The Effects of Self-perceived Parenting Attitudes on Visuo-spatial Attention and Mental Rotation Abilities among Adolescents

Sangyub Kim
School of Psychology, Korea University

Yeonji Baik
College of Interdisciplinary Studies in Cultural Intelligence, Dongduk Women's University

Sunghee Han
Institute of Human Behavior & Genetic, College of Medicine, Korea University

Kichun Nam (kichun@korea.ac.kr)
School of Psychology, Korea University

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Abstract

The present study aimed to investigate the effect of adolescents’ perceived negative evaluation of parenting on their visuo-spatial attention and mental rotation abilities. The experimental groups were divided into negatively evaluating group and positively evaluating groups based on their scores on the self-perceived parenting attitude scales. The UFOV task showed lesser accuracy of the negatively evaluating group when compared to the positively evaluating one in target perception presented in 20 degree visual angle. In the mental rotation task, the negatively evaluating group exhibited a small trade-off effect between response times and rotation angles, which implied an impatient strategy was employed to perform the task. Thus, both experimental groups differed in terms of their visual attention and mental-spatial abilities. This study suggests that the reduced visuo-spatial attention and mental rotation abilities may act as precursors for serious psychological symptoms caused by the negative self-evaluation of their parents’ parenting attitudes.

Introduction

Research on adolescence have found that teenage years is characterized by the emergence of social and developmental problems such as academic and school-adjustment problems, and conflicts with family and/or friends (Branje et al, 2009; Ehrlich et al, 2012; Hartos & Power, 2000; Pinquart & Silbereisen, 2002). In particular, conflict with parents is one of the major problems that adolescents have to resolve, which will, in turn, allow them to develop social skills and prevent them from developing maladaptive problems (Choi, 2007; Lee, 2012; Sohn et al., 2001). There have been abundant research findings that suggest effects of positive parent-adolescent relationship on parent-adolescent communication and adolescents’ academic achievements (Masselam et al, 1990), development of self-esteem (Brage & Meredith, 1994; Demo et al, 1987), and mental health (Collins et al, 1995), which conclusively indicate close connections between parental relationship and rising problems during adolescence. For this reason, adolescents’ evaluation of their parents’ parenting attitudes in turn influences their emotional development, which may give rise to psychological symptoms such as depression or aggression (Hale et al, 2005; Masud et al, 2019; Rapee, 1997). Authoritative parenting attitudes from the parents enable adolescents to form stable and positive relationships with their parents which allows them to develop psychological and emotional stability (Holmbeck, 1996; Jackson et al, 2005; Laible & Carlo, 2004). On the other hand, parents’ authoritarian parenting attitudes can cause adolescents to cut off their relationship with their parents which in turn lead to additional psychological and emotional problems (Laible & Carlo, 2004; Milevsky et al, 2007; Kim & Kim, 2005; Oh & Kong, 2007). Previous adolescent studies also have reported positive association between emotional problems and cognitive impairments (e.g, Matthews et al, 2008; Villemarette-Pittman et al, 2003). Matthews et al. (2008) observed that depressed adolescent girls showed poorer performance relative to healthy controls in visual memory and spatial working memory tasks, indicating a positive relationship between depressive episodes and deteriorated cognitive functions related to visual and spatial working memory. Villemarette-Pittman et al. (2003) employed a battery of verbal tests requiring a broad range of language and executive functions, and revealed that individuals
who exhibited impulsive aggression showed impaired executive functioning compared to nonaggressive controls. In addition, Hankin et al. (2010) conducted a study involving pure depressed, pure anxious, and comorbid adolescents (ages 9–17 years), and reported that these adolescents showed attentional biases to sad and angry faces, whereas control adolescents showed attentional avoidance of sad faces. Hence previous literature suggests that emotional instability is closely related to cognitive decline among adolescents, and such emotional instability may be influenced by adolescents’ developing internal representation of their parents’ parenting attitudes arising from negative parent-adolescent familial relationships.

