes after treatment, classification based on the MMPI-2-RF special problem scales can be used as an indicator of treatment outcome. Third, since this study was conducted on patients who visited one hospital, it is difficult to generalize the results to all patients with depressive disorders. It is necessary to check whether the subtypes derived through the data-driven approach can be reliably reproduced using other samples.

In conclusion, the current study suggests that using this classification model based on multidimensional symptoms may help clinicians better understand the patients at the initiation of treatment and develop more tailored treatment strategies. Clinicians may benefit from using the specific problem scale of the MMPI-2-RF, which allows detailed assessment of multidimensional symptoms rather than focusing only on symptoms that meet the criteria for diagnosing depression or the problem most suitable for the patient.

Author contributions statement

M.S. Gim, Associate Professor at Inje University, collected and analyzed the data and prepared the manuscript. J.Y. Choi, Associate Professor at Inha University, supervised the study plan and assisted with the analysis. Both authors participated in the revision of the manuscript and approved the final submission.

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Appendix 1. *Fit Information for Latent Profile Analysis Models with 1-6 Class (N = 473) (Choi, 2019)*

Model	Log-likelihood Values	AIC	BIC	SSA BIC	LMRa-LRT *p*-value	Entropy	BLRT *p*-value	Smallest Class Proportion
1	-42883.724	85859.449	86050.767	85904.771	N/A	N/A	N/A	N/A
2	-41963.185	84066.371	84357.508	84135.339	1828.706 (0.0008)	0.872	< .0001	46.7%
3	-41667.458	83522.916	83913.870	83615.530	587.481 (0.0198)	0.877	< .0001	25.6%
4	-41503.352	83242.704	83733.478	83358.965	326.006 (0.6025)	0.865	< .0001	23.04%
5	-41381.102	83046.205	83636.796	83186.112	242.857 (0.2920)	0.878	< .0001	6.6%
6	-41293.719	82919.438	83609.991	83082.991	173.592 (0.3005)	0.882	< .0001	9.7%

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; SSABIC = Sample size adjusted Bayesian information; LMRa-LRT = Lo-Mendell-Rubin adjusted likelihood ration test; BLRT = Bootstrapped likelihood ratio test.

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Appendix 2. *Comparison of Clinical Characteristics (N = 473) (Choi, 2019)*

Variables	Class 1 Mild group n (%)	Class 2 Helpless group n (%)	Class 3 Somatic group n (%)	Class 4 Avoidant group with anxiety n (%)	Class 5 Irritable group with anxiety n (%)	χ^2/F
MDD	82 (76.6)	100 (88.5)	112 (84.8)	79 (87.8)	30 (96.8)	10.98*
PDD	8 (7.5)	4 (3.5)	9 (6.8)	9 (10.0)	0 (0.0)	5.90
Psychotic feature	12 (11.2)	7 (6.2)	6 (4.5)	10 (11.1)	3 (9.7)	5.42
Comorbidity	38 (35.5)	44 (38.9)	77 (58.3)	51 (56.7)	25 (80.6)	31.41***
Anxiety disorder	6 (5.6)	7 (6.2)	9 (6.8)	10 (11.1)	4 (12.9)	3.85
PTSD	4 (3.7)	12 (10.6)	9 (6.8)	9 (10.0)	6 (19.4)	9.25
Alcohol use disorder	5 (4.7)	2 (1.8)	19 (14.4)	4 (4.4)	9 (29.0)	34.09***
Somatic symptom	5 (4.7)	5 (4.4)	8 (6.1)	5 (5.6)	0 (0.0)	2.14
Personality disorder	10 (9.3)	10 (8.8)	20 (15.2)	18 (20.0)	5 (16.1)	7.49

Note. MDD = Major depressive disorder; PDD = Persist depressive disorder; PTSD = Posttraumatic stress disorder; Somatic symptom = Somatic symptom disorder.
*$p < .05$, **$p < .001$.

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Moderating Effect of Psychological Flexibility in the Relationship between Neuroticism and Self-Harm

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Many people seek professional help because of self-harm, signaling a crisis in domestic mental health issues. Neuroticism significantly predicts self-harm through experiential avoidance as a coping strategy in response to negative stimuli. However, despite neurotic tendencies, a person with a high level of psychological flexibility may have the capacity to respond constructively to unpleasant situations or emotions. The current study measured neuroticism (K-IPIP-NEO-120), self-harm (K-SHI), and psychological flexibility (K-AAQ-II) in 551 South Korean adults (M = 271, F = 280, age range: 20–59 years). Results showed that psychological flexibility moderated the relationship between neuroticism and self-harm. Neuroticism significantly predicted self-harming behaviors when psychological flexibility was low or moderate, whereas high psychological flexibility prevented the risk of a connection between neuroticism and self-harm. Psychological flexibility may need to be addressed in clinical interventions and in self-harm prevention.

Keywords: neuroticism, self-harm, self-injury, psychological flexibility, experiential avoidance model, escape theory

Introduction

Self-harm is a major public health concern worldwide. It refers to damaging or poisoning one's bodily tissues, regardless of suicidal intent or motive (Hawton et al., 2003). Suicidal self-destructive behaviors and nonsuicidal self-injuries (NSSI) are located on the self-harm continuum, when there is uncertainty in categorizing one's intention to die (Zubrick et al., 2017). Self-harm can occur at any age but is most frequently observed between adolescence and early adulthood, especially in females (American Psychiatric Association, 2013; Plener, Schumacher, Munz, & Groschwitz, 2015). In South Korea, the number of teenagers who received psychological counseling due to self-harm tripled in 2018 (Lee, 2019), and the number of emergency visits due to NSSI and attempted suicide increased by approximately 8% in 2019 (Jung, 2020). Notably, some adolescents continue to engage in self-harming behaviors throughout adulthood (Barrocas, Giletta, Hankin, Prinstein, & Abela, 2015). Long-term consequences such as mental illness, psychiatric hospitalization, and even death by suicide highlight the importance of urgent interventions targeting self-harm in adults (Beckman et al., 2016).

Self-cutting, self-hitting, head-banging, and ingestion of foreign substances are common methods of self-harm. Typically, one engages with multiple behaviors in such episodes because one may try new methods owing to increased pain tolerance, or use different self-harming methods in response to certain types of emotions or circumstances (Nock, 2010). Prior studies indicate that a variety of self-harm methods appear to increase the acquired capability for suicide and thus may be a predictor of lethal suicide attempts (Van Orden et al., 2010; Willoughby, Heffer, & Hamza, 2015). Addressing self-harming experiences is crucial, lest they result in completed suicide (Suominen et al., 2004).

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Research supports a strong association between neuroticism and self-harm (Hafferty et al., 2019; MacLaren & Best, 2010). In the Five-Factor model, neuroticism consists of six sub-factors: anger, depression, anxiety, impulsiveness, vulnerability, and self-consciousness. People with high levels of neuroticism are prone to experiencing negative emotions and are more sensitive to stress (McGrae & John, 1992). They are also known for being vulnerable to criticism and display self-critical attitudes along with a sense of inadequacy (Watson, Clark, & Harkness, 1994). Characterized by emotional instability, affective disorders and self-destructive behaviors are expected to be more prevalent among individuals with neuroticism, than among those with other personality traits (Malouff, Thorsteinsson, & Schutte, 2005; Suyemoto, 1998). Unsurprisingly, neuroticism is considered a key characteristic of borderline personality disorder (BPD) in which self-harm is frequently observed (Kendler, Myers, & Reichborn-Kjennerud, 2011).

