Neural mechanisms underlying explicit evaluation of one's own and others' emotions: Understanding the role of empathic processing

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This study examined the effects of empathy on common and distinct mechanisms underlying evaluation of one's own emotions (*self*: How do I feel?) and others' emotions (*others*: How do others feel?) by manipulating whether a target person was perceived as a good person (concordant condition: likely to provoke empathy) or a bad person (discordant condition: ideally, less likely to provoke empathy). In addition, this study explored whether findings from simple conditions are generalized to complex, ecological conditions by conducting two fMRI experiments: one with a relatively simple condition (e.g., faces: fMRI Experiment I) and another with a complex condition (e.g., video clips: fMRI Experiment II). The manipulation of person-valence (good/bad) was effective in creating the concordant and discordant conditions. Emotional ratings of *self* and *others* increased (became more negative) when something bad happened to the good person. In contrast, emotional ratings of *self* decreased, but emotional ratings of *others* increased when something bad happened to the bad person. fMRI Experiment I demonstrated that broad common networks including the dorsomedial prefrontal cortex (DMPFC) were commonly involved in *self* and *others* irrespective of different person conditions. In contrast, some common regions involved in cognitive effort were uniquely identified in the bad person condition. No modulation by person-valence (good/bad) was found in *self*-distinct regions including the rostral anterior cingulate cortex (rACC) and insula and *other*-distinct regions including the posterior superior temporal sulcus (pSTS). However, modulation by person-valence was reported in some regions including the medial PFC (MPFC), which is possibly involved in regulation of undesired emotional responses to the bad person. These results provided new insights about brain mechanisms associated with explicit emotional processing when people do not empathize with other people. fMRI Experiment II partially replicated findings from fMRI Experiment I. The insula and pSTS were involved in *self* and o*thers*, respectively. Overall, this study highlighted the important role of empathic confounds in understanding the common and distinct mechanisms associated with evaluation of one’s own and others’ emotions and the involvement of similar distinct mechanisms associated with evaluation of one’s own and others’ emotions in complex, ecological social contexts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

fMRI: functional Magnetic Resonance Imaging

BOLD: Blood Oxygenation Level Dependent

ANOVA: Analysis of Variance

AFNI: Analysis of Functional NeuroImage

NIS: NeuroImaging Software

AIR: Automated Image Registration

ROI: Region of Intrest

TOM: Theory of Mind

ASD: Autistic Spectrum Disorder

AQ: Autism Spectrum Quotient

BDI: Beck Depression Inventory

QIDS-SR: Quick Inventory of Depressive Symptomatology-Self Report

TAS: Toronto Alexithymia Scale

IRI: Interpersonal Reactivity Index

EC: Empathic Concern

PT: Perspective-Taking

PD: Personal Distress

FS: Fantasy Subscale

MCSDS: Marlowe-Crowne Social Desirability Scale

PANAS: Positive and Negative Affect Schedule

Brain regions

AC-PC: Anterior Commissure - Posterior Commissure

SFG: Superior Frontal Gyrus

MFG: Middle Frontal Gyrus

IFG: Inferior Frontal Gyrus

DMPFC: Dorsomedial Prefrontal Cortex

VMPFC: Ventromedial Prefrontal Cortex

MPFG: Medial Prefrontal Cortex

LPFG: Lateral Prefrontal Cortex

ACC: Anterior Cingulate Cortex

rACC: Rostral Anterior Cingulate Cortex

cACC: Caudal Anterior Cingulate Cortex

VLPFC: Ventrolateral Prefrontal Cortex

PCC: Posterior Cingulate Cortex

TPJ: Temporo-Parietal Junction

SPL: Superior Parietal Lobe

IPL: Inferior Parietal Lobe

TP: Temporal Pole

aMTS: anterior Middle Temporal Sulcus

aITS: anterior inferior Temporal Sulcus

aSTS: anterior Superior Temporal Sulcus

pSTS: posterior Superior Temporal Sulcus

IOG: Inferior Occipital Gyrus

MOG: Middle Occipital Gyrus

FG: Fusiform Gyrus

PREFACE

I owe a debt of gratitude to numerous people who have supported and encouraged me during these many years of graduate school. First, I would like to thank my advisor, Greg Siegle. His encouragement and support helped me to survive graduate school and complete my dissertation work. His broad interests and scientific knowledge provided me the flexibility to study many research interests. I would also like to thank the members of my dissertation committee - Walter Schneider, Ron Dahl, Julie Fiez, and Kevin Pelphrey - for their training throughout graduate school and for their insightful comments and advice on my dissertation.

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1.0 GENERAL INTRODUCTION

1.1 OVERVIEW

The understanding of emotion in social contexts is critical for coordinating adaptive social interactions and relationships (Keltner & Kring, 1998; Norris & Cacioppo, 2007). For example, people are required to verbally describe emotions to express and to share with other people and also need to read others' emotions accurately in everyday social interactions. All these activities may be accompanied by explicit and conscious emotional processing. For successful social interactions, we need to know how we feel about ourselves and to understand how other people feel about situations. We can then decide whether we hide or express our emotions to other people and are able to detect whether others are hiding or expressing their emotions (Dimaggio, Lysaker, Carcione, Nicolo, & Semerari, 2008).

The example described above highlights some important aspects of emotional processing in social situations. Emotional processing in everyday social situations occurs in conscious, deliberate manners in both *self* (evaluation of one's own emotions) and *others* (evaluation of others' emotions) (e.g., Beer & Ochsner, 2006). To elucidate brain mechanisms underlying socio-emotional processing, it may be important to consider two aspects of emotional processing in social contexts: 1) explicit/conscious emotional processing, and 2) *self* and *others*. Therefore, this study considered these aspects in examining brain mechanisms associated with emotional processing in social contexts. In particular, this study focused on one primary research question relevant to studying emotional processing in social contexts: Are there common and distinct mechanisms associated with explicit/conscious emotional processing of *self* and *others* in social contexts?

However, there are two potential limitations in examining common and distinct mechanisms associated with explicit emotional processing of *self* and *others*. First, imaging studies have attempted to elucidate brain mechanisms underlying explicit emotional processing in *self* and *others,* specifically under empathic situations (Jackson, Brunet, Meltzoff, & Decety, 2006; Lamm, Batson, & Decety, 2007; Schulte-Ruther, Markowitsch, Fink, & Piefke, 2007). However, using empathic conditions may yield the same emotional states in *self* and *others*, indicating that these same emotions between *self* and *others* may cause possible confounding effects such as empathic processing in common and distinct regions of emotional processing in *self* and *others*. It still remains unclear whether empathic processing modulates common and distinct mechanisms involved in explicit emotional processing of *self* and *others*.

Another possible limitation is relevant to a lack of ecological validity. Imaging studies have been conducted in simplified experimental conditions such as static faces and pictures (e.g., Jackson, Meltzoff, & Decety, 2006; Schulte-Ruther et al., 2007). However, social contexts are more complex and naturalistic than simple experimental conditions (e.g., Adolphs, 2006; Iacoboni et al., 2004). Yet, relatively little is known about whether it is possible to generalize findings acquired in simple experimental conditions to more complex, ecological situations.

This study aimed to investigate the effects of empathy on common and distinct mechanisms associated with explicit emotional processing of *self* and *others* and the possibilities of generalization of findings from a simple condition to a complex condition. To examine the effects of empathy on brain mechanisms, this study assessed common and distinct mechanisms of explicit emotional processing in *self* and *others* using both concordant (likely to provoke more similar emotions to others) and discordant conditions (likely to provoke less similar emotions to others). To examine the possibilities of generalization, two fMRI experiments were conducted: one using simple experimental conditions (i.e., simple types of stimuli and tasks) and the other using complex experimental conditions (i.e., complex types of stimuli and tasks).

In the following sections, literature was reviewed regarding common and distinct mechanisms associated with explicit emotional processing of *self* and *others* and two potential limitations in examining brain mechanisms underlying explicit emotional processing of *self* and *others* were introduced.

1.2 BACKGROUND

1.2.1 Explicit emotional processing in social situations

This study focused on explicit and conscious emotional processing using experimental conditions demanding conscious and deliberate processing of emotion in social contexts. Although some researchers emphasize that emotional processing may be conscious and deliberate in social contexts (Dimaggio et al., 2008; Olsson & Ochsner, 2008; Robbins, 2008), less effort has been made to characterize brain mechanisms underlying explicit emotional processing compared to automatic emotional processing in social contexts.

Theoretical accounts suggest that emotional processing requires conscious and explicit processing of emotional information such as appraisal or evaluation (e.g., Lazarus, 2001;

Scherer, 2001). In particular, emotion in social interactive situations can be processed in a controlled, explicit manner (e.g., Keysers & Gazzola, 2007; Lieberman, 2007b; Olsson & Ochsner, 2008). Cognitive theories of emotion suggest that emotion-cognition interactions and general evaluative processing are involved in explicit emotional processing (Cunningham, Zelazo, Packer, & Van Bavel, 2007; Lewis, 2005; Roseman & Smith, 2001). Thus, emotion-cognition interactions and evaluative processing may serve as common mechanisms underlying explicit emotional processing.

In accordance with theoretical accounts, explicit emotional processing in social situations possibly depends on brain mechanisms associated with emotion-cognition interactions and evaluative processing. Imaging studies suggest that conscious/explicit processing is associated with interactions between prefrontal cortex (PFC) such as medial PFC (MPFC) and lateral PFC (LPFC) and subcortical regions such as the amygdala (Critchley et al., 2000; Hariri, Bookheimer, & Mazziotta, 2000; Hutcherson et al., 2005; Lange, 2003; Wright et al., 2008). The MPFC also plays a central role in evaluative processing commonly involved in a person's internal value system (Zysset, 2002). Additionally, neuroimaging studies have found common regions such as the medial PFC (MPFC) that are activated by both self-related processing and social cognition (Amodio & Frith, 2006; Mitchell, Banaji, & Macrae, 2005). Common mechanisms are summarized in Figure 1.1.

1.2.2 Evaluation of one's own (self) and others' emotions in social context

There are different objects/targets such as *self* and *others* to be evaluated in social interactions (Dimaggio et al., 2008; Lieberman, 2007a), indicating that people evaluate their own emotions and others' emotions in social contexts. There may be distinct mechanisms associated with evaluation of one’s own emotions and others’ emotions. However, brain mechanisms associated with explicit emotional processing of *self* and *others* have been investigated in separate studies in which focused on either *self* (Hutcherson et al., 2005; Lane, Fink, Chau, & Dolan, 1997)) or *others* (Lawrence et al., 2006; Vollm et al., 2006). Thus, such designs do not allow direct comparisons between *self* and *others*. In contrast, the current study used separate tasks to explicitly evaluate one’s own emotion and others’ emotions to delineate distinct brain regions, specifically associated with emotional processing in *self* and *others*, respectively.

Theoretical accounts and empirical studies provide evidence that there are two possible different mechanisms underlying explicit emotional processing of *self* and *others*. Theoretical accounts suggest that emotional processing of *self* may involve inferring emotional experience from inner states and conscious thoughts about current and past experiences. Evaluative processing of one’s own emotion (*self*) may thus include evaluation of bodily experience (interoception), conscious thoughts, and a felt action tendency (for a review, see Lambie & Marcel, 2002; Lane, 2000). The insula has been revealed as a key structure involved in subjective interoceptive and emotional states (Craig, 2002, 2004; Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004). The rACC has also been implicated in the representation of conscious emotional experience (Barrett, Mesquita, Ochsner, & Gross, 2007). Therefore, the insula and rACC would be hypothesized to play specific roles in explicit emotional processing of *self* such as evaluating one’s own emotional experience.

In contrast, emotional processing of *others* may involve Theory of Mind (TOM), suggesting that people use explicit knowledge or rules to infer others’ mental states (for a review, see Gallese & Goldman, 1998). Perspective-taking is another essential mechanism of empathy via deliberate imagination of others’ emotions (Leiberg & Anders, 2006). In accordance with theoretical accounts, some brain regions have been revealed as specific brain structures specifically associated with TOM and perspective-taking. The pSTS has been implicated in understanding of others' intentionality (Frith & Frith, 1999, 2006; Gallagher & Frith, 2003) and the temporal poles (TP) and temporo-parietal junction (TPJ) are involved in reasoning about others' mental states (Blakemore, Winston, & Frith, 2004; Saxe, 2006a). Thus, it is hypothesized that these brain regions would be more activated by evaluating of others' emotions, particularly representing distinct brain mechanisms associated with explicit emotional processing of *others*. Distinct mechanisms are summarized in Figure 1.1.

It is also important to note that explicit processing may include several different types of processing, depending on which aspects of information we pay attention to, which is usually manipulated by different task instructions. Thus, explicit/conscious processing of emotion makes *self* and *others* more distinguishable in social contexts and makes people more aware of emotional responses in *self* and *others* - an important component of empathy (Decety, 2007).

1.2.3 A meta-analytic study: Common and distinct brain regions

Imaging studies reviewed above provided evidence that there are common and distinct regions underlying explicit emotional processing of *self* and *others*. Consistently, a quantitative meta-analytic review demonstrated that these common and distinct regions were found across several studies (Lee & Siegle, in press). Thus, this study focused primarily on these common and distinct regions identified from the meta-analytic study.

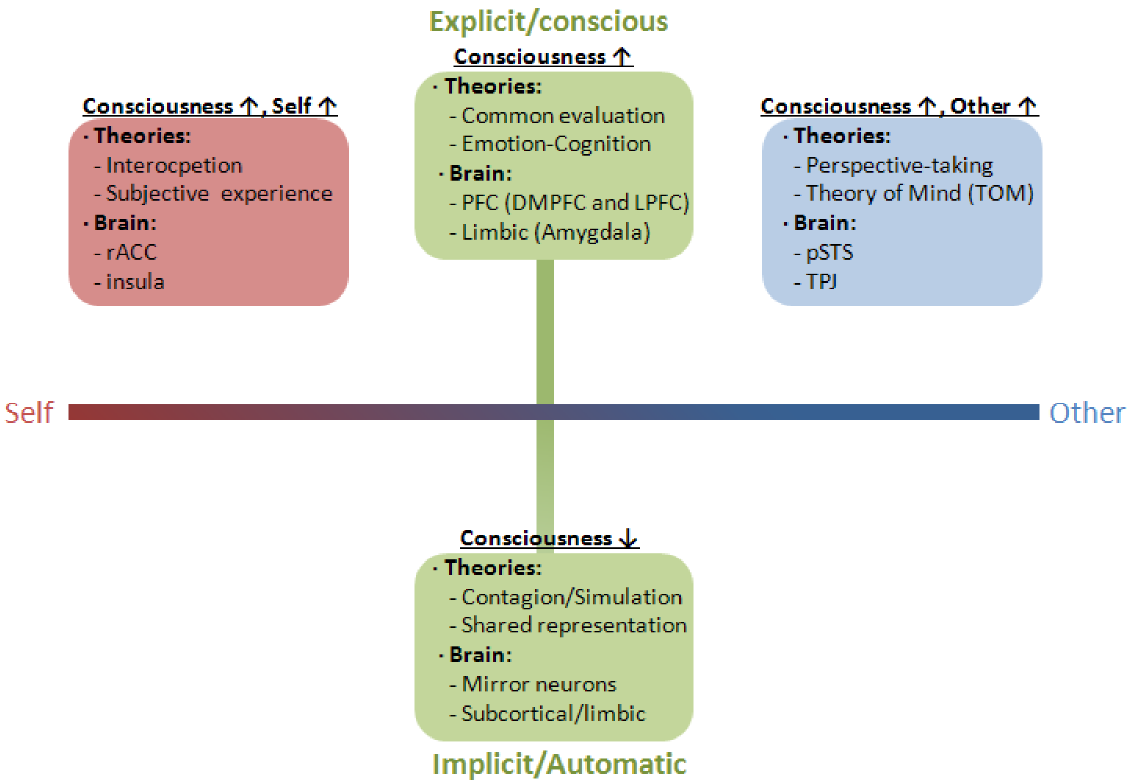

Figure 1.1. Summary of possible mechanisms of emotional processing based on two dimensions: Consciousness (explicit vs. implicit) of emotional processing and *self-other* distinction. This study focuses on conscious processing of emotion which makes *self-other* distinctive.

This meta-analytic study elucidated common brain networks such as amygdala, LPFC, and DMPFC, commonly involved in explicit emotional processing. Figure 1.2 presents brain maps exhibiting identified common brain regions. Distinct regions were also identified. The insula and rACC were specifically associated with explicit emotional processing of *self* whereas the pSTS and TPJ were specifically associated with explicit emotional processing of *others* (Figure 1.2).

However, these findings reflect integrating results from several imaging studies. For instance, most imaging studies included in the meta-analytic study used one emotion evaluation task which asked participants to evaluate either their own emotion or others' emotions. Thus, common and distinct brain regions identified in the meta-analytic study did not result from direct comparisons between *self* and *others*. It is still required to confirm these findings using evaluation tasks to assess emotional processing of *self* and *others* within the same fMRI design which allows direct comparisons between *self* and *others*.

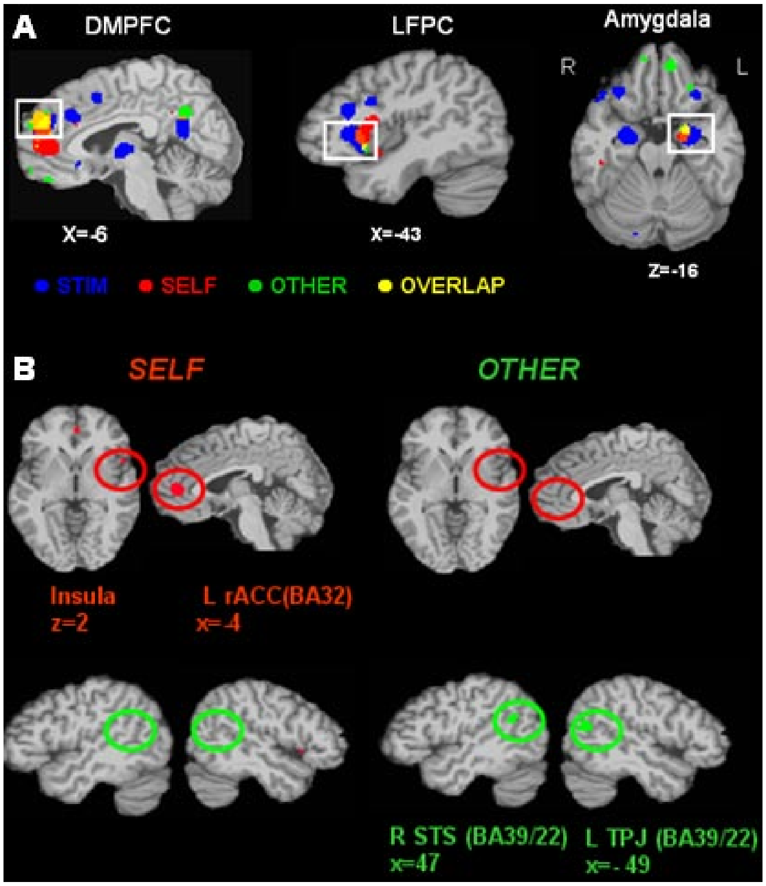

Figure 1.2. Brain networks underlying explicit evaluation of emotion. (A) Common regions included the DMPFC, LPFC, and amygdala. (B) Contrast meta-maps derived from the comparisons among two different tasks to assess brain mechanisms associated with explicit evaluation of emotion (First column:

‘SELF’ and Second column: ‘OTHER’; First row displays the results in the insula and rACC. Second row presents the findings in the pSTS and TPJ).

1.2.4 An empathy confound in emotional processing of *self* and *others*

The same emotion, such as empathy, between *self* and *others*, may be one potential limitation in elucidating common and distinct mechanisms when people evaluate both one’s own emotions and others’ emotions. For example, common regions could simply reflect emotional processing by the same emotions (empathy-like such as feeling bad for other people) in *self* and *others*. Furthermore, such confounding effects may prevent detecting distinct brain mechanisms underlying emotional processing of *self* and *others*.

In fact, with growing interest in emotional processing in social contexts, more recent studies have attempted to elucidate common and distinct neural substrates of explicit emotional processing in *self* and *others* within the same imaging studies by manipulating task instructions that guide participants to pay attention to emotions in either themselves or other people (Jackson, Brunet et al., 2006; Lamm et al., 2007; Ochsner, 2004; Schulte-Ruther et al., 2007). These studies showed common and distinct networks associated with explicit emotional processing of *self* and *others*.

However, these studies have attempted to identify brain mechanisms underlying explicit emotional processing in *self* and *others* either specifically under the same emotional condition (e.g., *self* and *others* have the same emotion (Ochsner, 2004; Schulte-Ruther et al., 2007)) or under pain empathic conditions including possible negative emotions in both *self* and *others* (Jackson, Brunet et al., 2006; Lamm et al., 2007). The concordant/empathic conditions may cause possible confounding effects on interpreting functions of common mechanisms.

Consistently, reviews suggest that previous studies of neural mechanisms underlying *self* and *others* are confounded by empathy (Lieberman, 2007a), defined as having the same emotional states in judgments of *self* and *others*. A new experimental paradigm in which different emotional responses resulted in evaluating *self* and *others* is required to test this potential empathy confounding effects on underlying mechanisms of *self* and *others*. Similarly, conventional false-belief tasks require people to separate their own belief from others' beliefs (target persons in the pictures) (Amodio & Frith, 2006; Frith & Frith, 1999; Gallagher et al., 2000).

Thus, this study included both conditions in which subjects have similar emotional responses to target persons (called 'concordant condition', 'empathy condition', or 'good person') and different emotional responses (called 'discordant condition', 'non-empathy condition', or 'bad person') with target persons in the stimuli.

1.2.5 A lack of ecological validity in emotional processing of *self* and *others*

A lack of ecological validity may be another potential limitation in examining brain mechanisms associated with explicit emotional processing of *self* and *others*. This limitation is because social situations in real life are more complex and naturalistic than in fMRI experimental environments (Spiers & Maguire, 2007). For example, people in social contexts may process and evaluate emotions in *self* and *others* continuously for successful social interactions (Iacoboni et al., 2004; Ruef & Levenson, 2007). However, imaging studies have used simple types of stimuli such as static faces with emotional expressions which could be perceived as not real social situations (Adolphs, 2006). Consistently, this limitation is pertinent to one major issue in social cognition, whether the findings from studies using simple experimental conditions would be generalized in complex, naturalistic social situations (Iacoboni et al., 2004; Spiers & Maguire, 2006, 2007). Despite the importance of ecological validity, it still remains unclear whether the same brain mechanisms identified in simple experimental conditions were maintained in complex conditions.

It is worthy to point out possible issues in considering generalization or ecological validity (Figure 1.3). The first issue is how to implement ecological social contexts in the restricted MRI environment. Mounting interest in ecological validity has lead to a number of imaging studies of social cognition using more dynamic, naturalistic stimuli. Endeavors to increase ecological validity in social affective research use video clips depicting social interactions (Levenson & Ruef, 1992; Zaki, Bolger, & Ochsner, 2008) and film clips selected from commercial movies or programs (Goldin et al., 2005; Hutcherson et al., 2005; Moran, Wig, Adams, Janata, & Kelley, 2004). These studies suggest that it is possible to improve ecological validity by using video clips and virtual reality in imaging research on brain mechanisms associated with social cognitive processing and emotional processing in social contexts.

A second challenging issue on ecological validity is how to assess continuous processing of specific social events (e.g., mentalizing and empathy) during ‘ongoing’ social experiences (Spiers & Maguire, 2007). A continuous rating method was use to collect continuous emotional responses while participants were watching movies in emotion research (Goldin et al., 2005). In particular, this method demands participants continuously pay attention to emotional responses to the movies (Hutcherson et al., 2005). These studies showed that it is possible to continuously measure emotions when people watch video clips describing ongoing social interactions.

Therefore, the present study improved ecological validity by using video clips describing social interactions and a continuous rating method in fMRI Experiment II. More importantly, few studies have investigated whether findings in simple experimental conditions are maintained in complex experimental conditions. Thus, this study examined the possibilities of generalization by comparing results from simple experimental conditions (fMRI Experiment I) with results from complex conditions (fMRI Experiment II).

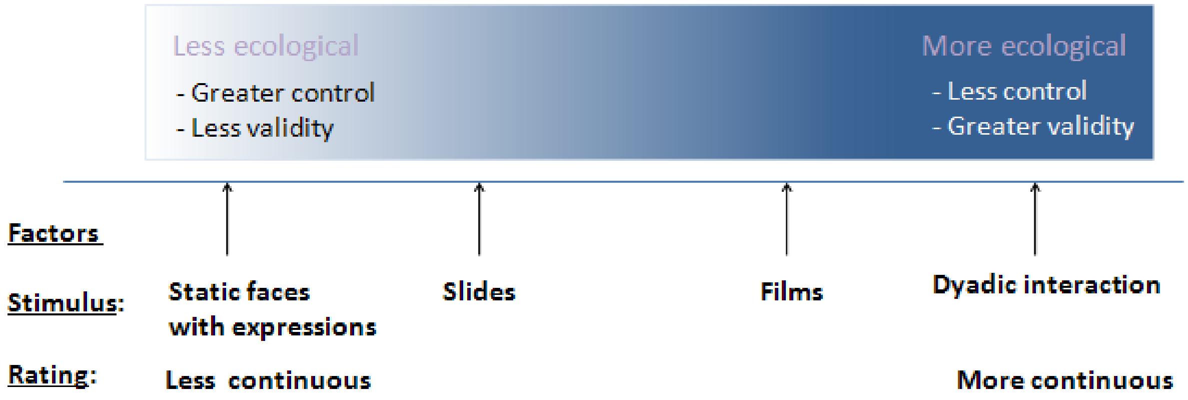

Figure 1.3 Ecological validity is another possible issue on social affective neuroscience research (Modified version of Levenson, 2003). This study improved ecological validity using video clips (stimulus) and a continuous rating method (rating).

1.3 OVERVIEW OF THE CURRENT RESEARCH

A main goal of this study was to explore neural mechanisms associated with explicit emotional processing of *self* and *others* in both concordant and discordant conditions. The second goal was to investigate whether the findings generalize to more ecological social contexts. One of the most challenging issues in this study was how to manipulate concordant and discordant conditions.

Behavioral Experiment I (2.0) was conducted to test the effectiveness of the manipulation of different empathy conditions and behavioral Experiment II (Appendix) was conducted to validate newly developed experimental paradigms compatible with fMRI experiments.

Subsequently, two fMRI experiments (fMRI Experiment I and fMRI Experiment II) were conducted to examine neural mechanisms. Both fMRI experiments used both concordant and discordant conditions by manipulating persons' characteristics in the stimuli. In fMRI Experiment I (3.0), participants were asked to view static faces presented with sentences and perform simple emotional evaluation tasks by clicking a number to indicate emotion in the scanner. fMRI Experiment II (4.0) was designed to generalize the findings from previous research to more complex, real life situations using video clips, so participants were asked to watch a series of video clips and continuously rate either their own emotions or emotions of people in the video clips.

2.0 BEHAVIORAL EXPERIMENT I: VALIDATION OF MANIPULATION BY PERSON-VALENCE (GOOD/BAD)[1]

2.1 INTRODUCTION

Upon hearing that someone has suffered from misfortune, feelings such as empathy and sympathy are common (Eisenberg & Eggum, 2009; Hatfield, Rapson, & Le, 2009) unless there is reason to be predisposed against that person (McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985; Zillmann, 2006). Lack of empathy with people against whom one is predisposed may thus depend on interactions between one's own emotional reaction ('how I feel', henceforth, *self*) and understanding of the other person's emotions ('how others feel', henceforth, *other*) (e.g., "I did not feel bad because I thought you did not feel bad"). Alternatively, emotional reactions may be due only to one of these factors. Thus, less emotional responses to people against whom one is predisposed could be a consequence of distinctions between *self* and *other* (e.g., "I did not feel bad although I know you felt bad"). This study examined whether influences of *self* and *other* interact or are independent when a subject is predisposed against a target person.