In general, “parenting attitudes” refers to the attitudes adopted by parents who share their physical and psychological environments with their children on a daily basis, which, in turn, forms the core component of family relationships (Kim et al., 2017). Expressing affection and enforcing discipline for children are important, as they learn socially appropriate behavior within the boundaries of their familial interactions (Cabrera et al., 2011). Parents are often the first people to establish relationships with their children after they are born. Thus, they influence the formation of their children's personalities and values. The personality and values of a child will affect the formation of their self-esteem in the future, and the self-esteem so formed determines whether they experience psychological symptoms like depression or anxiety (Battle et al., 1988; Sowislo & Orth, 2013). Adolescents are still developing in terms of their cognitive abilities and are incomplete beings both socially and financially, as they are not yet independent from their parents. Thus, adolescence is as a period in which the support of a caregiver, parents in most cases, is necessary to establish himself or herself as a member of society. Adolescents’ assessment on their parents’ attitudes may have more diverse effects on them (i.e., the quality of life, self-assessment, and social adjustment) even though parent-adolescent relationships are bidirectional, possibly because adolescents turn to their parents and internalize their parenting attitudes to form internal social figures of themselves. It indicates that self-perceived parenting attitude of the adolescents influences their life regardless of their parents’ perceiving on parenting or even actual abundant physical and spiritual contribution of their parents.

Therefore, the adolescents’ evaluation of parenting attitude can be considered as one of the central factors affecting emotional instability and a determining factor in psychological symptoms experienced by adolescents.

In addition, these psychological symptoms may bring about changes in their cognitive abilities. Some studies have discussed negative effects of anxiety on the task performance requiring working memory (i.e., Eysenck & Calvo, 1992), and others have reported cases of impaired spatial working memory among healthy individuals after they were exposed to an anxiety-provoking situation (Lavric et al, 2003; Shackman et al., 2006). These results suggest that psychological symptoms are closely associated with cognitive declines, indicating potential impairment in cognitive abilities due to emotional instability instigated by psychological symptoms.
The manifestation of psychological symptoms and related cognitive impairments are expected to appear in adolescence and research findings suggest that such psychological manifestations observed in later adulthood may have been accumulated since early childhood (Dodge et al, 2006; Huesmann et al, 2009; Meltzer et al, 2003; Newman et al., 1996). Moreover, cognitive abilities can change with minor changes in psychological symptoms, but these minor changes may not meet the criteria for adolescents to be diagnosed with mental disorders. Previous literature on mild cognitive impairment (MCI) and dementia have reported cases of cognitive ability changes which emerged before the clinical diagnosis of mental disorders related to cognitive impairment. Bäckman et al. (2005) and Ewers et al. (2011) observed that people who are diagnosed with MCI and dementia showed cognitive declines for several years before they were clinically diagnosed, indicating that cognitive impairment might be considered a preclinical symptom of MCI or dementia. Thus, an adolescent who perceives one’s parents’ parenting attitudes negatively may also show cognitive decline before the actual appearance of obvious psychological symptoms.

In fact, while most research has targeted younger children, there is a lack of research on cognitive decline of adolescents with psychological symptoms (Budds et al, 2017; Huhtala et al., 2011; Van Bakel & Riksen-Walraven, 2002). The cognitive abilities of younger children have been measured indirectly through playful interactions that use picture storybooks, object detection, and virtual role play, which makes it hard to differentiate and measure the scope of sub-cognitive abilities (e.g., memory and attention) (Kim et al., 2017). Therefore, it is essential to examine changes in specific sub-cognitive abilities according to the psychological symptoms among adolescents through cognitive tasks. The current study focused on the visuo-spatial attention and mental rotation abilities. The visuo-spatial attention is the set of a mechanism by which selectively focused visual target was pointed to specific objects, locations, or certain instants in time (Hubert-Wallander, Green, & Bavelier, 2011). Thus, irrelevant visual information is restrained while relevant visual information is captured in spatially constrained visual acuity. According to research, declined visuo-spatial attention is a typical alteration of cognitive ability in a stress-induced situation (Janelle et al, 1999; Janelle, 2002). It affects the formation of spatial representation in visual imagery processing based on objects and requires the involvement of primary and secondary visual cortices (Kosslyn et al., 1998). Decrease in visuo-spatial attention ability may induce deterioration of mental rotation ability.

Therefore, this study aims to understand whether dysfunctions in visuo-spatial attention and mental rotation abilities are evident among adolescents who have negative evaluation of their parents’ parenting attitudes, and whether their cognitive performance may serve as a cue to possible mental health disorders. It is reasoned that adolescents who evaluate parenting attitudes negatively may exhibit reduced visuo-spatial attention and mental rotation abilities when compared to those who evaluate their parents’ parenting attitudes positively.