Individuals with neuroticism may use the maladaptive coping strategy of experiential avoidance to control unwanted feelings and thoughts (Kokkonen & Pulkkinen, 2001). As one expends more effort to avoid negative stimuli, such an approach paradoxically becomes disruptive and dominant over one's lifetime. The Experiential Avoidance Model of NSSI (Chapman, Gratz, & Brown, 2006) suggests that self-injury is an attempt to avoid and terminate unwanted emotional arousals. A study using Ecological Momentary Assessment supports this model, reporting that people experience an ease of thought and emotion directly after self-injuring behaviors (Nock, Prinstein, & Sterba, 2009). This may result in repeated self-harm to quickly relieve negative emotions when they feel bad. Along with NSSI, suicidal behaviors serve avoidant functions. Baumeister's (1990) Escape Theory stresses that unpleasant psychological reactions create the motivation to escape. For instance, the feeling of failure is highly correlated with hopelessness; thus, suicide may seem to be the only viable solution to one's problems (Landrault et al., 2020). A recent meta-analysis found that the association between experiential avoidance and suicidal behaviors was moderate to strong (Angelakis & Gooding, 2021).

Unlike experiential avoidance, which links neuroticism and self-harm, psychological flexibility refers to one's capacity to be fully aware of and actively engage in both, internal and external experiences. Flexible attention helps one not to feel bound by one's thoughts or emotions, but rather commit to productive present attitudes that align with one's values (Hayes, Luoma, Bond, Masuda, & Lillis, 2006). Individuals with low psychological flexibility perceive unpleasant emotions, thoughts, and sensations to be highly negative (Levin et al., 2014). This feature significantly predicts emotional dysregulation and poor quality of life (Lucas & Moore, 2020; Paulus, Vanwoerden, Norton, & Sharp, 2016). A low level of psychological flexibility also correlates with suicidal ideation and self-harm, including suicidal behaviors (Krafft, Hicks, Mack, & Levin, 2019; Nielsen, Sayal, & Townsend, 2016; Tighe, Nicholas, Shand, & Christensen, 2018). In contrast, increased psychological flexibility is known to be a resilience factor that negatively correlates with depression, anxiety, and insomnia (McCracken, Badinlou, Buhrman, & Brocki, 2021). As psychological flexibility increased, the levels of emotional regulation and emotional acceptance improved in patients with psychosis and trauma (Spidel, Lecomte, Kealy, & Daigneault, 2018). Indeed, those who ceased to self-injure showed a higher level of psychological flexibility than those who continued self-harming behaviors (Callahan, Stori, & Donahue, 2021).

Neuroticism is a genetic trait that remains relatively stable throughout life (Lahey, 2009), and the rate of self-injury maintained after adolescence has been observed to be considerably high, even up to 50% (Klonsky, 2011). One should not neglect such a high risk of self-harm in adulthood, and a valid intervention strategy should be identified accordingly. Prior studies on self-harm have mainly focused on adolescents, and research on the relationship between psychological flexibility and self-harm remains at an early stage (Callahan et al., 2021). If there are negative influences that derive from a genetic trait and its biological vulnerability, it is vital that researchers explore protective factors that can reduce and prevent such effects. Taken together, we hypothesized that the severity of self-harm in people with neuroticism may differ depending on the degree of psychological flexibility that serves as a moderating factor.

Methods

Procedure

The participants were recruited via EMBRAIN, an online research company. The survey was conducted online from January

28, 2021, to February 1, 2021. On the first page of the survey, we provided basic information regarding the purpose and content of the research. While only those who provided informed consent could continue, the participants could withdraw at any time during the process. Finally, compensation was provided to those who completed the survey. The entire procedure was approved by the Institutional Review Board on January 13, 2021 (No. 1041078-202012-HRSB-354-01) and adhered to the Declaration of Helsinki.

Participants

A total of 551 participants (between 20 to 59 years old) were recruited using stratified sampling; 49.2% were men ($n = 271$) and 50.8% were women ($n = 280$). The mean age was 40.18 ($SD = 10.66$), and participants were evenly recruited among the age subgroups, with 20.3% in their 20s, 25.8% in their 30s, 27.0% in their 40s, and 26.9% in their 50s. Participants' areas of residence were also considered proportional to the size of the national administrative districts.

Measures

The Korean Version of International Personality Item Pool–NEO–120 (K–IPIP–NEO–120)

The IPIP-NEO-120 is a self-report questionnaire that evaluates personality traits based on the Five-Factor model (extraversion, agreeableness, openness, consciousness, and neuroticism). The original scale IPIP-NEO-300 (Goldberg, 1999) was shortened to 120 questions by Johnson (2014), and the Korean version was translated and validated by Jahng (2018). It is measured on a 5-point Likert scale ranging from 1 (not agree at all) to 5 (very agree), and the 24 questions regarding neuroticism were used. Cronbach's α was .91 in the present study.

The Korean Version of Acceptance–Action Questionnaire–II (K–AAQ–II)

The K-AAQ-II is a self-report questionnaire assessing psychological flexibility. Bond et al. (2011) developed a scale comprising seven items. Cho and Seo (2017) translated and validated the Korean version. Responses were rated on a 7-point Likert scale ranging from 1 (not at all) to 7 (always). All questionnaires were inversely coded for the sake of convenience in interpretation; consequently, the higher the total score, the higher the psychological flexibility. Cronbach's α was .94 in the present study.

The Korean Version of Self–Harm Inventory (K–SHI)

The Self-Harm Inventory (SHI), which was developed by Sansone, Wiederman, and Sansone (1998), evaluates one's self-harming behaviors within the previous six months. The Korean version was translated and validated by Kim, Woo, Koo, and Lee (2019). It comprised 22 dichotomous items to which participants could respond with "yes" (1 point) or "no" (0 points); higher scores indicated a greater range of self-harming behaviors. Six items were excluded to measure bodily inflictions only, and Cronbach's α in the present study was .80.

Data Analysis

No missing data were observed, and the raw data were analyzed using IBM SPSS version 26.0. Correlation analyses were performed for neuroticism and its subscales, psychological flexibility, and self-harm. The internal consistency of each measurement was calculated using Cronbach's α coefficient. The moderating effect of psychological flexibility was examined using Model 1 of SPSS PROCESS Macro (Hayes, 2021), and the significant region within the moderating effect was verified using the Johnson-Neyman method.

Results

Descriptive Statistics

Among the 551 participants, 55.2% were married ($n = 304$), 41.2% were single ($n = 227$), and 3.6% were divorced or bereaved ($n = 20$). Regarding educational level, .2% were below middle school ($n = 1$), 12.3% had graduated high school ($n = 68$), 75.1% were attending or had attended university ($n = 414$), and 12.3% were above university level ($n = 68$).

