The Neural Basis of the Effect of the Relationship with Parents on Self-esteem in Adulthood

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The Neural Basis of the Effect of the Relationship with Parents on Self-esteem in Adulthood

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

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Self-esteem is a positive view of one's own being, and it is formed through interaction with others, which plays a major role in enabling parents and children to lead an efficient life. Self-esteem is formed by being continuously influenced by communication. And communication has generally been regarded as the most important aspect of interpersonal relationship. In particular, the interaction between children and parents is the most essential relationship because it is the basis of all relationships, and parents are the central characters who greatly influence their children as a source of intellectual, emotional, social, linguistic and physical development of children. However, there is a deficit of research which describes the neurological associations that can support those notions objectively, and many of these studies have been carried out with children and adolescents only. This study investigated the brain activity underlying the emotional response to stimuli during the recall of a parent's facial expressions in various emotional situations. The sample included 24 participants (11 men, 13 women) recruited using local advertisements. The trial types were divided into four conditions: father-positive, father-negative, mother-positive and mother-negative.

The behavioral results showed no difference in the positive assessment of the mother and the father. However, the negative responses to the negative situations were greater for the mother than for the father. The participants also showed slower reaction times for the positive situations, than for the negative situations. In the imaging results, there was a main effect for parents in the calcarine cortex and the inferior frontal gyrus. Moreover, there was also a main effect for the valence in the fusiform gyrus, anterior cingulate cortex (ACC), insula, premotor cortex, inferior frontal gyrus, and thalamus. Furthermore, there was an interaction effect in the ACC and precuneus. Psychophysiological interaction (PPI) analysis was used to investigate the effective connectivity with the ACC. The PPI results showed that the connections between the ACC and the fusiform gyrus, and between the ACC and the postcentral gyrus were strong.

These results provide insight into the mechanism of the relationship with parents, and the relation to emotional situations. These results provide useful evidence regarding the importance of the relationship between parents and children, which is an essential factor for high self-esteem.

Key words: self-esteem, parental communication, adolescence, anterior cingulate cortex, precuneus, insula, fusiform gyrus, communication with parent

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I. INTRODUCTION

Self-esteem is a positive view of one's own being, and it is formed through interaction with others.[1] It plays a major role in enabling parents and children to lead efficient lives. Self-esteem is formed by being continuously influenced by respect, acceptance, interest, and successful experience from those who think it is important.[2] For high self-esteem, positive parent-child interaction should be prioritized. That is, warmth, assistance, and care from parents are necessary for the child's maturity, independence, confidence, ability and responsibility.[3]

However, simple affection and assistance alone are not sufficient to develop these traits. According to previous studies, communication has generally been regarded as the most important aspect of interpersonal relationships,[4] and the importance of effective communication among family members has been supported by many researchers.[2,4-7] Parents provide a network of communication experiences that teach individual language skills, and how to interact and compromise. In particular, the interaction between children and parents is the most essential relationship because it is the basis of all relationships, and parents are the central characters who greatly influence their children, as sources of intellectual, emotional, social, linguistic and physical development.[8] Communication is the most important medium that affects the relationships between parents and children, and it is a key component of human relationships that involve attitudes, thoughts, affection and ideas.[9]

Adolescents can learn how to communicate, compete, collaborate and compromise with others, through their interaction with their parents. Open communication between parents and adolescents has the benefits of emotionally cleansing, helping mental health, encouraging active interactions, and allowing individuals to feel accepted and understood.[10] This communication can be regarded as an important factor in forming the self-esteem of adolescents.[11-13] This is because the type of communication is believed not only to affect character formation, but also to affect an individual's perceived well-being greatly.[14] The self-esteem established in adolescence affects healthy behavior[15] and healthy personality formation.[16] However, low self-esteem tends to show externalizing problems, such as wrongdoing and antisocial behavior,[17-19] and there is a correlation between anxiety, including both social anxiety and general anxiety disorder, and depression.[20-22]

The results of these studies suggest that the relationship between parents and children is important for the formation of high self-esteem, and for explaining the variables that influence parent-child relationships and self-esteem. However, there has been little research into explaining a neurological linkage that can be objectively supported, and most of this research focuses on children and adolescents. Recent advances in neurological studies have focused on neurological structures in relation to close friends and parents,[23] studies of patient-parent relationships, for patients with schizophrenia,[24] and studies of brain activation in mother-child relationships.[25] Yet, to date, there have been no brain-based studies carried out into the relationship between parental relationships and self-esteem in adults.

The results of the brain imaging are based on the assumption that the activation of the medial prefrontal cortex (mPFC) and the anterior cingulate cortex (ACC) are associated with positive self-assessment, as revealed in previous studies. The results are also based on the activation of the dorsal anterior cingulate cortex (dACC),[26] posterior cingulate cortex (PCC) and ventral tegmental area (VTA),[27] which is associated with self-esteem. It is reasonable to expect the activation of the parahippocampal gyrus, ACC, and precuneus which are related to the memory recall of the parent[24] can be expected.

In this study, the author investigated the brain activity underlying the emotional responses to stimuli during recall or imagination of the parent's facial expression in various scenarios. The purpose of this study was to find out the relationship between the parental relationship and self-esteem and identify the brain basis that is related to such a relationship. Then the author attempted to identify the parent who has more influence on self-esteem. Ultimately, the author investigated to present the neurological basis for the diagnosis and intervention into the risk group with low self-esteem.

The author can assume that people with low self-esteem are more likely to choose a negative emotional expression and that this will be negatively correlated with parent-child communication quality. On the other hand, subjects with high self-esteem can be expected to have a high probability of choosing a positive emotional expression. The hypotheses are as follows: The ACC relating to self-esteem will be activated. The PCC related to high self-esteem level will be activated. And the precuneus will be activated according to the stimulus of the memory of the subjects' parents.

II. MATERIALS AND METHODS

This study was conducted by first submitting participants to a screening interview. Qualifying participants then moved on to the second stage of the experiment in which they completed personal psychological history inventories. Finally, qualifying participants were given an fMRI test to monitor their response to experimental stimuli. The data from the inventories was used to inform the analysis of the fMRI test results.

1. Participants

The sample included 29 initial participants who were recruited from local advertisements. The inclusion criteria were as follows: (1) Korean healthy volunteers of good general health, with no significant past medical history, (2) right-handedness (assessed using Edinburgh Handedness Inventory),[28] and (3) aged above 20 but less than 40 years old. Exclusion criteria were as follows: (1) any structural abnormalities on the brain MRI scan (e.g. prohibitive mental implants) (2) history of major medical disorders (e.g. diabetes mellitus or head injury), (3) had a psychiatric disorder (e.g. a major depressive disorder or anxiety disorder), (4) had a neurological or neurodevelopmental disorder, and (5) medication currently taken. Two participants who did not complete the behavior task were excluded, and three were additionally excluded due to framewise displacements of more than 3mm. Thus, the remaining 24 participants (11 men and 13 women) were included in the subsequent analysis.

2. Psychological Assessments Scales

The author used various clinical assessment scales for evaluating subjects' characteristics. Psychological states were assessed using the Parent-Adolescent Communication Inventory (PACI) ; Father, Mother,[29] the Rosenberg Self-Esteem Scale (RSES),[30] the Hospital Anxiety and Depression Scale (HADS),[31] the Family Adaptation and Cohesion Evaluation Scale-III (FACES-III),[32] the Beck Cognitive Insight Scale (BCIS),[33] and the Schizotypal Ambivalence Scale (SAS).[34] The participants completed the assessment scales before undertaking the imaging procedure.