Theoretical accounts suggest that there are distinct processes underlying evaluation of one's own emotions and others' emotions (e.g., Lee & Siegle, in press). In particular, evaluation

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[1] This section has been prepared for submission to a journal. Kyung Hwa Lee, Greg Siegle, & Ashley McFarland (2011). I can't empathize if you are evil although I know you feel bad. In preparation.

of one's own emotions (*self*) may be specifically processed by focusing on bodily experience (interoception) and conscious subjective experience (for a review, see Lambie & Marcel, 2002) while evaluation of others' emotions (*other*) may specifically depend on an ability to understand emotions of other people by perspective-taking (e.g., Goldie, 1999; Van Boven & Loewenstein, 2005) or that they use theory of mind (TOM), an ability to attribute mental states to others (e.g., Frye & Moore, 1991). We hypothesized that *self* and *other* would be particularly distinct when one is predisposed against a target (i.e., that self/other would interact with predisposition).

However, interactions between *self*/*other* and predisposition in emotion research have not been fully understood due to two potential limitations. First, emotional processing in social interactions could be associated with switching between evaluation of one's own emotions and others' emotions. However, prior research has often studied these processes separately. For example, extensive research has focused on assessing one's own emotional responses to socio-emotional stimuli such as emotional pictures and films describing social situations (e.g., Britton, Taylor, Berridge, Mikels, & Liberzon, 2006; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), demonstrating, e.g., that when subjects viewed people in emotional situations, they report subjective emotional experience and show physiological changes. Another literature has focused on possible mechanisms occurring when people infer other people's emotions. For example, when instructed to use other people's perspectives to understand others' emotions, adults show better prediction and identification of others' emotions (e.g., Davis, Conklin, Smith, & Luce, 1996; Levenson & Ruef, 1992; Rieffe, Terwogt, & Cowan, 2005). Thus, evaluation of both one's own and others' emotions should be assessed to examine emotional processing in social contexts.

Another limitation is that existent research on emotion evaluation generally uses situations in which one's own emotion is the same as a perceived emotion of others. For example, recent studies have used these two explicit assessments of emotions in the context of concordant conditions in which participants felt the similar emotions as others (e.g., protagonists or targets) presented in the stimuli (e.g., Ochsner, 2004; Schulte-Ruther et al., 2007). Similar emotions, such as empathy, in concordant conditions might make less of a distinction between *self* and *other* (Decety & Jackson, 2004), indicating that similar emotions may prevent detecting distinct processes associated with emotional processing of *self* and *other*. Thus, *self* and *other* should be examined in a discordant condition in which people feel less similar emotions than others.

Outside the lab, people often experience discordant emotions to others, such as pleasure at others' misfortune (van Dijk, Ouwerkerk, Goslinga, Nieweg, & Gallucci, 2006). In the lab, participants show decreased emotional responses to people against whom they are predisposed (judged as "evil" or whom they are made to dislike) in misfortunate situations compared to people they are not against (e.g., Hareli & Weiner, 2002; Zillmann & Cantor, 1977). However, these studies focused only on one's own emotional responses to people against whom they are predisposed. Thus, whether *self* and *other* are interactive or independent when people are predisposed against a target remains unclear.

To overcome these limitations, the present study therefore required participants to evaluate their own emotions (*self*) and the emotions of others (*other*) in response to the same stimuli. It also employed both concordant (likely to provoke less distinct emotion processes between *self* and *other*) and discordant conditions (likely to provoke more distinct processes between *self* and *other*) to examine distinctions between *self* and *other* processing.

To create concordant and discordant conditions, we employed a methodology similar to Zillmann and Cantor (1977) who used prior exposure to video clips of different persons describing either altruistic/good or harmful/bad behaviors to yield concordant or discordant emotions between *self* and *targets*. As order-effects for *self/other* judgments can also affect emotion-ratings (Gnepp, 1989; Hareli & Weiner, 2002; Pronin, 2008) we counterbalanced the order of *self* and *other* rating across subject-groups. Further, to account for potential habituation effects associated with repeat exposures additional groups in which participants evaluated one's own emotions twice (*self*-repeated) or others' emotions twice (*other*-repeated) were included to yield four groups of participants.

As described previously, we predicted that *self* and *other* would be distinct when people do not empathize with people against whom they are predisposed. Thus, we predicted that ratings of one's own emotions (*self*) and others' emotions (*others*) would both increase (more negative) when participants observed that something bad had happened to a "good" person. In contrast, ratings of *others* would also increase when something bad happened to a "bad" person, but *self* ratings would not increase as much as for a good person due to reduced empathic concerns for a "bad" person. We further hypothesized that condition order would not moderate these effects.

2.2 METHOD

2.2.1 Participants

Participants were 136 undergraduate students (61 males, mean (SD) age=19.2 (1.5) years) taking introductory psychology classes who received course credits for participation. They were assigned to five groups: four experimental groups with an experimental manipulation and with different orders of emotion rating tasks and one control group without any manipulation (see Table 2.1). All participants signed an informed consent form based on the Institutional Review Board at the University of Pittsburgh.

Table 2.1 Demographic information of subjects participating in four experimental groups and one control group

	Experimental between-subject groups				Control group
	Self-Other	Other-Self	Self-Self	Other-Other	Self-Other
N	29	27	26	26	28
Gender	12 M	10 M	11 M	12 M	14 M
	(42.38%)	(37.04%)	(42.31%)	(46.15%)	(50%)
	17 F	17 F	15 F	14 F	14 F
	(58.62%)	(62.96%)	(57.69%)	(54.85%)	(50%)
Age (M(SD))	18.7 (0.7)	19.3(1.9)	19.3 (1.2)	19.0 (1.2)	19.5 (2.0)

Note. M=male, F=female

2.2.2 Materials and procedure

The experimental groups underwent three different phases: 1) manipulation, 2) learning check, and 3) emotion rating tasks (Figure 2.1).

Manipulation phase. Participants were asked to read scripts describing the characteristics of two target persons and then watched video clips depicting their behaviors. One target person was more likely to be perceived as a ‘good’ person and the other target person was more likely to be perceived as a ‘bad’ person. The scripts included targets with neutral faces selected from the NimStim Face Stimulus Set (Tottenham et al., 2009) and sentences describing their characteristics. The good person was described as good and positive whereas the bad person was described as bad and negative. The faces of the good and bad persons were counterbalanced across the participants to avoid potential confounding effects by participants' different impression or preference to the targets.

To show the two targets' behaviors, participants were exposed to short video clips superimposed with the same neutral face from either the good or bad person. The video clips were selected from 'www.YouTube.com'. Both clips depicted interactions between women and children and the women's faces were not clearly recognizable to make participants believe the women in the clips were our superimposed target persons. The video clip of the "good" person described the woman as someone who enjoys entertaining a child who suffers from brain cancer (Carsonsweb, 2007). In contrast, the video clip of the "bad" person described the woman as someone who was abusing her child (Dreamindemon, 2008). Before participants watched the video clips, they received a brief background story to provide a clear clue about each video clip. After viewing the video clips, participants rated their subjective emotional responses to the target persons on a 9-point scale ranging from 1 (very negative) to 9 (very positive)[2].

Learning check. Participants were exposed to the neutral faces of the good or bad persons with words describing personal traits (e.g., Farb et al., 2007) and were required to answer whether the trait word describes the person correctly or not, based on their experience with each person during the manipulation. There were 20 match trials in which the faces and trait words were congruent (e.g., good person's face presented with 'kind') and 20 mismatch trials in which the faces and trait words were incongruent (e.g., good person's face with 'cruel'). This active

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[2] We added this post-rating scale to our study after we started collecting some data. Thus, we did not have a chance to collect post-rating data from first 38 subjects. Post-rating data from 70 subjects were analyzed (see Result section).

commitment during the learning check phase was designed to make participants more engaged in associating the target persons with their characteristics.

Emotion rating tasks. Participants were asked to perform two emotion rating tasks. Participants were asked to see stimuli consisting of one target's face and a sentence. Each emotional stimulus was presented with the same face of either 'good' or 'bad' persons with sad facial expression and one sentence describing a negative event that happened to them (e.g., failed an important exam). The sad faces were also selected from the Nimstim set and 15 sentences depicting negative life events were created based on literature (e.g., Holmes & Rahe, 1967). When participants viewed the stimulus, they were asked to rate either 1) their own emotions ('SELF' task: "How do you feel?"), or 2) the person's emotions in the stimulus ('OTHER' task: "How does this person feel?")[3]. A rating scale, ranging from 3 to -3 (3=very negative, 0=nothing or neutral, -3=very positive) was also presented at the bottom of the stimulus slide. Participants reported their own emotions or the persons' emotions by clicking a mouse.

This rating phase implemented a 2 x 2 factorial design with factors being the emotion rating task (*self* vs. *other*) and person condition (Concordant: good person vs. Discordant: bad person). The rating task factor was implemented as a block to reduce possible task-switch effects and carry-over effects. The number of trials in each block varied to exclude possible expectation/prediction effects. Each block began with a task instruction for 3-6 sec followed by 2-4 concordant and discordant trials in a randomized order. Each trial consisted of the presentation of a stimulus and rating scale for 6 sec followed by a fixation cross for 4 sec.

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[3] One control task was used to invent an experimental paradigm compatible with imaging research in this rating phase. For this control task, participants were presented with stimuli consisting of one neutral face and a sentence, and then asked to look at the face and click one of seven numbers instructed by the sentence ('NUMBER') (e.g., "Look at the face and click number 3). This task was used as a possible control task for a subsequent imaging study, thus it was not included for our analysis in this manuscript.

Participants completed 60 trials consisting of 15 trials in four different conditions (2 rating tasks x 2 persons). The 'Self-Other' group always rated one's own emotions first and then rated others' emotions whereas the 'Other-Self' group rated emotions vice versa. The 'Self-Self' group rated one's own emotions twice and the 'Other-Other' group rated others' emotions twice. After the completion of all phases, participants were carefully debriefed.

Control group. Participants in this group completed the same emotion rating phase as described in the experimental groups. However, they were not exposed to any manipulation before the rating phase, so they ideally perceived the target persons as neutral. Ratings in this group were used as a baseline, providing information regarding on how our manipulation influenced emotional ratings of *self* and *other* in both concordant and discordant conditions.

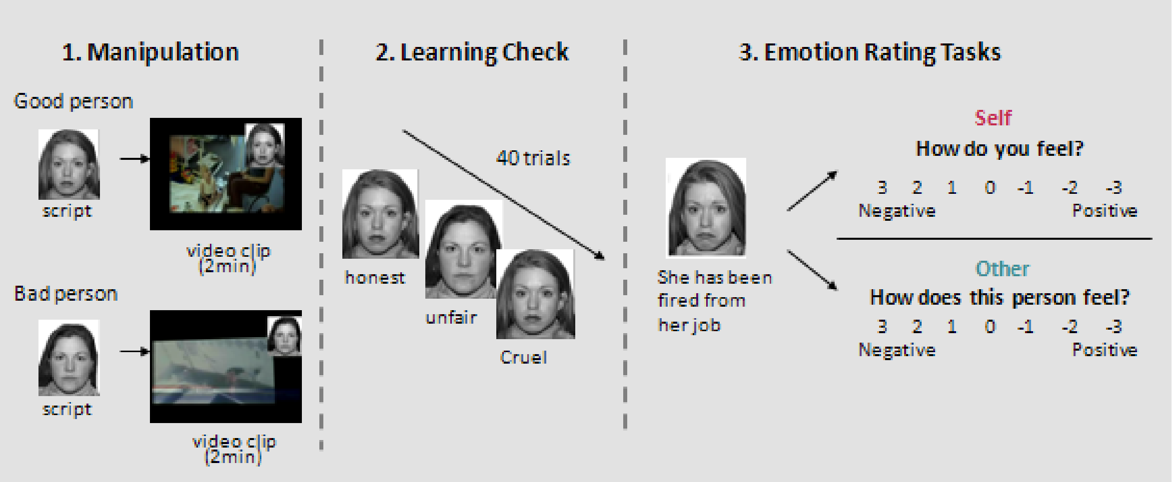

Figure 2.1 Diagram of experimental procedures

2.3 RESULTS

2.3.1 Manipulation and Leaning checks

After watching two video clips depicting two persons' behaviors, as previously noted, 70 of 108 participants in the experimental groups rated their emotional responses. Results showed that participants experienced the video clip of the good person (Emotion rating: $M = 8.26$, $SD = 1.00$) as more positive than the video clip of the bad person ($M = 1.7$, $SD = 0.97$), $t(69) = 33.12$, $p < .0001$, Cohen's $d = 3.96$.

Results of the learning check showed that accuracy rates were above 95% in the match and mismatch conditions. A 2 x 2 (Person (good vs. bad) x Condition (match vs. mismatch)) repeated measures ANOVA showed a significant interaction between Person and Condition, $F(1, 107) = 16.23$, $p < .001$, partial eta-squared (η_p^2) = .13. The learning check was performed more accurately in the good person ($M = 98.61\%$ correct, $SD = 3.73$) than in the bad person ($M = 94.54\%$, $SD = 9.01$) in the match condition, but not in the mismatch condition (good person: $M = 97.41\%$ correct, $SD = 4.61$ and bad person: $M = 97.78\%$ correct, $SD = 5.18$). High accuracy across all conditions indicated that participants were more likely to describe the good person with positive trait words and the bad person with negative words.

2.3.2 Emotion ratings of *self* and *other*

We hypothesized that emotional ratings of *self* and *other* would increase (more negative) in the concordant condition. In contrast, emotional ratings of *other* would increase, but self-ratings would not. To test this hypothesis, emotion ratings in the Self-Other and Other-Self groups were compared. A 2 (Task: Self vs. Other) x 2 (Person: Good vs. Bad) repeated measures ANOVA showed a significant interaction effect, $F(1, 55) = 86.95$, $p < .0001$, $\eta_p^2 = .61$. Simple main effects revealed decreased emotion ratings in the *self* compared to the *other* in the concordant condition ($p < .001$) and even lower self- compared to other- ratings in the discordant condition ($p < .001$) (Figure 2.2). Thus, there were decreased emotion ratings of *self* in the discordant compared to the concordant conditions ($p < .001$), but no differences in emotion ratings of *other* between concordant and discordant conditions ($p = 1.00$) (Figure 2.2). These results indicated that less similar emotion ratings between *self* and *other* in the discordant condition than in the concordant condition might be mainly due to decreased emotion ratings of *self* in the discordant condition.

2.3.3 Comparisons with controls who did not receive a 'Good/Bad' manipulation

Emotion ratings of *self* and *other* in the experimental groups were compared with those in the control group to test whether our manipulation affected one's own and others' emotions. Potentially, our manipulation would affect one's own emotional responses to the good and bad persons compared to when these persons were perceived as a neutral person (*self*), but not emotions of the good, bad, and neutral persons (*other*). As predicted, emotion ratings of *self* in the good person were higher than in the neutral person, $F(1, 81) = 6.22$, $p < .01$, $\eta_p^2 = 0.13$, but emotion ratings of *self* in the bad person were lower than in the neutral person, $F(1, 81) = 8.64$. $p <. 001$, $\eta_p^2 = 0.17$. Participants reported more intense emotional responses to the good person but less intense emotional responses to the bad person compared to the neural person (Figure 2.2). However, there were no significant differences in emotion ratings of *other* between the good and neutral persons, *F*(1, 81) = 1.02, *p* = .36, $\eta_p^2 = 0.03$, and between the bad and neutral persons, *F*(1, 81) = .90, *p* = .41, $\eta_p^2 = 0.02$. Ratings of others' emotions were not affected by our manipulation (Figure 2.2). These results reinforced that our manipulation influenced ratings of one's own emotion to targets in distress, but not ratings of targets' emotions.

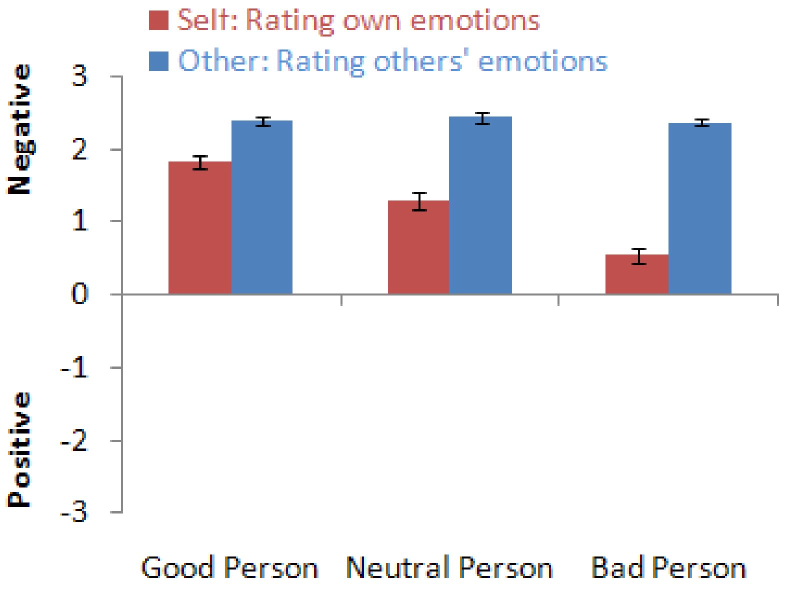

Figure 2.2 Emotion ratings of *self* and *others* in the experimental groups (Self-Other and Other-Self: Good and bad persons) and control group (Neutral person without manipulation). Note. Y-axis: emotion rating scale: 3=very negative, 0=nothing or neutral, and -3=very positive.

2.3.4 Order effects of explicit tasks to evaluate emotions in *self* and *other*

We investigated potential order effects of two different tasks on emotion ratings. Order effects might be introduced by factors such as habituation, or learning, occurring when the same stimuli were presented repeatedly. To examine order effects, we compared emotion ratings of *self* and *other* in the four experimental groups in which participants performed *self*- and *other*-rating tasks with different orders. ANOVAs on emotion ratings of *self* and *other* were thus conducted with Task Order (1st vs. 2nd) and Repeated Condition (non-repeated vs. repeated) as the between-subject factors. For emotion ratings of *self*, the Order x Repeated Condition interaction was not significant, *F*(1, 104) = .03, *p* = .87.There were no main effects of the Order, *F*(1, 104) = .02, *p* = .89, or Repeated Condition, *F*(1, 104) = .00, *p* = .98. For emotion ratings of *other*, the Order x Repeated Condition interaction was not significant, *F*(1, 104) = 0.01, *p* = .93. There was no main effect of the Order, *F*(1, 104) = 0.06, *p* = .81. However, there was a significant main effect of Repeated Condition, *F*(1, 104) = 4.31, *p* < .05. These results indicated that both *self*- and *other*-tasks were not affected by whether the task was performed first or second.

2.4 DISCUSSION

This study examined whether evaluation of one's own emotions (*self*) and others' emotions (*other*) are interactive or distinctive in response to "good" and "bad" people with the intention to affect likely empathetic concern. We manipulated concordant and discordant conditions using scripts and video clips depicting characteristics/behaviors of target persons who were described as either good or bad. This manipulation led participants to report positive emotional experiences with the video clip describing the good person and negative experiences with the video clip describing the bad person as in Zillmann & Cantor (1977) study. Participants associated the good person with positive trait words and the bad person with negative words, supporting the notion that people tend to attribute others' behaviors to their personal dispositions

(Pronin, 2008). These results suggest that our manipulation worked properly to create the concordant and discordant conditions.

As predicted, we found increased emotional ratings (more negative) of both *self* and *other* in the concordant condition. Participants reported negative emotional responses when bad things happened to the good person and understood the good person's emotions well when they were instructed to take her perspective. There was a significant difference in emotion ratings between *self* and *other*, suggesting that participants might not feel an emotional experience as intensely as they inferred the good person would, possibly due to limitations in inducing one's own emotions in the laboratory experiment (Rottenberg, Ray, & Gross, 2007). Despite this limitation, one's own emotional responses to the good person were more intense compared those to a neutral person as perceived in the control group, suggesting that even brief exposures to information about other people might increase one's own emotional responses to them.

Consistent with our hypotheses, participants described having much decreased emotional intensity when bad things happened to the bad person, compared to when bad things happened to the good person. This finding was consistent with previous studies that showed discordant emotional responses to a person who was bad or disliked (Epstude & Mussweiler, 2009; Hareli & Weiner, 2002; McHugo et al., 1985; Zillmann & Cantor, 1977). Prior negative experiences with the bad person might have lead participants to show discordant emotional responses to the bad person's misfortune. So, for example, participants may have had an initial concordant emotional reaction to the bad person's sad facial expression via automatic processes, but attempted to inhibit the initial emotional reaction via more deliberate processes, potentially to display more socially desirable responses.

Zillman (2006) also suggested that people monitor their emotional responses to other people in terms of social appropriateness through cognitive appraisal. In this study, participants might have viewed their concordant emotional reactions to the bad person as inappropriate responses and altered their reactions based on social or moral norms. Alternatively, discordant emotions sometimes happen when observers appraise that people who are experiencing negative life events are responsible for their misfortune (van Dijk, Goslinga, & Ouwerkerk, 2008). Participants may have appraised that the bad person was responsible for her misfortune such as having her license revoked.

Emotion ratings of *other* increased (more negative) similarly when something bad happened to both good and bad persons. This result indicates that participants successfully understood both good and bad persons' emotions with the explicit instruction of perspective-taking which led them to take their perspective in negative situations (e.g., Davis et al., 1996; Rieffe et al., 2005). This finding suggests that mechanisms associated with evaluating others' emotions might not be influenced by a target person's characteristics. Possibly, such mechanisms remain intact due to the apparent sad facial expression of the bad person and negative situation. Clear information about the targets' mental states such as facial or body expressions lead people to take others' perspective based on these social signals (Van Boven & Loewenstein, 2005). Obvious information also leads people to infer others' emotions without seeking additional information about their personal characteristics (Gnepp, 1989).

An alternative explanation is that participants may take a lay person's perspective to minimize involvement of their own emotional investment to evaluate emotions of the bad person. People infer others' mental states based on how they think a typical person if targets are dissimilar to themselves (Ames, 2004). Similarly, in the discordant condition, our participants might tend to infer others' emotions by taking typical people's perspective. Although we did not find difference in self-reported ratings when evaluating the bad and good person's emotions, there would be some different brain mechanisms based on whether participants take the bad person's perspective or typical persons' perspective.

There were no order effects of the rating tasks, indicating that evaluating one's own emotions and others' emotions is not affected by task orders. One previous study reported that the order effects of the emotion tasks was modulated by age (Hughes, Tingle, & Sawin, 1981). Younger children showed improved understanding of others' emotions if they evaluated others' emotion after they reported their own emotions; whereas, older children did not show this order effects. This result suggests that younger children use their own emotions to infer others' emotions, potentially due to less distinctive mechanisms of *self* and *other*. Thus, the order effects of *self-other* emotion rating tasks may diminish with age and the development of separate mechanisms between *self* and *other*. Importantly, we found that there were no order effects in both concordant and discordant conditions. The concordant condition may have a limitation to examine order effects because self-other mechanisms in this condition are more likely shared. No order effects in the discordant condition also supports that one's own emotions and others' emotions are evaluated independently. If order effects were found, the decreased intensity of one's own emotions might have caused the subject to report reduced intensity of the bad person's emotions. Furthermore, the result of the task order effects was not qualified by habituation effects, indicating that repeated exposure to the same stimuli with different social contexts may not have habituation effects on emotional evaluation.

Our findings have implications for research on social affective neuroscience and clinical neuroscience. Our main findings may contribute to a better understanding of complex emotional processing in social contexts, such as empathy (Decety & Jackson, 2004). For example, our results demonstrated that people do not feel empathic concerns for the bad person although they understand/know the bad person’s emotions, indicating that *self* and *other* are distinct when people are predisposed against other people. This study demonstrates that empathic confound could be controlled by manipulating target persons’ characteristics. Thus, the implication is that we have a paradigm which removes the empathy confound for use in future research. Dysfunctional emotional processing of *self* and *other* is also closely associated with affective disorders such as autistic spectrum disorder (ASD) and psychopathy (Decety & Moriguchi, 2007). Distinctions between *self* and *other* may shed light on a better understanding of underlying mechanisms associated with these disorders.

This study has several limitations. First, we used only negative situations, so there may be a limitation of generalizing our findings to positive life events. Although previous studies demonstrated that people reported discordant emotional responses (negative or displeasure) to the person who was described as bad or aggressive in positive situations (Zillmann & Cantor, 1977), it remains to be seen how people evaluate bad persons’ emotions in positive situations. Second, we measured self-reported emotional ratings of one’s own emotions and others’ emotions. Although self-reports of emotions provide valuable information, consciously evaluating emotions may interrupt ongoing emotional process, indicating that self-reported ratings may represent biased responses modulated by beliefs and social desirability (Gray & Watson, 2007). Third, we used relatively simple socio-emotional stimuli including negative faces and sentences, which may not fully represent social situations in the real world. Such lack of ecological validity may prevent our findings from being generalized to more naturalistic social situations.

Despite these limitations, our findings provide evidence that there are distinct processes associated with evaluating one’s own emotions and others’ emotions. Interestingly, discordant condition only modulated one’s own emotional states but not understanding of others’ emotions. These results suggest that greater dissociation of underlying mechanisms between evaluating one’s own emotions and others’ emotions arise as a function of empathic concern/sympathy for other people. Our study design translates neatly to more mechanistic investigations, e.g., using fMRI, allowing further investigation of neural substrates of evaluating one’s own emotions and others’ emotions in concordant and discordant conditions.

3.0 FMRI EXPERIMENT I: EXPLICIT EMOTIONAL PROCESSING OF *SELF* AND *OTHER* IN CONCORDANT AND DISCORDANT CONDITIONS

3.1 INTRODUCTION

Both theoretical accounts and imaging studies suggest that there are common and distinct mechanisms involved in the evaluation of one's own emotions and other people's emotions (for a review, see Lee & Siegle, in press). However, imaging studies report common and distinct brain regions in concordant conditions in which participants have the same emotion as the person whose emotion was evaluated (e.g., Jackson, Brunet et al., 2006; Schulte-Ruther et al., 2007). Such concordant conditions, which involve shared emotions (e.g., empathy) between *self* and *others,* may cause potential confounding effects on the delineation of common and distinct brain networks. Specifically, shared emotional processing in concordant conditions may aid in elucidating common mechanisms, yet prevent the detection of distinct mechanisms between *self* and *others*.

Relatively little is known about whether shared emotional processing (e.g., empathic processing) modulate common and distinct brain mechanisms associated with explicit/conscious emotional processing of *self* and *others*. To examine potential confounding effects, brain mechanisms can be investigated in two different conditions: one in which people are likely to report more similar emotions to a target person in the stimulus (concordant/empathy condition) and one in which they are likely to report less similar emotions to a target person (discordant/non-empathy condition). The present study explored brain mechanisms involved in explicit emotional processing of *self* and *others* in both concordant and discordant conditions to examine possible confounding effects.