**Method**

**Participants**
A total of 67 adolescents were recruited from XXX high school and participated in this study. Among them, 8 failed to comply with the experimental procedures and were excluded from the final data analysis. The participants were categorized into the two experimental groups according to their evaluation on their parents’ parenting attitude with a median split method. We used the scores on the father’s parenting attitude to assign the participants to each experimental group even though both of the father’s and mother’s parenting attitude were measured. You and Yi (2010) reported that the perceived parenting attitudes of adolescences were more highly correlated for fathers than mothers. In addition, Kim (2002) showed paternal rejection-indifferent and hostile attitude more significantly explained symptoms of depression and externalizing problems of adolescent male students, considering with the proportion of male participants in this study (about 78% of the total participants; 46 males, 13 females). Using the participants’ evaluation on their father’s parenting attitude is more appropriate to determine the criterion only for the experimental group classification as their father’s parenting attitude has a strong positive correlation with their mother’s parenting attitude ($r = .629$, $p < .001$). Eventually, the negatively perceiving group reported low scores of both the father’s and mother’s parenting attitudes, on the contrary, the positively perceiving group showed high scores of both the father’s and mother’s parenting attitudes. Thus, data from 29 (23 males, 6 females) negative and 30 (23 males, 7 females) positive evaluation groups were analyzed. The average ages of the negatively and positively perceiving groups were 18.44 ($SD: .87$, range: 17-19 years) and 18.40 years ($SD: .81$, range: 17-19 years) respectively. This study complied the ethical standards laid down in the 1964 Declaration of Helsinki. All participants comprehended the ethics code and provided written consent with their parents’ permission toward their engagement in this study. A small amount of money was paid as a reward for their participation. Participants were excluded if they: 1) had a known history of neurological impairment because of a stroke or brain damage, 2) had been diagnosed with mental retardation, 3) had a known history of impairment of major sensory organs, 4) had a known history of substance abuse or gambling addiction, 5) were unable to participate voluntarily, 6) had severe medical conditions that had the potential to interfere with their ability to participate in the study.

To examine the negative effects of the psychological symptoms on their performance in the UFOV and mental rotation tasks, the participants were given self-reported psychological questionnaires after performing the UFOV and mental rotation tasks in order to measure the possibility of symptoms associated with attention deficit hyperactivity disorder (ADHD), depression, anxiety, aggression, and manic-depression. Research has shown that the emotional state of an individual interacts with their cognitive abilities. For instance, decreased visuo-spatial attention ability has been associated with ADHD symptoms (Swanson et al, 1991), anxiety and aggression (MacNamara & Hajcak, 2010; Manning, 2020; Waters et al, 2014), depression (Keller et al, 2020; McClintock et al, 2010), and manic-depression (Peckham et al, 2010). People with ADHD (Silk et al, 2008), anxiety (Borst, 2013), depression (Chen et al., 2013a, 2013b), aggression (Kim et al, 2019), and manic-depression (Chrobak et al., 2018) showed declined mental rotation abilities.

Hence, self-reported psychological questionnaires (ADHD, BAI, BDI, K-AQ, and K-MDQ) were administered to the participants to measure the symptoms of the abovementioned mental disorders. Finally,
participants were given parents’ attitude evaluation questionnaires (PAT-F and PAT-M, Oh & Lee, 1982) to compare negative and positive evaluation groups. The negative evaluation group scored 187.76 ($SD$: 10.99) and the positive evaluation group scored 236.03 ($SD$: 16.81) on the father's parenting attitude scale, which indicated a significant difference ($t(57)=-13.005, p<.001$). On the mother’s parenting attitude scale, the negative evaluation group scored 198.28 ($SD$: 23.43), whereas the positive evaluation group scored 228.67 ($SD$: 35.84), indicating a significant difference ($t(57)=-3.841, p<.001$). There were no significant differences in other self-reported psychological questionnaire scores between the experimental groups ($t(57)=1.603, p=.114$ for ADHD; $t(57)=1.496, p=.140$ for BAI; $t(57)=1.174, p=.245$ for BDI; $t(57)=1.739, p=.087$ for K-AQ; $t(57)=.749, p=.457$ for K-MDQ). The scores were not so severe that they had to be clinically diagnosed with mental disorders, either. Table 1 shows all raw scores from the questionnaires.