2.1. The Parent-Adolescent Communication Inventory (PACI)

The Parent-Adolescent Communication Inventory (PACI) is a tool for assessing the quality of communication between parents and children consisting of two subtests. The first subtest measures the openness of the family communication, by assessing any communication problems and the positive aspects of expressing one's intentions freely. The second subtest measures the negative aspects of the interaction and communication among family members.

Each subtest consists of a total of 20 questions, each of which is leveled on a five-point scale (1 = not like that at all, 5 = always the case). For each sub-scale, a score range of 10 to 50 is available, and the opposite scoring questions are as follows: open family communication = 1,3,6,7,8,9,13,14,16, and 17 problem family communication = 2,4,5,10,11,12,15,18,19, and 20. The Cronbach α = .86 for 20 questions about communication with father and Cronbach α = .85 for 20 questions about communication with mother.

2.2. The Rosenberg Self-Esteem Scale (RSES)

The Rosenberg Self-Esteem Scale (RSES) is a test that measures an individual's self-respect, whether degree of self-respect and self-approval. The questionnaire is composed of five positively and five negatively worded items. The ten items are rated on a four-point Likert scale, ranging from 1 ("strongly disagree") to 4 ("strongly agree"). The negatively worded items were to be reverse scored. The score range is 10 to 40 points, and the higher the score, the higher self-esteem. Cronbach $\alpha = 0.79$.

2.3. Hospital Anxiety and Depression Scale (HADS)

The Hospital Anxiety and Depression Scale (HADS) is commonly used to determine the subject's levels of anxiety and depression and it is a fourteen-item scale that generates ordinal data. Seven of the items relate to anxiety and seven relate to depression. Zigmond and Snaith[31] created this measure specifically to avoid reliance on aspects of these conditions that are also common somatic symptoms of illnesses, such as fatigue and insomnia or hypersomnia. Each item on the questionnaire is scored from 0 to 3 and this means that a person can score between 0 and 21 for either anxiety or depression. The HADS uses a scale and therefore the data returned from the HADS are ordinal. A number of researchers have explored HADS data to establish the cut-off point of 8/21 for anxiety or depression. For anxiety (HADS-A) this gave a specificity of 0.78 and a sensitivity of 0.9. For depression (HADS-D) this gave a specificity of 0.79 and a sensitivity of 0.83.

2.4. The Family Adaptation and Cohesion Evaluation Scale-III (FACES-III)

The Family Adaptation and Cohesion Evaluation Scale-III (FACES-III) is a self-reporting measurement tool developed to assess the degree of cohesion and adaptability of family functions while classifying types of family systems. This scale was first developed in 1978, then modified supplemented and standardized on three occasions, 1981 (FACES-II: 50 questions) and 1984 (30 questions), and 1895(FACES-III), and is now widely used in the field of clinical and research as a useful tool for family functional diagnosis and family type classification. Ten questions of cohesion (the odd-numbered questions) and ten questions of adaptability (the even-numbered questions), have a range of at least 10 points and a maximum of 50 points, and higher scores can be interpreted as a higher family cohesion and adaptability. Cronbach α = .78.

2.5. The Beck Cognitive Insight Scale (BCIS)

The Beck Cognitive Insight Scale (BCIS) was developed to evaluate patients' self-reflectiveness and their overconfidence in their interpretations of their experiences. A 15-item self-report questionnaire was subjected to a principal component analysis, yielding a 9-item self-reflectiveness subscale and a 6-item self-certainty subscale. A composite index of the BCIS reflecting cognitive insight was calculated by subtracting the score for the self-certainty scale from that for the self-reflectiveness scale. The scale demonstrated good convergent, discriminant, and construct validity.

3. Stimulus Materials and Procedures

The participants viewed pictures of women and men which had been adjusted to look old so that subjects could recall their parents' face. A cross-fixation point on a grey background was presented on screen throughout each session. During each trial, an emotional situation which was positive, negative or neutral was displayed for 3,000ms and the inter-trial interval was 2,000ms. For each emotional situation given, participants were to respond by recalling or imagining the facial expressions of their father or mother by pressing a button with their left and right finger while undergoing fMRI scans. An example of a trial sequence and design paradigm is shown in Figure 1.

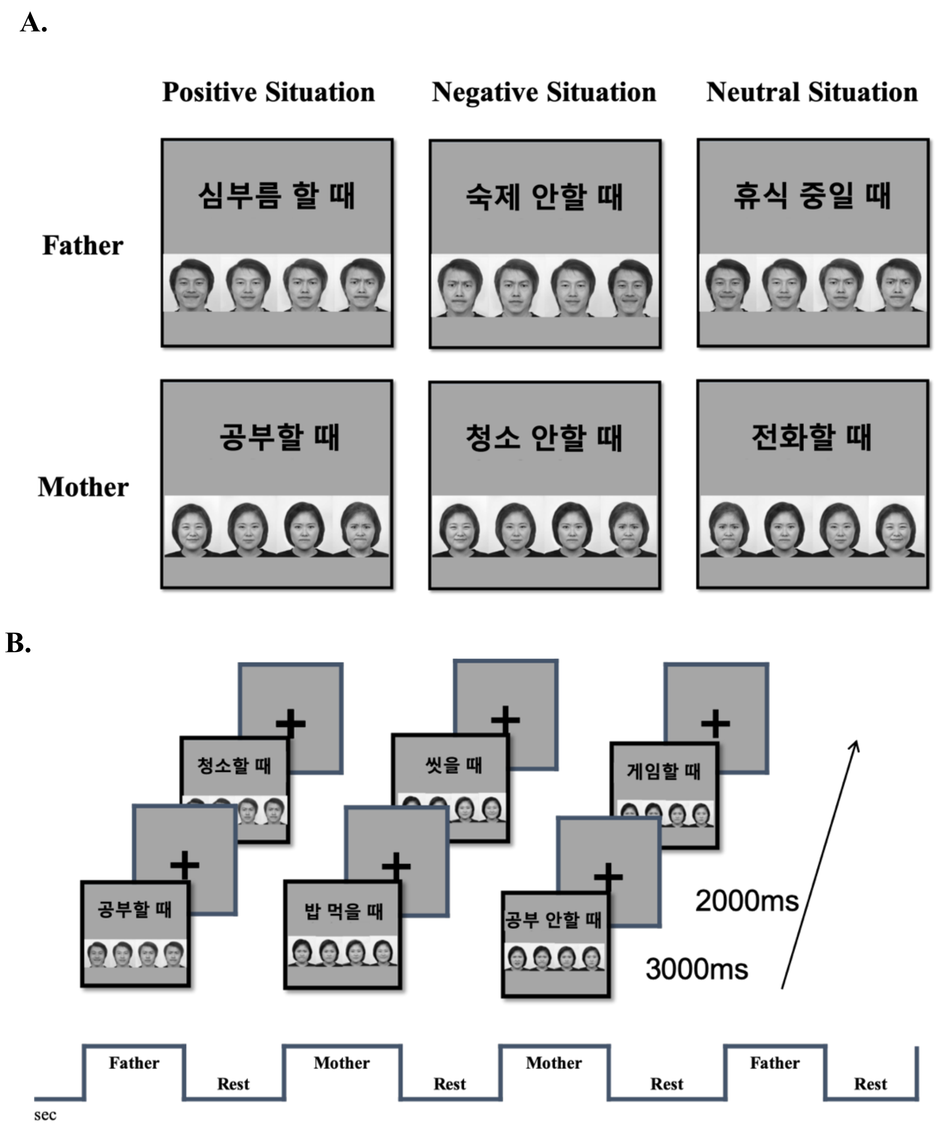


Figure 1. Task Stimuli and Design Paradigm. The participants had to press the left-hand button when they selected the two pictures on the left side and press the right-hand button when they selected the two pictures on the right side (A). The situations in the pictures consisted of three types of emotional situation: positive, negative and neutral (B).