Discordant emotion, such as a reduced empathic response, is an example of one's own emotional response to others, which can be adaptive in certain socio-emotional situations (Heider, 1958; Zillmann, 2006). Similarly, empathic processing, which is closely related to emotional processing of *self* and *others* (Decety & Jackson, 2004), can be modulated by factors including the relationship between viewers (e.g., participants) and targets (e.g., protagonists presented in stimuli) and other social contexts (de Vignemont & Singer, 2006; Hein & Singer, 2008). In line with this notion, social psychologists have developed experimental conditions in which people do not empathize with other people through the manipulation of characteristics of the targets (Lanzetta & Englis, 1989; Zillmann & Cantor, 1977). Research has demonstrated that people report feeling empathy with pleasure and distress when these emotions were expressed by cooperative or benevolent people, whereas they did not empathize with competitive or malevolent people. Similarly, behavioral Experiment I showed that one's own emotional responses to a bad person in the discordant condition were decreased (possibly less empathic concern) compared to a good person in the concordant condition, although there was no difference in emotional understanding between the good person and the bad person.

Consistent with this observation of behavior, recent imaging studies on empathy and social cognition have investigated how less empathic (e.g., unfair targets) or discordant conditions (e.g., dissimilarity between *self* and *other*) modulate neural mechanisms associated with empathy (Lamm, Meltzoff, & Decety, 2010; Singer et al., 2006) and social cognition (Krienen, Tu, & Buckner, 2010; Mitchell, Macrae, & Banaji, 2006). However, to date, these imaging studies have reported inconsistent results. Previous studies have reported no modulation. For example, Lamm et al. (2010) showed that the same brain regions, including the ACC and insula, were involved in empathizing with similar and dissimilar targets. Targets' similarity also did not affect neural mechanisms associated with inferring others' minds (Krienen et al., 2010). In contrast, there is evidence that a target's characteristics in social contexts modulated neural responses in neural networks associated with social and empathic processing. Similarity dissociated MPFC regions, such as VMPFC regions, were more activated when mentalizing a similar person, whereas DMPFC regions were more activated when mentalizing a dissimilar person (Mitchell et al., 2006). Singer et al. (2006) showed that empathic responses and related brain activation decreased when people observed an unfair person experiencing pain.

Previous studies also suggest that cognitive control may play an important role in social and emotional processing in dissimilar person conditions (Lamm et al., 2010; Rilling, Dagenais, Goldsmith, Glenn, & Pagnoni, 2008). Cognitive control would be engaged in inhibition of pre-established empathic tendency to dissimilar people. For example, cognitive control, such as regulatory function, plays a central role in the inhibition of undesired emotional responses to people in discordant conditions. More cognitive effort and conflict would be elicited by discordant conditions than concordant conditions because discordant conditions may be less common and certain than concordant conditions. Thus, cognitive control and effort could be associated with modulation of empathic processing.

Although previous studies have provided evidence regarding modulation due to different persons' characteristics, there are still a number of issues to take into account when investigating modulation effects. For example, Mitchell et al. (2006) examined modulation effects in the context of social cognition, but not in the contexts of emotional processing or empathy. Despite some commonality of brain mechanisms involved in social cognition and involved in emotional processing in social contexts, there may be subtle differences in the mechanisms. Singer et al. (2006) did not use explicit evaluation tasks to assess the underlying mechanisms of *self* and *others.* Without explicit evaluation tasks, it may be difficult to disentangle different roles of *self* and *others* in emotional processing in discordant conditions. As behavioral Experiment I reported, modulation could happen in mechanisms associated with *self*, but not *others*.

In the present study, participants were exposed to two different persons' behaviors and characteristics. In particular, participants were supposed to perceive one person as "good" and the other person as "bad". This was manipulated to create a concordant condition in which participants and the target person in the stimulus were more likely to have more similar emotions (e.g., more empathy) and a discordant condition in which participants and the target person were more likely to have less similar emotions (e.g., less empathy). Participants were scanned when evaluating either their own emotions or the emotions of the good or bad target persons in the negative life events. Participants also performed a control task included as a control condition. In this task, they were asked to view a neutral face and click one of the numbers on the screen. It was assumed that the control task does not engage any processes associated with explicit emotional evaluation. In addition, participants completed dispositional questionnaires (e.g., alexithymia and empathy) to examine whether dispositional measures are correlated with emotion ratings and brain regions involved in distinct emotional processing of *self* and *others*.

This study aimed 1) to replicate findings from previous research (our meta-analytic study) with regard to the concordant condition, and 2) to explore the modulation of empathic processing on neural substrates of *self* and *others*. Two main questions were addressed: *1) Are there common and distinct neural mechanisms activated by explicit emotional evaluation in self* *and others?* It was hypothesized that MPFC, LPFC and limbic regions would be commonly activated by both *self* and *others* in the concordant condition. The insula and rACC would be more activated by explicit processing of *self* than *others,* whereas the STS and TPJ would be more activated by explicit emotional processing of *others* than *self* in the concordant condition.

2) Does the discordant condition, which is less empathic, modulate common and distinct mechanisms? If common and distinct regions are not associated with empathic processing (e.g., shared emotions), then substantially similar common and distinct regions would be yielded regardless of different empathy conditions, which may account for no modulation of empathic processing. However, if common and distinct regions are associated with empathic processing, there would be modulation by empathic processing. Modulation might happen in two different manners according to Singer et al. (2006), who showed modulated activation in empathy-related brain regions by the less empathic condition, and Mitchell et al. (2006), who reported different brain regions involved in the dissimilar condition. Similar brain regions would be revealed as common and distinct regions; however, activation in these regions would be modulated. For example, based on the hypothesized emotional ratings, decreases in ones' own emotional responses to the bad person would be associated with changes in *self*-distinct brain regions, such as the rACC and insula. Second, additional processing, such as cognitive effort and regulatory function, that could be engaged by the discordant condition would recruit additional common or distinct brain regions.

3.2 METHOD

3.2.1 Participants

Eighteen healthy, right-handed female participants were recruited for this study (mean age = 22.7 years, SD=8.3 years). To control for possible gender differences in brain mechanisms associated with empathy (Schulte-Ruther, Markowitsch, Shah, Fink, & Piefke, 2008), only female participants were recruited. Participants were screened to rule out the presence of a specific clinical population with autistic spectrum disorder (ASD), using the Autism Spectrum Quotient (AQ: Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and with high levels of depression, a possible confounding variable in emotional evaluation, using the Beck Depression Inventory (BDI: Beck, Steer, & Brown, 1996) or the Quick Inventory of Depressive Symptomatology-Self Report (QIDS-SR: Rush et al., 2003)[4]. Participants passed this clinical screen (AQ < 32, BDI < 9, and QIDS-SR ≤ 6). None of subjects had any history of neurological or psychiatric disorders.

Additionally, to control for adequate abilities to identify one's own emotional states and others' emotional states, participants were screened for alexithymia and empathic ability using the Toronto Alexithymia Scale (TAS: Bagby, Parker, & Taylor, 1994) and the Interpersonal Reactivity Index (IRI: Davis, 1983). All participants scored within the normal range for the alexithymia, TAS < 55, and received similar scores for the IRI subscales (EC: empathic concern, PT: perspective-taking, PD: personal distress, and FS: fantasy) based on the norm values (Lamm et al., 2007). Participants received course credits or were paid for their participation in this

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[4] Participants were recruited through two different research projects which used a slightly different screening procedure. One project used the BDI and another used the QIDS-SR) to assess levels of depression.

experiment. All participants signed an informed consent form approved by the Institutional Review Board of the University of Pittsburgh. Table 3.1 presents demographic information and scores of ASD, depression and dispositional traits.

One participant did not complete this experiment due to technical problems with a MR-compatible mouse, and another participant was excluded due to excessive head movement during the scanning. Thus, 16 participants (mean age = 22.9 years, SD=8.7 years) were included in the final analysis.

Table 3.1 Demographic information and dispositional measures

	Total	Experiment 1	Experiment 2
N	18	16 (of 18)[a]	15 (of 18)[b]
Age	22.7 (8.3)	22.9 (8.7)	22.1 (8.7)
Depression[c]			
BDI (N=8)	1.00 (1.51)	0.57 (0.98)	1.33 (1.63)
QIDS-SR (N=10)	3.60 (1.17)	3.56 (1.24)	3.67 (1.22)
AQ	13.06 (3.93)	13.00 (4.18)	12.47 (3.68)
TAS	35.89 (6.52)	35.94 (6.37)	35.67 (6.79)
IRI			
FS	18.00 (6.12)	17.31 (6.15)	17.73 (6.47)
EC	22.44 (3.50)	22.75 (3.53)	22.07 (3.58)
PT	17.83 (3.49)	17.75 (3.16)	17.80 (3.78)
PD	9.11 (4.28)	8.81 (3.99)	9.47 (4.55)

Note. Eighteen subjects participated in the fMRI experiments. [a] One of them did not complete the first fMRI experiment due to technical problems with a MR-compatible mouse. One participant was excluded due to head movement. [b]Three participants did not complete the second fMRI experiment due to technical problems with the video clips. Thus, fourteen participants completed ‘both’ fMRI experiments. [c]Depression was screened by either the BDI or the QIDS-SR.

3.2.2 Procedure

Before the scanning session, participants received the same manipulation and learning check sessions that were used in behavioral Experiment I (see manipulation phase). During the manipulation, participants were asked to watch video clips to learn about two target persons. Unlike behavioral Experiment I which used the faces selected from the Nimstim Face Stimulus Set, the static faces of two main target persons were selected from two video clips used in the second fMRI experiment (see Method for fMRI Experiment I) for compatibility with the manipulation and two subsequent fMRI experiments[5]. Apart from the faces, other stimuli and manipulation procedures were the identical to the behavior pilot study.

After watching video clips, participants were asked to report their emotional experiences for each of the video clips. Two additional post-ratings of the video clips were conducted. Participants were asked to report similarity (e.g., how similar are you to her?) and preference (e.g., how much do you like her?) on a 9-point Likert scale. Participants also performed a learning check in which they decided whether a trait word described the presented person correctly. After participants completed the manipulation and learning check, they participated in this fMRI experiment. After scanning, participants were asked to complete two questionnaires to test whether social desirability and mood affected emotional evaluation: one that measured social desirability using the Marlowe-Crowne Social Desirability Scale (MCSDS: Crowne &

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[5] The static faces and manipulation using these faces were validated in behavioral Experiment II (see Appendix).

Marlowe, 1960) and one that measured mood using the Positive and Negative Affect Schedule (PANAS: Watson, Clark, & Tellegen, 1988). Participants were then debriefed.

3.2.3 Experimental paradigm

During the fMRI assessment, participants were asked to view stimuli and perform one of three tasks that were structured by different instructions: the SELF task ("how do you feel?"), the OTHER task ("how does this person feel?"), and the CONTROL task ("which number do you click?"). In the experimental condition, participants were asked to perform emotion-rating tasks identical to those used in behavioral Experiment I. To rule out a tendency to report emotions favorably, participants were given clear instructions regarding the confidentiality of their emotion ratings and the importance of their honest responses.

In the control condition, participants were presented with stimuli consisting of a neutral face and a sentence, and then asked to look at the face and press one of seven numbers as instructed by the sentence. The control condition used neutral stimuli rather than emotional stimuli to exclude any potential automatic/unconscious empathic processing, such as emotional contagion, which could be activated by the mere presence of emotional faces (Coricelli, 2005; Schulte-Ruther et al., 2007). Participants in the control condition could be engaged in low levels of social information processing (e.g., face), sentence processing, and motion by mouse clicking. Due to the lack of an order effect with the different emotion-rating tasks during behavioral Experiment I, participants always rated their own emotions first, rated others' emotions and then performed the control task.

The same experimental design used in behavioral Experiment I was implemented in this fMRI experiment. This experiment had a 2 x 2 factorial design with emotion rating task (*self* vs.

others) and person condition (good vs. bad persons) as the main factors. A mixed blocked /slow event-related design was used to reduce potential task-switch effects and to allow examination of the time-course of event-related neural responses (Figure 3.1). Similar to behavioral Experiment I, emotion-rating task factor was implemented as a block and the number of trials in each block varied. Each block began with a task instruction for 5.01 sec, followed by 2-4 concordant (good person) and discordant (bad person) trials in a randomized order. Each trial consisted of the presentation of a stimulus and a rating scale for 6.68 sec to allow participants to complete emotional evaluation, followed by a fixation cross for 8.35 sec to allow the hemodynamic signal to return to baseline. The order of blocks was pseudo-randomized.

3.2.4 Imaging acquisition and Analysis

3.2.4.1 Imaging acquisition

Images were acquired on a 3T Trio scanner (Siemens, Erlangen, Germany). Thirty-two 3.2-mm slices were acquired parallel to the AC-PC line using a reverse-weighted echo planar (EPI) pulse sequence (T2*-weighted imaged depicting BOLD signal; TR=1670ms, TE=29ms, FOV=205mm, flip angle=75). Each image was acquired in 1.67 sec, allowing 9 scans per trial. High-resolution T1-weighted MPRAGE images (1 mm, axial) were also collected for use in cross-registration.

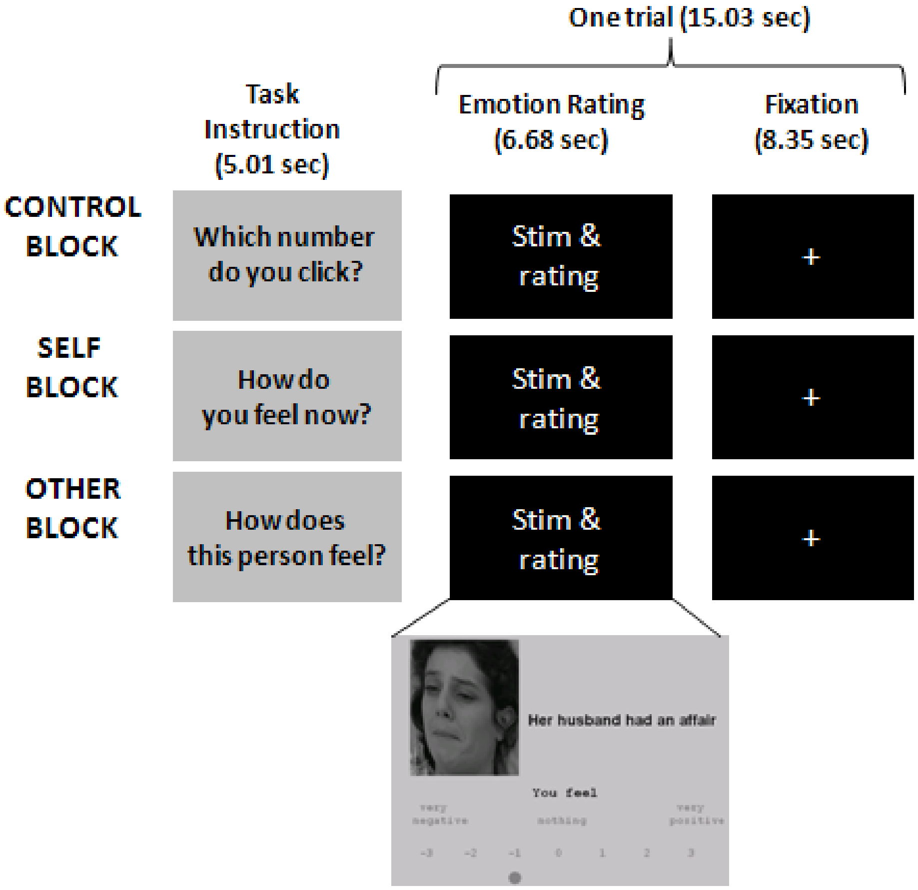

Figure 3.1 fMRI experimental paradigm. Each block began with a task instruction and had 2-4 trials of good and bad persons.

3.2.4.2 fMRI data preprocessing

fMRI analyses were conducted using locally developed NeuroImaging Software (NIS) (Fissell et al., 2003) and Analysis of Functional Neuroimaging (AFNI) software (Cox, 1996). Motion correction was conducted using the six-parameter AIR algorithm (Woods, Mazziotta, & Cherry, 1993). Quadratic trends within runs were removed to eliminate any effects of scanner drift, and outliers were rescaled. The fMRI data were temporally smoothed (five-point middle-peaked filter), cross-registered to a reference brain using the 12-parameter AIR algorithm, and spatially smoothed (6-mm full width at half maximum).

3.2.4.3 Type I error control

Component effects used in the computation of conjunction analyses were thresholded at p<.05, such that the conjunction was effectively thresholded at $p < .05 * .05$ or $p < .0025$. Main effect and interaction effect maps were thresholded at an uncorrected $p < .0025$. To control type 1 error at p<.05 across the whole brain for each family of tests (i.e., less than 5% chance that even one voxel was identified in error), voxelwise tests at a given statistical threshold ($p < .0025$) were subjected to empirically determined contiguity thresholds based on the spatial autocorrelation of statistical maps using AFNI's AlphaSim program. Thus, both the uncorrected p-value and contiguity threshold necessary to achieve a corrected brain-wise p<.05 were reported with each test described below.

3.2.4.4 Statistical analysis

Two research questions were addressed: 1) *Are there common and distinct regions associated with explicit emotional evaluation in self and others in the concordant condition (for replication)?* First, for replication, an ROI analysis was conducted. Time-series in these ROIs defined from our meta-analytic study (Lee & Siegle, in press) were extracted and tested using mixed-effect analyses with Participant as a random factor and Scan (s1~s9) and Task (Self vs. Control, Other vs. Control, or Self vs. Other) as repeated measures, assuming an AR1 covariance structure using restricted maximum likelihood estimation (REML) to control for temporal autocorrelation. Common regions were considered if there were both significant Scan x Task (Self > Control) and Scan x Task (Other > Control) interaction effects. Distinct regions were tested by Scan x Task (self-distinct regions: Self > Other or other-distinct regions: Other > Self).

A whole-brain exploratory analysis was also performed. To find regions that are commonly activated by *self* and *others* in the concordant condition (good person), two separate random-effects whole-brain voxelwise ANOVAs on *self* (Task [Self vs. Control] x Scan ANOVA) and *others* (Task [Other vs. Control] x Scan ANOVA) were conducted with Participant as a random factor, and Scan and Task as fixed factors. Then, a conjunction analysis between '*self*>control' and '*other*>control' maps was performed. Brain regions associated with '*self>control*' and '*other>control*' were defined by the peak activity (at scan5, approximately 8.35 sec following stimulus/rating onset) of time-courses. To elucidate distinct brain regions in the concordant condition, a random-effects whole-brain voxelwise ANOVA on Task (Self vs. Other) x Scan was performed with Participant as a random factor, and Scan and Task as fixed factors. Brain regions associated with '*self>other*' and '*other>self*' were defined by the peak activity of time-courses.

2) Does the discordant condition, which is less empathic, modulate common and distinct mechanisms? To answer this question, an ROI analysis was conducted to compare time-courses of brain activation between the concordant and discordant conditions in ROIs that were empirically identified from the concordant condition. Time-courses in all empirically common and distinct regions were extracted in the discordant condition. Mixed-effect analyses were conducted using Participant as a random factor, and Scan and Task as repeated measures to examine whether these regions showed similar time-courses of brain activation in the discordant condition. A whole-brain exploratory analysis was also conducted to investigate modulation by different empathic conditions. The same conjunction analysis used in the concordant condition was employed to identify common regions in the discordant condition. The conjunction maps in the concordant and discordant conditions were compared to check for similarities and differences in the common networks. To examine modulation of empathic processing on distinct mechanisms, a random-effects whole-brain voxelwise ANOVA with Participant as a random factor, and Scan, Task, and Person as fixed factors found brain regions with significant Scan x Task (Self vs. Other) x Person (Good vs. Bad) interactions. Scan x Task interactions were also tested to find distinct regions involved in *self* and *others* that were not modulated by empathic processing.

3.3 RESULTS

3.3.1 Manipulation check

3.3.1.1 Post-ratings on video clips of good and bad persons

Consistent with behavioral Experiment I, participants reported more positive subjective experiences with the video clip of the good person (Valence rating: M = 7.50, SD = 1.09) as compared to that of the bad person (M = 1.67, SD = 0.77), $t(17)$ = 15.65, p < .001, d = 3.69. They reported liking the good person (M = 8.33, SD=0.69) more than the bad person (M = 1.06, SD = 0.24), $t(17)$ = 41.07, p < .001, d = 9.68. They also reported that they were more similar to the good person (M = 5.83, SD = 1.54) than the bad person (M = 1.06, SD = 0.24), $t(17)$=13.36, p < .001, d = 3.15. Consistent with the results of behavioral Experiment I, these findings support the effectiveness of the manipulation for creating two different person conditions, one in which the person was more likely to be perceived as good and the other in which the person was more likely to be perceived as bad.

3.3.1.2 Learning check

Accuracy on the learning check was over 95% for both the good and bad persons, indicating that participants accurately described the good person as positive (M = 98.33%, SD = 5.07%) and the bad person as negative (M = 97.78%, SD = 5.04%). A 2 Persons (Good vs. Bad) x 2 Conditions (Match vs. Mismatch) repeated measures ANOVA showed no main effects of Person, $F(1, 17) = 0.13$, $p = .73$, or Condition, $F(1, 17) = 0.00$, $p = 1.00$, as well as no interaction effect, $F(1, 17) = 0.00$, $p = 1.00$. Accuracy with regard to Person was not modulated by the Condition. These results demonstrate that participants performed well on this descriptive task.

3.3.2 Emotion rating data

A 2 Tasks (Self vs. Other) x 2 Persons (Good vs. Bad) repeated measures ANOVA revealed a significant interaction effect, $F(1, 15) = 25.42$, $p < .001$, $\eta_p^2 = .63$ (Figure 3.2). As expected, simple main effects with a Bonferroni correction for multiple comparisons showed a significantly decreased self-emotion ratings compared to other-ratings in the discordant condition ($p < .01$), but no significant difference between self- and other-ratings in the concordant condition ($p = .19$). There was also a significantly decreased self-ratings in the discordant conditions compared to the concordant condition ($p < .01$) but no significant difference in the emotion ratings of *others* between these two conditions ($p = 1.00$). These results are consistent with behavioral Experiment I, which indicates that participants felt more similar emotional responses to the good person than the bad person. Consistent with this finding, less similarity between *self* and *other* in the discordant condition than the concordant condition was due to the decrease in one's own emotional responses to the bad person.

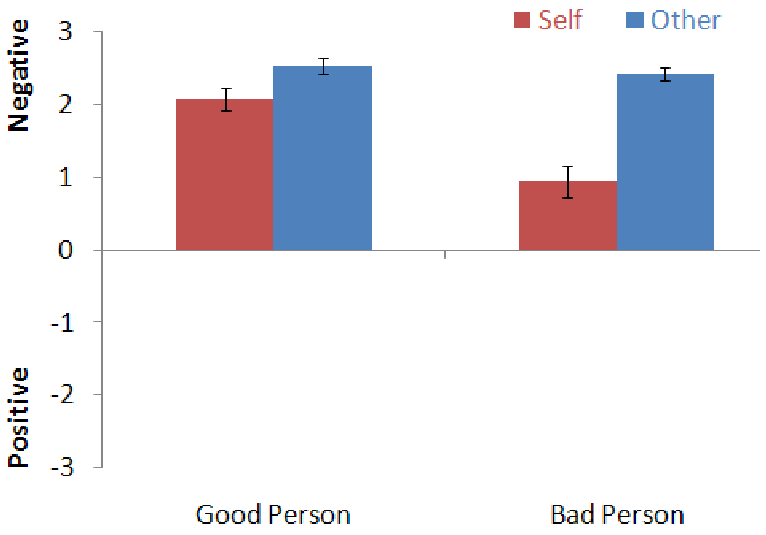

Figure 3.2 On-line emotion ratings of *self* and *others* during the scanning. Note. Y-axis: emotion rating scale: 3=very negative, 0=nothing or neutral, and -3=very positive.

3.3.3 Imaging results

3.3.3.1. Concordant condition ('good' person) for replication

3.3.3.1.1 ROI analysis: ROIs identified in the meta-analytic study

It was hypothesized that the DMPFC, LPFC, and amygdala would be common regions associated with explicit emotional evaluation of *self* and *others*. The insula and rACC were hypothesized as distinct regions specifically involved in explicit emotional processing of *self*, whereas the STS and TPJ were hypothesized as distinct regions specifically involved in emotional processing of *others*.

Common regions. Mixed-effect analyses showed significant interaction effects of Scan x Task (Self > Control) and Scan x Task (Other > Control) in the DMPFC, but not in the LPFC and amygdala. Time-courses in the DMPFC showed significantly greater activity in both *self*, $F(8, 195.08) = 2.30$, $p < .05$, $\eta^2 = .09$, and *other*, $F(8, 218.05) = 3.17$, $p < .01$, $\eta^2 = .10$, compared to the control task. However, the LPFC and amygdala did not show significant Scan x Task interaction effects in both *self* and *other* (all *ps* > .70).

Distinct regions. The insula and rACC, which are hypothesized as *self*-distinct regions, did not show significant Scan x Task (Self > Other) interaction effects (all *ps* > 1.0). There were no significant interaction effects of Scan x Task (Other > Self) in the pSTS and TPJ, which are *other*-distinct regions (all *ps* > .70). However, it is worth noting that some distinct regions, including the insula, showed the predicted brain activation patterns (Self > Other), although they did not yield significant results. It is possible that the power may not have been large enough to detect significant differences, which could be due to the small areas of the ROIs.

3.3.3.1.2 Whole-brain exploratory analysis

Common regions. A conjunction analysis was conducted to identify brain regions that showed '*self*>*control*' and '*other*>*control*' in the concordant condition. This analysis revealed several brain regions commonly involved in explicit emotional processing of both *self* and *others*. These regions included the DMPFC (BA10/9), PCC/Precuneus (BA23/30/31), VMPFC (BA10), VLPFC/IFG (BA47), bilateral TPJ extending to IPL (BA39/40), bilateral aSTG/MTG (BA21/22), left temporal pole (TP), and visual cortex (BA18/19) (Table 3.2). The peaks of time-courses in these regions were greater in both *self* and *others* compared to the control task. Time-courses are presented in the DMPFC, PCC/precuneus, and VLPFC (Figure 3.3A and 3.3B).