<Insert Table 1 here>

**Self-report Psychological Questionnaires**

The father's (PAT-F) and the mother’s (PAT-M) parenting attitude scales were used to evaluate parenting attitudes as perceived by the adolescents. Psychological questionnaires on ADHD, BAI, BDI, K-AQ, and K-MDQ were given to participants to minimize the individual differences between groups that may be affected by other possible symptoms of mental disorders.

**Parent’s attitude evaluation questionnaire**

This study used Lee's (2008) PAT-F and PAT-M scales which are the recent versions of adolescent's evaluation of their parents’ parenting attitudes originally developed by Oh and Lee (1982). Each questionnaire was divided into four categories comprising 15 questions each, namely affection, autonomy, achievement, and rationality. Thus, they comprised 60 questions in all. The participants were instructed to respond to these questionnaires by choosing an option on a 5-point Likert scale that ranged from 1=strongly disagree to 5=strongly agree. The total score ranged from 60 to 300 points where higher scores denoted greater positive evaluation of the perceived parenting attitudes.

**ADHD questionnaire**

It was originally developed by Conners (1997) to measure ADHD symptoms as a self-reported questionnaire. It comprises three different versions for parents, teachers, and adolescents, and each has a regular (L) and short (S) form (Conners & Wells, 1985). The standardized Korean-version of adolescent short-form questionnaire, with a 4-point Likert scale (0=disagree, 1=slightly agree, 2=agree, 3=strongly agree), was adopted. It comprised 27 questions from 4 subscales (behavior and cognitive problems, hyperactivity, and ADHD indicators) (Bahn, Shin, Cho, & Hong, 2001). The level of ADHD was assessed based on the total scores which ranged from 0 to 81 points. If the total score exceeds 42 points, the respondent may be diagnosed with ADHD (Bahn et al., 2001).

**Beck anxiety inventory (BAI)**
The Korean version of BAI was used to measure the level of anxiety among participants (Kwon & Oei, 1992). It was originally developed by Beck et al. (1988) and was used to assess an individual’s level of anxiety in this study. All responses were self-reported on a 4-point Likert-scale (I did not feel anxiety at all=0; I felt a little anxiety=1; I felt a lot of anxiety=2; I felt severe anxiety=3 points). The level of anxiety was evaluated by computing the total scores of 21 items, which ranged from 0 to 63 points. Higher total scores indicated higher levels of anxiety (Kwon & Oei, 1992).

The Korean version of Beck Depression Inventory II

The extent of depressive disorder was measured using the Korean version of Beck Depression Inventory II (Sung et al., 2008). This inventory was developed by Beck et al. (1961) and was used to assess the severity of depressive symptoms among adolescents over the age of 13 years throughout adulthood. Participants had four options to choose from (I did not feel depression at all=0; I felt some depression=1; I felt quite a lot of depression=2; I felt severe depression=3). The total score for 21 questions indicated the level of depression, which ranged from 0 to 63 points. The criteria for being depressive was classified into 4 different levels (0–9 points: not depressive; 10–15 points: slightly depressive; 16–23 points: severely depressive; 24–63 points: extremely depressive) (Hahn et al., 1986).

Korean-Aggression questionnaire (K-AQ)

The Korean version of the Aggression Questionnaire (K-AQ) was used to measure the level of aggression among the participants (Kwon & Seo, 2002). This questionnaire was developed by Buss and Perry (1992). It comprised four measurement sub-scales (levels of physical and verbal aggression, anger, and hostility). The participants had 5 options to choose from (not at all=1; slightly agree=2; agree=3; usually agree=4; absolutely agree=5 points), and the total score for 27 questions ranged from 27 to 135 points. A higher total score indicates higher levels of aggression (Kwon & Seo, 2002).

Korean-Mood disorder questionnaire (K-MDQ)

The Korean version of the Mood Disorder Questionnaire was used to measure bipolar disorder among the participants (Jon et al., 2005; Kim et al, 2012). The questionnaire was developed by Hirschfeld et al. (2000). Participants had to pick between two options (yes=1; No=0). The total score for 13 questions ranged from 0 to 13 points. A score of 7 points implied being potentially diagnosed with bipolar disorder (Kim et al., 2012).