The mean score for neuroticism was 67.51 ($SD = 13.68$, range: 33–112); for psychological flexibility it was 35.56 ($SD = 9.40$, range: 7–49), and for self-harm it was .44 ($SD = 1.30$, range: 0–12). The skewed distribution of the K-SHI score was log-transformed (Feng et al., 2014), and all the research variables met the normality criteria (Kline, 2015). A total of 117 individuals (21.2%) reported a history of self-harm within the previous 6 months.

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Table 1. *Means, Standard Deviations, and Correlations between Key Variables*

Variable	*M*	*SD*	1	1-1	1-2	1-3	1-4	1-5	1-6	2	3
1. Neuroticism	67.51	13.68	-								
1-1. Anger	11.00	3.59	.830***	-							
1-2. Depression	10.01	4.01	.867***	.717***	-						
1-3. Anxiety	12.44	3.03	.867***	.720***	.744***	-					
1-4. Immoderation	10.96	2.68	.565***	.325***	.318***	.322***	-				
1-5. Vulnerability	11.15	2.54	.714***	.402***	.468***	.536***	.503***	-			
1-6. Self-Consciousness	11.94	2.01	.630***	.402***	.489***	.513***	.177***	.462***	-		
2. Psychological Flexibility	35.56	9.40	-.711***	-.587***	-.727***	-.660***	-.290***	-.426***	-.421***	-	
3. Self-harm	.44	1.30	.388***	.333***	.433***	.376***	.130***	.150***	.249***	-.413***	-

***$p < .001$.

Table 2. *The Moderating Effect of Psychological Flexibility*

Variable	Coefficient	*SE*	*t*	95% CI	ΔR^2
Constant	.9395	.4799	1.9577	(-.0032, 1.8822)	
Neuroticism (A)	.0110	.0053	2.0663*	(.0005, .0215)	
Psychological Flexibility (B)	-.0355	.0076	-4.6704***	(-.0504, -.0205)	
Interaction (A*B)	-.0017	.0003	-5.3887***	(-.0024, -.0011)	.0416
Psychological Flexibility	*B*	*SE*	*t*	LLCI	ULCI
-1 *SD* (-9.40)	.0275	.0060	4.5811***	.0157	.0392
M (.00)	.0110	.0053	2.0663*	.0005	.0215
+1 *SD* (9.40)	-.0054	.0063	-.8615	-.0178	.0069

Note. *SE* = standard error; CI = confidence interval; LLCI = lower limit confidence interval; ULCI = upper limit confidence interval.
*$p < .05$; ***$p < .001$.

Correlations

The Pearson's correlation results are shown in Table 1. The correlations between neuroticism and its subscales, psychological flexibility, and self-harm were all significant ($p < .001$).

Moderation Analysis

The neuroticism and psychological flexibility scores were mean-centered before the analysis. Age, sex, and educational status were entered as covariates. The study model had 22% explanatory power and showed statistically significant results [$r^2 = .22$, $F(6, 544) = 25.62$, $p < .001$]. The interaction effect of neuroticism and psychological flexibility further described 4.2% self-harm. A Johnson-Neyman analysis was performed to determine which domains of psychological flexibility have significant moderating effects. The results of the moderation analysis are shown in Table 2 and Figure 1.

The slopes at low (-1 *SD*) and intermediate (*M*) levels of psychological flexibility were significant ($B = .0275$, $t = 4.5811$, $p < .001$; $B = .0110$, $t = 2.0663$, $p < .05$). However, the slope at high levels of psychological flexibility (+1 *SD*) was not significant ($B = -.0054$, $t = -.8615$, $p = .3894$) (Table 2). Johnson-Neyman analysis indicated that the boundary score of the significant interval was 35.86, which means that for those with a psychological flexibility score of 35.86 or higher, neuroticism does not significantly predict increased self-harm.

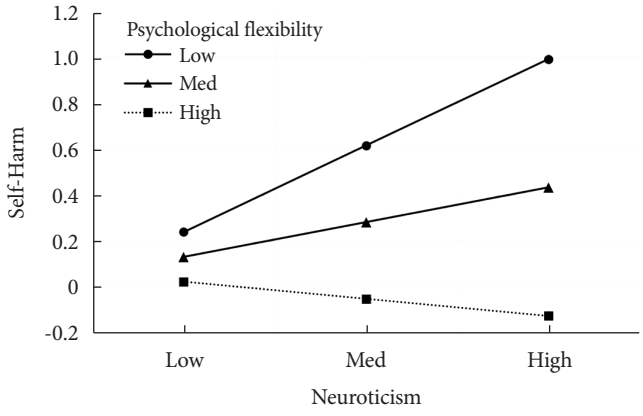

Figure 1. *The Moderating Effect of Psychological Flexibility in the Relationship between Neuroticism and Self-Harm.*

Discussion

This study examined whether psychological flexibility moderates the effect of neuroticism on self-harm among 551 adults in South Korea. PROCESS Macro (Hayes, 2021) was used to conduct moderation analysis. As hypothesized, the moderating effect of psychological flexibility was significant.

First, neuroticism was positively correlated with a variety of self-harm methods; higher levels of neuroticism were associated with higher engagement in self-harm methods. Prior research states that as the method of self-injury diversifies, the severity level increases (Favaro et al., 2008). This implies that higher levels of neuroticism may lead to higher severity of self-harm. Neuroticism is characterized by unstable emotions, sensitivity to stress, and an emotion-oriented approach to problems (Hafferty et al., 2019). Such characteristics make it difficult for individuals with high neuroticism to accommodate or manage the emotions and thoughts caused by negative stimuli. Consistent with our results, many studies suggest that individuals with high neuroticism employ maladaptive coping strategies to control themselves, and self-harm is one such strategy (Boyes & French, 2009; Suls & Martin, 2005; Nock et al., 2009).

The second major finding of this study was that psychological flexibility moderated the relationship between neuroticism and self-harm. The significance of each relationship differed, depending on the degree of psychological flexibility. For those with high psychological flexibility, neuroticism did not significantly explain self-harm. In other words, high psychological flexibility functions as a protective factor against emotional instability and does not increase the severity of self-harm. According to Hayes et al. (2006), people with high psychological flexibility do not avoid negative emotions; rather, they interact with the internal and external environments in an accepting and active manner. Such people may not choose self-harm as a coping response because they can adjust their moods or behaviors in beneficial ways that align with their values. The current study demonstrates that an individual with neurotic tendencies, who is inherently sensitive to stimuli, can utilize constructive coping mechanisms through psychological flexibility, which can be acquired and learned during one's lifetime.

In contrast, low or moderate levels of psychological flexibility significantly predicted increased severity of self-harm among individuals with neuroticism. For low or moderate levels of psychological flexibility, neuroticism appears to activate experiential avoidance behavior without any safety filter, namely, self-harm. Our result is consistent with previous research showing that those with self-harm experiences have lower levels of emotional acceptance and higher levels of experiential avoidance than the control group (Anderson & Crowther, 2012). Similarly, low or moderate levels of psychological flexibility in individuals with PTSD symptoms predict an increase in negative urgency and aggression; whereas a high level of psychological flexibility appears to mitigate this effect (Dutra & Sadeh, 2018).