Table 3.2 Common regions between s*elf* and *others* in the good person and bad person conditions

	Concordant condition (good person)							Discordant condition (bad person)						
					Tal coordinates							Tal coordinates		
Regions	Lat	BA	SIZE	MAX F	X	Y	Z	Lat	BA	SIZE	MAX F	X	Y	Z
Frontal cortex														
DMPFC/SFG	L	9/10	351	5.38	-4	57	25	L	9	1175	16.44	-3	49	32
DMFPC/SFG	L	10	35	4.51	-8	65	17	R	9/10	677	14.78	8	56	25
DMPFC/SFG	R	9/10	701	8.46	9	58	24	R	8	237	8.96	2	24	49
DMPFC/SFG	L	8	527	8.19	-10	46	44							
VMPFC/MPFC	L	10	304	6.36	-3	56	2	L	10	313	7.13	-3	58	3
VMPFC/MPFC	R	10	217	6.72	4	56	-5	R	10	1150	9.64	7	59	6
VMPFC/MPFC	R	10	690	7.1	6	58	5	R	10/11	137	4.94	8	40	-12
VLPFC/IFG	L	47	598	5.2	-41	26	-3	L	45/47	4654	19.49	-45	22	3
VLPFC/MFG	L	47	64	5.4	-33	34	-4	L	47	32	7.35	-33	33	-4
cACC								R	32/8	144	5.78	4	24	35
cACC/MPFC								L	32	66	8.16	-2	22	39
DLPFC/MFG								R	9	477	5.14	48	26	33
pSMA/SFG								L	6	397	6.73	-4	3	53
SFG/MFG								L	10	124	4.53	-25	56	14
SFG								R	8	325	5.67	16	33	51
Parietal cortex														
PCC	R	23/31	59	5.16	4	-45	24	R	30/31	410	8	11	-61	15
PCC	-	31	1908	11.33	0	-44	32	R	31/23	5366	13.4	1	-35	34
								L	30/31	742	5.91	-12	-60	12
Precuneus	R	7/31	3152	11.93	1	-54	37	R	7/31	7462	13.96	2	-58	40
								L	7	237	6.83	-16	-70	47
TPJ extending to IPL	L	39	240	5.26	-40	-58	35	L	40/7	1987	12.02	-39	-57	42
TPJ extending to IPL	R	39/40	516	6.84	42	-61	41	R	40/39	434	6.27	46	-58	35
Temporal cortex														
TP/aMTS	L	21/38	480	6.19	-49	4	-25	L	21/20	4226	16.4	-53	-2	-17
TP/aSTS	L	38	323	5.8	-48	12	-22	L	38	5471	17.7	-51	0	-8
aMTS	R	21	928	7.8	62	-6	-9	R	21/20	92	7.39	62	-5	-17
aSTS	R	21/22	328	7.26	59	-11	-1	R	22/21	358	9.87	60	-10	-1
aSTS/MTS	L	22/21	1661	10.36	-55	-11	0							
pSTS extending to IPL								L	22/13	1025	11.49	-51	-39	16
Visual cortex														
Inferior Occipital G	L	18/19	149	6.23	-32	-77	-5	L	19/18	605	12.38	-35	-75	-5
								R	19	421	10.73	36	-77	-5
Middle Occipital G	L	18/19	1881	7.48	-29	-83	6	L	19/18	3764	14.38	-29	-78	7
Middle Occipital G	R	19/18	1451	7.93	31	-89	11	R	19/18	2522	10.6	32	-85	6
Cuneus	L	17	371	5.45	-19	-83	7	L	18/17	3603	12.52	-11	-83	13
Cuneus								R	17	1249	9.2	18	-85	9
Cuneus								R	19	416	9.21	25	-84	32
LingualGyrus	R	17/18	60	5.76	19	-85	4	R	18	5927	11.8	2	-78	-3
Subcortical and Cerebellar														
CingulateG/Caudate								L	-	74	8.34	-15	-5	27
CingulateG/Caudate								R	-	238	5.9	16	1	28
LentiformNucleus								L	-	350	5.5	-21	9	0
LentiformNucleus								R	-	82	4.54	25	2	12
Thalamus								L	-	249	6.02	-20	-28	9

Thalamus	R	-	144	5.18	22	-27	9
ParahippocampalGyrus	L	19/37	136	5.76	-32	-48	-5
Amygdala	L	-	277	8.62	-25	-5	-15
Uncus	L	-	46	6.34	-31	0	-29
Declive	R	-	806	7.34	32	-65	-15
Culmen	L	-	39	4.18	-16	-29	-19

Note. Results are significant at p < .0025, 25 voxels contiguity (good person condition) and at p < .0025, 21 voxels contiguity (bad person condition). L/R = left/right, BA=Brodmann Area, Size=number of voxels

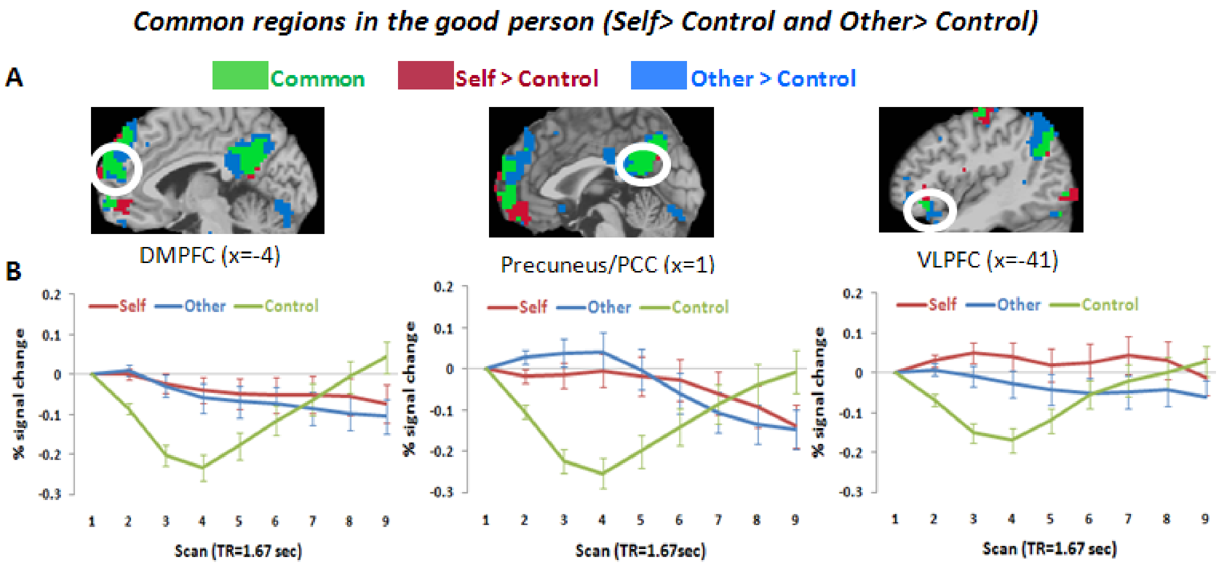

Figure 3.3 Common regions in the good person condition: A. Brain regions, such as the DMPFC, PCC, and VLPFC, commonly involved in both *self* and *other*. B. Time-courses in these regions: Peak brain activation (scan5) was greater in both *self* and *other* conditions compared to the control condition.

Distinct regions. As hypothesized, some brain regions, such as the rACC (BA24), were identified as distinct regions that were specifically involved in *self*. *Self*-distinct regions also included the MFG, part of STS, and SPL/postcentral gyrus (Table 3.3). The rACC showed greater activation at the peak of time-courses in *self* compared to *other* (Figure 3.4A and 3.4B). In contrast, parts of the pSTS/MTS (BA21/22) and left IPL (BA40) were revealed as distinct regions that were selectively involved in o*ther*. *Other*-distinct regions also included part of the IPL, PCC, and visual cortex (Table 3.3). The pSTS/MTS and IPL showed greater activation at the peak of time-courses in *other* than *self* (Figure 3.4A and 3.4B).

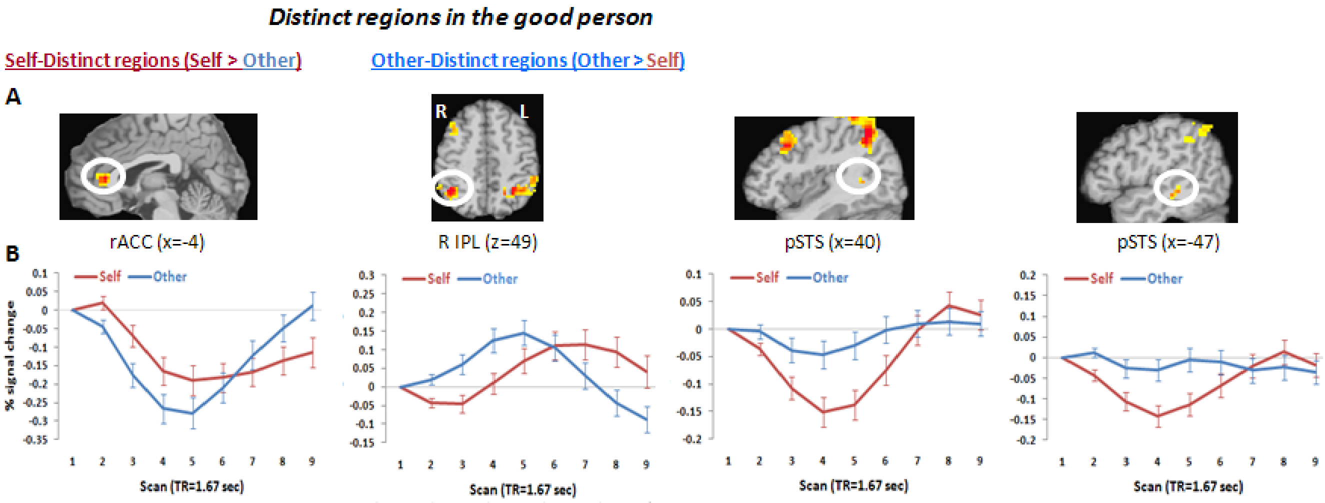

Figure 3.4 Distinct regions in the good person condition: A. Distinct brain regions involved in both *self* (rACC) and *other* (IPL and pSTS). B. Time-courses in these regions: A peak of brain activation in the rACC was greater in *self* compared to *other*, whereas a peak of brain activation in the IPL and pSTS was greater in *other* compared to *self*.

Table 3.3 Distinct regions in the good person condition

Self > Other					Tal coordinates		
Regions	Lat	BA	SIZE	MAX F	X	Y	Z
Frontal cortex							
rACC	R	24	228	7.35	3	34	12
SFG	L	10	154	5.07	-23	49	22
MFG	L	9/8	169	5.87	-31	27	36
MFG	R	8	142	5.87	40	27	39
MFG	R	6	473	6.97	32	4	46
PrecentralG	R	6	110	4.33	32	-11	57
Parietal cortex							
SPL	L	40	166	7.02	-34	-42	42
SPL	R	40/7	1753	8.49	42	-44	51
SPL/Precuenus	L	7	92	9.43	-25	-51	45
SPL/Precuenus	R	7	850	10.11	30	-54	51
Temporal cortex							
STS	R	22/39	27	4	43	-56	17
MTG	L	19	63	3.99	-35	-76	22
Other > Self							
Frontal cortex							
SFG	L	8	94	5.91	-2	35	48
SFG	R	8	102	5.37	5	28	50
SFG	L	10	159	5.11	-22	51	15
MFG	R	8	689	6.74	39	19	42
MFG	R	6	52	5.04	26	-4	43
CingulateG/CaudateBody	L	-	1052	9.23	-14	-2	29
Parietal cortex							
IPL/SPL	R	40	1025	9.91	42	-50	47
Precuneus	R	39	35	5.26	28	-58	34
IPL/SPL	L	40	1138	7.54	-37	-49	49
Precuneus	L	7	193	7.24	-25	-49	49
PCC	R	31	68	4.93	14	-37	26
CingulateG	-	23/24	75	4.68	0	-19	30
Temporal cortex							
pSTS	R	39	6	3.6	40	-46	13
pSTS/pMTS	L	21/22	64	4.61	-47	-30	3
Visual cortex							
Cuneus	L	17	109	4.83	-21	-81	10
LingualG/FusiformG	L	18	1231	8.3	-15	-77	-8
Subcortical and cerebellar							
Amygdala/parahippG	L	-	30	3.96	-23	-2	-21
Declive	R	-	409	5.36	19	-65	-17
Declive	L	-	347	6.41	-8	-73	-13

Note. Results are significant at p < .0025, 11 voxels contiguity. L/R = left/right, BA=Brodmann Area, Size=number of voxels

3.3.3.2. Modulation by empathic processing (good/bad persons)

3.3.3.2.1 ROI analysis: ROIs empirically identified in the concordant condition

An ROI analysis was conducted to examine whether brain activation in the common and distinct regions identified in the concordant condition are consistent with those in the discordant condition. To accomplish this, time-courses in the common and distinct regions were extracted in the discordant condition. For the common regions, mixed-effect analyses were conducted to test whether these regions showed greater activity in both *self* and *others* than the control task. For the distinct regions, mixed-effect analyses of Scan x Task x Person were performed to test potential modulation by different empathic conditions.

Common regions. The DMPFC showed a significant Scan x Task interaction (Self > Control), $F(8, 183.74) = 5.71$, $p < .001$, $\eta^2 = .20$, and a marginally significant Scan x Task interaction (Other> Control), $F(8, 190.73) = 1.88$, $p =.06$, $\eta^2 = .07$. There were significant interaction effects of Scan x Task for both *self* and *others* in the PCC/precuneus (Self > Control, $F(8, 168.58) = 4.56$, $p < .001$, $\eta^2 = .18$; Other > Control, $F(8, 196.55) = 3.19$, $p < .01$, $\eta^2 = .11$), and VLPFC (Self > Control, $F(8, 202.21) = 7.40$, $p < .001$, $\eta^2 = .23$; Other > Control, $F(8, 219.70) = 2.07$, $p < .04$, $\eta^2 = .07$) in the discordant condition. These regions showed greater activation in both *self* and *others* compared to the control task. Other common brain regions, such as the bilateral TPJ and bilateral aSTS/MTS, showed similar significant interaction effects (all *ps* $<.001$, $\eta^2 > .08$). These results indicate that similar common brain networks are involved in general emotional processes between *self* and *others* in the discordant condition.

Some brain regions, such as the DMPFC, PCC/precuneus, bilateral TPJ, VLPFC, and left TP, showed increased activity for *self* (all *ps* $< .05$, $\eta^2 > .09$) and the PCC/precuneus showed increased activity for *other* ($p < .01$, $\eta^2 = .010$) in the discordant condition compared to the concordant condition, indicating that brain activation in these regions were modulated by the discordant condition. However, other common regions, such as the aSTS/MTS and visual cortex, that are likely involved in social and visual processing did not show different time-courses in the discordant condition compared to the concordant condition, indicating that these regions were not modulated by the discordant condition.

Distinct regions. The rACC was identified as a *self*-distinct region associated with explicit emotional processing of *self*, whereas the IPL and pSTS were identified as *other*-distinct regions in the concordant condition. A mixed-effect analysis showed no significant interaction effect of Scan x Task x Person (*p* >. 80), indicating that rACC activity was not modulated by the discordant condition. *Other*-distinct regions, such as the bilateral IPL and pSTS, did not show significant Scan x Task x Person interaction effects (all *ps* > .10). These results indicate that brain activity in distinct regions was not modulated by the discordant condition.

3.3.3.2.2 Whole-brain exploratory analysis

Common regions. A conjunction analysis revealed similar, but relatively broader, networks as common regions in the discordant condition than in the concordant condition. These common regions consisted of the DMPFC (BA10/9), PCC/Precuneus (BA23/30/31), VMPFC (BA10), VLPFC (BA47), bilateral TPJ extending to inferior parietal lobe (IPL) (BA39/40), aSTG/MTG (BA21/22), and superior frontal gyrus (BA8) (Table 3.2). Similarity in common regions between the concordant and discordant conditions was presented as overlapping regions (Table 3.4 and Figure 3.5). Activation in all common regions was greater in both *self* and *other* as compared to the control task. Figure 3.6A presents time-courses in the DMPFC, PCC/precuneus, and VLPFC. Unique common regions were found in the discordant condition.

As hypothesized, these unique common regions included the right DLPFC and cACC (Table 3.2 and Figure 3.6B) in the discordant condition, which potentially represents conflict and cognitive effort in the discordant condition. Common regions uniquely involved in the discordant condition also included some subcortical regions, such as the thalamus, ventral striatum (ventral putamen), and parahippocampal gyrus extending to the amygdala (Table 3.2).

Table 3.4 Same common regions for both good person and bad person conditions

					Tal coordinates		
Regions	Lat	BA	SIZE	MAX F	X	Y	Z
Frontal cortex							
DMPFC/MPFC	L	8/9	231	7.3	-4	50	39
DMPFC/MPFC	L	9/10	259	5.38	-4	58	26
DMPFC/SFG	L	8	375	8.19	-9	46	43
DMPFC/SFG	R	10/9	373	8.14	9	59	24
VMPFC/MPFC	L	10	143	6.23	-2	57	2
VMPFC/MPFC	R	10	499	7.1	5	58	4
VLPFC/IFG	L	47	335	5.08	-42	27	-1
MFG	L	47	18	5.09	-33	33	-4
PrecentralG	L	6/4	365	8.3	-37	-11	59
Parietal cortex							
PCC	L	23/31	73	5.08	-2	-47	24
PCC	R	31	44	5.16	4	-45	24
Precuneus	R	7/31	2987	11.93	1	-54	37
TPJ extending to IPL/SPL	L	39	188	5.26	-40	-58	35
TPJ extending to IPL/SPL	R	39	86	5.58	45	-58	36
Temporal cortex							
aSTS/aMTS	L	21/22	1305	10.23	-56	-12	1
aMTS/aSTS	R	21	766	7.8	62	-6	-9
TP/aMTS	L	21/38	380	6.19	-49	4	-25
Occipital cortex							
MOG/IOG	L	18/19	1113	7.48	-30	-79	5
MOG	L	19/18	718	7.93	31	-89	9
Cuneus/Lingual G	L	17	299	5.45	-19	-83	7
Cuneus/Lingual G	L	17	294	7.11	20	-87	8

Note. L/R = left/right, BA=Brodmann Area, Size=number of voxels

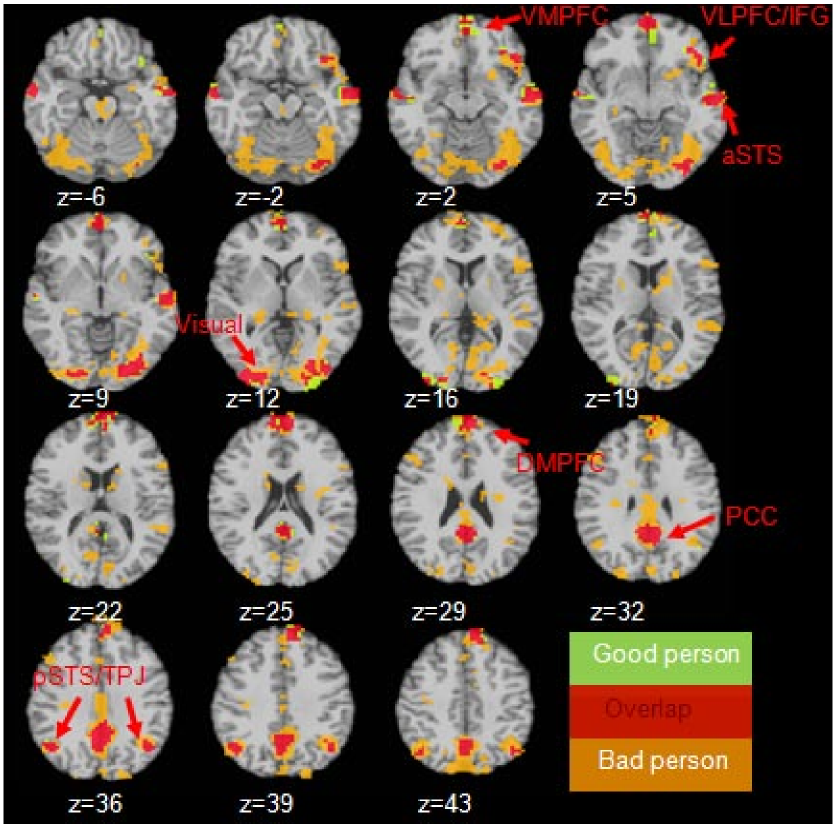

Figure 3.5 The same common regions in both the good person and bad person conditions are presented as overlapping regions (red). Several main common regions, like the DMPFC and PCC, overlap in both conditions. However, common regions in the good person condition were more widespread compared to common regions in the bad condition. Some unique common regions, like cACC and DLPFC, were identified in the bad person condition.

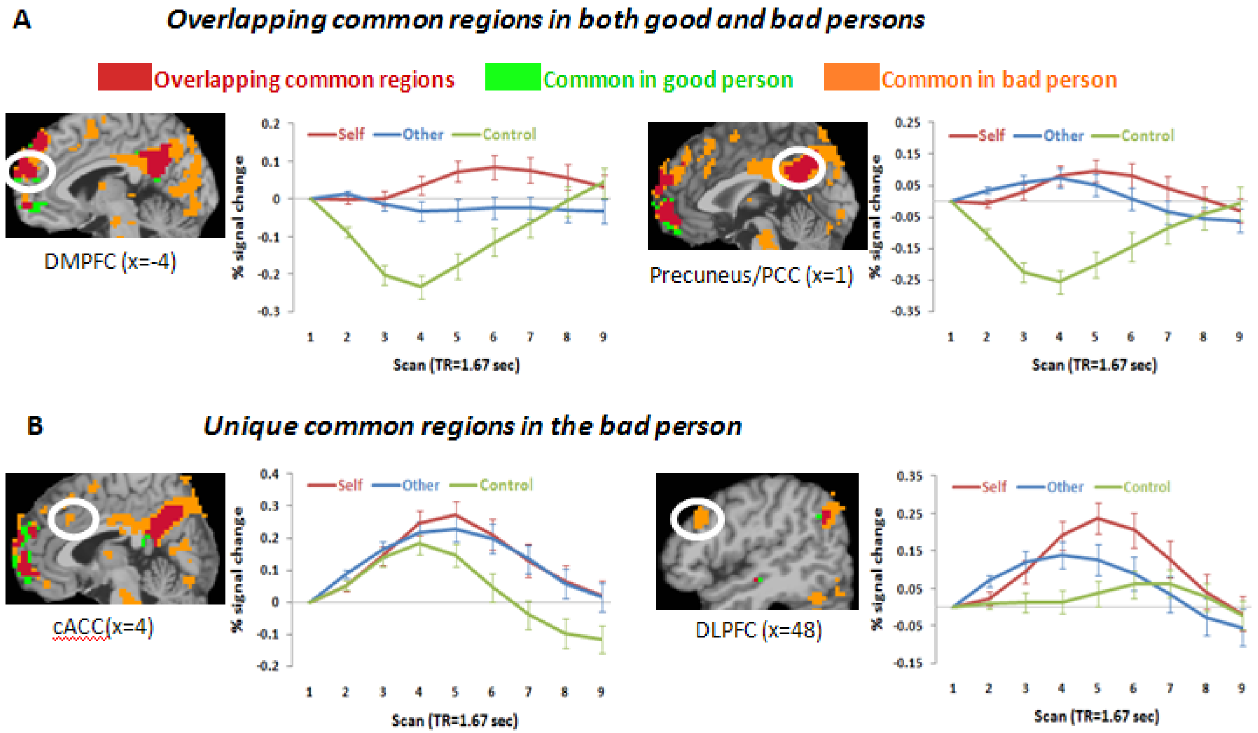

Figure 3.6 Common regions in the good person and bad person conditions: A. Similar common brain regions, such as the DMPFC and PCC, were found in the concordant and discordant conditions. A peak of time-courses in *self* and *other* was greater than control in the overlapping common regions. B. Unique common regions, such as the cACC and DLPFC, were also found in the discordant condition. Such common regions represent enhanced conflict and cognitive effort in evaluating one's own emotional responses to the bad person and the bad person's emotions.

Distinct regions modulated by empathic processing. A random-effects whole-brain voxelwise ANOVA (Scan x Task x Person) identified several brain regions that were modulated by different empathic conditions (Table 3.5). The brain regions included the DMPFC, VMPFC (BA32/10) adjacent to the rACC, and left VLPFC (BA47) extending to the insula (BA13) and STS (BA22). These regions showed no difference in brain activity between *self* and *others* in the concordant condition, but did show significant differences between *self* and *others* in the discordant condition (Figure 3.7). Modulation in these regions was due to increased activity by *self* in the discordant condition.

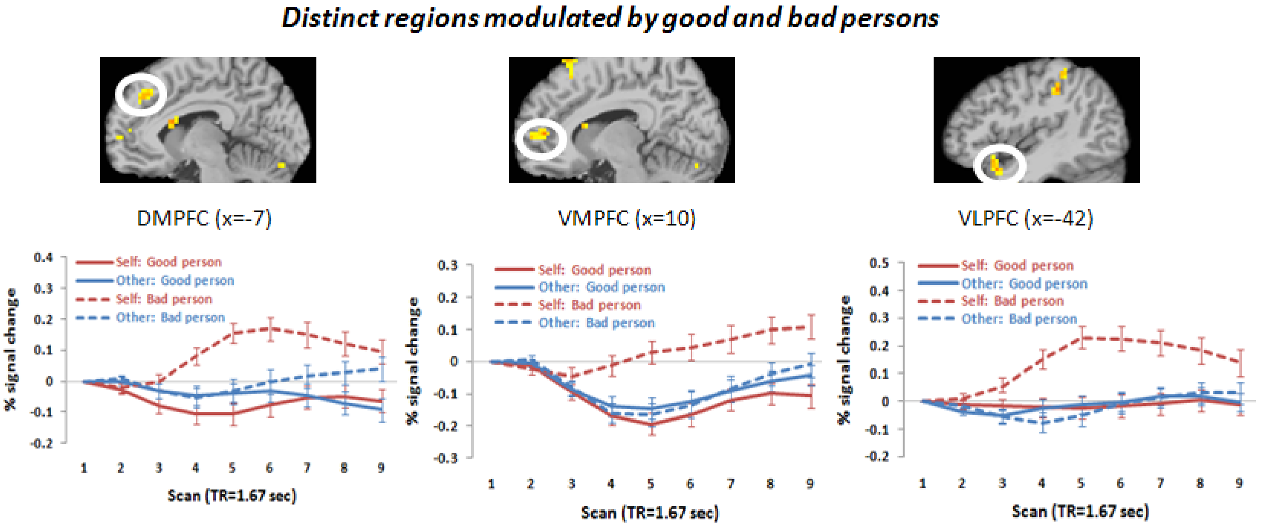

Figure 3.7 Modulation by the good and bad persons. The DMPFC/SMA, MPFC adjacent to the rACC, and VLPFC/aSTS/insula were modulated by good and bad persons. These regions may be involved in inhibition or regulation of one's own emotional responses to the bad person, consequently leading to a decrease in one's own emotional responses to the bad person. Thus, increased activity in these regions represents enhanced regulatory functions.

Table 3.5 Distinct brain regions modulated by empathic processing (good/bad persons)

					Tal coordinates		
Regions	Lat	BA	SIZE	Max F	X	Y	Z
Frontal cortex							
DMPFC	L	8	280	4.5	-7	37	38
DMPFC/SFG	L	8	415	5.46	-15	45	43
MPFC/VMPFC	R	10	668	5.05	10	49	13
SFG	R	10	61	4.46	23	52	10
SFG	L	9	119	4.96	-12	50	21
SFG	R	6/8	135	4.7	5	29	54
VLPFC/insula/aSTS	L	47	370	5.3	-42	17	-10
MPFC	L	9	50	4.03	-20	36	19
CingulateG	R	-	293	5.12	17	-15	29
CingulateG	L	24	234	4.71	-13	3	30
ACC	L	33/24	69	4.99	-5	13	22
MFG	R	6	227	5.78	34	1	46
PrecentralG	R	6	50	3.89	35	-8	61
PostcentralG	L	40	309	5.02	-38	-30	48
Temporal and Visual cortex							
MTG	L	21	152	5.06	-38	1	-31
Cuneus	R	30	263	7.9	23	-71	8
LingualGyrus/IOG	L	18	719	5.33	-16	-83	-7
MOG	L	18/19	83	4.26	-26	-81	-10
MOG/Cuneus	R	18	399	6.25	26	-88	18
Cerebella							
Declive	R	-	192	5.66	5	-72	-15
Declive	L	-	14	3.66	-3	-73	-14
DecliveofVermis	R	-	333	5.52	1	-72	-15

Note. Results are significant at p < .0025, 25 voxels contiguity. L/R = left/right, BA=Brodmann Area, Size=number of voxels

Distinct regions not modulated by empathic processing. The ROI analysis showed that *self*- and *other*-distinct regions were not modulated by different empathy conditions. A random-effects whole-brain voxelwise ANOVA revealed Scan x Task (Self vs. Other) interaction effects in several brain regions (Table 3.6). In accordance with the ROI analysis, *self*-distinct regions, such as the rACC (BA24), showed higher activity in *self* than *others* across the two different persons conditions (Figure 3.8A and 3.8B). Consistent with the original hypothesis, the bilateral insula showed greater activity in *self* and *others* regardless of different empathy conditions

(Figure 3.8A and 3.8B). Part of the right IPL and pSTS were also identified as *other*-distinct regions. These regions demonstrated greater activity in *others* than *self* (Figure 3.8C).