Experimental tasks

The first cognitive task used in this study was the useful field of view (UFOV) task, which has been typically used to measure visuo-spatial attention abilities (Green & Bavelier, 2003; Myers et al, 2000). Figure 1-A presents the experimental procedure for this task. Instructions were given to the participants followed by a fixation point that lasted 2,000 ms at the center of the computer monitor screen. After the fixation point was presented, target stimuli were presented for 100 ms in one of the 8 directional positions ("left-bottom," “middle-bottom,” “right-bottom,” “left,” “right,” “left-top,” “middle-top,” and “right-top”). The
The experimental condition was the visual angle of the target in which it was presented. The target stimulus was presented at the viewing angles of 10°, 20°, or 30° from the center of the screen. Participants were instructed to respond by pushing the numeric pad of the keyboard as quickly and accurately as possible according to the target positions presented regardless of the visual angle. For example, participants had to press number “3” on the numeric pad while responding correctly on the target stimulus presented at a 10° angle on the screen (“right-bottom” position). Similarly, number “7” had to be pressed while responding to the target stimulus presented at “left-top” at the 30° angle. 3 practice trials were firstly given to the participants and then 120 main trials were presented, 40 stimuli in each experimental condition (3 visual angles).

The second cognitive task was the mental rotation task developed by Shepard and Metzler (1971) to measure both mental rotation and visuo-spatial attention abilities (Johnson, 1990; Pietsch & Jansen, 2012; Moreau et al., 2011). Mental imagery refers to the ability to express the spatial and temporal state of an object accurately by forming the shape or movement of the object through visual representation (Guillot & Collet, 2005). It requires one to memorize the visual shape and spatial information of an object and then transform its position by changing its mental image of the perceived object. In the experimental procedure of this task (Figure 1-B), instructions were first given and a fixation point was presented for 2,000 ms followed by the two 3D figures, which were displayed simultaneously on the left and right visual fields of the participants with computer monitor screen. They had to determine by pressing the keyboard whether the two 3D shaped targets were identically shaped objects as quickly and accurately as possible if the objects were rotated (slash (/) button – two targets were identical, ‘z’ button – two targets were nonidentical). The experimental condition for this task comprised the rightward rotated-angles of the two presented figures (0°, 30°, 60°, 90°, 120°, 150°, and 180°), and 196 stimuli were created using 28 stimuli, 14 identical pairs and 14 nonidentical pairs placed in 7 angles. Identical pairs were same in shape but nonidentical pairs were different. These different pairs were used to measure accurate responses with mental rotational representation related to spatial memory, which supplements the problem of response bias toward “Yes (two 3D targets are same in shape)” in identical pairs as Shepard and Metzler (1971) only included identical target pairs to judgments, occurring response biases of judgments interfering with appropriate analyses on response times and accuracy rates.

<Insert Figure 1 here>

**Statistical analysis**

A separate two-way mixed ANOVA was performed on the accuracy rates and response times from UFOV and the mental rotation tasks. For UFOV, statistical analysis was conducted on the three visual angle conditions (10°, 20°, 30°) with group (positively and negatively evaluating groups) as the between-subject variable. For the mental rotation task, statistical analysis was performed on seven rotation-angle conditions (0°, 30°, 60°, 90°, 120°, 150°, and 180°) with group as the between-subject variable.

**Results**
This study investigated the changes in adolescents’ visuo-spatial attention and mental rotation abilities based on their evaluation of their parents’ parenting attitudes. The research question was whether the group that evaluated their parents’ parenting attitudes negatively would show a decrease in visuo-spatial attention and mental rotation abilities when compared with the one that evaluated parenting attitudes positively.