The emotional and parental aspects of the stimulus are presented in Table 1. Regarding the emotional condition factors, the trial types are presented according to the emotional situation, in order to analyze the emotional response score. Emotional situations were used to identify examples that correspond to positive, negative, and neutral daily living, through a preliminary survey. The neutral situations were used as controls in the analysis. Along with each emotional situation, a photo was presented to represent the father and mother, which also consisted of a photo of a positive or negative expression, to reflect the facial expressions or reactions, depending on the situation. The emotional response scores were based on choosing a very positive (2), positive (1), negative (-1), and very negative (-2) facial expression. Thus, there were four trial types: father's facial expression in a positive situation (FP), father's facial expression in a negative situation (FN), mother's facial expression in a positive situation (MP), and mother's facial expression in a negative situation (MN).

The task sequence was composed of a mixed design paradigm which included null events. There were two types of block and the task was repeated five times. Each block included positive, negative, and neutral emotional condition and father and mother parental condition. Each block lasted for 3,000ms with the jitter lasting 2,000ms, and between each block there were 16 seconds of rest, during which the subjects passively viewed a fixation cross.

In order to secure the validity of the experimental paradigm according to the purpose of the study, pilot experiments were conducted, and the final experimental design suitable for functional MRI was devised. Most of the relevant studies in the literature are letter-oriented tasks, such as the completion of sentences about a parent or a familiar relationship with others, and the selection of an appropriate adjective to explain the image. In recent research, self-esteem and self-evaluation related brain activation areas have been identified by using the subjects' own photographs and photographs of others.[27] In this study, the degree of aging was added to the face, according to the facial expression, to aid the imagination process.

The stimuli were presented via the IFIS SA/E-Prime system (IFIS-SA, Integrated Functional Imaging System, MRI Devices Corporation, Waukesha, WI: Psychology Software Tool, Inc., Pittsburgh, PA). Participants' heads were cushioned with earmuffs that contained the headphones.

Table 1. Stimulus Condition for Analysis

Parent condition	Emotional condition	Trial type	Emotional response score
Father(F)	Positive(P)	FP	Positive trend: 1, 2 Negative trend: -1, -2
	Negative(N)	FN	
Mother(M)	Positive(P)	MP	
	Negative(N)	MN	

4. Image Procedures

A. Scanning Procedures

Functional and structural MRI were performed using a 3T Philips Ingenia scanner (Philips Medical Systems, Best, The Netherlands). The functional images were acquired using a T2*-weighted gradient echo-planar imaging (FEEPI) sequence (31 slices of 3mm thickness and no gaps, repetition time [TR] = 2000ms, echo time [TE] = 30ms, flip angle [FA] = 90°, image matrix = 124 x 124, field of view [FOV] = 220mm) with an in-plane resolution of 1.719mm x 1.719mm. In order to minimize signal loss in the orbitofrontal cortex, imaging slices were obtained at a tilted angle of 30° from the anterior commissure-posterior commissure line. Structural images with a resolution of 0.859mm x 0.859mm x 1.2mm were acquired using a 3D T1-weighted gradient echo (T1-TFE) sequence (170 slices, TR = 9.692ms, TE = 4.59ms, image matrix = 224 x 224) before functional data acquisition.

B. Image Processing

SPM12 (Statistical Parametric Mapping, Welcome Department of Cognitive Neurology, London, UK) was used for image analysis.[35] As each block started with a 2,000ms fixation screen, the first 6 images at each session location were discarded from the analysis and the remaining 120 images were preprocessed. Preprocessing included realignment, slice time correction, coregistration, spatial normalization, and spatial smoothing. Corrections for differences in the slice acquisition time were performed for the interleaved sequence. Head motions were corrected by realignment, and then the corrected images were coregistered with the T1-weighted image which finished segmentation for each subject. The T1-weighted image was segmented considering grey and white matter and then the image was coregistered and normalized to the standard T1 template. The resulting transformation matrices were applied to the coregistered functional images. Functional data were smoothed with a Gaussian kernel of 6mm full-width at half-maximum (FWHM).

5. Statistical Analysis

Functional data were analyzed using a general linear model. Experimental trials were modeled separately using a canonical hemodynamic response function for individual data. Multiple linear regression, as implemented in SPM12 using a least-squares approach, was used to obtain parameter estimates. These parameter estimates were then further analyzed by testing specific contrasts using the participant as a random factor. Images for the parameter estimates for each trial type were created for each participant in the 1st-level analysis. The trial types were divided into four conditions (FP, FN, MP, and MN). Individual realignment parameters were entered as regressors of no interest, to control for movement-related variance. The parameters for each condition were entered into the second-level analysis using a flexible factorial model and a paired *t*-test across the participants. In the flexible factorial model, the activation maps for the main effects and interactions were analyzed using a 2 (parent condition; father and mother) x 2 (emotional situation; positive and negative) flexible factorial model. Then, in order to assess the effect of the emotion and parent effects were conducted. Furthermore, in order to assess the effect of the positive or negative emotion, a paired *t*-test of the emotional valence was conducted under each emotional variation condition, as a post-hoc analysis.

Finally, psycho-physiological interaction (PPI), which is a functional brain imaging analysis method, was used in an additional analysis. PPI was used to estimated context-specific changes in effective connectivity (coupling) between a region of interest (seed) and other brain regions.[36-37] Thus, PPI analysis identified brain regions for which the activity depends on an interaction between the psychological context (the task) and the physiological state (the time course of the brain activity) of the seed region.[38]

Paired t-test and repeated measures analyses of variance (ANOVA) were performed to analyze the descriptive, behavioral and neural data. Pearson correlation coefficients were calculated to examine the associations between the psychological assessments and the imaging data. The statistical significance was set at a threshold of $p<0.05$. Statistical analyses were carried out using SPSS 25.

III. RESULTS

1. Demographic and Psychological Assessments of the Participants

There was only one group so there was no significant difference in the sex of the participants. However, a comparison of scores based on the hypothesis that there are differences in the communication type of the father and mother showed significant differences in open and problem type communication with their mother and father (Table 2 and Figure 2). This result showed the pattern of emotion toward the father and mother.

Table 2. Demographic and Psychological Assessments of the Participants

Characteristic	Mean(N=24)	Male(N=11)	Female(N=13)	t	p-value
Age	28±7.37	30.00±4.49	26±8.97	1.238	.229
Education year	15.75±3.99	16.73±3.55	14.92±4.29	1.109	.280
PACI-Father					
Open	31.29±7.87	33.36±7.37	29.54±8.14	1.197	.244
Problem	25.38±5.57	25.55±6.01	25.23±5.42	.135	.894
PACI-Mother					
Open	38.29±8.89	37.91±8.60	38.62±9.47	-.190	.851
Problem	23.33±5.55	23.36±5.16	23.31±6.07	.024	.981
RSES	24.88±2.38	25.27±2.41	24.54±2.40	.745	.464
HADS					
Anxiety	5.21±3.30	4.45±2.07	5.85±4.04	-1.032	.313
Depression	5.13±3.57	5.36±4.11	4.92±3.20	.295	.770
FACES-III					
Cohesion	3.00±1.69	2.91±1.51	3.08±1.89	-.237	.815
Adaptability	6.50±1.84	6.91±1.04	6.15±2.30	1.060	.304
BCIS					
Self-reflective	20.33±3.12	21.27±2.24	19.54±3.76	1.340	.194
Self-certainty	16.96±2.01	16.73±1.79	17.15±2.23	-.510	.615

PACI (Parent-Adolescent Communication Inventory), RSES (Rosenberg Self-Esteem Scale) HADS (Hospital Anxiety and Depression Scale), FACES-III (Family Adaptation and Cohesion Evaluation Scale), BCIS (Beck Cognitive Insight Scale).