Table 3.6 Distinct regions regardless of empathic processing (good/bad persons)

Self > Other

					Tal coordinates		
Regions	Lat	BA	SIZE	MAX F	X	Y	Z
Frontal cortex							
rACC	R	32/24	874	8.5	4	35	12
Subgenual ACC	R	-	47	4.49	10	21	-5
SFG	L	9	5520	10.98	-9	39	34
MFG	R	10	286	7.98	30	58	11
MFG	L	10	1334	8.54	-31	48	15
MFG	R	9	1745	7.14	38	21	39
MFG	L	9	865	6.54	-38	29	31
MPFC	R	9	436	6.3	7	46	25
MPFC	L	6	458	6.59	-9	16	46
IFG	L	45	196	4.77	-54	21	11
Insula/VLPFC	L	13/47	169	4.61	-39	11	-5
Insula/VLPFC/aSTS	R	13/47	520	8.06	41	13	-3
PostcentralG	R	2	131	5.45	53	-24	51
PrecentralG	L	6	54	4.14	-38	2	35
Parietal cortex							
SPL	L	40	3063	10.17	-38	-47	46
AngularG	R	40	2639	10.24	41	-50	48
Precuneus	L	7	928	9.38	-22	-52	49
Precuneus	R	7	1270	9.12	24	-60	44
Temporal cortex							
pMTS/STS	L	22	612	5.14	-51	-35	9
pMTS	R	21/22	208	6.33	57	-37	-2
pMTS	L	39/19	224	4.98	-39	-60	18
aMTS/ITS	L	21/20	2326	10.25	-54	-1	-17
aSTS	L	22/21	488	6.44	-55	-6	-2
TP	L	38	343	6.63	-46	9	-21
TP	R	38	349	8.49	52	14	-23
Occipital cortex							
Cuneus	R	17	492	5.85	13	-81	12
Cuneus	R	19	140	4.87	26	-89	26
SOG	R	19/39	127	5.43	36	-77	29
LingualGyrus/IOG	R	18	254	5.47	26	-75	-5
MOG/LingualG	L	19	1557	12.93	-27	-86	10
MOG	L	37/19	140	5.8	-40	-67	3
Subcortical and cerebellar							
Hippocampus/ParahippG	L	-	275	6.36	-28	-35	-2
SubthalamicNucleus	L	-	29	7.05	-7	-11	-5

MedialDorsalNucleus	R	-	30	5.61	5	-12	13
Thalamus/Pulvinar	R	-	721	11.26	13	-26	2
Other > Self							
Frontal cortex							
MFG	L	-	218	7.09	-27	54	9
MFG	R	-	109	4.97	39	16	44
MFG	R	10	393	7.59	33	54	8
Pre/PostcentralG	L	4	788	5.53	-30	-21	62
Parietal Cortex							
IPL/SPL	R	40	935	8.68	45	-45	47
IPL	L	40	7	3.51	-40	-41	50
PCC/Precuneus	R	31	70	5.58	21	-36	33
PCC	R	23	16	5.05	12	-34	26
Precuneus	R	7	56	4.43	17	-53	45
Temporal cortex							
pSTS	R	22	106	7.16	39	-50	14
Visual cortex							
Cuneus/MOG	L	17	111	6.47	-21	-81	10
Cuneus/LingualG	L	18	542	5.49	-5	-75	8
Subcortical and cerebellar							
Thalamus	L	-	313	6.79	-7	-20	1
ParahippocampalG	L	27	82	5.86	-12	-34	0
Culmen	R	-	21	4.08	14	-43	-9
Declive	L	-	925	6.33	-18	-67	-16

Note. Results are significant at $p < .0025$, 11 voxels contiguity. L/R = left/right, BA=Brodmann Area, Size=number of voxels

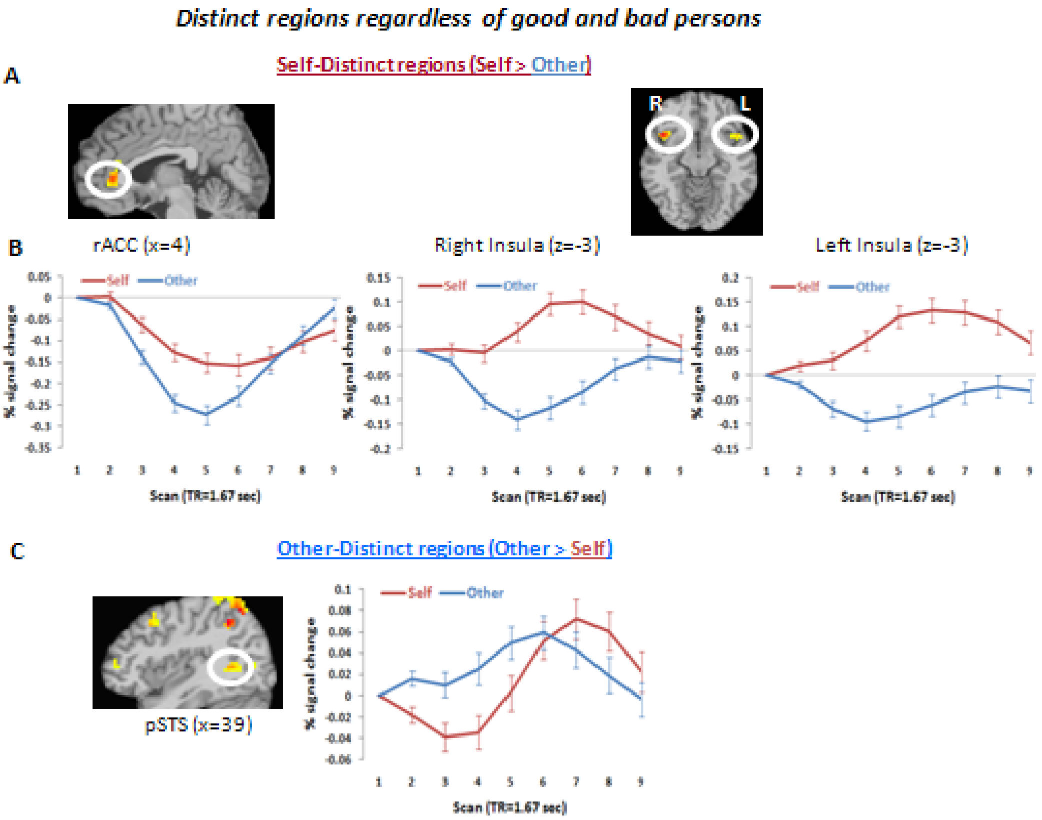

Figure 3.8 Distinct regions regardless of the good/bad persons: A. Distinct regions are specifically involved in *self*. B. As hypothesized, the rACC and bilateral insula showed greater peak activity in *self* compared to *other*. C. Distinct regions were specifically involved in *other*. Peak activity in the pSTS was greater in *other* than *self*.

3.3.4 Additional analyses

3.3.4.1 Relationship between dispositional measures and emotion ratings

Relationships between emotional ratings of *self* and *others* and dispositional individual differences are evident. As shown above, *self*-ratings were significantly different between the concordant and discordant conditions, indicating that their relationships may be different between the two conditions. Relationships between *self*-ratings and dispositional measures were tested separately in each condition. Specifically, the dispositional measures related to *self* were alexithymia (TAS) and the subscales of the IRI (empathic concern (EC) and personal distress (PD)). *Self*-ratings were not significantly correlated with alexithymia and PD. *Self*-ratings were positively correlated with EC in the concordant condition (r = .53, p < .05), but not in the discordant condition (r = .39, p = .13), which indicates that individuals who have high levels of EC reported more intense emotional responses to the good person relative to those who have low levels of EC. Emotion ratings of *self* reflect empathic concern for the good person in the concordant condition.

Relationships between *other*-ratings and dispositional measures related to *others*, such as autistic traits (AQ) and the perspective taking subscale (PT) of the IRI, were tested. *Other*-ratings were negatively correlated with AQ (r = -.39, p < .05). Individuals with high levels of autistic traits rated that other people felt less intense emotions compared to those with low levels of autistic traits. *Other*-ratings were not significantly correlated with levels of PT traits.

Social desirability (MCSDS) was examined as to whether participants' tendency to report answers in a socially desirable manner was correlated with emotion ratings of *self* and *others*. *Self*-ratings were not significantly correlated with social desirability (r = .29, p = .13), whereas *other*-ratings were positively correlated with social desirability (r = .56, p < .01). Individuals with high levels of social desirability reported that other people felt more intense emotions compared to those with low levels of social desirability. This result indicates that understanding others' emotions accurately may be a socially desirable human behavior. Mood (PANAS) was not correlated with *self*-ratings and *other*-ratings.

3.3.4.2 Relationships between dispositional measures and peak brain activation in distinct regions

Possible relationships between distinct regions and dispositional measures were examined. There might be correlations between self-distinct regions and dispositional measures (alexithymia, EC, and PD) which may modulate evaluation of one's own emotion. Peak rACC activity was not significantly correlated with alexithymia, EC, and PD in either person condition. Peak activity in the left insula was positively correlated with EC in the discordant condition ($r = .53$, $p < .05$), but not in the concordant condition ($p > .10$). Individuals with high levels of EC showed higher peak activity in the left insula relative to those with low levels EC. It is possible that no modulation of empathic processing in the insula may be mediated by EC.

Peak left insula activity was not significantly related to alexithymia and PD. Peak activity in the right insula was positively correlated with alexithymia in the discordant condition ($r = .50$, $p < .05$), but not in the concordant condition ($p > .10$). Individuals with high levels of alexithymia showed greater right insula activity in the discordant condition compared to those with low levels of alexithymia. High alexithymia individuals may have more difficulty identifying their own emotional responses to the bad person than to the good person, which would cause more effortful self-processing in the right insula. Peak activity in the right insula was not significantly correlated with EC or PD.

There might be correlations between other-distinct regions and dispositional measures (AQ and PT) which may modulate evaluation of others' emotions. Other-related regions, including the IPL and pSTS, were not significantly correlated with autistic traits and PT. Additionally, neither *self*- nor *other*-distinct regions were significantly correlated with social desirability and mood.

3.4 DISCUSSION

This study examined 1) the common and distinct neural mechanisms involved in evaluating one's own emotions (*self*) and others' emotions (*others*) (replication) and 2) whether these common and distinct mechanisms were modulated by empathic processing through the manipulation of different characteristics of target persons. In the following sections, three main findings were discussed. First, this study partially replicated findings from past research integrated by a meta-analysis. Second, this study demonstrated that common and distinct regions were not modulated by empathic processing. Finally, there were brain regions modulated by empathic processing.

Replication of findings from previous studies in the concordant condition

This study partially replicated findings from our meta-analytic study regarding common and distinct mechanisms associated with explicit emotional processing of *self* and *others* in the concordant condition. Consistent with our meta-analytic study, the DMPFC (BA10/9) and VLPFC (BA47) were identified as common regions. However, the subcortical regions, such as the amygdala, involved in emotional processing were not identified as common regions. Presumably, such common emotional information may be processed by different brain regions, such as the aSTS/MTS and TP, which have been implicated in social and emotional information processing (Nummenmaa & Calder, 2009; Wicker, Perrett, Baron-Cohen, & Decety, 2003). More distributed common brain regions including the PCC and VMPFC were found compared to our meta-analysis study. This may be due to more common processing between two types of emotional evaluation (*self* and *others*) than between three different types of emotional evaluation (*self*, *others*, and *stimulus*) which were compared in the meta-analytic study. Potentially, mechanisms commonly involved in *self* and *others* may represent shared evaluative processing between *self* and *others* rather than emotion-cognition interactions associated with conscious/explicit emotional processing.

As hypothesized, the rACC and pSTS were identified as distinct regions specifically involved in *self* and *others*, respectively. Inconsistent with our meta-analytic study, the insula and TPJ were not identified as distinct regions. The insula showed greater activation in *self* than in o*ther*, but activation differences between *self* and *others* were not significant at our statistical threshold (p<.0025). More trials may be required to increase the power to detect significant differences in this region. Surprisingly, bilateral TPJ regions that were hypothesized to be distinct regions were identified as common networks. Lombardo et al. (2010) reported that the TPJ region is commonly involved in mentalizing about both *self* and *others.* The TPJ, as a common network, may represent inferential processing of current mental states of both *self* and *others*.

Common and distinct mechanisms not modulated by empathic processing

It was hypothesized that if common and distinct regions were not associated with empathic processing, similar common and distinct regions would be identified regardless of different empathy conditions. Substantially similar common and distinct regions were found regardless of different empathic processing (Figure 3.9 (A)). These suggest that some common and distinct regions are not confounded by empathic processing.

Common regions. Widespread common networks were identified including the MPFC, PCC/precuneus, TPJ (BA39/40), anterior STS/temporal pole (BA22), and visual cortex. These distributed common networks may be associated with shared general processes between *self* and *others*, such as voluntary emotional evaluations (i.e., keep thinking about how I feel and how others feel), in socially interactive situations (Adolphs, 2003; Gusnard, Akbudak, Shulman, & Raichle, 2001) and in imagined socio-emotional situations (Frewen et al., 2010).

Interestingly, these common networks, including the DMPFC, VMPFC, PCC and TPJ, overlapped considerably with default mode networks (DMN) (Fox et al., 2005; Fransson, 2006; Schilbach, Eickhoff, Rotarska-Jagiela, Fink, & Vogeley, 2008). Default mode networks are correlated with spontaneous internal processing and social cognition, including self-reflection and mentalizing (Fair et al., 2008; Iacoboni, 2006; Schilbach et al., 2008). Thus, common mechanisms of explicit evaluation of one's own and others' emotions represent default mode networks in social interactive contexts. Activity in the common networks may represent internal processing, which occurs similarly during baseline/resting states in social contexts. Time-courses in the common regions showed relatively little change during evaluation of one's own emotion and others' emotions compared to baseline, possibly due to pre-established ongoing, conscious/internal processing during the baseline in socio-emotional situations.

Alternatively, widespread common networks may be driven by deactivation in the control condition. The control task was associated with relatively low levels of social information processing (e.g., face), but associated with simple cognitive processing (e.g., reading sentences). Thus, common networks were deactivated by simple cognitive processing or external processing of stimuli in the control condition. Deactivation by the control task is possibly due to a reallocation of resources to switch internal processing to performance of the control task (McKiernan, Kaufman, Kucera-Thompson, & Binder, 2003) or due to a lack of internal processing (Fransson, 2006).

Self-distinct regions. The rACC (BA24) and anterior insula (AI: BA13) were specifically involved in evaluation of one's own emotions. However, there regions were not modulated by empathic processing. The task requiring participants to evaluate their own emotions triggered this region to engage in interoceptive and subjective experiences, and self-evaluation regardless of different empathy conditions. Consistent with these results, a recent study showed that these regions may not solely be related to empathy (Danziger, Faillenot, & Peyron, 2009).

Time-courses showed that the rACC was deactivated by both evaluation of one's own and others' emotions. The rACC was frequently reported as a brain region that was deactivated by self-evaluation (Beer, Lombardo, & Bhanji, 2010), internally cued emotional evaluation (Gusnard et al., 2001) and self-relevance (Moran, Macrae, Heatherton, Wyland, & Kelley, 2006). Specifically, Moran et al. (2006) reported that the rACC showed less deactivation in the high self-relevance condition than the low self-reference condition. Less deactivation in the rACC for *self* could represent more self-referential processing that is involved in one's own emotions compared to others' emotions, which is related to less self-referential processes. The AI was activated by interoceptive or self-awareness in evaluation of one's own emotions engaged in, but was deactivated in evaluation of others' emotions.

However, no modulation of empathy in the rACC and AI was inconsistent with previous studies which showed that the ACC and AI are involved in empathy. This discrepancy may be due to two possible reasons. First, previous studies examined the role of the rACC and AI in empathy, specifically in the contexts of pain and disgust (for reviews, see Lamm, Decety, & Singer, 2011). Thus, the rACC and AI in these studies would be specifically involved in somatovisceral empathy (Zaki, Weber, Bolger, & Ochsner, 2009). Second, previous studies did not use any explicit evaluation tasks, indicating that the rACC and AI are more likely involved in automatic empathic processing compared to our study.

Other-distinct regions. The IPL and pSTS/MTS were identified as distinct brain regions for *other*. The IPL, which is dorsally adjacent to the TPJ, is involved in Theory of Mind (TOM) and perspective taking (Kobayashi, Glover, & Temple, 2007; Ruby & Decety, 2004). As predicted, these regions were not modulated by empathic processing, which is consistent with emotion rating results showing similar *other*-ratings in both concordant and discordant conditions. The understanding of others' emotions may not be influenced by the target's characteristics, but may be influenced by emotional cues, such as facial expression. Activation in these regions did not differ from baseline to the evaluation of others' emotions, which reflects preoccupied social processes in the prestimulus baseline (Adolphs, 2003). Deactivation in *self* may reflect suspension of on-going social information processes in the pSTS.

Common and distinct mechanisms modulated by empathic processing

It was hypothesized that if common and distinct regions are associated with empathic processing, there would be modulation of empathic processing. As predicted, brain regions possibly involved in cognitive control and regulatory function were modulated by empathic processing (Figure 3.9 (B)), indicating that these regions were confounded by concordant/empathic processing.

Common regions. Modulation of the common regions by empathic processing may happen in two manners. First, common/shared regions between *self* and *other* may be biased by specific task demands (Lombardo et al., 2010). The ROI analysis showed that brain activation in some common regions, including the DMPFC and PCC, increased in *self* and *other* in the discordant condition. Such increased activation may be due to more effortful internal, evaluative processing of *self* and *other* in the discordant condition that is less common, but more ambiguous relative to the concordant condition (D'Argembeau et al., 2005; Mitchell et al., 2006).

Second, relatively more widespread common networks were found in the discordant condition compared to the concordant condition. As hypothesized, additional common regions, such as the cACC and DLPFC, were uniquely identified in the discordant condition. The cACC and DLPFC are implicated in conflict and cognitive effort (Botvinick, Cohen, & Carter, 2004; Wagner, Maril, Bjork, & Schacter, 2001). Conflict and cognitive effort to control a prepotent shared processing, such as an empathic tendency, may recruit the cACC and DLPFC. Additional subcortical regions that are unique common regions in the discordant condition may be due to negative emotional responses to the bad person’s face, which stimulates conflict and cognitive effort to evaluate one’s own emotions and the bad person’s emotions. However, there is a limitation in examining whether unique subcortical regions are solely associated with negative emotional responses to the bad person because it is difficult to disentangle possible different processes associated with the faces and negative sentences which are presented together.

Distinct regions. Brain regions, including the DMPFC, MPFC, and VLPFC, were modulated by empathic processing. These regions are implicated in the involvement of emotion regulation and inhibition (e.g., Dolcos & McCarthy, 2006; Urry, 2006; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008). Time-courses in the DMPFC/MPFC and VLPFC showed increased activity only when evaluating one’s own emotional responses to the bad person. Thus, increased activity in these regions indicates a regulatory function to inhibit socially undesirable emotional responses to the bad person, which could involve regulation strategies, such as reappraisal or distance. This finding suggests that these regions contribute to inhibition of empathic concern for the bad person. Importantly, modulation occurred adjacent to *self*-distinct regions, such as the MPFC and VLPFC, adjacent to rACC and AI, respectively. The rACC and AI may trigger the MPFC and VLPFC to regulate empathic concern for the bad person.

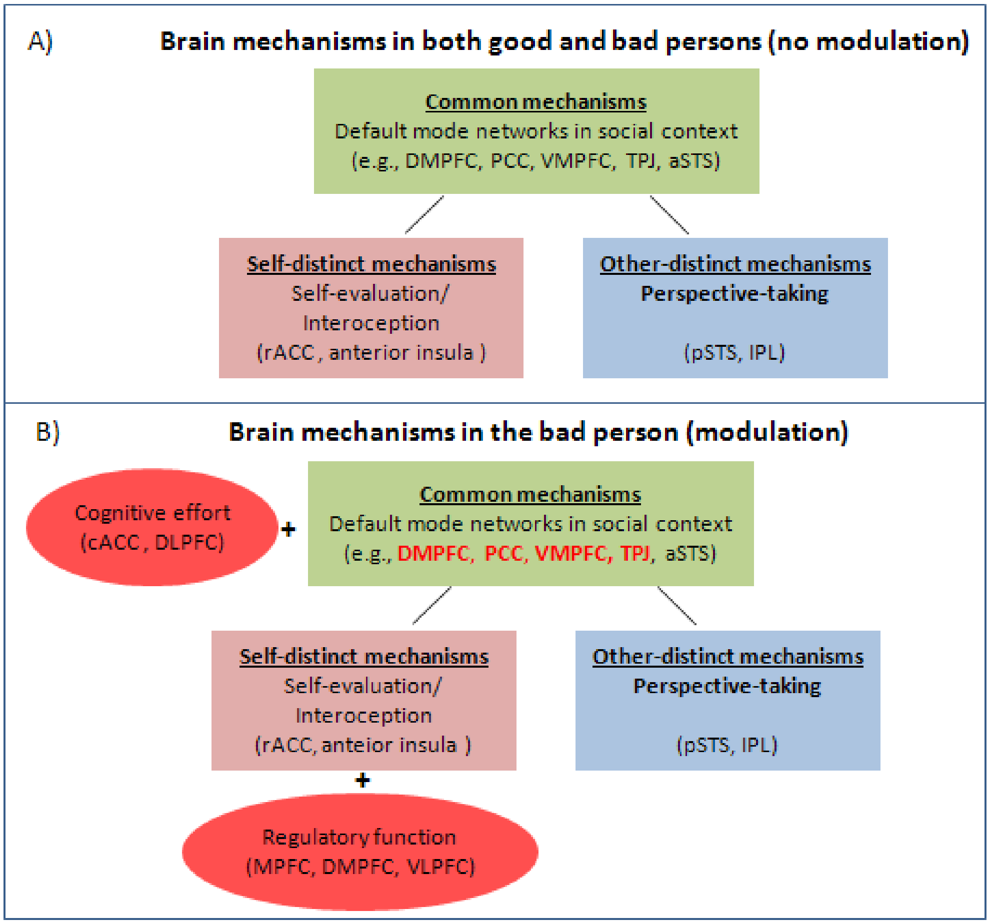

Figure 3.9 Summary of common and distinct brain regions associated with explicit evaluation of one's and others' emotions. A) Brain regions not confounded by empathic processing (good/bad persons). B) Brain regions modulated by empathic processing: 1) Modulation increased activation in common regions including the DMPFC, PCC, etc. (colored by bold red) and recruited additional common regions involved in cognitive effort and conflict and 2) Modulation recruited brain regions, possibly involved in regulation of undesired emotions.

Limitations and conclusion

There are some limitations to this study. As noted in behavioral Experiment I, this fMRI experiment has the same limitations in terms of stimuli types (simple form of stimuli, such as faces) and positive emotions. One potential limitation is that this study used fifteen sentences describing real-life negative events to obtain sufficient hemodynamic signals. It is possible that the use of several negative events befalling one person could make the experimental condition less realistic, meaning that the multiple events prevented the provoking of genuine emotions. This potential problem can be addressed in the second fMRI experiment in which more realistic ecological stimuli were used.

Despite such limitations, this study replicated common and distinct networks that have been elucidated by past research with the focus on the empathy condition. Explicit emotional evaluation of *self* and *others* recruits widespread common networks that potentially represent default mode networks in social contexts, and distinct regions, which are specifically involved in *self* and *others*. Another key finding is that there are common and distinct regions confounded by empathic processing. Modulation of empathic processing reflects more cognitive effort and conflict that is demanded by the discordant condition. Moreover, a decrease in one’s own emotional responses in the discordant condition may be due to increased activation in brain regions involved in regulatory function. These results suggest that future research of affective cognitive neuroscience should consider using both concordant and discordant conditions to avoid potential confounding effects by empathic processing on brain mechanisms associated with emotional processing in social contexts. Overall, this study suggests that social situations in which people do not empathize with other people may require multiple processes, including increased cognitive effort and regulatory function, as well as common and distinct mechanisms.

4.0 FMRI EXPERIMENT II: EXPLICIT EMOTIONAL PROCESSING OF *SELF* AND *OTHERS* IN COMPLEX, ECOLOGICAL SOCIAL CONTEXTS

4.1 INTRODUCTION

Explicit emotional processing in *self* and *others* occurs when people are engaged in actual social situations, demanding them to continuously monitor their own emotion and others' emotions (Levenson & Gottman, 1985). However, few imaging studies have been conducted to delineate neural mechanisms of explicit emotional processing in *self* and *others* in the context of complex social situations. Thus, relatively little is known about whether neural mechanisms of emotional processing in *self* and *others* in simple conditions are maintained in complex, ecological social contexts. The goal of this experiment was to examine brain networks associated with explicit emotional processing of *self* and *others* using complex, dynamic socio-emotional stimuli. More importantly, brain regions identified in fMRI Experiment I using simple conditions were directly compared to brain regions associated with the current experiment to investigate the feasibility of extending findings resulting from less ecological contexts (fMRI Experiment I) to more ecological social contexts (current experiment).

Literature consistently suggests that examining neural substrates using complex, ecological social situations is important in generalizing findings in simple experimental conditions to more ecological social contexts (Adolphs, 2006). To date, however, little attention has been devoted to examining whether neural mechanisms underlying emotional processing in simple experimental conditions using static pictures and simple discrete tasks are similarly engaged in explicit emotional processing in complex, ecological social contexts. Our solution to answer this research question was to conduct two different fMRI experiments: one fMRI experiment using simple experimental conditions using simple/impoverished information and another using complex experimental conditions using complex, dynamic socioemotional information. The findings from both fMRI experiments were then compared.

It was also critical that possible confound variables should be controlled. For example, to control potential variability driven by individual differences and experiment conditions, participants should take part in both fMRI experiments and the same experimental conditions (e.g., evaluation tasks and different person conditions) should be employed for both experiments, except for the main research condition, such as complexity levels of social contexts. Therefore, this experiment used the same participants and experimental conditions (e.g., evaluation tasks: *self*- vs. *other*-rating tasks, and different empathy conditions: concordant (empathy or good person) vs. discordant (non-empathy or bad person)) as fMRI Experiment I to investigate explicit emotional processing in *self* and *others* in complex social contexts. However, it used different socio-emotional stimuli such as video clips describing more realistic social situations and a different evaluation method (continuous emotion evaluation) which occurs in real life social contexts. Direct comparisons between fMRI Experiment I and the current experiment were accomplished by conducting ROI analyses. For example, brain activation in the ROIs identified in fMRI Experiment I was assessed to examine whether brain activation showed similar patterns in the current experiment.

Previous imaging studies provided evidence of possible generalization of previous findings in more realistic social contexts, although these studies have some limitations in controlling other factors such as subjects, tasks, and cognitive demands due to methodological problems. Regarding social cognition, Spiers et al. (2006) explored neural mechanisms involved in the experience of mentalizing during the navigation of virtual reality. They found that the pSTS, MPFC, and temporal pole (a well-known brain region involved in mentalizing), were activated by thinking about others' thoughts and beliefs, which spontaneously occurred in more dynamic naturalistic contexts. In emotion research, Zaki et al. (2010) showed that the MPFC and IPL were associated with continuous emotion ratings of others' emotions. Hutcherson et al. (2005) reported that the rACC and insula, both associated with one's own emotions, were activated during evaluation of ones' own emotional responses to emotional clips. However, these studies examined brain regions involved in only one evaluation task, either *self* or *others*. To date, few studies have examined brain mechanisms associated with explicit emotional processing of both *self* and *others* in complex, ecological conditions. Furthermore, few studies have compared results from simple experimental conditions with those from complex conditions.