To reduce avoidant responses that manifest as self-harm, more scholarly attention to the role of psychological flexibility in clinical intervention is needed. Acceptance and Commitment Therapy (ACT) is a third-wave cognitive behavioral therapy that aims to improve psychological flexibility, which allows living a life aligned with one's values amid a constantly changing environment (Hayes et al., 2006). Research on adolescents states that one's need for self-change by wound recognition, life goals, self-restoration through acceptance, social support, and connection serve as protective factors against self-injury (Kim, 2017). Notably, these protective factors are consistent with the core concepts of ACT. If such factors are unsatisfactory, they may persist into adulthood.

The limitations of the current study and future suggestions are as follows: First, the questionnaire was conducted online and was accessible via desktops and mobile phones only. Those who were unfamiliar with online surveys may have been excluded from the sample; thus, a generalization of the results should be considered. Second, the scale used to assess self-harm does not measure frequency or context; thus, the analysis of specific self-harm patterns is limited. While the SHI is the most widely used measurement for assessing self-harm, more delicate tools may be beneficial for future studies. Third, self-harm is the end product of complex interactions between biological, psychological, and social factors across one's lifespan. Our study mainly addressed internal factors such as personal traits and psychological vulnerabilities. In future studies, the effects of environmental factors should be investigated to understand self-harm comprehensively.

Despite these limitations, the results of this study highlight the

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risks of neuroticism and the significance of psychological flexibility. Neuroticism is a biological antecedent that predicts maladaptive coping mechanisms, including self-harm (Boyes & French, 2009; Gunthert, Cohen, & Armeli, 1999). Furthermore, psychological flexibility can be considered a buffer. The results of this study suggest that even those who are likely to be exposed to self-destructive behaviors because of their innate personality traits can prevent and mitigate their symptoms through psychological flexibility. Providing appropriate resources and teaching acceptance-based coping mechanisms may be helpful to people with neuroticism. This finding may provide foundational evidence for designing programs that promote psychological flexibility and prevent or alleviate self-harming behaviors. Additionally, the Experiential Avoidance Model and the Escape Theory were validated empirically. Further research on the efficacy of such programs, in addition to further research on contextual issues that may vary according to one's age, are needed.

Author contributions statement

CP, a graduate student at Chung-Ang University, conceptualized the research, collected and analyzed the data, and wrote the draft of the manuscript. MHH, professor at Chung-Ang University, supervised the research process and reviewed the manuscript. All the authors provided critical feedback, participated in the revision of the manuscript, and approved the final submission.

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Difference in Cognitive Dysfunction Between Adult ADHD and Neurotic Patients in the Korean Population: A Preliminary Research

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Adulthood Attention-Deficit Hyperactivity Disorder (ADHD) debilitates high-level executive functioning, attention and impulse control. There is a lack of consensus regarding the specific cognitive markers for ADHD compared with other psychiatric disorders that show attention-related problems as secondary symptoms. This study aimed to aid clinicians in utilizing existing tools for intelligence and cognitive function by investigating the key variables that differentiate ADHD from other mental disorders. As preliminary research, the study compared the performances of 35 patients with ADHD and 26 patients diagnosed with other neurotic disorders on the Korean Wechsler Adult Intelligence Scale-IV (K-WAIS-IV), Conners Continuous Perceptual Test 3rd Edition (CPT 3) and Conners Continuous Auditory Test of Attention (CATA). The ADHD group performed significantly lower on the Verbal Comprehension Index (VCI) and Working Memory Index (WMI) of K-WAIS-IV; the difference was significant in Similarity, Vocabulary and Arithmetic subtests. Perceptual Reasoning Index (PRI) and VCI differed significantly in the ADHD group unlike their neurotic counterpart. Of the variables in CPT 3, only detection differentiated ADHD from other neurotic disorders. Our results implicate there are novel standards and key variables that should be considered when differentiating ADHD from other psychiatric disorders.

Keywords: ADHD, CPT, K-WAIS-IV, attention, diagnostic differentiation

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is characterized by deficits in maintaining attention and selective attention, lack of concentration, hyperactivity, and impulsivity. Approximately half of those diagnosed with ADHD as a child persist into adulthood ADHD – specifically symptoms of inattention, poor concentration, lack of planning, and impulsivity (Adler et al., 2017; Kessler, Adler, Barkley et al., 2005; Kessler et al., 2010). Diagnosing ADHD in adults presents several challenges. Deficits in attention and impulsivity control are symptoms of not only ADHD but also other psychopathological disorders (Adler, Spencer, Stein, & Newcorn, 2008; Gentile, Atiq, & Gillig, 2006). While structural interviews and self-reported questionnaires such as Structured Clinical Interview for DSM-5 and Adult ADHD Self-Report Scale-V.1.1 Symptoms Checklist (ASRS-V1.1) have been actively utilized for diagnosis (Kessler, Adler, Ames, et al., 2005; Osório et al., 2019), this may not be suffice when patients report a myriad of symptoms and life events that do not precisely rule out other diagnoses.

This limitation called for objective cognitive data. Neuropsychological tests aid in diagnosing and obtaining individualized characteristics of ADHD, usually by observing deficits related to executive dysfunction (Du Rietz et al., 2016; Gualtieri & Johnson, 2005; Homack & Reynolds, 2005). K-WAIS-IV is a tool regularly used to

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measure cognitive domains, including verbal comprehension, perceptive construction and reasoning, working memory, and processing speed (Kim & Kim, 2017). CPT 3 & CATA are performance-measuring computerized tools, devised to measure vigilance and sustained attention (Conners, 2014). They are most commonly used in South Korea and other countries as they are believed to provide objective data tailored to assess the patient's characteristic weaknesses regarding attention (Homack & Reynolds, 2005; Park et al., 2019; Won, Choi, & Kim, 2020). However, there is still an ongoing debate as to how these tools can be used practically (Hall et al., 2016).

Numerous studies have investigated the differences in cognitive function between adult ADHD patients and healthy controls using WAIS and CPT 3. In the initial standardization of the American WAIS-IV (Wechsler, 2008), Pearson Assessments reported that adults with ADHD showed poor performance in Arithmetic (AR), Coding (CD), and Matrix Reasoning (MR) which are subtests comprising Perceptive Reasoning (PRI), Working Memory (WMI) and Processing Speed Index (PSI). Meanwhile, a meta-analytic study stated that adults with ADHD differed from non-ADHD adults in both verbal and performance IQ on WAIS-III (Bridgett & Walker, 2006). While some studies reported that adults with ADHD and the healthy controls showed differences in CPT performance, there is no consensus regarding which of the measured variables is statistically signficiant (Advokat et al., 2007; Boonstra et al., 2005; Malloy-Diniz et al., 2007). While these studies contributed to conceptualizing the cognitive characteristics of adults with ADHD compared to those of healthy controls, such differentiation was not sufficient as clinicians in practice are responsible to not only for differentiating adults with ADHD from the normal population but also for making a differential diagnosis. Patients with other psychopathological disorders show cognitive impairment in areas that are known to be deficient in ADHD. Several studies have reported that adults with depression have significantly lower PSI, memory, psychomotor skills, and attention on WAIS-III and WAIS-IV (Gorlyn et al., 2006; Kim & Park, 2020; Marazziti, Consoli, Picchetti, Carlini, & Faravelli, 2010; Wechsler, 2008). Overlapping patterns of dysfunction that exist among different disorders complicate diagnostic differentiation, leaving room for further exploration.