The results of the accuracy rates and response times in the UFOV task are described in Fig. 2 and Table 1. A two-factor (group condition × visual angle condition) mixed ANOVA was carried out on the accuracy rates. There were significant main effects for the group and the visual angle conditions ($F(1, 57) = 5.481, p = .023, \eta_p^2 = .088$; $F(2, 114) = 9.849, p < .001, \eta_p^2 = .147$). The two-way interaction effect between group and visual angle conditions was not significant ($F(2, 114) = 1.198, p = .306, \eta_p^2 = .021$). The main effect of two groups showed that significantly lower accuracy rates in the negatively evaluating adolescent group than the positively evaluating one. However, The LSD post-hoc test on the main effect of the visual angle condition revealed significantly higher accuracy rates in 10° and 20° visual angles, as opposed to the 30° visual angle ($p = .280$ for comparison between 10° and 20°; $p = .004$ for comparison between 10° and 30°, $p < .001$ for comparison between 20° and 30°). Next, the two-factor mixed ANOVA was performed on the response times. It showed no significant main effects and the two-way interaction effect in the group and visual angle conditions ($F(1, 57) = 1.312, p = .257, \eta_p^2 = .022$ for the group main effect; $F(2, 114) = 2.078, p = .130, \eta_p^2 = .035$ for the visual angle main effect; $F(2, 114) = 1.595, p = .207, \eta_p^2 = .027$ for the two-way interaction effect of those two conditions).

<Insert Fig. 2 here>

The results of accuracy rates and response times in the mental rotation task are described in Fig. 3 and Table 2. The two factor (group condition × rotation-angle condition) mixed ANOVA was performed on the accuracy rates of the identical pair judgments, not for nonidentical pairs. There were significant main effects of the group and the rotation-angle conditions ($F(1, 57) = 5.413, p = .024, \eta_p^2 = .087$; $F(6, 342) = 23.137, p < .001, \eta_p^2 = .289$). The interaction effects between group and rotation-angle conditions were not significant ($F(6, 342) = .790, p = .578, \eta_p^2 = .014$). As the results show, the main effect of group condition means lower accuracy rates in the negatively evaluating adolescent group than in the positively evaluating one. The LSD post-hoc test on the significant rotation-angle condition revealed that higher accuracy rates were observed in smaller rotation-angle conditions. Next, the two factor (group condition × rotation-angle condition) mixed ANOVA was performed on the response times. There were significant main effects of the group and the rotation-angle conditions ($F(1, 57) = 6.016, p = .017, \eta_p^2 = .095$; $F(6, 342) = 6.416, p < .001, \eta_p^2 = .101$). The two-way interaction effect between the group and the rotation-angle conditions was significant ($F(6, 342) = 2.278, p = .036, \eta_p^2 = .038$). As the results show, the main effect of group condition indicates faster response times in the negatively evaluating adolescent group than in the positively evaluating one. Besides, the LSD post-hoc test on the significant main effect of the rotation-
angle condition showed faster response times in 0° than other rotation-angle conditions ($p < .001, p < .001, p < .001, p = .001, p = .028$). Also, faster response times in 90° than in 180° was shown ($p = .031$). Simple main effect analysis on the two-way interaction effect revealed significantly faster responses in the negatively evaluating adolescent group than the positively evaluating one in the response times in 0°, 30°, 60°, 90°, 120°, and 150° rotation angle conditions ($F(1, 57) = 4.716, p = .034, \eta^2_p = .076; F(1, 57) = 4.739, p = .034, \eta^2_p = .077; F(1, 57) = 5.569, p = .022, \eta^2_p = .089; F(1, 57) = 4.574, p = .037, \eta^2_p = .074; F(1, 57) = 6.892, p = .011, \eta^2_p = .108; F(1, 57) = 8.355, p = .005, \eta^2_p = .023$).

Discussion

This study examined the influences of adolescent evaluation of their parents’ parenting attitudes on visuo-spatial attention and mental rotation abilities. It examined changes in adolescents’ visuo-spatial attention and mental rotation abilities based on their evaluation of parenting attitudes, while their self-reported psychological symptoms were controlled for ADHD, BAI, BDI, K-AQ, and K-MDQ. It sought to understand whether the group that evaluated parenting attitudes negatively would show declined visuo-spatial attention and mental rotation abilities when compared with the one that evaluated parenting attitudes positively.