The research question addressed was: *Are the findings from fMRI Experiment I maintained in more dynamic, complex social situations?* To answer this question, ROI analysis was conducted on common and distinct regions identified from fMRI Experiment I. Brain activation extracted from these ROIs was statistically tested to explore whether brain activation showed similar patterns in the current experiment. Furthermore, whole-brain exploratory analyses were also performed to investigate whether similar common and distinct regions were found in this experiment compared to fMRI Experiment I.

Based on previous evidence, it was primarily hypothesized that similar findings regarding evaluation tasks and different empathy conditions would result in more complex, ecological social contexts. Common ROIs would show greater activation in *self* and *others* than in the control condition. Distinct ROIs, specifically associated with *self*, would show greater activity in *self* than in *others* whereas distinct ROIs, specifically associated with *others*, would present greater activity in *others* compared to *self*. Common and distinct ROIs modulated by empathic processing would show similar patterns of brain activation. Whole-brain exploratory analysis would reveal similar common and distinct regions identified from fMRI Experiment I and similar modulation effect.

4.2 METHOD

4.2.1 Participants

Participants were the same eighteen healthy, right-handed females who participated in fMRI Experiment I. After they completed fMRI Experiment I, they were asked to participate in the current experiment. The order of fMRI Experiment I (first) and the current experiment (second) was fixed to prevent the identification of the good and bad persons who were fictional characters acting in commercial films. Three participants failed to complete this fMRI experiment due to technical problems associated with playing video clips (e.g., accidental crashes). Demographic information of the remaining participants is presented in Table 3.1.

4.2.2 Stimuli and Tasks

Two short video clips depicting negative social situations (e.g., sad) were used in an experimental condition. Video clips were selected from two commercial films: Fried Green

Tomatoes (Avnet, 1991) and Terms of Endearment (Brooks, 1983). Two 90 sec video clips extracted from Fried Green Tomatoes described social interaction situations in which the main actress was watching her best friend pass away due to illness. Two 90 sec video clips extracted from Terms of Endearment described social interaction situations in which the main actress learns that her cancer treatment is no longer effective and is forced to tell her children that she is dying.

The two video clips were used for the concordant condition (empathy condition) manipulated by training participants to perceive a main actress in the film as a “good” person and the other two clips were used for the discordant (non-empathy) condition manipulated by training participants to perceive a main character as a “bad” person. Video clips used in the concordant and discordant conditions were counterbalanced across participants. This allowed us to control possible effects caused by different content/quality of video clips. Two other 90 sec video clips were used for the control condition. They were selected from Away From Her (Polley, 2006) and depicted social interactions, but not involving emotions, such as the main actress’s introduction of a facility to a visitor.

In the experimental condition, participants were asked to perform two emotional evaluation tasks while watching the video clips. They continuously evaluated either 1) their own emotional responses to the main characters in the video clips (SELF task) or 2) the main characters’ emotions in the video clips (OTHER task) on a scale ranging from 1 to 9 (1=very negative, 3=little negative, 5=neutral, 7=little positive, 9=very positive). The rating scale was located at the bottom of the screen and a green dot was used as an anchor (Figure 4.1). In the control condition, participants were asked to watch neutral video clips and judge ‘how is the main character’s face centered on screen?’ on a scale ranging from 1 to 9 (1=very left-sided, 3=little left-sided, 5=center, 7=little right-sided, 9=very right-sided). Neutral clips were also used to exclude possible automatic emotion and empathic processing. This face task as a control condition was assumed to demand participants to process minimum levels of social information by looking at characters' faces in the video clips.

4.2.3 Experimental paradigm and procedure

As mentioned above, this experiment took place after the completion of fMRI Experiment I. Participants trained how to continuously evaluate their own emotions or others' emotions using different video clips during the practice session and how to use a mouse to report emotions on the continuous rating scale. They were reminded about task instructions and experimental procedures immediately before the current fMRI Experiment.

During the fMRI assessment, participants were asked to watch video clips and to continuously rate their own emotions and others' emotions based on different task instructions for SELF and OTHER in the experimental condition. They also performed the continuous face rating task to report the location of the main character's face on the screen while they were watching video clips in the control condition. This experiment included SELF, OTHER, and control blocks. Each block began with the presentation of a person cue (good, bad, or control persons) for 8.35 sec and a task instruction (self, other, and control tasks) for 6.68 sec, followed by two video clips. Each block lasted for 180.36 sec and consisted of two video clips. E-prime 2.0 (www.pstnet.com) was used to play video clips and to collect continuous emotion ratings.

Emotional video clips were assigned to either concordant ("good" person) or discordant ("bad" person) epochs which included both SELF and OTHER blocks. The experimental epoch lasted for 360.72 sec, the SELF block for 180.36 sec and the OTHER block for 180.36 sec. Like fMRI Experiment I, a 2 x 2 factorial design was used with factors, emotion rating task (*self* vs. *others*) and person condition (good vs. bad persons). Each video clip was presented twice, once for the SELF block and once for the OTHER block. The order of two different person conditions was counterbalanced across participants. The control condition included one control block for 180.36 sec. Figure 4.1 describes the experimental paradigm used for this fMRI experiment.

Behavioral Experiment II validated video clips, a continuous emotional rating technique, and manipulation of the good/bad persons on emotion ratings used in this fMRI experiment (see Appendix). Consistent with emotion ratings in behavioral Experiment I and fMRI Experiment I, continuous emotion ratings were more similar between *self* and *others* in the concordant condition than in the discordant condition. Less similarity in the discordant condition was consistently due to reduced emotional responses to the bad person in the discordant condition.

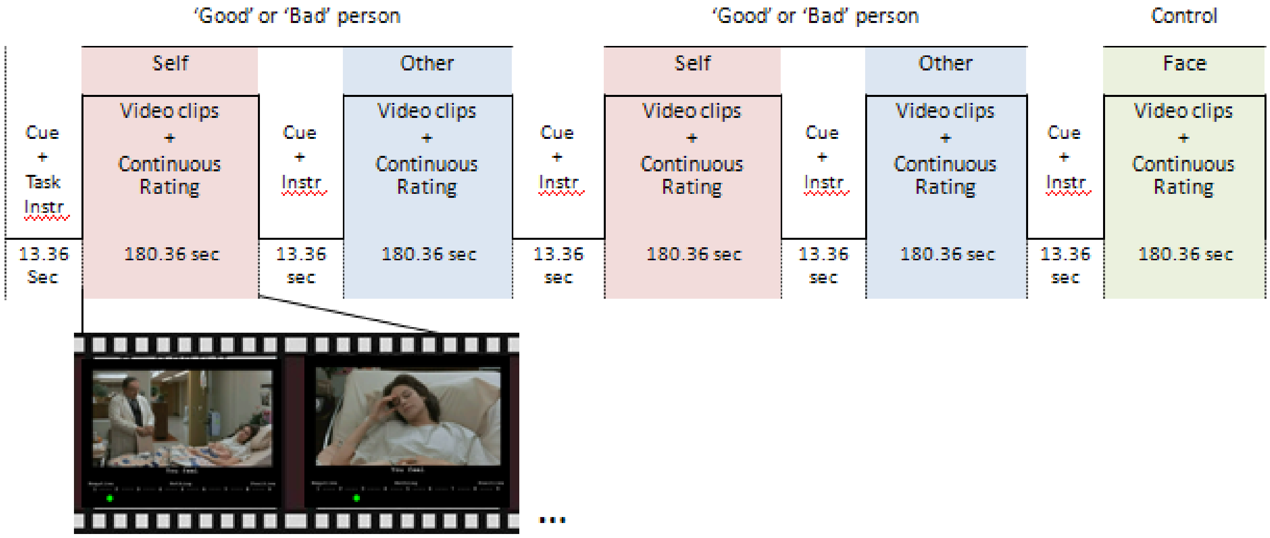

Figure 4.1 Experimental paradigm for fMRI Experiment 2. The order of good/bad persons was counterbalanced across subjects

4.2.4 Continuous emotion rating preprocessing

Continuous rating data were resampled to 20 Hz. These data were recorded by an x-position (ranging from 10 to 630 corresponding to screen pixels on the 640 pixel wide screen) of a MR-compatible mouse on the screen. The rating scale ranged from 1 (very negative) to 9 (very positive). The ‘very negative’ scale corresponds to 10 in the x-position and the ‘very positive scale’ corresponds to 630 in the x-position. The ‘neutral’ scale corresponds to 310 in the x-position. Finally, negative emotion intensity was determined as the absolute value of deviation of the continuous ratings from a neutral position (310).

Analyses of continuous emotion rating data were conducted in Matlab by comparing across-individual averages of continuous ratings in different rating tasks and person conditions at each time-point. First, continuous emotion ratings of *self* and *others* were compared to test significant differences between *self* and *others* in good and bad persons, respectively. Second, continuous ratings of *self* were compared between good and bad persons to examine whether one’s own emotional responses decreased when the bad person was compared to the good person. Continuous ratings of *others* were compared between the good and bad persons, predicting no difference in understanding of others’ emotions between the good and bad persons. Third, continuous ratings were compared in four different conditions (self, other, good person, and bad person). Average ratings in time periods showing significant differences between four conditions were compared to test an interaction effect of Task and Person using a 2 Task (Self vs. Other) x 2 Person (Good vs. Bad) repeated measures ANOVA. Guthrie and Buchwald (1991)’s method was used to control type I error when point-by-point tests in entire continuous ratings were performed to detect significant time periods of the continuous ratings at $p<.05$. Significance was defined in terms of continuous series of time-points that reliably differ.

4.2.5 Imaging acquisition and analysis

4.2.5.1 Imaging acquisition, fMRI data preprocessing, and type I error control

The same imaging acquisition was used as in fMRI Experiment I. fMRI data were preprocessed using the same preprocessing stream used in fMRI Experiment I except the detrending of imaging data. The same method used in fMRI Experiment I was used for type I error control. Detrending might remove neural responses activated by different conditions, thus imaging data was not detrended. Possible trends of imaging data were examined in different ways. First, time-courses of each subject were tested to possible trends in the main ROIs. There were no uniform linear or quadratic trends across subjects in the ROIs. No-detrended data also were compared to detrended data for group analysis. Both data showed similar patterns of brain activation, but no-detrended data showed greater differences between conditions (more significant results) compared to detrended data in most ROIs (more than 70% of the ROIs). No-detrended data showed greater numbers of activated voxels in whole brain analysis compared to detrended data.

4.2.5.2. Statistical analysis

One key research question was addressed: *Are the findings from fMRI Experiment I maintained in complex, ecological social situations?* Two specific questions were addressed: *1) Are the same common and distinct regions associated with explicit emotional processing of self and others identified in complex, naturalistic social situations?*; and 2) *Is the same modulation of empathic processing identified in complex, naturalistic social situations?* To answer these specific questions, both ROI and whole brain exploratory analyses were conducted.

ROI analysis in *priori* regions was conducted to examine 1) whether common ROIs are activated by both SELF and OTHER tasks compared to the control condition and whether distinct ROIs are more activated by SELF or OTHER tasks, *vice versa*; and 2) whether there is similar modulation of empathic processing in the identified brain regions in fMRI Experiment I. To do this, time-series in the empirically identified ROIs from fMRI Experiment I were extracted and smoothed. The time-series showed many variations over a long duration (3 min). To reduce these variations, varimax rotated principal components exploratory factor analyses were conducted. The factor analyses revealed time factors that explain most of the variance across scans in each ROI. Three factors were identified accounting for over 80% of the variance. Eigen values for all factors in each ROI were >1.0.

To examine common regions, repeated measures ANOVAs were performed on each common ROI, with Time Factor (Three factors) and Task (Self vs. Control or Other vs. Control) as within-subject factors. For distinct regions, repeated measures ANOVAs were performed on each distinct ROI, with Time Factor and Task (Self vs. Other) as within-subject factors. To examine modulation of empathic processing, repeated measures ANOVAs were performed on each ROI, with Time Factors, Task (Self vs. Other), and Person (Good vs. Bad) as within-subject factors. To control for sphericity violation as tested by Mauchley's test ($p < .05$), the more conservative Greenhouse-Geisser test was used. If there were significant Time Factor x Task interaction effects, time courses were further investigated.

Whole-brain exploratory analyses were conducted using block contrast analysis which tested different brain activations between two block conditions (e.g., Self > Control, Other > Control, Self > Other). At the single-subject level, a multiple regression model was implemented with AFNI 3dDeconvolve. Contrast images of beta weights from the regression were created and used in group level analysis. At group level analysis, a one sample t-test was conducted with contrast images (e.g., Self >Control and Other >Control). To find common regions which were more activated by both *self* and *other* compared to control, conjunction analyses between two contrast images (Self > Control and Other > Control) were conducted separately in the concordant and discordant conditions . Two conjunction maps were compared to examine any similarity or difference in the common mechanisms. One sample t-tests, implemented by 3dttest in AFNI were performed using contrast images (Self > Other and Other > Self) to identify *self*-distinct regions, greater activity in *self* than in *other*, and other-distinct regions, more activated by *other* than *self*. To elucidate brain regions modulated by empathic processing, a Task (Self vs. Other) x Person (Good vs. Bad) ANOVA was conducted using the 3dANOVA in AFNI.

4.3 RESULTS

4.3.1 Continuous emotion ratings of *self* and *others*

Figures 4.2A and 4.2B present across-individual averages of continuous emotion ratings of *self* and *others* in the good and bad persons, respectively. Although significant differences between *self* and *others* were shown in several short time periods (e.g., 45.05 to 67.55 sec: $F(1,14) = 9.76$, $p < 0.05$; 170.25 to 180.35 sec: $F(1,14) = 9.91$, $p < 0.05$) in the good person condition, significant differences between *self* and *others* were shown in long time periods (e.g., 4.60 to 74.25sec: $F(1,14) = 17.10$, $p < 0.05$; 120.65 to 143.20 sec: $F(1,14) = 11.57$, $p < 0.05$; 146.40 to 180.35sec: $F(1,14) = 13.02$, $p < 0.05$) in the bad person condition.

As shown in Figures 4.2C and 4.2D, significant differences in *self*-ratings between the good and bad persons were found in long time periods (e.g., 22.40 to 75.00 sec: $F(1,14) = 17.20$, $p < 0.05$; 121.45 to 131.85 sec: $F(1,14) = 6.73$, $p < 0.05$) whereas significant differences in other-ratings between two persons were found in only one short period (113.25 to 117.35 sec: $F(1,14) = 5.05$, $p < 0.05$). In particular, there was a significant Task x Person interaction effect in average ratings from 4.05 to 74.05 sec, $F(1,14) = 8.94$, $p < .05$, $\eta_p^2 = .39$ (Figure 4.2E). Consistent with ratings results from simple experimental conditions (see behavioral Experiment I and fMRI Experiment I), the greater dissimilarity of emotions between *self* and *others* in the bad person compared to the dissimilarity in the good person could be due to less intense self-ratings in the bad person condition.

Figure 4.2 Continuous emotion rating data: A. Continuous emotion ratings between *self* and *other* in the concordant condition, B. Continuous emotion ratings between *self* and *other* in the discordant condition, C.

Continuous emotion ratings of *self* between the concordant and discordant conditions, D. Continuous emotion ratings of *other* between the concordant and discordant conditions, E. Continuous emotion ratings in four conditions and a significant interaction of Task x Person in average ratings from 4.05 sec to 74.05 sec. Significant different areas between conditions are highlighted below the x axis (pink: p <. 05). Note. x-axis = time in seconds, y-axis = negative emotion intensity (from 0: no negative emotion at all to 310: the most intense negative emotion).

4.3.2 Imaging results

4.3.2.1 ROI analysis

Common regions. ROI analysis was conducted in common regions from fMRI Experiment I, including the DMPFC, PCC, VLPFC, VMPFC, TPJ, aSTS, and TP. A repeated measures ANOVA on the PCC showed a significant Time Factor x Task (Self vs. Control), $F(2,28) = 7.96$, $p < .01$, $\eta_p^2 = .36$, and Time Factor x Task (Other vs. Control), $F(2,28) = 3.44$, $p < .05$, $\eta_p^2 = .20$ (Figure 4.3A). The VLPFC also demonstrated a significant Time Factor x Task (Self vs. Control), $F(2,28) = 3.74$, $p < .05$, $\eta_p^2 = .21$, and a marginally significant Time Factor x Task (Self vs. Control), $F(2,28) = 2.73$, $p = .08$, $\eta_p^2 = .16$ (Figure 4.3B). The left aSTS showed a significant Task (Self vs. Control) main effect, $F(1,14) = 5.45$, $p <. 05$, $\eta_p^2 = .28$, and a Task (Other vs. Control) main effect, $F(1,14) = 5.19$, $p < .05$, $\eta_p^2 = .27$. Inconsistent with fMRI Experiment I, the control condition showed greater activity compared to *self* and *other* in the VLPFC and aSTS (Figure 4.3C). Other common regions did not show significant results.

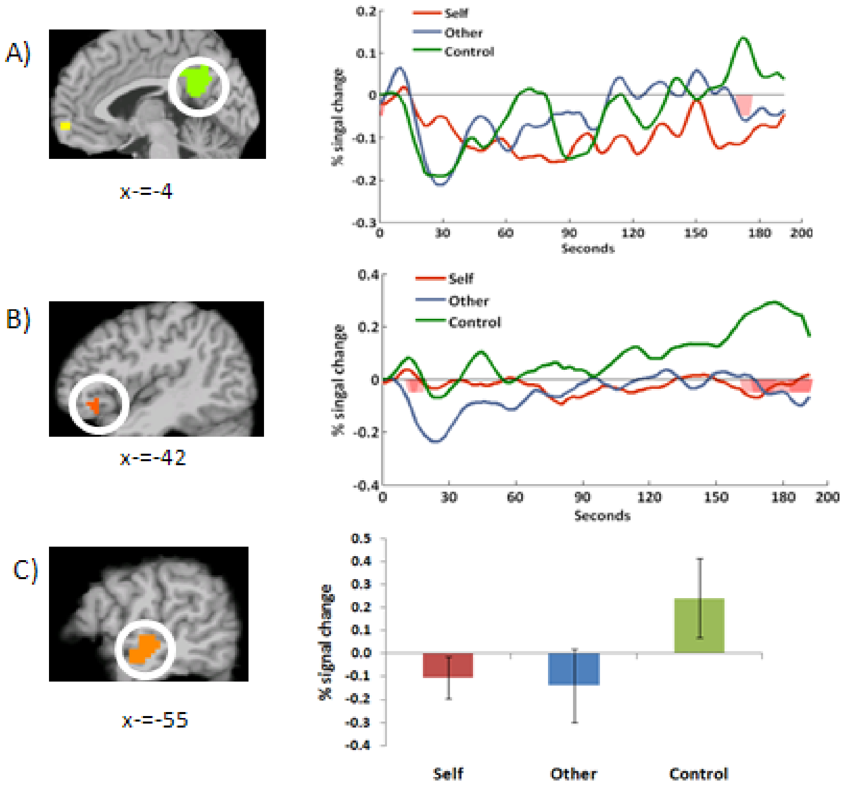

Figure 4.3 Brain activation in the common ROI regions. A. Time-series in the PCC (Time Factor x Task interaction). B. Time-series in the VLPFC (Time Factor x Task interaction). Significant different areas between conditions are highlighted below the x axis (light pink: p<.10, dark pink, p<.05). C. Averaged brain activation across time in the left aSTS (Task main effect). The control task showed greater activity than *self* and *others* in the VLPFC and aSTS.

Distinct regions. ROIs of distinct regions included rACC and anterior insula (*self*-distinct regions), and IPL and pSTS (*other*-distinct regions). Repeated measures ANOVAs on the bilateral anterior insula showed significant Time Factor x Task (Self vs. Other), (left insula: Greenhouse-Geisser adjusted $F(1.42, 19.83) = 6.04$, $p < .05$, $\eta_p^2 = .30$; right insula: $F(2, 28) = 6.80$, $p < .01$, $\eta_p^2 = .33$). As shown in Figure 4.4, insula activity was greater in *self* than in *others*. However, significant differences in insula activity between *self* and *others* were driven by the first about 60 sec. The rACC revealed no significant Time Factor x Task and Task main effects.

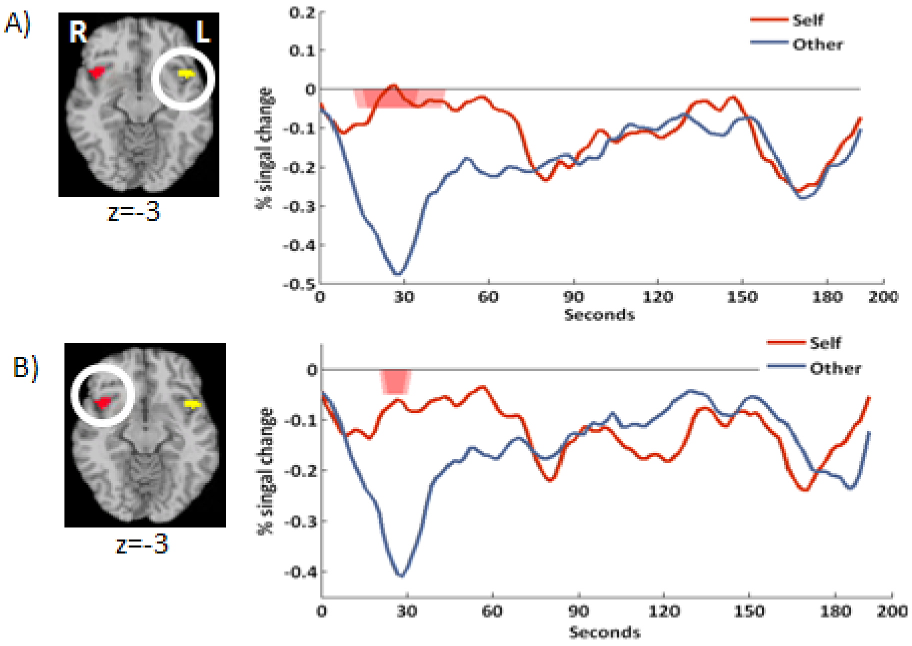

Figure 4.4 Time-series in self-distinct ROI regions: left anterior insula (A) and right anterior insula (B). Both regions showed significant Time Factor x Task interaction effects. Both regions showed greater activity in *self* than in *others* for the first about 60 sec. Significant different areas between conditions are highlighted below the x axis (light pink: p<.10, dark pink, p<.05).

There was a marginally significant Task main effect on the IPL, $F(1, 14) = 3.36$, $p = .09$, $\eta_p^2 = .19$. The pSTS demonstrated a significant main effect of Task, $F(1, 14) = 13.97$, $p < .01$, $\eta_p^2 = .50$. Brain activity in the IPL (Figure 4.5A) and pSTS was greater in *others* than in *self* (Figure 4.5B). Consistent with the results from fMRI Experiment I, *other*-distinct regions are specifically involved in evaluation of others' emotions.

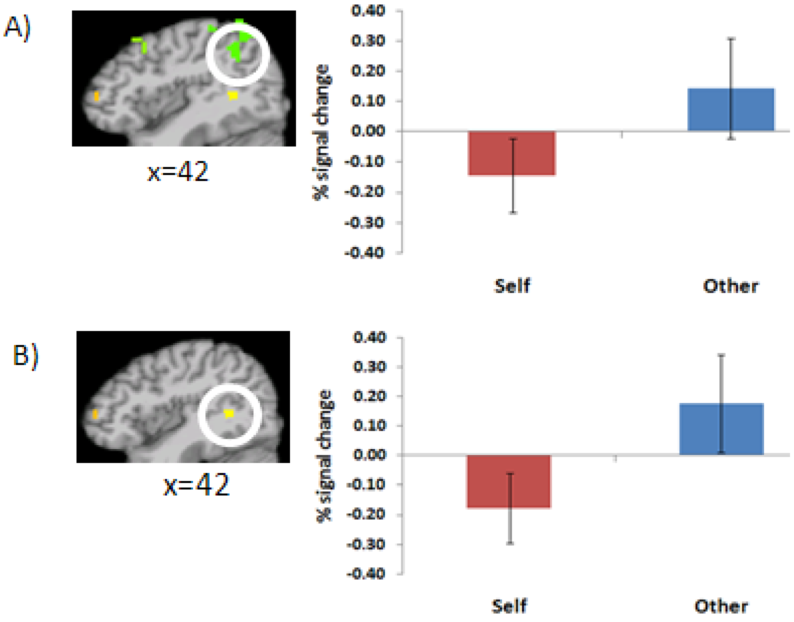

Figure 4.5 Averaged brain activity across time in *other*-distinct ROI regions: IPL (A) and pSTS (B). The IPL showed a marginally significant Task main effect and the pSTS showed a significant Task main effect. Both regions showed greater activity in *others* than in *self*.

Common and distinct regions modulated by empathic processing. The cACC and DLPFC were found as unique common regions for the discordant condition. Inconsistent with fMRI Experiment I results, repeated measures ANOVAs on the cACC and DLPFC did not show any significant effects of Task main or Time Factor x Task interaction effects.

The DMPFC, MPFC, and VLPFC were found as distinct brain regions modulated by empathic processing in fMRI Experiment I. There was a significant Task x Person interaction effect in the DMPFC, $F(1, 14) = 8.07$, $p < .05$, $\eta_p^2 = .37$. This region showed a significant difference between *self* and *others* in the discordant condition (p<.05), but not a significant difference between *self* and *others* in the concordant condition (p=.60). Unlike the results from fMRI Experiment I, activation patterns in this region were different. For example, this region was deactivated during evaluation of the bad person's emotions compared to the other three conditions (Figure 4.6A). Inconsistent with fMRI Experiment I, the MPFC showed no significant modulation effect, but showed a significant Time Factor x Task (Self vs. Other), $F(2, 28) = 3.67$, $p < .05$, $\eta_p^2 = .21$. This region showed greater activity in *self* than in *others* regardless of different person conditions. Similarly, greater activity in *self* in this region was maintained for about the first 60 sec (Figure 4.6B). This region seems to be specifically involved in *self*, but not modulated by empathic processing in the current experiment. None of effects were significant in the VLPFC.

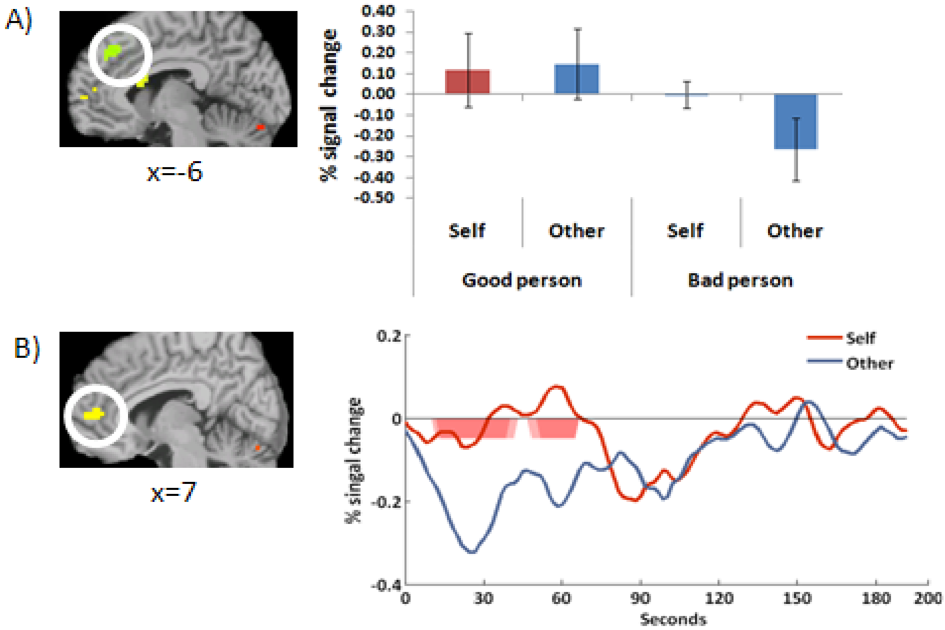

Figure 4.6 Brain activation in distinct ROI regions modulated by empathic processing: DMPFC (A) and MPFC (B). The DMPFC showed a significant Task x Person interaction effect. There was only significant activation difference between *self* and *others* in the discordant condition. However, the MPFC showed a significant Time Factor x Task main effect. Time-series in this region was similar to that in *self*-distinct regions such as the insula.