When comparing ADHD to other psychiatric disorders, studies have found mixed results for the efficiency of the tools intended to measure various areas of cognitive functioning. A recent study by Guo et al. (2020) used several executive function-related tasks to differentiate adults with ADHD from adults with other psychiatric disorders, ranging from simple mood disorders to schizoaffective disorders. They found neuropsychological impairments in both groups, but failed to define a pattern specific to adults with ADHD. Another study using CPT, measures of attention, psychomotor speed, executive function and arithmetic skills reported no difference in performance between clinical groups (Walker, Shores, Trollor, Lee, & Sachdev, 2000). They compared the ADHD group with a psychiatric group consisting of 15 individuals with mood disorders, 10 with anxiety disorders, and 5 with mixed mood and anxiety disorders. Other studies have reported differing results, as they found that the ADHD group to showed impairment in the verbal memory, concept shifting, and processing speed unlike other psychiatric/healthy controls (Marchetta, Hurks, Krabbendam, & Jolles, 2008; Wiig & Nielson, 2012). When ADHD and mood disorders were compared, two studies found that CPT significantly differentiated the two, with no consensus on which variables differentiated them (Fasmer et al., 2016; Pettersson, Söderström, & Nilsson, 2018). In contrast, studies have questioned the competence of CPT in diagnosing children with ADHD when it was found that children with ADHD did not have higher CPT scores than psychiatric/healthy controls (McGee, Clark, & Symons, 2000; Riccio & Reynolds, 2001). While prior studies have attempted to target the cognitive areas for clinicians when discerning ADHD from other mental disorders, limitations for generalization exist.

This study aims to provide a perspective for clinicians on how to utilize cognitive and attention-related tests in terms of understanding the differences between attention deficit of ADHD and other mental disorders. This was done by examining and comparing cognitive dysfunction patterns in adult with ADHD and those with other neurotic mental disorders. The neurotic patient group comprised disorders including depression, anxiety, and bipolar II disorders. K-WAIS-IV, CPT 3, and CATA, which are commonly used assessment tools to measure cognitive abilities and attentional problems of ADHD in South Korea, were used (Park et al., 2019; Won, Choi, & Kim, 2020). CPT 3 & CATA were selected for this study because despite the controversy regarding their effectiveness

in differentiating ADHD from non-ADHD disorders, they are still considered useful tools for ADHD diagnosis by many clinicians (Matier-Sharma, Perachio, Newcorn, Sharma, & Halperin, 1995; Slobodin, 2020; Tallberg, Råstam, Wenhov, Eliasson, & Gustafsson, 2019). However, due to the relatively small sample size and the exploratory nature of the study, this study was considered preliminary research.

Methods

Participants and Procedures

Initially, 64 patients above age 18 who were prescribed CPT 3 & CATA between March 2017 and August 2020 were included in this study. At their initial intake, they were psychologically examined and diagnosed by trained psychiatrists according to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-5; American Psychiatric Association, 2013) at Kangbuk Samsung Hospital, South Korea. As a retrospective study, only patients reporting subjective memory complaints were eligible for CPT 3 & CATA prescriptions. Therefore, our study consisted of subjects representing the hurdles that clinicians expect in their daily practices. Of these participants, those who had other neurological dysfunctions, symptoms of psychosis, or severe physical ailments were excluded. After the initial intake, clinical psychologists certified or under-training performed psychological examinations, including K-WAIS-IV, CPT3, and CATA. As the study was preliminary, the number of subjects fit Johanson and Brooks's (2010) recommendation of a minimum of 24 subjects per group to achieve a high Bootstrap confidence level.

The study was approved by the Institutional Review Board of Kangbuk Samsung Hospital.

Measures

K–WAIS–IV

K-WAIS-IV, standardized by Hwang, Kim, Park, Chey, and Hong (2012), is an individually administered, comprehensive clinical instrument for assessing intelligence. It provides index scale scores representing intellectual functioning in specified cognitive areas and a full scale intelligent quotient (FSIQ) that represents general intellectual ability. Four index scales ($M = 100$, $SD = 15$) are comprised of 2-3 core subtests ($M = 10$, $SD = 3$). The test was developed based on Cattell-Horn-Carroll theory (CHC) classification. Table 1 lists the index scale and its subtests. Difference between PRI and VCI was additionally observed in this study to obtain more means for clinical use.

CPT 3

CPT 3 was used to assess variables regarding attention, including sustained attention, impulsivity control, vigilance and inattentiveness using visual cues (Conners, 2014). Using the laptop, the participant responded to any letter except for letter X by pressing the space bar. The task consisted of 6 blocks, with 3 sub-blocks each consisting of 20 trials (total = 360 trials for 14 minutes). Within each block, sub-blocks with different inter-stimulus intervals (ISI) of 1, 2 and 4 seconds were used with a display time of 250 milliseconds. T-score above 70 can be interpreted as very elevated or atypically slow, 60–69 as elevated or slow, 55–59 as high average or a little slow, 45–54 as average, 40–44 as low or a little fast, and below 40 as atypically fast. The variables presented using the program is provided in Table 2. The number of patients with T-scores above or equal to 60 in any variable (CPT 3 ≥ 60) was also counted for group comparison.

CATA

CATA assesses the auditory attention-related problems (Conners, 2014). Using headphones, the participant pressed the space bar when the high tone was paired with a low tone. Participants did not respond when a high tone was heard alone. The assessment ran for 14 minutes with 200 trials divided into 4 blocks. Table 2 presents the resulting variables. Patients with T-scores above or equal to 60 in any variable (CATA ≥ 60) were counted for group comparison.

ASRS–V1.1.