The results of the UFOV task show that the negatively evaluating group had lower accuracy rates in 20° visual angle of the target, thus indicating deteriorated visuo-spatial attention ability. In the mental rotation task, the positively evaluating group showed a typical trade-off effect between response times and rotation-angles (i.e., a linear relationship between the amount of rotation-angles and increase in response time) as reported in Wilson et al. (2004), whereas the negatively evaluating group performed in a less typical fashion by showing a small trade-off function. In addition, the negatively evaluating group had a tendency of lower accuracy rates and faster response times when compared to the positively evaluating one, indicating that more hasteful responses were made in the former than in the latter. Generally, slower response times and higher accuracy rates were observed when the participants used conservative strategies while performing the tasks (Wickelgren, 1977), suggesting that the negatively evaluating group may use an impatient strategy in the task performance due to deterioration of mental rotation ability.

On mental rotation task, negative evaluation group showed rather atypical trade-off between accuracy rates and response times, suggesting different strategic planning in forming internal representation of objects. According to Wilson et al. (2004), children with developmental coordination disorder (DCD) encounter difficulties in producing accurate visuo-spatial representations, and a small trade-off function between response times and accuracy rates was observed among children with DCD when compared to the control group in the mental rotation task. Authors have concluded that children with DCD do not automatically use motor imagery, but rather depend on the alternative object-based strategy to perform the task due to deficit of motor imagery. The small trade-off between accuracy rates response times
among negative evaluation group may also rely on different cognitive strategies to perform the task due to their impairment in forming internal representation of the object during mental rotation task.

Therefore, the results of this study suggest that the negative evaluation of parenting attitudes by adolescents may first induce a distinct decrease in cognitive abilities such as visuo-spatial attention and mental rotation before the actual diagnosis of related mental disorders takes place. It is a fact that cognitive abilities like emotions, do not change dichotomously but rather continuously from monotonous to dramatic, based on the psychological symptoms. This is the reason why cognitive deficits of visuo-spatial attention and mental rotation may precede the obvious diagnosis of psychological symptoms induced by the negative evaluation of parenting attitudes.

Why did we observe initial deterioration of both visuo-spatial attention and mental rotation abilities for adolescents who have rated negatively on their perception of their parents’ parenting attitudes? First, negative emotions like depression, anxiety, fear, and anger induced by emotionally unstable states make it hard to control the appropriate information processing for a given set of stimuli (Clarke et al, 2013; Ille et al, 2013; Penton-Voak et al., 2013; Rossignol et al, 2013). When humans become emotionally unstable, the emotional state changes violently and they react sensitively to the stimuli, which, in turn, leads to emotional instability (Ryu & Kim, 2016). This is called a “human defense mechanism” in psychology and helps avoid situations or stimuli while eliciting negative emotions within oneself (Oh & Oh, 2011). It results in selective attention toward specific traits in the course of perceptual and cognitive information processing (Shin & Hyun, 2007). In this regard, Janelle et al. (1999) investigated the change in attentional focus in the states of anxiety and excitement. They instructed their participants to detect cues related to the purpose of the experiment among several cues that were presented in the peripheral visual field during a virtual driving task. The participants encountered great difficulty in identifying the related cue from among the distractors, as their levels of anxiety and excitement rose. Besides, in their analysis of gaze behaviors, the participants with narrower attentional fields induced by high levels of anxiety were more disturbed by the irrelevant cues that were presented in the peripheral visual field.

Other research have also shown that negative emotions (i.e., anxiety) affect spatial working memory rather badly (Lavric et al., 2003; Li et al, 2006; Shackman et al., 2006). Lavric et al. (2003) found poorer performance in the spatial working memory task in threat provoking condition relative to safety condition when they assessed levels of anxiety through heart rate recordings and self-report scales. Li et al. (2006) also reported similar effects of negative emotion on spatial working memory by using the event-related potential technique in a modified n-back task. The authors found greater P300 effect for negative emotion in the anterior and posterior areas which reflect cognitive impairment in spatial working memory. Shackman et al. (2006) found that threat-induced anxiety selectively disrupted the performance of spatial working memory but not verbal working memory. In addition, Taylor-Tavares et al. (2007) observed an impairment in the spatial working memory and attentional shifting ability specifically in unipolar depression group relative to bipolar depression group. Hence, negative emotions induced by adolescent’s adverse perceptions of their parents’ parenting attitudes may potentially impair their ability to effectively use spatial working memory, which may have in turn led to a deterioration in their mental rotation ability.
Other studies have dealt with the relationship between experiences of stress in the early stage of life and the presence of subsequent psychiatric symptoms (Bremner et al, 1993; Carrion, et al., 2009; Fisher et al., 2009; Kilpatrick et al., 2003). Experiencing stress early on in life may lead to the development of other psychiatric symptoms, such as anxiety, depression, post-traumatic stress disorder (PTSD), and substance abuse later in adulthood. Bremner and Vermetten (2001) found changes in the neural underpinnings of related cognitive abilities after the revelation of psychiatric symptoms. This supports the idea that stress that occurs among children as a result of inadequate parenting may produce cognitive deficits and psychological symptoms.