4.3.2.2 Whole-brain exploratory analysis

Common regions. The conjunction analysis showed no regions commonly more activated by *self* and *others* compared to the control task. In other words, no overlapping between Self > Control and Other > Control were found in both concordant and discordant conditions. Checking each contrast image revealed that the Self > Control contrast image was different from the Other > Control contrast image. For example, some regions such as MPFC showed greater activity in *self* than in control. In contrast, other regions such as PCC were more activated by *others* than control.

Distinct regions. The contrast Self > Other revealed that the MPFC showed greater activation in *self* than in *others* (Table 4.1 and Figure 4.7A). This region was not the same as the rACC as seen in the fMRI Experiment I. This region is located adjacent to the MPFC which is identified as a self-distinct region from the ROI analysis in the current experiment. Although this region is not exactly the same as the MPFC region, it is consistent with previous studies, illustrating the involvement of this region in self-related processing. The left insula activation survived at a significant level, $p<.05$ (uncorrected).

The contrast Other > Self revealed that the pMTS/STS extending to visual cortex was more activated in evaluation of others' emotions than in evaluation of one's own emotions (Table 4.1 and Figure 4.7B). Other regions such as PCC/precuneus and IPL were also identified as *other*-distinct regions (Table 4.1).

Table 4.1 Whole-brain analysis: Distinct regions in both person conditions

Self > Other					Tal coordinates		
Regions	L/R	BA	SIZE	MAX F	x	Y	z
MPFC	L	10	33	4.51	-1	57	19
MPFC	R	9	17	4.67	2	54	20
Other > Self							
pMTS/pSTS	R	39	278	6.6	34	-71	20
PCC	R	31	359	6.61	15	-45	27
Precuneus	R	31	133	5.67	12	-65	25
Precuneus	R	7	8493	8.28	6	-59	42
SPL/Precuneus	R	7	761	5.75	25	-62	53
SPL	L	7	258	5.98	-11	-63	54
MiddleOccipitalGyrus/Cuneus	R	30	271	6.46	31	-72	15

Note. Results are significant at $p < .0025$, 14 voxels contiguity (Self > Other) and 33 voxels contiguity (Other > Self). L/R = left/right, BA=Brodmann Area, Size=number of voxels

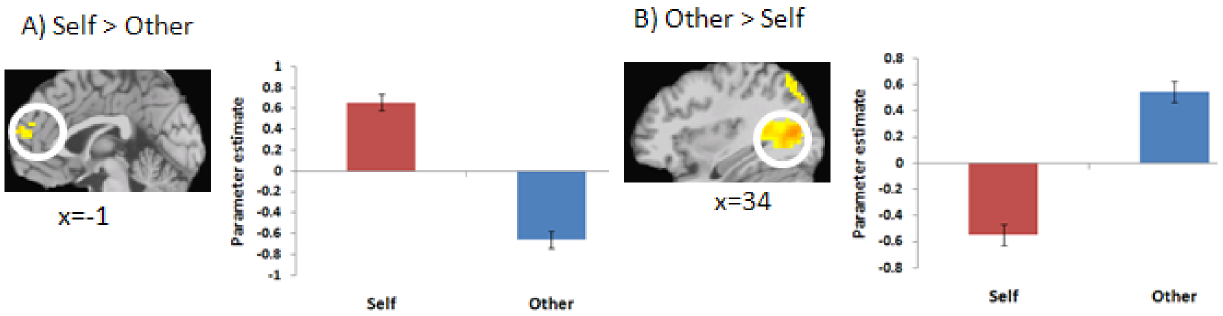

Figure 4.7 Distinct regions in the whole-brain exploratory analysis. A. The MPFC showed greater activation in *self* than in *others*. B. The pMTS/STS extending to visual cortex showed greater activation in *others* than in *self*.

Distinct regions modulated by empathic processing. Table 4.2 presents brain regions that showed significant Task x Person interactions. These regions included the DMPFC (BA8), VLPFC (BA47/46) extending to the insula, PCC/precuneus, aSTS/insula, and pSTS/TPJ. Consistent with results from fMRI Experiment I, the DMPFC and VLPFC were modulated by different person conditions. It should be noted that these regions were slightly different and broader compared to regions identified from fMRI Experiment I. A post-hoc test with Bonferroni correction on the DMPFC and VLPFC showed significantly greater activity for *self* than for *others* in the discordant condition (*ps* < .01), but no significantly different activity between *self* and *others* in the concordant condition (*ps* > .07) (Figure 4.8A and 4.8B).

Table 4.2 Whole-brain analysis: Distinct regions modulated by empathy (Task x Person interaction)

					Tal coordinates		
Regions	L/R	BA	SIZE	MAX F	X	y	z
Frontal cortex							
DMPFC	L	8	554	25.11	-5	44	39
DMPFC	R	8	60	22.22	3	47	40
VLPFC/insula	R	47/13	563	21.8	41	29	6
ACC/Subgenual	L	25	14	13.68	-3	3	-5
Insula (middle)	R	13	251	16.49	44	0	1
IFG	R	47	165	16.98	40	15	-13
SFG	L	6	542	20.11	-20	-6	64
PostcentralGyrus	L	2	325	17.88	-52	-22	35
PostcentralGyrus	L	3	181	17.63	-48	-15	47
PostcentralGyrus	L	6/9	1008	25.47	-44	-6	28
Temporal cortex							
pMTS/pSTS	L	22/19	288	23.92	-37	-57	19
SupramarginalGyrus/pSTS	L	39	52	14.15	-47	-52	26
aSTS/aMTS	R	38/22/21	722	17.8	49	2	-8
pSTS	L	22	132	14.69	-54	-27	5
Parietal and Visual cortex							
AngularGyrus	L	39	783	23.66	-38	-64	31
PCC/Precuneus	L	31/23	1456	20.44	-5	-38	28
IPL	L	40	145	18.05	-58	-34	25

IPL	L	40	429	19.03	-39	-60	41
SPL/precuneus	L	19/7	277	23.47	-29	-68	44
SPL/precuneus	L	7	248	17.53	-19	-62	54
SOG/Cuneus	L	19/39	119	23.08	-33	-77	30
Subcortical							
Caudate	L	-	140	14.53	-5	11	3
LentiformNucleus	R	-	14	12.42	23	11	-6
Amygdala/parahipp	R	-	162	15.1	25	-2	-14

Note. Results are significant at $p < .0025$, 28 voxels contiguity, L/R = left/right, BA=Brodmann Area, Size=number of voxels

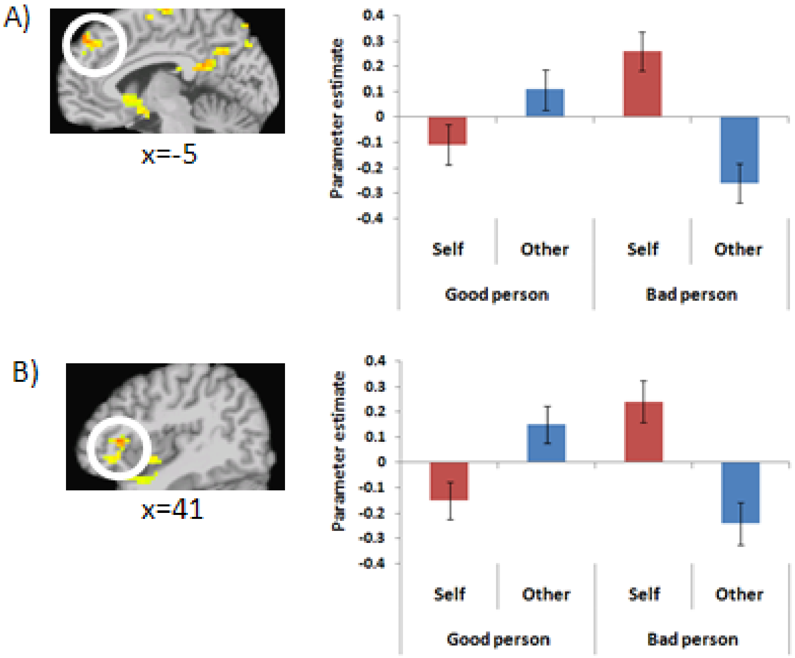

Figure 4.8 Distinct regions modulated by empathic processing in the whole-brain exploratory analysis. A. The DMPFC showed significant differences between *self* and *others* in the discordant (bad person) condition, but not in the concordant (good person) condition. B. The VLPFC also showed similar patterns of activation as the DMPFC.

4.4 DISCUSSION

This experiment aimed to explore the possible generalization of findings from simple experimental conditions (fMRI Experiment I) to more complex, ecological conditions (current experiment). Specifically, it examined whether similar common and distinct mechanisms resulting from simple conditions were involved in explicit emotional processing in complex experimental conditions. Ecological validity in this experiment was enhanced by using continuous ratings of emotions and video clips describing more real life emotional events. As predicted, continuous emotion ratings between *self* and *others* in the concordant condition were more similar than those in the discordant condition. These emotion rating results are consistent with results of behavioral Experiment I and fMRI Experiment I. Common regions were not replicated in this experiment. In accordance with fMRI Experiment I, similar distinct regions were found in this experiment. The anterior insula was specifically involved in *self* while pSTS and pMTS regions were specifically involved in *others*. The DMPFC (BA8) and VLPFC (BA 47) regions were modulated by different person conditions, supporting the hypothesis that empathic processing modulates brain regions, associated with explicit emotional processing in complex, ecological conditions. These findings partially support the idea that findings in the simple experimental conditions could be generalized in complex, ecological experimental conditions. Further discussion focuses on four things regarding the main findings.

Common regions: A control condition may matter in ecological fMRI experiments

This study failed to replicate common regions. Surprisingly, the ROI analysis showed that some common regions such as aSTS identified from fMRI Experiment I were less activated by *self* and *others* than the control condition. This result might be due to the control condition in which participants continuously reported the location of the main actress's face in the video clip. This task was presumed to be involved in low levels of socio-emotional and cognitive processing. However, the continuous face rating may lead participants to pay more attention to the social information (e.g., faces and body motion) and to make more of an effort to continuously trace the face location than perform emotion rating tasks. This elevated social information processing and task maintenance may be associated with increased activation in the aSTS and VLPFC in the control task.

No common regions were revealed in the whole-brain analysis. A discrepancy between Self > Control and Other > Control contrasts may contribute to the null results. The contrast of Self > Control showed some MPFC regions, which are possibly associated with more internal processing in *self* than in the control condition. However, the contrast of Other > Control revealed pSTS and PCC/precuneus regions, which are possibly associated with more social cognitive processing such as mentalizing in *others* than in the control condition.

These findings raise a question about the important role of a control condition as a baseline in complex and ecological experiments. A control condition is supposed to rule out some brain processes, which are irrelevant to primary brain processes linked to experimental conditions (Gusnard & Raichle, 2001). However, it is difficult to rule out specific processes by a control condition in complex experimental conditions because complex and dynamic brain processes occur in complex, ecological conditions (Gilbert, Zamenopoulos, Alexiou, & Johnson, 2010). In particular, it is difficult to create a control condition as a 'common' baseline for different experimental conditions (e.g., *self* and *others*) in complex experimental conditions. Thus, it is important to carefully select a proper control condition in designing fMRI experiments using complex, naturalistic contexts.

Distinct regions: Temporal characteristics of brain activation in complex social contexts

The ROI and whole-brain analyses on distinct regions replicated findings from fMRI Experiment I. As predicted, the anterior insula and MPFC were specifically involved in evaluation of one's own emotions whereas the pSTS was specifically involved in evaluation of others' emotions in complex experimental conditions. These results were also consistent with previous studies which used video clips to examine brain regions involved in *self* (Hutcherson et al., 2005) and *others* (Wolf, Dziobek, & Heekeren, 2010; Zaki et al., 2009). These results suggest that distinct regions play specialized roles in different emotional evaluations even in complex, ecological conditions.

Interestingly, time-courses in these distinct regions showed different temporal characteristics of distinct regions in ecological social contexts. Brain activity in *self*-distinct regions depended on time. For example, greater brain signal by *self* in the insula lasted for about 60 sec in the beginning and diminished for the remainder of time. It is possible that brain processes associated with evaluating one's own emotions may become more automatic and less attentive after approximately 60 sec. This transition from conscious to automatic processing around 60 sec may lead to diminished distinctions between *self* and *others*. In contrast, brain activity in *other*-distinct regions did not depend on time. Actually, increased pSTS activity by evaluation of others' emotions was maintained for the entire 3 min (Task main effect). Evaluation of others' emotions may recruit both taking perspective of others and processing external emotional cues that may be maintained even for a long time to continuously monitor others' emotions.

These results may provide new evidence that brain mechanisms are temporally dynamic when evaluating one's own emotion, but not when evaluating others' emotions. In particular, these findings emphasize the potential importance of the dynamic temporal characteristic of *self*-distinct regions in complex, ecological experimental conditions. It is also interesting to note that brain regions involved in perspective-taking or TOM may be constantly engaged in understanding others' emotions over time. Interoceptive processing or self-awareness involved in evaluation of one's own emotion is more time-dependent than perspective-taking involved in evaluation of others' emotions. It may be difficult to keep focusing on one's own emotions for a long time in complex social situation. In contrast, it may be essential to keep inspecting others' emotions in ecological social interactions. These temporal characteristics of brain activation in *self* and *others* should be considered in future ecological emotion research.

Modulation of empathic processing: Roles of modulation in complex social contexts

The DMPFC identified as modulated regions in fMRI Experiment I was replicated in the current experiment in the ROI analysis. Relative to fMRI Experiment I, slightly different and broad DMPFC and VLPFC (BA47) regions were modulated by different empathy conditions in the whole-brain analysis. In fMRI Experiment I, modulation was driven by increased brain activity only in evaluation of one's own emotional responses to the bad person in the non-empathy condition, indicating that modulation is considered as considered as regulatory inhibition of one's own emotional responses to the bad person. However, the current experiment showed more complicated interactive patterns between *self/others* tasks and good/bad persons than fMRI experiment I. For example, brain activation was greater in *self* than in *others* in the discordant condition, but brain activation in *self* in the bad person condition was not significantly different from brain activation in *others* in the good person (see Figure 4.8).

However, modulation by empathic processing may be not explained by an unformed factor, such as emotion regulation in complex, ecological conditions. Potentially, brain regions modulated by empathic processing may be associated with multiple processes such as emotion regulation, increased effort, and switching attention between evaluation tasks in ecological social contexts. Modulation in complex social situations may reflect functional flexibility depending on multiple processes. Different processes may be more active at some time points than at other time points across long time windows, such as during real social interactions. In accordance with this idea, time course in the VLPFC increased activation in evaluation of one’s own emotions to the bad person for about the first 60 sec, but increased activation in evaluation of the good person’s emotions for the middle 60 sec (Figure 4.9). This preliminary examination of time course supports some possibilities that different processes involved in modulation may be associated with different temporal characteristics.

Different temporal characteristics in different conditions may raise some concerns about the interpretation of specific roles of these modulation regions in explicit emotional evaluation in complex, ecological condition. For example, it is difficult to interpret whether significant differences between *self*-bad person and *others*-bad person are specifically associated with regulatory function if there are no significant differences between *self*-bad person and other conditions (*self*-good person or *other*-good person). Specific functional roles in these modulated regions at different time points in complex experimental conditions remain to be investigated in future studies. Spiers & Maquire (2006) used a retrospective verbal report protocol which collects participants’ thoughts step-by-step while participants were watching their own performance during scanning to assess the contents of mental processes in social contexts.

Possibly, this method may allow us to examine how specific mental processes (e.g., self-awareness, regulation, or task switch) are associated with brain activation.

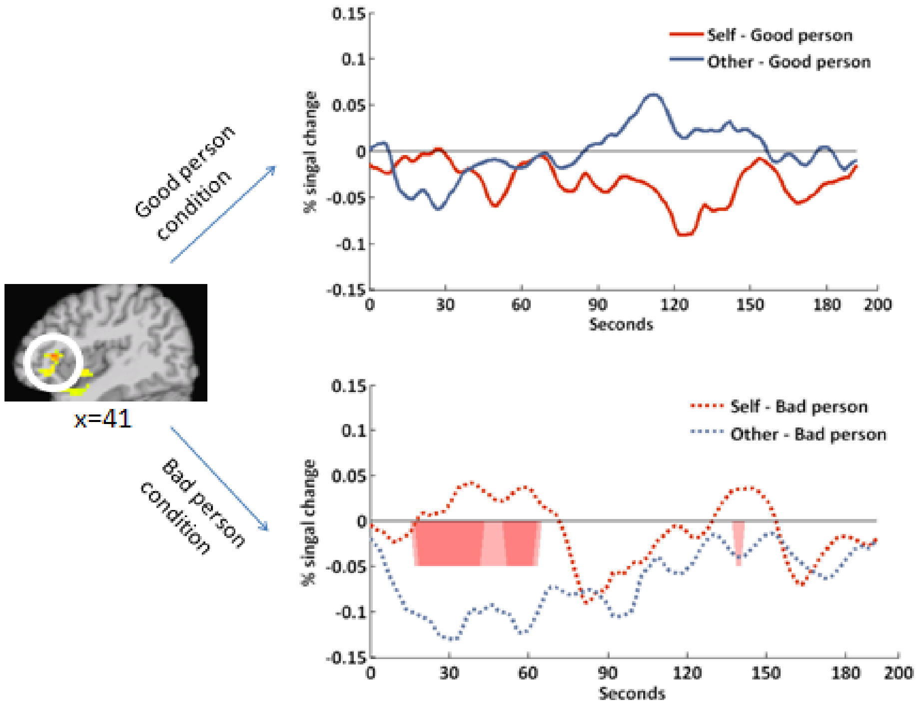

Figure 4.9 Time courses in the VLPFC, modulated by empathic processing were examined. As suggested, there are some possibilities that different processes associated with different conditions may be more salient in different time points.

Possibilities of generalization of findings from simple conditions to complex conditions

The ROI analysis approach enables direct comparisons between fMRI Experiment I and the current experiment. Brain activity in the same brain regions was examined in both fMRI experiments. Brain activity in common regions was not generalized from fMRI Experiment I to the current experiment. As discussed above, these divergent results may be due mainly to the control condition used in the current experiment. Therefore, future studies of explicit emotional evaluation in ecological social contexts should be careful about selecting a control condition or baseline to identify common mechanisms of *self* and *others*. Some possibilities still remain for generalization of common mechanisms from simple experimental conditions to complex experimental condition.

The results of distinct brain regions provide evidence that it is possible to generalize findings from simple experimental conditions to complex, ecological experiment conditions. Brain activity in distinct regions showed similar findings between fMRI Experiment I and the current experiment. In both experiments, the insula is specifically involved in evaluating one's own emotions while the pSTS is specifically involved in evaluating others' emotions. Brain responses in *self*-distinct and *other*-distinct regions showed different temporal characteristics over time. Thus, future studies of emotional processing in ecological social contexts should consider dynamic temporal characteristics of brain signals in designing experimental paradigm and in analyzing imaging data.

The current experiment showed similar modulation of empathic processing compared to fMRI Experiment I. Similar brain regions such as the DMPFC and VLPFC were involved in modulation of empathic processing in the current experiment, but their response patterns were more dynamic and complex compared to fMRI Experiment I. It is relatively simple to interpret the role of modulation of empathic processing in the simple condition such as the involvement of modulation in inhibition of undesired emotions. However, it is complicated to interpret complex, dynamic patterns of brain responses in the complex condition, specifically with a long duration. Thus, more ecological experimental designs yield harder-to-interpret results. Future research should consider solutions to overcome difficulties of data interpretation.

It is worthy to note that some possible variabilities caused by individual differences and experimental conditions were minimal in comparing the two fMRI experiments. Except for different levels of ecological validity, both fMRI experiments used the same participants and experimental conditions (e.g., Task and Person). Similar findings between two experiments provide evidence that similar brain mechanisms are involved in explicit emotional evaluation in both simple and complex, ecological social situations. Overall, this study suggests some possibilities to generalize findings from relatively simple conditions to complex, ecological conditions representing more real life social situations.

Limitation and conclusions

This experiment has several limitations. First, as discussed above, the control condition (continuous face rating) used in the current experiment was not suitable to find some commonality between *self* and *others*. Future research is needed to use proper control conditions to elucidate common mechanisms. Second, there was a limitation in selecting video clips in order to use the same target persons across different experiments. Video clips were selected from only two commercial films because the target persons (main actresses) had to be shown in the films. Within one commercial about 120 min- film, there were not many negative emotional events for the main actresses although these films were carefully selected. Future studies could possibly create stimuli (video clips and faces) for better experimental controls. As an example, two people's (real actresses) altruistic and bad behaviors are recorded for a manipulation. Video clips describing the same people in several distressing situations are recorded for scanning, allowing the collection of brain activation in several ecological situations. This method would be more controlled, but would have greater ecological validity than the commercial films. Finally, although 3-min video clips permitted us to find some new evidence such as temporal characteristics of brain activation, the relatively long duration stimuli may lead to some limitations in interpreting results.

Despite these limitations, however, this experiment provided evidence that similar brain mechanisms are associated with explicit emotional processing of *self* and *others* in both simple and complex experimental conditions. Further, these results suggest that similar brain networks would be engaged in explicit emotional processing in real life situations. To our knowledge, this is the first study to directly compare imaging results from an experiment using simple condition with results from an experiment using complex condition within subject design. Although there are several unresolved issues, this study challenges the possibilities of generalization. This study contributes to understanding how brain mechanisms function in explicit evaluation of one’s own and others’ emotions in ecological social situations.

5.0 GENERAL DISCUSSION

5.1 SUMMARY OF STUDIES

5.1.1 Manipulation and behavioral emotion ratings

Summary. Two behavioral experiments validated the manipulation method to create concordant and discordant conditions (behavioral Experiment I (2.0) and behavioral Experiment II (Appendix)). These studies demonstrated that a prior experience with other people - such as knowing their characteristics and behaviors - led participants to perceive one target person as good and another person as bad. It is important to note that the two studies consistently illustrated similar manipulation effects although they used slightly different faces, such as posed Nimstim faces and naturalistic faces captured from films. The manipulation altered evaluation of one's own emotional responses to the good and bad persons, but did not alter evaluation of the good or bad persons' emotions. Interestingly, one's own negative emotional responses to the bad person were less intense than those to the good person, indicating that people showed less empathic concerns for the bad person in distress. Less empathic concerns for the bad person were reported in complex, naturalistic social contexts. This result suggests that behavioral findings from simple conditions could be generalized in complex conditions.

Novel findings. First, our manipulation is an effective way to create concordant (more empathic) and discordant (less empathic) conditions. Second, evaluation of one's own emotion is influenced by different person conditions, but not evaluation of others' emotions. This result contributes to a deeper understanding of how people do not empathize with other people. Third, reduced empathic concerns for the bad person in the simple experimental condition were consistently found in the complex, ecological condition. This result suggests that some complex social behavior may be examined in laboratory environments using more naturalistic emotional stimuli.

5.1.2 Brain mechanisms associated with explicit emotional processing in the simple condition

Summary. fMRI Experiment I (3.0) examined common and distinct mechanisms when evaluating one's own emotions and others' emotions in the concordant and discordant conditions 1) to replicate previous imaging studies and 2) to investigate modulation of empathic processing.

This experiment partially replicated common and distinct mechanisms identified in previous studies. Consistent with previous studies, the DMPFC and VLPFC were identified as common regions. In addition to these regions, other common networks included the PCC, TPJ, and aSTS. These common regions may serve shared processing between *self* and *others* in the concordant conditions. Similar distinct regions were also identified. As hypothesized, evaluation of one's own emotion recruited the rACC, which is involved in self-related processing, while evaluation of others' emotions recruited the pSTS, which are involved in perspective-taking.

Some brain regions were modulated by empathic processing. Common regions including the cACC and DLPFC were more commonly activated by *self* and *others* than the control task in the discordant condition. These common regions may be engaged in cognitive effort and conflict which occur in the discordant condition. Furthermore, the MPFC and VLPFC implicated in emotion regulation were more activated in evaluation of one's own emotions of the bad person than other evaluation conditions. Enhanced activity in these regions may be associated with decreased empathic concerns for the bad person. These findings suggest that the discordant condition, which may be less common and certain in real life situations, produced cognitive effort in evaluation of one's own emotions and others' emotions and regulatory demands specifically in evaluation of one's own emotions to the bad person. However, there was no modulation in *self*-distinct regions, such as the rACC and insula and *other*-distinct regions, such as the pSTS and IPL.

Subregions of the MPFC and VLPFC/insula involved in explicit emotional processing. It is noteworthy that MPFC and VLPFC regions may be involved in different functions associated with explicit emotional evaluation in social contexts. These regions subserve diverse functions in explicit emotional processing by allocating such functions to their subregions (Figure 5.1). Past research suggested subregions in the MPFC that are involved in various functions regarding emotion and empathy (Saxe, 2006b; Vogt, 2005; Wager, van Ast et al., 2009; Wager, Waugh et al., 2009). This study demonstrated possible subregions in the MPFC associated with explicit processing of *self* and *others*. Common mechanisms of *self* and *others* in explicit emotion evaluation are more likely associated with the VMPFC (BA10) and DMPFC (BA10/9), which is an anterior part of the MPFC. This subregion may represent the integration of socio-emotional evaluative processes related to both *self* and *others*. Self-related processing, specifically involved in evaluating one's own emotions, recruits the rACC (BA24). One's own emotional responses to the bad person were regulated by the MPFC, which is located between the common MPFC and self-distinct MPFC regions. Undesired emotional responses in certain social contexts may be regulated by this subregion.

The LPFC subregions were suggested by cognitive research about cognitive control (e.g., Badre, 2008). However, relatively little is known about possible subregions of the VLPFC with regard to emotion research. Interestingly, this study demonstrated that possible subregions of the VLPFC/IFG extending to the insula, which subserve different roles in emotion evaluation. Explicit emotional processing may be associated with specific processes that are cognitively demanded, such as task maintenance or cognitive control. The VLPFC (BA47), as a common region, is involved in the cognitive aspects of evaluating one’s own emotion and others’ emotions, whereas the anterior insula (BA13), as a distinct region, is specifically activated by the evaluation of one’s own emotions. The VLPFC extending to the insula and STS, located between common subregions and *self*-distinct subregions, may play an important role in emotion regulation. In sum, these findings suggest that different functions in explicit emotional evaluation may be represented in the subregions of the regions engaged in explicit emotional processing of *self* and *others* in social contexts.