ASRS-V1.1. is an instrument that consist of 18 DSM-IV TR criteria. Of the 18 questions, Part A consisted of 6 questions that were most predictive of symptoms consistent with ADHD. Four or more marks in Part A are warranted for further investigation of ADHD (Adler, Kessler, Spencer, & World Health Organization, 2013; American Psychiatric Association, 1980; Barkley & Poillioin, 1994; Bieder-

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Table 1. *K-WAIS-IV Subtests, Description, and CHC Classification*

Subtests	Definition and what it measures	CHC abilities
Verbal Comprehension Index (VCI)	Composed of subtests measuring verbal abilities that require reasoning, comprehension, and conceptualization	
Similarities (SI)	The participant is presented with two words that represent common objects of concepts and is asked what their core similarity is. It is designed to measure verbal concept formation, verbal reasoning, lexical knowledge, induction.	Gc, Gf
Vocabulary (VC)	The participant is asked to define a given word. It is designed to measure word knowledge and verbal concept formation.	Gc
Information (IN)	The participant is asked to answer questions that address a broad range of general knowledge topics. It is designed to measure the ability to acquire, retain, and retrieve general factual knowledge.	Gc
Perceptual Reasoning Index (PRI)	Composed of subtests measuring nonverbal reasoning and perceptual organization	
Block Design (BD)	The participant is asked to arrange given blocks according to a given picture as fast as they can within a time limit. It is designed to measure the ability to analyze and synthesize abstract visual stimuli.	Gv
Matrix Reasoning (MR)	The participant is given an incomplete matrix or series of images and is asked to find the option that completes the series. It involves fluid intelligence, broad visual intelligence, classification and spatial ability, knowledge of part-whole relationships, simultaneous processing, and perceptual organization.	Gf
Visual Puzzles (VP)	The participant is asked to choose 3 puzzle piece like images that can be arranged to the given completed puzzle image within a time limit. It is designed to measure nonverbal reasoning and the ability to analyze and synthesize abstract visual stimuli.	Gv
Working Memory Index (WMI)	Composed of subtests measuring working memory, attention and concentration	
Digit Span (DS)	The participant is given a series of numbers and is asked to recall them either by the same order, in reverse order, or in ascending order. It is designed cognitive flexibility, mental alertness, learning and memory, attention, encoding, and auditory processing, and mental manipulation.	Gsm
Arithmetic (AR)	The participant is given a series of mathematical problems to solve within a time limit. It involves mental manipulation, concentration, attention, short- and long-term memory, numerical reasoning ability, and mental alertness.	Gf, Gsm, Gq
Processing Speed Index (PSI)	Composed of subtests measuring the speed of mental and graphomotor processing	
Symbol Search (SS)	The participant is to scan a search group and indicate whether one of the symbols in the target group matches within a time limit. It involves processing speed, short-term visual memory, visual-motor coordination, cognitive flexibility, visual discrimination, speed of mental operation, attention, and concentration.	Gs
Coding (CD)	The participant copies symbols that are paired with numbers within a time limit using a key. It involves processing speed, short-term visual memory, learning ability, psychomotor speed, visual perception, visual-motor coordination, visual scanning ability, cognitive flexibility, attention, concentration, and motivation.	Gs

Note. Gc = Crystallized intelligence; Gf = Fluid reasoning; Gv = Visual processing; Gsm = Short-term memory; Gq = Quantitative knowledge; Gs = Processing speed (Weschler et al., 2008).

man et al., 1993).

Statistical Analyses

Descriptive statistics on participant characteristic were performed using an independent t-test for continuous variables and Pearson's chi-square test for categorical variables, as appropriate. Participants who showed performance below or above the range identified by multiplying the interquartile range by 1.5 across all variables were identified as outliers and were exempted from the research sample. Paired t-test was performed to examine within-group differences between VCI and PRI. Levene's test was performed to compare the variance in certain variables between the two groups. Coefficient of variance (CV) was calculated by dividing the standard deviation by the average and multiplying it by 100. Chi-square test was used to determine whether the ratio of CPT 3 ≥ 60 and CATA ≥ 60 was statistically different between the two groups. To examine group differences, controlling for age, analysis of covariance (ANCOVA) using univariate general linear modeling was performed. A two-

Table 2. *Variables of CPT3 & CATA*

Variables	Definition
CPT 3 & CATA	
Detectability (*d'*)	Measurement of how well the respondent discriminates non-targets from targets
Omission	Missed targets
Commission	Incorrect responses to non-targets
Hit Reaction Time (HRT)	Mean response speed for all non-perseverative responses
HRT Standard Deviation (HRT SD)	Consistency of response speed to targets of the entire administration
HRT Block Change	Slope of change in HRT across the 6 blocks of the assessment
CPT 3 only	
Perseveration	Responses made in less than 100 milliseconds following the presentation of a stimulus
Variability	Mmeasure of response speed consistency within sub-blocks
HRT Inter-Stimulus Interval (ISI) Change	Slope of change in reaction time across the 3 ISIs.
CATA only	
Perseverative Commissions	Recorded when the participant incorrectly responds after a low tone, but before the high tone.

tailed *p*-value of less than .05 was considered statistically significant. IBM SPSS Statistics 24 was used for all statistical analyses.

Results

Descriptive Statistics

In the recruitment stage, 36 adult patients with ADHD and 28 neurotic patients were recruited for the study. However, one patient from the ADHD group and two patients from the neurotic patient group were identified as outliers and excluded. The two outliers in the neurotic patient group were diagnosed with Bipolar II disorder. The single outlier in the ADHD group was primarily diagnosed as Persistent motor tic disorder with ADHD as a secondary diagnosis. This resulted in a research sample of 35 ADHD patients and 26 neurotic patients. We were not able to retrieve CATA performance data for two ADHD patients and four neurotic patients due to patients' refusal or computer-related technical problems. Both groups did not statistically differ in age, sex ratio, and education, although ADHD participants (23.71 ± 6.68 years) were generally younger than the neurotic patient group (28.19 ± 11.12 years). Both groups included more males than females. More than half of the patients in the neurotic group were primarily diagnosed with unipolar mood disorder: 10 Adjustment disorders, 6 Major depressive disorder, 5 Persistent depressive disorder, 3 Bipolar II disorder, 1 Social anxiety disorder, and 1 Panic disorder (Table 3). For ASRS-V1.1, the ADHD group reported significantly more ADHD symptoms (4.06 ± 1.66) than the neurotic patients (2.96 ± 1.97) (t_{56} = -2.31, p = .025).

Table 3. *Demographic Data*

	ADHD patients (n = 35)	Neurotic Patients (n = 26)	*p*-value
Age (Mean ± SD)	23.71 ± 6.68	28.19 ± 11.12	.055
Sex (male:female)	23:12	18:8	.777
Education	12.43 ± 1.27	12.69 ± 2.26	.564
Distribution of psychopathology (n (%))			
ADHD	35 (100%)		
Major depressive disorder		5 (19.23)	
Mild		3 (11.54)	
Moderate		2 (7.70)	
Persistent depressive disorder		6 (23.08)	
Adjustment disorders		10 (38.46)	
Bipolar		3 (11.54)	
Social Anxiety		1 (3.85)	
Panic disorder		1 (3.85)	
ASRS-V1.1	4.06 ± 1.66	2.96 ± 1.97	**.025**

Note. *p*-values less than .05 are in bold print.