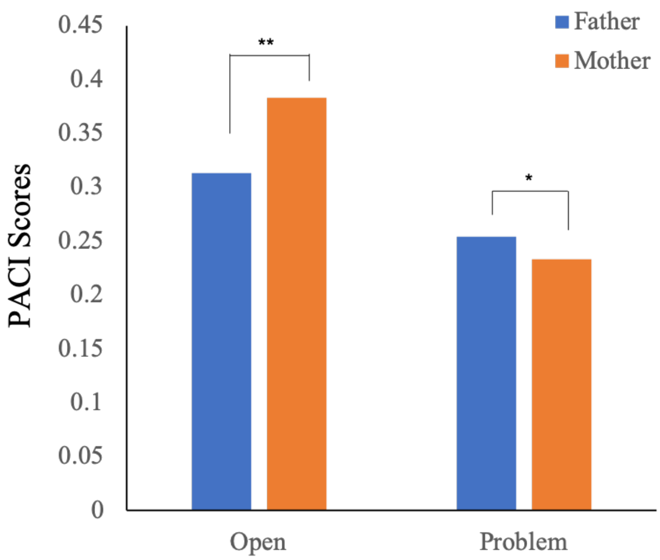


Figure 2. Differences in PACI according to the Valence. *p< .05, **p< .01

2. Behavioral Results

The behavioral results of the parents' facial expression recall or imagine task, the response and the reaction times (RTs), are shown in Table 3. There were significant differences between the FP and FN, and between the MP and MN response patterns, but there was no difference between FN minus FP and MN minus MP. Additionally, there were significant response differences between FP and FN, and between MP and MN, and there were also differences in reaction time.

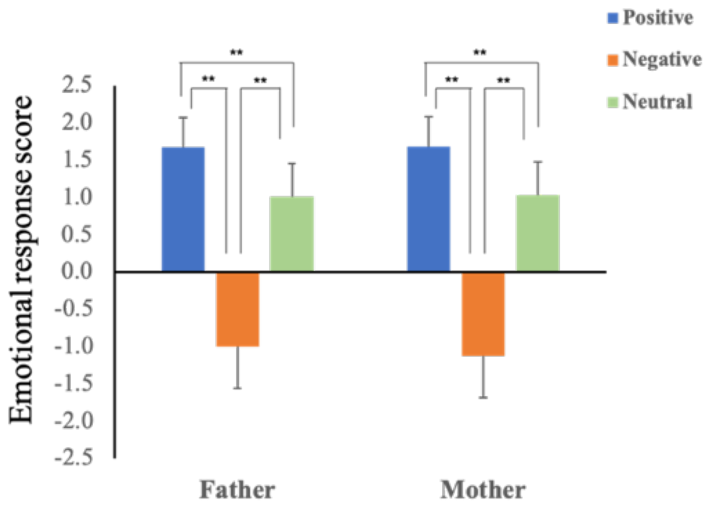
The repeated measures ANOVA revealed a significant internal x external interaction effect for the emotional response score (Figure 3A). The emotional response scores of the father showed significant differences ($F = 200.49$, d.f. = 2, 69, $P = .000$) and also significant differences of mother's ($F = 246.27$, d.f. = 2, 69, $P = .000$). The reaction time showed significant differences between the father's reaction time ($F = 14.49$, d.f. = 2, 69, $P = .000$) and mother's reaction time ($F = 8.50$, d.f. = 2, 69, $P = .001$) (B) (Figure 3). There were no significant differences with negative and neutral reaction time of father's ($p = .128$) and mother's ($p = .711$).

Table 3. Behavioral Results of the Task

	Father				Mother			
	Positive	Negative	Neutral		Positive	Negative	Neutral	
	M±SD	M±SD	M±SD	t	M±SD	M±SD	M±SD	t
Emotional response score	1.67 ±0.40	-1.00 ±0.60	1.01 ±0.42	16.96**	1.68 ±0.38	-1.12 ±0.52	1.03 ±0.47	20.57**
Reaction Time (ms)	1310.79 ±194.11	1662.90 ±290.11	1527.14 ±186.71	-7.27**	1350.90 ±213.01	1607.77 ±270.31	1553.35 ±191.91	-5.30**

*p< .05, **p< .01

A.



B.

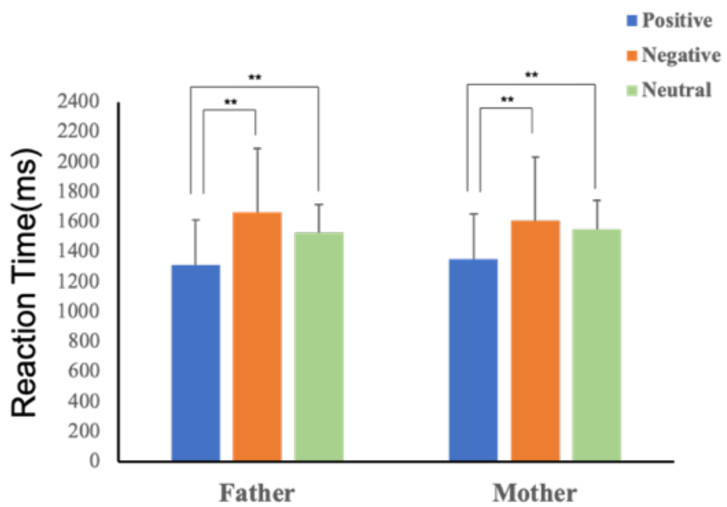


Figure 3. Behavioral Results for the Emotional Response Score and Reaction Time (ms). Emotional response score (A) and reaction time (B). **p< .01.

The open type in the Parent-Adolescent Communication Inventory (PACI) of the father and the behavioral response for the FP ($r = .449$, $p = .028$) and MP ($r = .505$, $p = .012$) conditions showed a positive correlation. Likewise, the open type in PACI of the mother and the behavioral response in MP showed a positive correlation ($r = .662$, $p = .000$). The problem type in PACI of the father and the FP behavioral response ($r = -.500$, $p = .013$) and the type in PACI of the mother and the behavioral response for the FP ($r = -.599$ $p = .002$) and MP ($r = -.582$, $p = .003$) conditions showed a negative correlation. There was a positive correlation between the self-esteem scale and the behavioral response in the FP condition ($r = .435$, $p = .034$) (Table 4). Moreover, MP condition presented negative correlations with the adaptation score of the FACES-III ($r = .445$, $p = .029$) and the self-certainty score of the BCIS ($r= .499$, $p= .013$). However, there was no correlation between the HADS, the self-reflective score of the BCIS and behavior results. In particular, there was no correlation with reaction time and psychological assessment (Table 4).