The deterioration of the visuo-spatial attention and mental rotation abilities may lead to alterations in other cognitive abilities, as cognitive domains of humans are interconnected (Costanzi et al., 2019; Holmes & Mathews, 2005; Mammarella, 2011). Kim et al. (2020) highlighted the possibility that declined visuo-spatial attention ability as a result of high-level social phobia induced emotional perception bias in the recognition of facial expressions. This suggests that changes in some cognitive abilities as a result of psychological symptoms can alter related ones. Thus, changes in cognitive abilities as a result of psychological symptoms can also be influenced by interactions among the cognitive abilities (Kim et al., 2017; Kim et al., 2018; Kim et al., 2019; Kim et al., 2020). Emotional instability preceded by cognitive deficits (i.e., deteriorated visuo-spatial attention and mental rotation abilities) may impair other related cognitive abilities. This implies that decreased visuo-spatial attention and mental rotation abilities may be used as behavioral markers in understanding and diagnosing psychological symptoms.

The negative evaluation of parenting attitudes by adolescents resulted in the deterioration of visuo-spatial attention and mental rotation abilities among adolescents before they were diagnosed with associated mental disorders. These cognitive deficits may be an indicator of changes in psychological symptoms induced by the negative perception of parenting attitudes among adolescents, even before they are diagnosed with clinical mental disorders. Our results suggest that the cognitive decline observed among adolescents with negative evaluation of parenting attitudes may act as a behavioral marker, and this may serve as prognostic factors influencing clinical outcome of psychological symptoms arising from emotional instability within a family. Future research should explore how the deterioration in visuo-spatial attention and mental rotation abilities, which are prognostic symptoms of possible psychological disorders, can affect other related cognitive functions like emotional perception bias and cognitive control.

**Declarations**

**Data availability**

The collected and analyzed data in this study are only available after permission of the authors if acceptable requests.

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**Author Contributions Statement**

SY coordinated and contributed to the paper (70%), YB provided data curation and writing & editing (10%), SH contributed in the methodology (10%), and KN provided leadership and writing (10%). All authors confirmed and approved the final version of manuscript.

**Compliance with Ethical Standards**

**Conflict of Interest**

The authors declare no competing interests.

**Ethical Approval**

All the experimental procedures in the current study were approved by the Institutional Review Board of the Korea University.

**Informed Consent**

The authors have followed detailed ethical guidelines during the preparation of this work. As mentioned in the method section of this paper, all the informed consents from the human participants were included after notifying respect on the rights of humans and safety about the personal information and data of the participants so as to prevent abuse or misuse of their information from unknown accessible for personal purpose.

**Acknowledgements**

The authors would like to thank the participations of adolescent subjects with having no problems in all the experimental procedures in the current study.

**References**


Tables
Table 1
The accuracy rates and response times of the two experimental groups in the UFOV task. The value within brackets denotes the standard error.

<table>
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<th>Visual angle 10°</th>
<th>Visual angle 20°</th>
<th>Visual angle 30°</th>
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<tr>
<td></td>
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<td>RT</td>
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<td>(58.87)</td>
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<td>898.13</td>
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<td>(35.46)</td>
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</table>

Table 2 is available in the Supplementary Files section.

Figures

Figure 1
The experimental paradigms of (A) UFOV task and (B) mental rotation task are illustrated. (A) Participants had to identify the direction in which the target had been presented. (B) Participants had to determine whether the two given 3D-shaped targets were identical.
Figure 2

Response times and accuracy rates of two experimental groups in the performance of the UFOV task. Error bars represent the standard error. (* $p<.05$)

Figure 3

Response times and accuracy rates of two experimental groups in the performance of the mental rotation task. Error bars represent the standard error. (* $p<.05$)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table2.docx