FSIQ and subtest scores in K-WAIS-IV were within the average range, except for VCI subtest SI, PSI subtests SS and CD (Table 4). While the ADHD group showed average performance in SI, the neurotic patient group scored above average. Both groups showed lower than average performance on SS, while only those with ADHD showed lower than average performance for CD. The difference between PRI and VCI was also examined for each group. PRI was statistically significantly higher than VCI for adults with

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Table 4. *Group Difference in K-WAIS-IV performances*

	ADHD patients	Neurotic patients	*p*-value
	Estimated mean (se)	Estimated mean (se)	
FSIQ	99.28 (2.47)	104.63 (2.88)	.170
VCI	101.55 (1.96)	108.41 (2.28)	**.028**
SI	10.72 (0.36)	12.03 (0.42)	**.023**
VC	9.77 (0.44)	11.39 (0.51)	**.022**
IN	10.00 (0.49)	10.65 (0.57)	.397
PRI	107.79 (2.58)	106.40 (3.01)	.731
BD	10.77 (0.64)	10.42 (0.75)	.725
MR	11.41 (0.41)	11.76 (0.48)	.594
VP	11.22 (0.475)	10.51 (0.55)	.336
WMI	96.93 (2.94)	107.48 (3.42)	**.025**
DS	9.40 (0.57)	10.54 (0.66)	.202
AR	9.32 (0.66)	11.88 (0.76)	**.015**
PSI	90.82 (2.60)	92.85 (3.03)	.618
SS	8.02 (0.61)	7.79 (0.71)	.810
CD	7.83 (0.53)	9.11 (0.62)	.129
PRI-VCI	6.24 (2.40)	-2.01 (2.80)	**.031**

Note. FSIQ = Full Scale Intelligence Quotient; VCI = Verbal Comprehension Index; SI = Similarity; VC = Vocabulary; IN = Information; CO = Comprehension; PRI = Perceptual Reasoning Index; BD = Block Design; MR = Matrix Reasoning; VP = Visual Puzzle; PCm = Picture Completion; WMI = Working Memory Index; DS = Digit Span; AR = Arithmetic; PSI = Processing Speed Index; SS = Symbol Search; CD = Coding; PRI-VCI = difference between PRI and VCI. *p*-values less than .05 are in bold print.

ADHD (t_{34} = -2.481, p = .018), while the difference between VCI and PRI was not statistically significant for the neurotic patient group (t_{25} = -0.263, p = .795).

When averaged, neither group showed atypical performance on CPT 3 & CATA. However, statistically significant difference in variance was observed between certain CPT 3 variables: the variance for d' (F(1,59) = 7.87, p = .007), omissions (F(1,59) = 9.77, p = .003), and commissions (F(1.59) = 7.48, p = .08). The ADHD group exhibited significantly higher variance in d' and commissions, while the neurotic patient group showed higher variance for omissions for CPT 3 (Table 5). CATA did not show such significant evidence.

Cognitive Differences Between ADHD and Neurotic Disorders

In terms of K-WAIS-IV, ADHD and neurotic patients showed statistically significant differences in VCI (p = .028), SI (p = .023), VC (p = .022), WMI (p = .025) and AR (p = .015). The ADHD group showed lower performance in all of the aforementioned indices and subtests compared to the neurotic patient group (Table 4). There was no significant group difference in CD, although the ADHD group generally showed lower than average performance, whereas the neurotic patient group reported average performance. Patients with ADHD and neurotics also showed significant differences when the discrepancy between PRI and VCI was compared. Adults with ADHD had higher PRI scores than VCI scores, whereas neurotic adults did not.

For CPT 3, the group significantly differed in terms of d' (p = .044). The ADHD group showed poorer performance than the neurotic patient group in correctly identifying and responding to the target stimulus. There were no significant group differences in any of the CATA variables in terms of average (Table 5). When the patterns of CPT 3 & CATA performances were examined individually, it was difficult to find a singular performance pattern that could represent each group. Therefore, we counted CPT 3 ≥ 60 and CATA ≥ 60. CPT 3 ≥ 60 was 0.63 for the ADHD group, while it was a comparatively small ratio of 0.42 for the neurotic patient group. However, this difference was not statistically significant. CATA ≥ 60 was relatively the same between the two groups; it was 0.33 for the ADHD group and 0.30 for neurotic group. The variance per group was further examined by calculating the CV per variable (Table 5). Regarding CPT 3, except for Omissions, HRT and HRT ISI Change, the ADHD group showed higher variance in most of the variables than the neurotic patient group. The difference was statistically significant only for d', omissions and commissions. This tendency for the ADHD group to have a larger variance compared to the neurotic patient group was not clearly observed for CATA. In contrast, the neurotic patient group showed a significantly higher CV than the ADHD group for perseverative commissions.

Discussion

Our study aimed to provide a guideline for clinicians to utilize K-WAIS-IV, CPT 3, and CATA to understand the difference in cognitive deficits between ADHD and other psychotic disorders with subjective attentional complaints. Our study showed an interesting difference between adult patients with ADHD and neurotic patients. Previous studies could not draw consensus on the specific cognitive areas in which ADHD differs from other patients

Table 5. *Group Difference in CPT 3 & CATA Performances*

	ADHD patients	Neurotic patients	*p*-value
	Estimated mean (se)	Estimated mean (se)	
CPT 3			
d'	49.37 (1.74)	43.81 (2.03)	**.044**
Error type			
Omissions	50.13 (1.53)	45.64 (1.79)	.065
Commissions	51.53 (1.69)	46.74 (1.97)	.074
Perseverations	48.06 (0.61)	46.85 (0.71)	.206
Reaction time			
HRT	44.74 (1.51)	47.96 (1.76)	.177
HRT SD	44.41 (1.30)	42.95 (1.52)	.476
Variability	46.33 (1.25)	43.07 (1.44)	.098
HRT Block Change	50.30 (1.69)	49.16 (1.91)	.659
HRT ISI Change	47.25 (1.38)	48.21 (1.58)	.656
Ratio of patients with T score ≥ 60 in any variable	0.63 (22:35)	0.42 (11:26)	.111
Coefficient of Variance (%) of CPT 3			
d'	23.43	17.75	**.007**
Error type			
Omissions	22.55	76.84	**.003**
Commissions	22.55	17.28	**.008**
Perseverations	21.50	7.19	.426
Reaction time			
HRT	7.61	21.53	.149
HRT SD	17.65	17.15	.495
Variability	17.76	14.51	.152
HRT Block Change	16.71	17.79	.850
HRT ISI Change	20.50	18.19	.642
CATA			
d'	48.84 (1.33)	47.88 (1.64)	.654
Error type			
Omissions	46.72 (0.48)	46.10 (0.59)	.426
Commissions	49.05 (0.97)	48.39 (1.19)	.673
Perseverative commissions	47.37 (1.41)	50.99 (1.74)	.116
Reaction time			
HRT	42.71 (1.37)	39.75 (1.68)	.183
HRT SD	47.61 (1.29)	46.18 (1.59)	.494
HRT Block Change	52.85 (1.57)	52.64 (1.94)	.935
Ratio of patients with T score ≥ 60 in any variable	0.33 (11:33)	0.30 (7:23)	.819
Coefficient of Variance (%) of CATA			
d'	14.08	18.11	.282
Error type			
Omissions	7.33	3.07	.246
Commissions	9.61	13.34	.481
Perseverative commissions	7.74	23.40	**.013**
Reaction time			
HRT	19.09	17.75	.309
HRT SD	14.23	17.60	.873
HRT Block Change	15.48	19.62	.378

Note. *d'* = detectability. *p*-values less than .05 are in bold print.