Table 4. Correlation between the Behavior Results and the Psychological Assessment Scale

	Response				Reaction Time(ms)			
	FP	FN	MP	MN	FP	FN	MP	MN
PACI-Father								
Open	**.449***	.151	**.505***	.325	.042	.312	.237	.389
Problem	**-.500***	-.134	-.378	-.208	.288	-.034	.093	-.098
PACI-Mother								
Open	.281	-.143	**.662****	-.142	-.048	.110	-.174	.245
Problem	**-.599****	.018	**-.582****	.019	.105	-.268	.025	-.325
RSES	**.435***	-.216	.016	.079	-.224	.075	.046	-.079
HADS								
Anxiety	-.191	.035	-.002	-.062	.258	.163	.127	.203
Depression	-.238	-.276	-.103	-.233	.058	.134	-.081	.139
FACES-III								
Cohesion	.268	.098	.392	.163	-.088	.058	-.019	.034
Adaptation	.318	.216	**.445***	.243	.053	.178	.172	.244
BCIS								
Self-reflective	-.036	.127	.141	.158	.131	.053	.196	-.124
Self-certainty	.172	-.092	**.499***	-.124	-.01	.079	-.111	.275

*p< .05, **p< .01, Father-Positive situation (FP), Father-Negative situation (FN), Mother-Positive situation (MP), Mother-Negative situation (MN), PACI ; Parent-Adolescent Communication Inventory, RSES ; Rosenberg Self-Esteem Scale, HADS ; Hospital Anxiety and Depression Scale, FACES-III ; Family Adaptation and Cohesion Evaluation Scale, BCIS ; Beck Cognitive Insight Scale.

3. fMRI Analysis

A. The Main Effect for Parents

The results of the main effect for the parental condition and the valence condition are presented in Table 5. There were two activation regions, the calcarine cortex and inferior frontal gyrus. The main effect for the parents in the calcarine cortex (**$p < .001$) (A) and the inferior frontal gyrus (*$p < .05$, **$p < .01$) (B) was significant. There were significant differences between the father and the mother in the calcarine cortex ($t = -6.76$, $p = .000$) and the inferior frontal gyrus ($t = -3.00$, $p = .006$). The neural regions activated more when recalling the mother than the father (Figure 4).

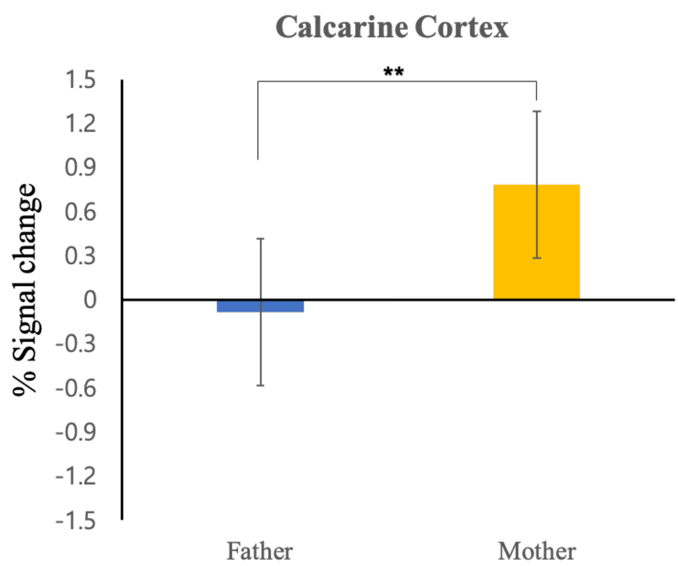
Table 5. The Main Effects for the Task

		Coordinates (MNI)					
Anatomical region	HEM	x	y	z	Cluster size	F	Z
Main effect of the parent							
Calcarine cortex	B	-10	-90	0	749	31.76	5.08
		10	-84	2		25.63	4.60
		12	-92	0		23.72	4.43
Inferior frontal gyrus	L	-50	14	20	215	24.76	4.53
		-36	22	18		12.24	3.19
Main effect of the emotion							
Fusiform gyrus	B	38	-74	-14	18460	147.75	Inf
		-36	-74	-20		143.67	Inf
		12	-88	-4		115.32	Inf
Premotor cortex	L	-38	-4	58	1519	29.57	4.92
		-42	2	34		28.41	4.83
		-44	10	32		25.85	4.62
Premotor cortex	R	48	8	34	697	26.48	4.67
		32	0	62		22.95	4.37
		54	14	36		22.78	4.35
Insula	L	-32	20	6	132	24.02	4.46
		-32	34	0		16.54	3.72
		-26	18	0		12.85	3.27
Anterior cingulate cortex	B	-2	24	36	312	22.63	4.34
		14	20	30		22.10	4.29

		Coordinates (MNI)					
Anatomical region	HEM	x	y	z	Cluster size	F	Z
		-2	12	42		17.42	3.82
Inferior frontal gyrus	L	-34	22	-24	121	22.02	4.28
		-42	22	-18		20.90	4.17
		-34	18	-8		17.42	3.82
Thalamus	L	-2	-20	12	132	19.29	4.01
		-10	-24	10		16.18	3.68

Significant clusters were obtained at voxel level $P_{unc.} < .001$ and cluster level $P_{FWE} < .05$. The reference coordinate system the Montreal Neurological Institute (MNI) atlas, as follows: left-right (x), anterior-posterior (y), superior-inferior (z). HEM(Hemisphere) as follows: bilateral (B), left (L), right (R).

A.



B.

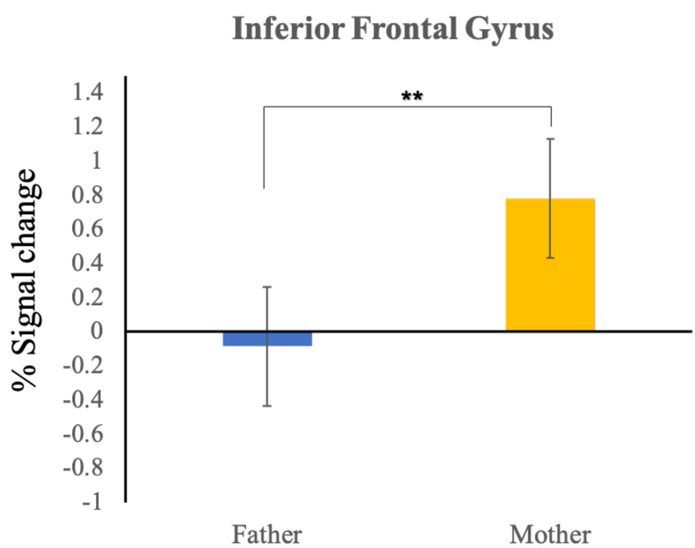
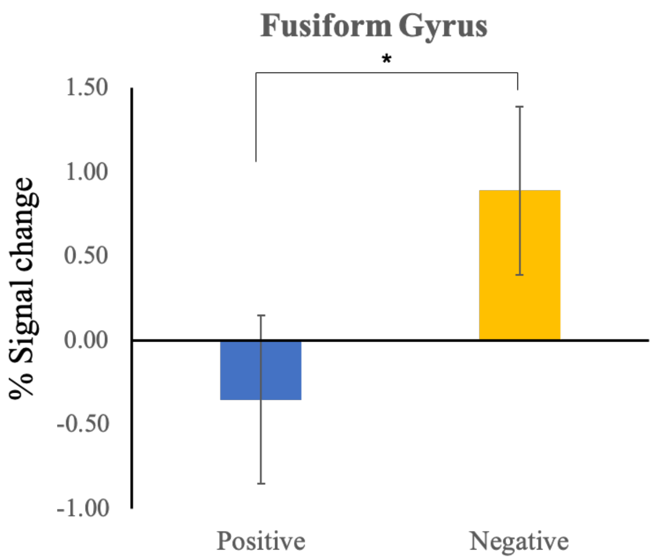


Figure 4. Main Effect for Parents. (A) Main effect for parents in the calcarine cortex (B) Main effect for parents in the inferior frontal gyrus.