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(Advokat et al., 2007; Boonstra et al., 2005; Malloy-Diniz et al., 2007). Our study found differences between verbal comprehension and arithmetic. Verbal comprehension is defined as an individual's ability to correctly convey how one understands and comprehends verbal information. Arithmetic measures the ability to mentally sustain and proficiently manipulate auditory information using mathematical knowledge. It requires not only the capacity to self-monitor and sustain attention and concentration but also fluid reasoning. Our results concede with prior studies in certain aspects since low performance on AR can represent low performance in verbal working memory (Marchetta et al., 2008; Schoechlin & Engel, 2005; Wechsler et al., 2008; Woods, Lovejoy, & Ball, 2002). However, our study differed in that participants showed significant differences in verbal comprehension and did not show differences in processing speed. This difference may be because the disorders used as the control group differ from study to study (Marchetta et al., 2008; Walker et al., 2020; Wiig & Nielson, 2012).

The results of our study raise the question of why differences in cognition between the disorders are observed, considering that non-ADHD psychiatric patients are also known to show deficits in executive function, memory and attention (Castaneda et al., 2011; Marazziti et al., 2010; Solé et al., 2011; Tsourtos, Thompson, & Stough, 2002). Based on our results, however, it may be hypothesized that the severity of deficiency among those with ADHD and neurotic disorders differs according to cognitive area. While those with ADHD and neurotic disorders both show deterioration in their processing speed, it may be that the severity of dysfunction in terms of working memory is worse in ADHD. This is likely because the two groups did not differ in their performance on DS and PSI but differed in their AR performances. While DS requires simple memory recall of a series of auditory stimuli, AR requires more subjective effort to understand the question and to logically induce the relationship between numbers to retrieve the answer. AR has also been shown to correlate with fluid reasoning (Wechsler, 2008). Two studies on children with ADHD have shown that these children perform worse on mathematics and tests relevant to fluid reasoning than the healthy controls (Semrud-Clikeman, 2012; Tamm & Juranek, 2012). The process required to show good performance in AR seems to be closely linked to deficits caused by ADHD.

In our results, the ADHD group showed lower performance in areas of verbal comprehension and this performance was significantly compared to their performance in visual spatial reasoning. Most existing studies do not report a major difference in verbal comprehension (Gorlyn et al., 2006; Kim & Park, 2020; Marazziti et al., 2010; Wechsler et al., 2008). However, a recent study comparing ADHD and non-ADHD children using Wechsler Intelligence Scale for Children 4th edition (WISC-IV) showed statistically significant differences in SI along with other WMI and PSI subtests (Ünal et al., 2021). Another study using WISC-III reported that children with ADHD showed significantly lower VC scores compared to their normal controls (Andreou, Agapitou, & Karapetsas, 2005). A study examining Taiwanese participants using the Chinese version of WISC-IV also indicated that their PRI scores were significantly higher than their VCI scores among children with ADHD (Yang et al., 2013). Such findings may indicate that children with ADHD have difficulty acquiring crystallized abilities earned through education, experience and socialization. This difficulty seems to persist into adulthood. While other studies have suggested that adults with ADHD show deficits in PRI, WMI, and PSI with relatively stable VCI (Gorlyn et al., 2006; Kim & Park, 2020; Marazziti et al., 2010; Theiling & Petermann, 2016; Wechsler et al., 2008), a number of reports have shown that adults with ADHD continue to show lower performance in verbal comprehension regardless of age than the healthy controls (Barkley & Fischer, 2011; Biederman et al., 2010; Bridgett & Walker, 2006). A review by Van Lieshout, Luman, Buitelaar, Rommelse, and Oosterlaan (2013) found that both children and adults with ADHD show low intelligence, with lower verbal rather than performance IQ. It may be hypothesized that in comprehending verbal information adults with ADHD fail to pinpoint the gist of the definition of given words and instead hastily report a shallow impression of them. The aforementioned studies also seem to show that the difference between VCI and PRI observed in our study accounts more for the fact that adults with ADHD show less than expected performance on the VCI subtest than them performing superior on the PRI subtests. This phenomenon can be utilized by clinicians when searching for signs of adult ADHD using K-WAIS-IV.

Of the variables provided by CPT 3 and CATA, d' from CPT 3 was the only variable showing a significant difference between the

ADHD and the neurotic patient groups. *D*' is the core variable provided by CPT 3 as it measures whether the participant can differentiate the target from non-target stimuli and react accordingly. It is difficult to conclude whether this finding is consistent with previous findings since they also failed to find a consistent pattern in the task performance of patients with ADHD. The average performance in CPT3 & CATA from our study fell within the limits of "average performance." It appears that the averaged data failed to reflect the nature of the patients' heterogeneous performance. The ADHD group also showed higher variance in certain CPT 3 variables than the neurotic patient group. This can be understood as the ADHD group having more individuals scoring on either spectrum of extremities compared to the neurotic patient group (Table 5). Heterogeneity in their performance may indicate that ADHD encompasses different subtypes of disorders (e.g. inattentive type vs. hyperactive type). This may serve as a basis to emphasize the importance of subtyping ADHD at a diagnostic level. While the ADHD group showed a higher variance for *d*' and commissions, the neurotic patient group showed a higher variance for omissions. This may indicate that while patients with ADHD report similar complaints regarding attention, individual differences exist in their pattern of attention. This may be further analyzed by subtyping ADHD in future research. Omissions may better demonstrate differences in individuals' attentional difficulties in neurotic mental disorders. However, a future study with a larger sample size to better represent each psychiatric disorder is needed to support this hypothesis. Although the difference in CPT $3 \geq 60$ between the two groups was not statistically significant, the difference may become more evident if a larger sample size is acquired. The results from CATA were less discriminant.

This study provides particular signs of cognitive deficiency specific to adult ADHD that can be easily applied in a South Korean clinical setting. However, this study had several limitations. Since the study was exploratory with a relatively small number of subjects, post-hoc statistical analyses were not available. A follow-up study with more participants for each psychiatric disorder will help in further statistical validation of the results of this study. Another limitation is that the study could not utilize the results of the subtests within DS of K-WAIS-IV. This information may have allowed for further understanding of the working memory of ADHD and non-ADHD patients. In addition, as this was a retrospective study, the results from the DS subtests were not reported in the patients' psychological assessment reports making them ethically impossible for research utilization. Furthermore, the study only utilized the primary diagnosis of patients. Considering the possible impact comorbid disorders can have on cognitive function in the ADHD group, this could be another limitation of this study.

The goal of our study was to explore attention-related characteristics that differ between ADHD and other neurotic disorders using assessments commonly used in clinical practice. Although the results are preliminary, we succeeded in identifying the key variables that showed major differences between the two groups. We also illustrated a realistic portrait of how results of CPT 3 and CATA are not uniform among adults with ADHD and suggest how these results can be used to further understand individualized ADHD symptoms. Therefore, in the light of our findings, clinicians may gain practical insights into how to interpret patients' test.

Author contributions statement

SC, intern at Kangbuk Samsung Hospital, collected and analyzed the data, and prepared the manuscript. JL, a clinical psychologist and supervisor at Kangbuk Samsung Hospital, supervised the research process. DS, a psychiatrist at Kangbuk Samsung Hospital, supervised the medical examination of the participants. All the authors provided critical feedback, participated in the revision of the manuscript and approved the final submission.

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