B. The Main Effects of Valence

The main effects of valence in the fusiform gyrus, premotor cortex, insula, ACC, inferior frontal gyrus, and the thalamus are shown in Table 5. In particular, there are significant differences between positive situation and negative situations. The participants showed greater activations when thinking about negative situations than positive ones in the fusiform gyrus (t = -13.08, p = .000) and the insula (t = -4.69, p = .000) (Figure 5).

A.



B.

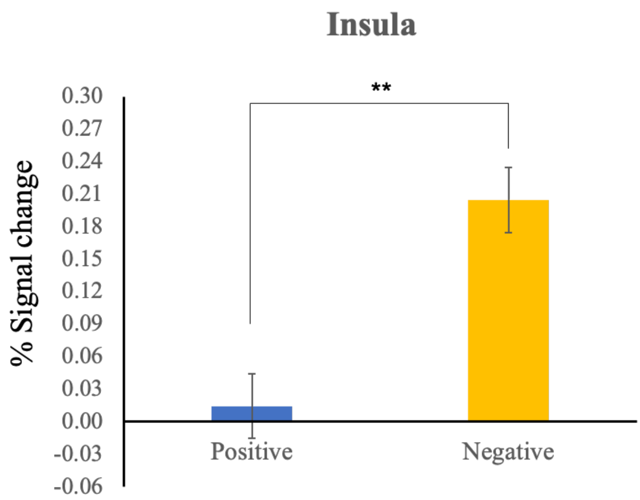
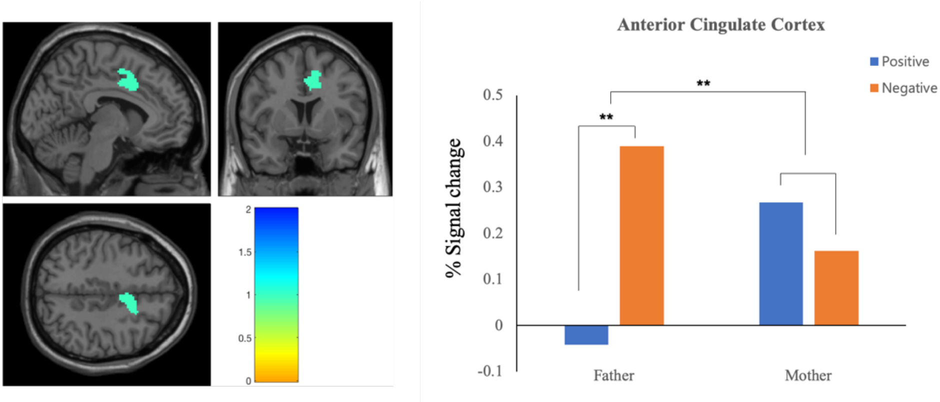


Figure 5. Main effects of Valence. (A) The main effects of valence in the fusiform gyrus, and (B) the main effects of valence in the insula.

C. The Interaction Effect between Parent and Valence

There was an interaction effect in the ACC and precuneus. There was a considerable difference in valence for the participants' fathers, especially when comparing each valence response for their parents. There was also a difference in valence for the mother and the father, and when comparing the level of brain activation for the father, it was greatly activated in the negative situation especially (Figure 6A). Correlations between the ACC and scales were observed. In a positive situation, the level of the ACC activation for mothers had a negative correlation with the depression scores. Moreover, in negative situations, there was a negative correlation with the level of the ACC activation for fathers and the self-reflective scores. There was no correlation between the ACC and any of the other assessments (Figure 6B, 6C).

A. The Interaction Effect in the ACC



B. Correlation with the ACC and Scales

	Anterior Cingulate Cortex			
	FP	FN	MP	MN
PACI-Father				
Open	.017	.041	.225	.245
Problem	-.253	-.137	-.336	-.248
PACI-Mother				
Open	-.098	-.079	.148	.015
Problem	-.234	-.007	-.234	-.06
RSES	.07	-.175	-.031	.032
HADS				
Anxiety	.02	-.081	-.313	-.097
Depression	-.252	-.216	**-.445***	-.179
FACES-III				
Cohesion	-.023	.031	.097	.003
Adaptation	-.234	-.108	.027	-.069
BCIS				
Self-reflective	-.324	**-.415***	-.297	-.336
Self-certainty	-.125	-.101	.121	-.011

C.

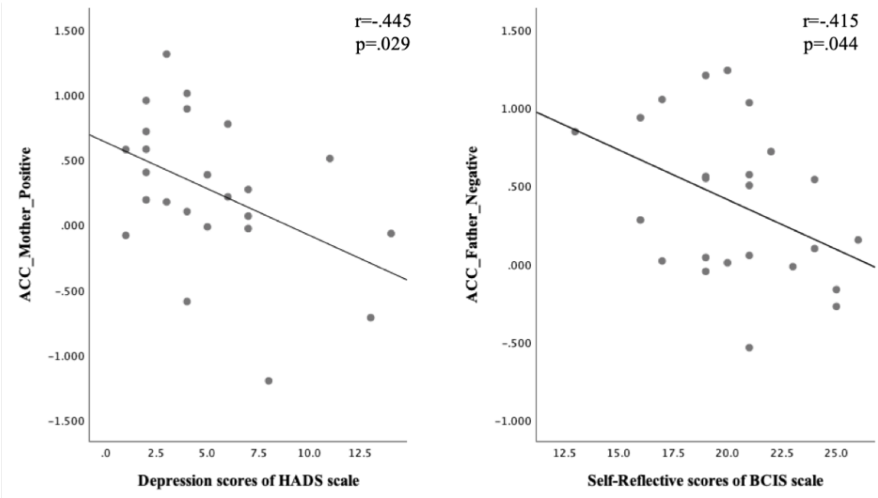
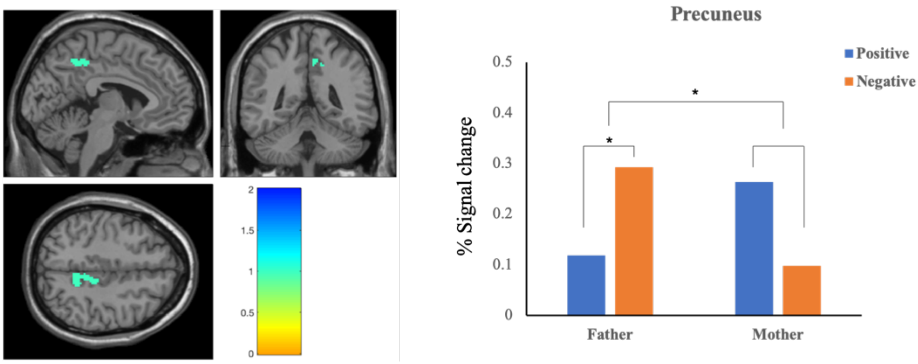


Figure 6. Interaction Effect in the ACC. (A) Brain regions (ACC) with an interaction effect, and the post-hoc graph (*p< .05, **p< .01). (B) Table of correlations between the ACC and the psychological assessment. (C) Negative correlation graph with the ACC, the depression scores and self-reflective scores. ACC; Anterior Cingulate Cortex, HADS; Hospital Anxiety and Depression Scale, BCIS; Beck Cognitive Insight Scale

There was also an interaction effect in the precuneus. This difference in pattern appeared to be the same as for the ACC. There was a difference in the level of brain activation for the mother and the father, and when comparing the level of brain activation with the valence for the father, the precuneus was greatly activated in negative situations in particularly (Figure 7A). There was also correlation with the precuneus and the scales as follows: the Rosenberg Self-Esteem Scale (RSES). The level of the precuneus activation for fathers in negative situations was correlated negatively with the self-esteem scores. There was no correlation with any of the other assessments (Figure 7B, 7C).

A. The Interaction Effect in the Precuneus



B. Correlation with the Precuneus and Scale

	Precuneus			
	FP	FN	MP	MN
PACI-Father				
Open	-.191	.062	-.103	.225
Problem	.092	-.09	.179	-.047
PACI-Mother				
Open	-.21	.045	-.14	.185
Problem	-.066	-.027	.229	-.003
RSES	-.082	**-.436***	-.356	-.247
HADS				
Anxiety	.121	-.09	-.106	-.011
Depression	.019	-.21	-.115	-.236
FACES-III				
Cohesion	-.094	.252	-.085	.153
Adaptation	-.241	.081	.025	.049
BCIS				
Self-reflective	-.346	-.222	-.158	-.035
Self-certainty	-.338	-.045	-.009	.109

C.

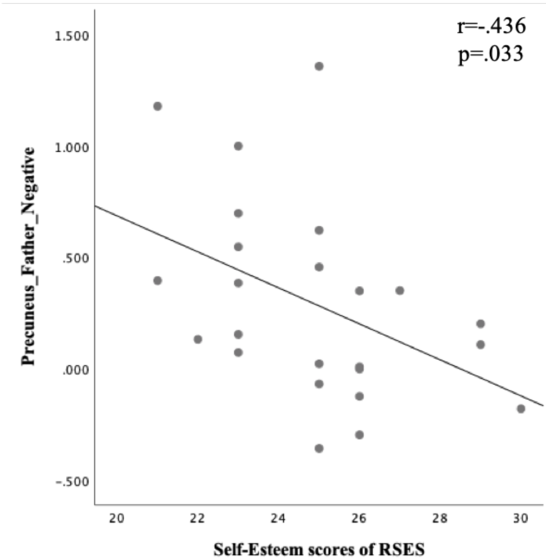
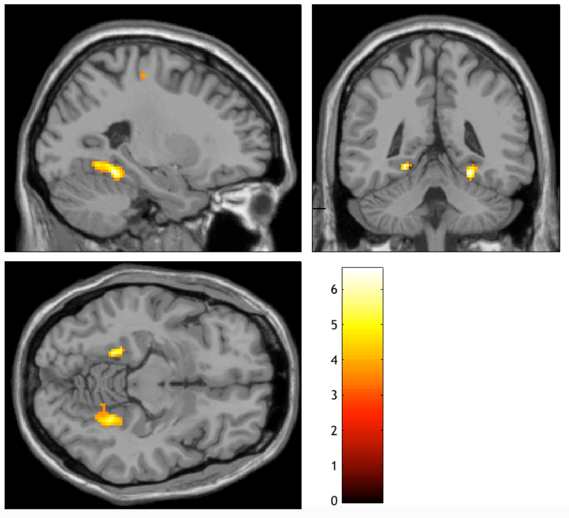


Figure 7. Interaction Effect in the Precuneus. (A) Brain region (precuneus) for the interaction effect and the post-hoc graph (*p< .05). (B) Table of correlations with the precuneus and the psychological assessment. (C) Negative correlation graph with the precuneus and self-esteem scores. RSES; Rosenberg Self-Esteem Scale

D. The Psychophysiological Interaction Effect

The psychophysiological interaction analyses showed connectivity strengths of the ACC with the fusiform gyrus and the postcentral gyrus (Figure 8A). The connectivity strengths were correlated with the anxiety score. The connectivity strengths between the ACC and the fusiform gyrus were positively correlated with the scales. No other correlation was significant (Figure 8B, 8C).

A. Fusiform gyrus



B.

	Connectivity Strength with ACC	
	Fusiform gyrus	Postcentral gyrus
PACI-Father		
Open	-.113	-.118
Problem	.143	.11
PACI-Mother		
Open	-.19	-.06
Problem	-.005	-.065
RSES	.079	.076
HADS		
Anxiety	**.482***	.06
Depression	.322	-.114
FACES-III		
Cohesion	.092	.15
Adaptation	.125	.346
BCIS		
Self-reflective	.161	.071
Self-certainty	-.15	-.107

C.

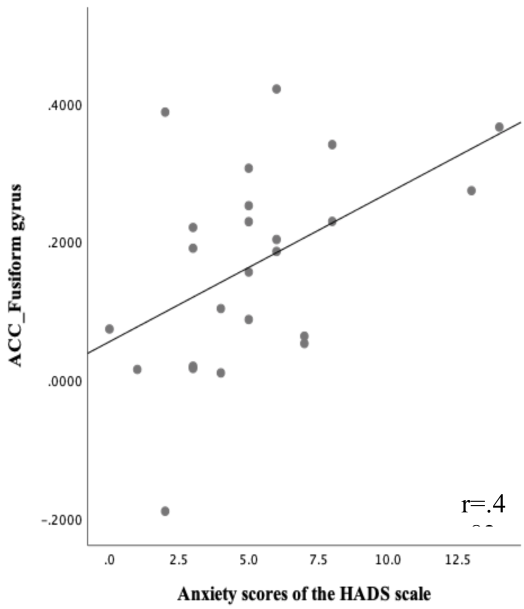


Figure 8. The Psychophysiological Interaction Effects. (A) The psychophysiological interaction effect in the fusiform gyrus and the postcentral gyrus. (B) Correlation table for the ACC with the fusiform, postcentral gyrus and the psychological assessments. (C) Correlation graph for the PPI and the psychological assessments. ACC; Anterior Cingulate Cortex, PPI; Psychophysiological Interaction, HADS; Hospital Anxiety and Depression Scale

IV. DISCUSSION

In this experiment, the difference between the parent condition and the emotional condition, and their underlying neural processes, were investigated through subjects' imagination of their parents' facial expressions. The behavioral data analysis showed no difference in the positive assessment of the mother and the father. However, the negative responses to negative situations were greater for the mother than for the father. That is, when negative situations were presented, the mother's facial expression was perceived to be more negative than the fathers. However, regarding reaction times, it took longer for the subjects to react in negative situations than in positive situations. The time it took for the subjects to think and respond in the mother condition was shown to be slightly different to the father condition, with subjects thinking longer in positive situations and making decisions faster in negative situations. These results could be inferred from the fact that the situation was directly recalled and reacted to, depending on the cultural environment in which the life time with the mother was longer than that for the father. The results were similar to the results of a previous study,[23] in terms of the brain activation regions engaged during a trait judgement task of familiar others and the self. The more intimate with mother, the faster subjects responded to mother-judgments.

The behavioral data and the clinical assessments showed various correlations. None of the variables correlated with the reaction time, but there were correlations with the response and the scales. There was a positive correlation between the self-esteem scores and the FP response. That is, the more positive about the father, the higher the self-esteem scores. The result of the previous studies suggest that parenting and parent-child relationships affect the formation of high self-esteem. In particular, unlike the results that emphasized the importance of mother-to-child relations,[3] one study explained the influence of the father by showing that the more positive about the father, the higher the self-esteem. This result may be somewhat unfamiliar, but assuming that a positive relationship with a mother is basically formed, it could be explained that a positive relationship with a father would mean a high degree of intimacy with the parents, thus contributing to the formation of higher self-esteem. On the other hand, the results of the PACI about the father and mother showed the mother's influence on the response. These results show that the mother can affect various aspects of a person, such as the communication type between a child and their parents and the adaptation to the others. According to the results of a study that investigated the length of a conversation between a child and their parents, this result is a phenomenon that can be seen widely given that the time of conversation with mother is about four times longer than that with the father.[3] This is because the longer the conversation time, the greater possibility of open communication.[39]

Previous studies report that the activity of the ACC and the insula in patients with schizophrenia was greater, relative to that for healthy controls, for the mother condition.[24] Additionally, the dACC has been implicated in cognitive aspects of emotion, including the conflict resolution of emotional stimuli with negative valence.[40] Moreover, there was a statistically significant negative correlation between the self-esteem scores and the neural activation on the contrast of self-versus-other, in the right dACC.[26] Therefore, the results of the present study can make a connection with these previous results to suggest that the ACC influences ambivalence and self-esteem during tasks involving a child's memory retrieval of their mother. In particular, Wang et al. (2012) showed that the mPFC and ACC activities were greater for mother trait judgment than for father, best friend and familiar others judgments,[23] supporting the present results of the interaction effect for parent x valence in the ACC. The author assumed that the VTA associated with a high level of self-esteem will be activated, but the VTA is a part of the reward system and it was activated in positive self-face evaluation in an other study.[27] Because this was a direct study of self-esteem evaluated positively by looking at self-face, there are some differences from the results of this study, which investigated the relevance between self-esteem based on relationship with parents.

Oikawa et al. (2012) suggested that the PCC is the neural correlate of positive self-face evaluation, and that there is a neural relationship between self-face evaluation and self-esteem.[27] The PCC is part of the cortical midline structure which has been reported to play a role in the processing of self-referential stimuli.[41] In the study, there was a negative correlation between self-reflective scores on the BCIS scale and the ACC activation in the FN condition. These results explained that, as with the PCC related to self-reflection, the ACC can be found to be relationship with self-reflection.

Precuneus activation has been implicated in the imagery of episodic memory, especially in the title-cued retrieval of specific events and in self-processes, such as reflective self-awareness.[24] According to a previous study, one possibility is that the precuneus and the PCC were specifically involved in processing intentions of the self.[42] Moreover, in the study, the precuneus showed activation during emotional memories of the subjects' parents, and correlation with self-esteem scores. There was the same pattern in the results of a clinical assessment and the interaction effects. In the study, there was an interaction effect for the parent and the valence with the ACC. In particular, there was a significant difference in the attitudes toward the father and the mother, these results showed the pattern of emotions toward the father and the mother. Therefore, these results explained that many people feel more positive about their mother than about their father.

In a previous study, social anxiety disorder patients exhibited hyper-reactivity in the bilateral fusiform gyrus, in response to fearful faces, as well as greater connectivity between the fusiform gyrus and the amygdala.[43] The results of the present study show that the PPI results showed greater connectivity between the fusiform and the ACC. In addition, there was a significant positive correlation between the anxiety scores and the connectivity between the ACC and the fusiform gyrus, and this implies that there is a negative relationship between self-esteem and anxiety.

The previous study said that the higher the levels of children's depression and anxiety were, the higher their self-esteem which consist of their scholastic competence, social acceptance, athletic competence, physical appearance, behavioral conduct, global self-worth, and self-expression were.[44] Therefore, it indicated that the formation of high self-esteem for children is important and affected by anxiety and depression, which in turn are influenced by the relationship with parents.

There are some potential limitations and suggestions in the current study. First, because of the small sample size, age or sex variation was not analyzed, thus further study with an extensive sample would be required. Second, the criteria for comparing the basis that affect self-esteem need to be clear, so comparing with patient or dividing groups based on the self-esteem scores would be necessary.

V. CONCLUSIONS

This study has successfully demonstrated the brain regions employed while recalling parents' facial expressions for given situations. Moreover, the results indicate the self and emotion are associated with the ACC and precuneus activations, and these are negatively correlated with depression, self-reflectiveness and self-esteem. The PPI analyses showed greater connectivity between the ACC and the fusiform gyrus, which was positively correlated with anxiety. Together, these provide insight into the mechanism of the relationship between children and their parents and their relations to emotional situations involving the parents. The results of the study offer helpful evidence for emphasizing the importance of the relationship between parents and their children, which is an essential factor in the formation of high self-esteem.

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ABSTRACT (IN KOREAN)

부모와의 관계가 성인기 자아존중감에 미치는 영향의
신경적 기저

<지도교수 김 재 진>

연세대학교 대학원 의과학과

김 은 성

자아존중감은 자신의 존재를 긍정적으로 보는 것이며, 타인과의 상호작용에 의해 형성되는데, 이는 부모나 자녀가 효율적인 삶을 살 수 있도록 큰 역할을 한다. 이러한 자아존중감은 부모와의 의사소통을 통해 형성된다. 의사소통은 개인간 관계의 중요한 측면으로 여겨져 왔으며 특히, 부모와 자녀와의 상호작용은 가장 본질적인 관계로 모든 인간관계의 바탕이 되며, 자녀에게 큰 영향을 미치는 중심인물이다. 그러나 이를 객관적으로 뒷받침할 수 있는 신경학적 연관성을 설명한 연구가 충분하지 않았고, 기존의 연구 역시 대부분 어린이와 청소년을 대상으로 한 것이었다.

본 연구에서는 부모의 얼굴 표정을 상상하거나 회상하도록 하는 정서적 상황과 얼굴 표정 사진 자극이 주어질 때 감정적 반응에 따른 뇌 활성화 영역을 조사하였다. 총 대상자는 24명으로 연구 공고를 통해 모집하였다. 자극 유형은 아버지 얼굴-긍정적 상황, 아버지 얼굴-부정적 상황, 어머니 얼굴-긍정적 상황, 어머니 얼굴-부정적 상황의 조건으로 제시되었다. 각 자극은 3초동안 제시되었고, 자극간 간격은 2초였다.

정서적 반응 결과는 어머니와 아버지의 긍정적 평가에서 차이가 없었지만 아버지보다 어머니에 대한 회상에서 부정적 상황에 대해 더 부정적으로 반응한 것으로 나타났다. 또한 부정적 상황에서는 나타나지 않았던 반응 시간의 차이가 긍정적 상황에서 더 늦게 반응하는 것으로 나타났다. 이미지 결과에서 부모의 주효과는 조거피질과 아래앞머리회에서 나타났고, 정서의 주효과는 방추상회, 앞대상겉질, 그리고 뇌섬엽 등에서 나타났다. 상호효과는 앞대상겉질과 쐐기앞부분에서 나타났다. 특히, 앞대상겉질과 효과적인 연결관계를 찾기 위해 실시한 정신생리학적 상호작용 분석 결과, 방추상회와 뒤중심회가 강한 연결관계에 있음을 알 수 있었다.

본 연구에서 도출된 결과들은 부모와 정서적 상태에 따른 부모와의 관계에 대한 기전과 통찰력을 제시한다. 또한 높은 자아존중감 형성에 필수적 요소인 부모와 자녀와의 관계의 중요성에 유용한 근거를 제시한다.

핵심 되는 말: 자아존중감, 부모 관계, 청소년기, 앞대상겉질, 쐐기앞부분, 뇌섬엽, 방추상회, 부모와의 의사소통