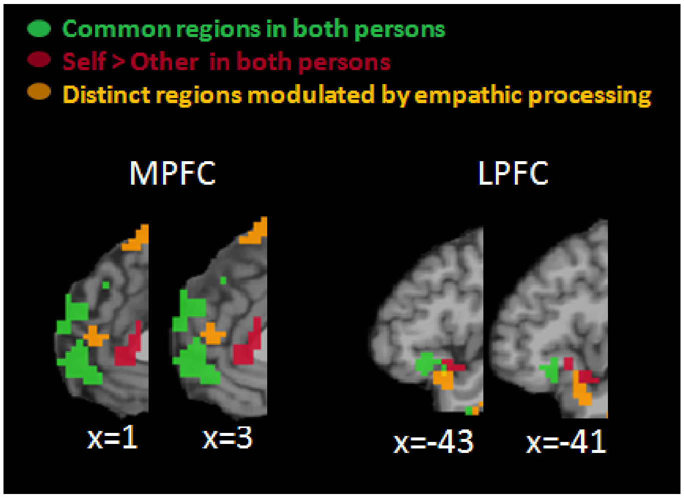

Figure 5.1 Functional subregions in the MPFC and LPFC that are associated with explicit emotional processing of *self* and *others*

Novel findings. First, no studies to date have reported common mechanisms involved in both evaluation of one's own emotions and others' emotions in the discordant condition. Thus, common involvement of the cACC and DLPFC in *self* and *others* provides new evidence that cognitive effort and conflict were engaged in explicit emotional evaluation in the discordant condition. Second, consistent with emotion ratings, modulation by empathic processing was particularly associated with evaluation of one's own emotional responses to the bad person in the discordant condition. However, modulation may not affect brain mechanisms associated with evaluation of others' emotions. These results provide new insights into understanding of brain mechanism associated with explicit evaluation of one's own and others' emotions when people do not empathize with other people.

5.1.3 Brain mechanisms of explicit emotional processing in the complex condition

Summary. fMRI Experiment II (4.0) explored common and distinct mechanisms involved in explicit emotional processing of *self* and *others* in both concordant and discordant conditions in complex, ecological conditions. This experiment aimed to investigate the possibilities of generalizing findings from simple conditions to complex experimental conditions. Findings failed to replicate common regions associated with both *self* and *others* in this experiment. This failure was associated with the improper control condition used in this experiment. However, similar distinct regions were found in this experiment. The insula and MPFC were specialized for evaluation of one's own emotion while the pSTS and IPL were specialized for evaluation of others' emotions. Interestingly, insula activity involved in interoception was not sustained over time whereas pSTS activity involved in perspective-taking was sustained over time. This finding suggests that *self*- and *other*-distinct regions may have different temporal characteristics in the complex, ecological condition. Similar brain regions including the DMPFC and VLPFC were modulated by empathic processing in this experiment. However, brain activity in these regions showed different patterns relative to fMRI Experiment I. Unlike fMRI Experiment I, there was no clear evidence that these regions are involved in the regulatory function in inhibition of emotional responses to the bad person. Thus, the roles of these regions should be interpreted with caution. Despite some inconsistent findings, results from this experiment provide evidence that findings from simple experimental conditions could be generalized in complex experimental conditions.

Novel findings. To our knowledge, this is the first fMRI experiment to examine brain mechanisms engaged in both continuously evaluating ones' own emotions and continuously evaluating others' emotions in complex emotional situations. It is important to note that findings from the simple condition (fMRI Experiment I) were compared to those in the current experiment which used complex experimental conditions. Most of the results found in this experiment are considered new in social affective neuroscience research.

5.2 RELATIONSHIP TO EMPATHY

This study examined common and distinct mechanisms associated with explicit emotional processing of *self* and *others*, which are closely related to mechanisms underlying empathy. Such close relationships between self/other and empathy might cause confounding effects on delineating common and distinct mechanisms underlying explicit emotional processing of *self* and *others*. This idea motivated this study to examine modulation of empathic processing in common and distinct mechanisms. Empathy is a multi-dimensional construct that includes self-awareness (*self*), perspective-taking (*other*), and shared representation (Batson, 2009; Decety & Jackson, 2004). Thus, some common and distinct mechanisms underlying explicit emotional processing of *self* and *others* may be closely related to subcomponents of empathy. This also suggests that empathy confounds might occur in each subcomponent of empathy, implying that empathy confounds may be associated with complex processes.

Thus, in the following sections, how our findings of common and distinct mechanisms associated with explicit evaluation of one's own and others' emotions fit into empathy mechanisms will be discussed. This discussion would help to integrate our findings and understand brain mechanisms of *self* and *others* in the context of empathy.

5.2.1 Common between *self* and *others*: Shared representation of empathy

Shared representation of empathy indicates both 'shared *self-other*' (no distinction between *self* and *other*) and 'shared emotions', which are closely related to common mechanisms of explicit emotional processing of *self* and *others*. Shared *self-other* representation has been implicated in perception and action, such as mirroring and simulation governed by mirror neurons (e.g., IFG (BA44/45) (Decety & Jackson, 2004). However, mirror networks were not found as common regions in this study. Perhaps common regions in this study represent more 'reflective' shared representations due to the explicit/conscious demands during the evaluation tasks (Lombardo et al., 2010). Past empathy research reported that shared emotions were represented in the ACC and anterior insula in the context of pain and disgust (for a review, see Lamm et al., 2011). Inconsistent with past empathy research, the ACC and insula were found as *self*-distinct regions in this study. This may be due to the use of explicit tasks that specified the self-related processing roles of the ACC and insula in the current study. Shared emotions could be represented in different brain regions, such as the aSTS, which are involved in socio-emotional processing, rather than the rACC and insula in this study. It still remains unclear which common regions reflect shared *self-other* representation and shared emotions. The discordant condition, which is less empathic, modulated brain activation regarding shared representations and recruited brain regions involved in cognitive effort and conflict. These results are consistent with the empathy study, which demonstrated modulation of some social factors on neural substrates of empathy. Modulation of the common mechanisms may represent the flexibility of shared representations and the involvement of cognitive control.

5.2.2 ***Self*** **vs.** ***Others*****: Affective empathy vs. cognitive empathy**

Researchers often view empathy as involving two different components, affective empathy and cognitive empathy (Davis, 1983). Affective empathy is an ability to experience emotional responses (e.g., empathic concern and personal distress) to other people, whereas cognitive empathy is a cognitive capacity to understand the emotions of others via perspective-taking and TOM. Thus, *self*-distinct mechanisms may represent affective empathy, whereas *other*-distinct mechanisms may represent cognitive empathy. The rACC and insula, which are self-distinct regions, are associated with an ability to experience one's own emotion. In contrast, the pSTS, which is an *other*-distinct region, is parallel with the capacity to understand others' emotions. However, these distinct regions were not modulated by different empathy conditions. Potentially, affective and cognitive empathy reflect mental abilities (or processes) to feel empathy, but not outcomes of empathy. Thus, there are two different processes to share emotions of other people: one relates to evaluating one’s own emotions and the other relates to evaluating others’ emotions. These processes may be on-going and keep operating in any social interactive contexts.

Interestingly, fMRI Experiment 2 showed that different brain activation in the insula between *self* and *others* did not last for a long period of time, which indicates that self-related processing may become automatic (e.g., less attentive). However, different brain activation in the pSTS was maintained for a long duration, which suggests that the cognitive ability to understand others’ emotion is persistent.

5.2.3 Modulation of empathy: Regulatory function in empathy

Emotion regulation is also a fundamental component of empathy (Decety & Jackson, 2004). Potentially, empathy is needed to be regulated if it is too high or low in certain social interactions (Hodges & Biswas-Diener, 2007). Hodges and colleague (2002) suggested that emotion regulation of empathy may occur in different components of empathy, such as affective (*self*-distinct) and cognitive (*other*-distinct) empathy. As discussed above, no direct modulation of different empathy conditions was found in the *self*-distinct and *other*-distinct regions. To date, few studies have examined the regulatory functions in subcomponents of empathy.

However, this study provides evidence with regard to the understanding of empathy regulation mechanisms. Brain regions adjacent to *self*-distinct regions that are modulated by empathic processing are associated with emotion regulation. In particular, increased activation in brain regions involved in emotion regulation may lead to decreased empathic concern for the bad person. Thus, modulation may be associated with regulatory components of empathy.

There was no modulation related to *other*-distinct mechanisms. There may be strong tendency to understand others' emotions accurately regardless of social contexts. This tendency may be not influenced by different social factors, especially if there are clear emotional cues (e.g., sad face) to understand others' emotions. Alternatively, there may be some emotion regulation in the *other*-distinct mechanisms. For example, rather than taking the perspective of the bad person, participants may take the perspective of a layperson to show socially desirable empathic accuracy. However, such regulatory function may be too subtle to be represented in *other*-distinct regions differently. Future studies should examine some possible emotion regulation associated with *other*-distinct mechanisms.

There is evidence regarding the regulation of the understanding of others' emotions. Physicians who are repeatedly exposed to people in pain regulate their empathy by inhibiting early perceptual processing of others' emotions (Decety, Yang, & Cheng, 2010). Such regulation may help physicians attend to their treatments without the costs incurred by high empathy (e.g., high personal distress). Unlike such specific situations, normal people in daily life may not have the motivation to regulate their understanding of others' emotions. It may also be difficult for the average person to inhibit the processing of others' emotions if there are clear emotional cues conveyed by others. Physicians may be trained to control early mechanisms associated with the understanding of others' emotions.

5.2.4 Adaptive functions of regulated empathic concern for others

This study demonstrated that participants reported a reduction of their own emotional responses to the bad person, indicating that there is a situation in which people do not empathize with other people. This modulation may be associated with adaptive functions in social interactions by controlling empathic responses to other people. Despite existence of non-empathic responses, research on empathy primarily focused on the positive aspects of empathy.

Empathy is considered one of the most socially desirable human behaviors (Hodges & Biswas-Diener, 2007). For example, empathic responses to others' misfortune and prosocial behaviors are thought to be appropriate and socially desired. A lack of empathy is associated with psychological disorders such as psychopathy and autism. Similarly, since attention was paid to social affective neuroscience, researchers have characterized neural mechanisms underlying empathy (Lamm et al., 2011).

However, too much empathy may lead to disadvantages (Hodges & Biswas-Diener, 2007). As described above, if physicians have too much empathy, they may feel a strong sense of personal distress due to empathic concerns for patients, which consequently could cause emotional exhaustion and prevent the effective treatment of patients. Another example is soldiers who are at war. If they have too much empathy, they may not survive given that they may not kill their enemy. In certain interpersonal situations, empathy regulation is required for individuals to keep their professional careers and to survive. Indeed, military training teaches soldiers to inhibit a prepotent tendency to feel empathic concern for the enemy (Hodges & Biswas-Diener, 2007). In addition to special groups, this study demonstrated that even ordinary people appear to regulate their empathic concerns for people who are bad/evil. Perhaps ordinary people know when they need to control their empathic responses to others, especially with regard to social norms and knowledge. Thus, the inhibition of empathic concerns could serves as an adaptive mechanism that is associated with appropriate behavioral outcomes, allowing individuals to adjust to specific social situations.

Importantly, this study demonstrated specific mechanisms that potentially underlie empathy regulation as an adaptive mechanism. A decrease in empathic concern, as measured by the ratings of one's own emotions, was associated with an increase in brain activation in regulatory regions. There were also domain-general regulatory functions, such as activity in common regions subserves cognitive effort and conflict resolution. Less empathic response to the bad person in the discordant condition may reflect the outcomes of regulatory functions, such as increased domain-general cognitive control and down-regulated predominant empathic tendency to regulate one's own emotions.

5.3 ECOLOGICAL VALIDITY

Ecological validity has been considered one of the biggest concerns and most challenging issues in the research field of social affective neuroscience (Blakemore, 2006; Spiers & Maguire, 2007; Zaki & Ochsner, 2009). It is important to explore brain mechanisms associated with evaluation of one's own emotions and others' emotions in ecological social situations to understand how the brain deals with emotional processing in real-life social interactions. This importance of ecological validity motivated us to conduct fMRI Experiment II which assessed brain mechanisms in complex experimental situations. In particular, this study attempted to increase ecological validity by considering three factors possibly associated with real-life social situations. First, in spatial domains, real-life social situations describe more complex emotional information conveyed by multimodal signals, such as visual, auditory, and semantic processing, than simple experimental conditions (Zaki & Ochsner, 2009). Second, in temporal domains, real-life social situations are more dynamic and last longer than simple experimental conditions (Rottenberg et al., 2007). Thus, this study used video clips depicting socio-emotional situations and lasting for 3 minutes. Third, in the measurement of emotions, explicit emotional processing happens continuously in real-life emotional situations relative to simple experimental conditions (Ruef & Levenson, 2007). fMRI Experiment II showed that distinct regions identified in the simple experimental condition were recruited by continuous ratings of one's own emotion and others' emotions, suggesting that similar brain mechanisms may be engaged in explicit emotional processing in laboratory environments and real-life situations. However, there were several unresolved issues in conducting experiments using complex conditions.

5.3.1 Issues for future research: Lessons learned from fMRI Experiment II

fMRI Experiment II had technical and methodological problems. First, it is well known that there is a trade-off between ecological validity and experimental control (Levenson, 2003). Specifically, fMRI experiments were conducted in more restricted laboratory environments than those of behavioral studies, consequently causing more experimental control problems, such as sound control (e.g., volume of video clips) in the scanner, use of an MR-compatible mouse, and time limitation. One important problem revealed in this study is associated with control conditions (as baseline) to extract only experimentally relevant processes (Morcom & Fletcher, 2007). Thus, one should be cautious in designing fMRI experiments using complex conditions. The second issue is related to the analysis of imaging data. Brain signals would be more dynamic and complicated in complex, ecological situations or even more in real-life social situations. Brain signals may also vary irregularly and be less predictable in complex conditions than in simple conditions (Malinen, Hlushchuk, & Hari, 2007). In fact, fMRI Experiment II exhibited irregular, varied brain activity over time. Another issue is related to the interpretation of findings. In particular, if there are more than two experimental factors in complex experimental conditions, it is difficult to interpret findings about temporal variations. For example, fMRI Experiment II found that some distinct regions were modulated by empathic processing, but it was difficult to understand the roles of these regions in explicit emotional processing.

5.4 RELATIONSHIP TO OTHER LITERATURE AND IMPLICATIONS

This study attempted to constrain both common and specific roles of brain regions in emotional processing in social contexts which are either *more* likely to provoke empathy or *less* likely to provoke empathy. Such an endeavor contributes to a better understanding of brain functions in evaluation of one's own and others' emotions in social affective neuroscience. In addition, findings from this study extend the understanding of brain mechanisms underlying explicit emotional processing to other research fields such as cognitive neuroscience and social neuroscience. Thus, in the following sections, how our findings regarding evaluation of one's own and others' emotions fit into brain mechanisms associated with relevant research areas will be discussed. In addition, some implications for future studies in these research fields will be suggested.

5.4.1 Social affective neuroscience: one’s own emotions and others’ emotions

Emotional processing in social contexts may be associated with specific or different processing yielded by social information or cues such as faces being compared to emotional processing in non-social contexts. For example, evaluation or appraisal of other people’s emotions may be selectively involved in emotional processing in social contexts. As appraisal theories of emotion suggest, emotion (e.g., one’s own emotion) is affected by how one appraises or evaluates stimuli or events (Roseman & Smith, 2001). Similarly, one’s own emotion may be influenced by how one appraises and perceives emotions of others in social contexts. Thus, evaluation of one’s own and others’ emotions is tightly interrelated in social contexts. Brain mechanisms of one’s own and others’ emotions are also closely intertwined in emotional processing in social contexts.

Yet, the extent to which brain mechanisms associated with evaluation of one’s own and others’ emotions are intertwined is unclear. Although empirical studies reported that different brain mechanisms were involved in emotional processing in social contexts compared to non-social contexts (Britton, Phan et al., 2006; Norris, Chen, Zhu, Small, & Cacioppo, 2004), it still remains unclear why these brain mechanisms are selectively involved in emotional processing in social contexts. Possibly, selective brain mechanisms in social contexts may be involved in multiple processes, such as shared processing of one’s own and others’ emotions and distinct processing by evaluation of others’ emotions.

In addition, previous imaging studies often assessed brain mechanisms associated with emotional processing in social contexts without considering the relationships between one’s own emotions and others’ emotions. For example, most studies included in our meta-analytic studies used one task that request participants to evaluate either one’s own emotions or others’ emotions.

Thus, interpretation of specific roles of brain networks identified in these previous studies is limited. As our meta-analytic study reported, brain networks were consistently associated with both common and distinct mechanisms across these previous studies. This finding indicated that distinct brain regions identified by one specific evaluation task could represent confounded neural mechanisms of common and specific emotional processing rather than solely distinct mechanisms of specific processing.

Our study demonstrated that each emotional evaluation task recruited both common and distinct brain regions, indicating that brain mechanisms associated with evaluation of one's own and others' emotions are intertwined as well as separated. Thus, to specify whether brain networks are involved in common or distinct processing, both evaluation of one's own and others' emotions should be assessed within a study. There are some reasons why evaluation of one's own and others' emotions should be assessed separately within a study. First, emotional processing in social contexts involves complex, multiple processes such as shared and distinct processes of *self* and *others*. Multiple processes in explicit emotional processing recruit brain networks which play different roles but are functionally connected. For a better understanding of how the brain deals with emotional processing in social interactive contexts, specific roles in brain regions should be understood. Second, evaluation of one's own and others' emotions is closely related to affective disorders such as autistic spectrum disorder (ASD), alexithymia, and psychopathy. Thus, a better understanding of brain mechanisms involved in evaluation of one's own and others' emotions separately may contribute to better detection of these affective disorders and better treatments for individuals with these disorders. Further clinical implications will be discussed in the last section.

5.4.2 Cognitive neuroscience: Cognitive control in social contexts

This study reported that the discordant condition recruited additional processing which is associated with cognitive control such as cognitive effort and regulatory function. Increased brain activation in common brain regions such as the rACC and DLPFC represents increased conflict in the discordant condition and cognitive efforts in evaluation of one's own emotional responses to the bad person and the bad person's emotions.

Yet an alternative explanation is that the discordant condition manipulated in the laboratory environment may introduce new factors rather than empathy confounds. New factors may simply represent increased attention or cognitive processing, especially when occurring in non-routine experimental conditions such as our discordant condition. Past research on cognitive neuroscience has employed incongruent conditions to increase cognitive interference which then triggers increased cognitive control in laboratory experiments (e.g., Badre, 2008; Botvinick et al., 2004). This past research also demonstrated that the cACC and DLPFC were activated by increased cognitive interference conditions, indicating that these brain regions are involved in cognitive control. Thus, it is possible that increased activation in the cACC and DLPFC represents domain-general cognitive control rather than cognitive control related to empathy confounds.

Despite this possibility, it is worthy of note that our experimental manipulation by good/bad persons may increase cognitive control and conflict interpreted as empathy confounds. Our study suggests that the discordant condition generates conflict, especially emotional conflict, caused by a discrepancy between selecting one's own emotional responses to the bad person and understanding the bad person's negative emotions conveyed by the bad person's sad face in negative life events. Consistent with this idea, recent imaging studies examining brain mechanisms involved in emotional conflict reported that similar brain regions such as cACC and DLPFC are involved in emotional conflict caused by incongruent conditions in which negative words were superimposed in faces with positive expressions or vice versa (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Haas, Omura, Constable, & Canli, 2006).

Thus, our study suggests that increased cognitive control or conflict may represent one possible aspect of empathy confounds as emotional conflict. With respect to literature on cognitive neuroscience, it is also suggested that the involvement of the cACC and DLPFC in cognitive control is not limited based on whether conflict is caused by cognitive or emotional contexts. One implication of our study for future research to investigate cognitive control mechanisms involved in emotional conflict is that our experimental paradigm provides a more ecological way to create conflict (emotional conflict) situations compared to other previous tasks such as the word-face Stroop task (Haas et al., 2006) and emotional conflict resolution task (Etkin et al., 2006). Although interactions with the good/bad persons in our study are relatively more artificial than interactions with other people (e.g., impression formation) in naturalistic social situations, our study showed that prior experience with other people altered one’s own subsequent emotional responses to the other people. In fact, there are real-life social situations in which people have emotional conflict and show non-empathic responses to other people. Our study provides substantial evidence as to how the brain functions in such challenging social situations.

5.4.3 Social neuroscience: In-group vs. out-group

Our study has implications for understanding neural substrates of in-group biases, which are defined as a preference for in-group members over out-group members. Our findings regarding self/other distinct mechanisms and empathy modulation may fit into the understanding of brain mechanisms involved in social interactions with in-group and out-group members. Previous imaging studies showed that brain regions involved in social perception were modulated by in-group vs. out-group (e.g., Phelps et al., 2000; Wheeler & Fiske, 2005). Beyond the perceptual level, it still remains unclear how the brain reacts differently to in-group members and out-group members in complex social interactions such as higher social cognition and empathy.

Potentially, self-related processing and social cognition such as mentalizing, which are intertwined in social interactive situations, may be involved differently in interactions with in-group and out-group members. Our results suggest that brain mechanisms underlying *self* and *others* may play a critical role in understanding how people are interact differently with in-group members vs. out-group members. In our study, participants might consider the good person as in-group whereas they might consider the bad person as out-group based on their prior experience with the good and bad persons. Perhaps, there would be greater dissociation between *self* and *others* in the out-group compared to the in-group. Such greater dissociation could be due to inhibition of self-referential processing or self-knowledge when interacting with out-group members. Inhibition of self-referential processing may lead to less individuated processing, which is associated with more personalized- or self-knowledge, when judging out-group members' minds compared to in-group members' minds. Alternatively, dissociation of *self* from *others* may increase conflict and cognitive control in an out-group condition.

One recent imaging study showed that the brain regions involved in individuated processing, which are more deliberate and reflective social cognitive processes, were modulated by in-and out-group conditions (Freeman, Schiller, Rule, & Ambady, 2010). VMPFC regions were selectively involved in individuated processing when judging in-group members, but not when judging out-group members. They suggested that the VMPFC represents self-referential processing engaged in judgment of in-group members. Thus, no selective VMPFC activation when judging out-group members indicates that self-referential processing is not involved in judgment of out-group members. However, there is a limitation to this interpretation because they did not explicitly assess self-judgment. Thus, it is unclear whether reduced VMPFC activation may represent reduced mentalizing, reduced self-referential processing, or reduced common/shared mechanisms between mentalizing and self-referential processing. To clarify the role of brain regions modulated by in- and out-groups, judgments of *self* and *others* are needed.

At low levels of social processing, such as perception, in-group and out-group biases may be simple. For example, people have a preference for faces of in-group members over those of out-group members. However, at high levels of social processing such as mentalizing and empathy/altruism, in-group and out-group biases may be complex and diverse. For example, people do not always empathize with others who are in-group members. Empathic responses to in-group members varied as a function of perceived similarities (e.g., Sturmer, Snyder, Kropp, & Siem, 2006). Responses to out-group members varied from empathy (feeling bad for them) to schadenfreude (pleasure at others' misfortune or distress) (e.g., Leach, Spears, Branscombe, & Doosje, 2003). Additional analysis of our study also showed that empathic responses to the bad person varied as a function of negative events. We hypothesized that people sometimes showed schadenfreude when the bad person was in negative life events. However, our findings showed that a few people reported positive emotions (schadenfreude) only when the bad person deserved the negative events such as 'her business license is being revoked'. In addition, participants showed empathic concerns for the bad person who experienced very negative life events such as ‘she has breast cancer’. These findings suggest that future study should carefully examine how in-groups and out-groups modulate brain mechanisms involved in complex social behaviors such as empathy.

5.4.4 Clinical implications

Explicit processing of emotion in *self* and *others* is an important subcomponent of empathy and a critical concept associated with affective disorders such as ASD, alexithymia, and psychopathy (for a review, see Blair, 2008a, 2008b; Decety & Moriguchi, 2007). ASD is characterized by deficits in a broad range of social interactions, possibly via difficulty in mentalizing or taking others’ perspective (Decety & Moriguchi, 2007). Individuals with ASD may have abnormal development of *self-other* mechanisms (Dapretto et al., 2006). Individuals with a high score of alexithymia, referring to a deficit in emotional processing in *self*, demonstrated impaired understanding of others’ mental states in TOM tasks (Moriguchi et al., 2006) and less empathic responses to others’ pain (Moriguchi et al., 2007). These findings suggest that investigating both mechanisms underlying *self* and *others* contributes to comprehensive understanding of the mechanisms of ASD and alexithymia. Additionally, emotional processing of *self* and *others* in the non-empathy situation may provide additional information to understand the underlying mechanisms of affective disorders.

6.0 CONCLUSION

This study explored common and distinct brain mechanisms associated with evaluation of one's own emotions and others' emotions. In particular, this study focused on 1) modulation by empathic processing on these brain mechanisms and 2) generalization of findings from the relatively simple experimental condition to complex, naturalistic social contexts. This study made two important contributions to a better understanding of the brain mechanisms underlying evaluation of one's own emotions and others' emotions which are closely related to understanding complex human social behavior such as empathy. First, this study demonstrated that there are some common and distinct mechanisms modulated by empathic processing and other common and distinct regions not modulated by empathic processing. Modulation was specifically associated with increased cognitive efforts and regulatory demands in common and self-distinct mechanisms. Second, some possibilities of generalization of these findings from the simple condition to the complex, ecological condition were proved in both behavioral and imaging studies. This study takes the first step to support the notion that similar brain mechanisms might be involved in evaluation of one's own emotions and understanding others' emotions in both simplified and real life social contexts.

APPENDIX A

BEHAVIORAL EXPERIMENT II: VALIDATION OF NOVEL PARADIGMS

INTRODUCTION

To use the same target persons (e.g., faces) manipulated as either good or bad persons in both fMRI experiments, neutral and emotional faces of both persons were captured from the video clips used for fMRI Experiment II. These faces were different from those (Nimstim faces) used in behavioral Experiment I. They may be more naturalistic than the posed Nimstim faces with regard to emotional expression. It is unclear whether findings from behavioral Experiment I are maintained in more ecological, complex experiment condition. Additionally, a behavioral pilot study is required to validate the second fMRI experiment in which participants continuously rated one's own emotions or the emotions of a main character when they were watching the video clips. Thus, another behavioral experiment was conducted 1) to replicate the results from behavioral Experiment I using new naturalistic faces (replication of manipulation and emotion ratings of *self* and *others* in the simple experiment condition), and 2) to investigate whether there are more similar emotional responses between *self* and *other* in the concordant condition as compared to the discordant condition in complex and ecological situations (validation of a new paradigm for fMRI Experiment II).

METHOD

Thirty-four undergraduate students (6 males, mean age (SD) =19.18 (2.11) years) were recruited for participation in this pilot study. They received course credits for their participation and signed a consent form approved by the Institutional Review Board of the University of Pittsburgh.

They participated in the same manipulation and learning check sessions as behavioral Experiment I (see Method sections in behavioral Experiment I and in fMRI Experiment I). Following the manipulation and learning check sessions, participants were asked to complete emotion ratings in a simple condition similar to the first fMRI experiment. They evaluated either their own emotions or the emotions of others while viewing a stimulus that consisted of a face and sentence in simple experiment condition (see Method section for fMRI Experiment I). Participants were then asked to complete continuous emotion ratings in a complex condition similar to fMRI Experiment II. In this complex condition, they were asked to continuously rate their own emotions or the emotions of others while viewing the video clips (see Method section for fMRI Experiment II). There was a third simple experimental condition that served as a baseline in the simple experiment condition. Participants were asked to rate their own emotions and the emotions of a neutral person who was new (no prior experience with this person) to the participants. Emotion ratings in the neutral condition were used as a baseline to examine whether the manipulation affected emotion ratings using a within-subjects design. Although behavioral

Experiment I compared emotional ratings in the concordant, discordant, and control conditions, it employed a between-subjects design, which potentially includes individual variability.

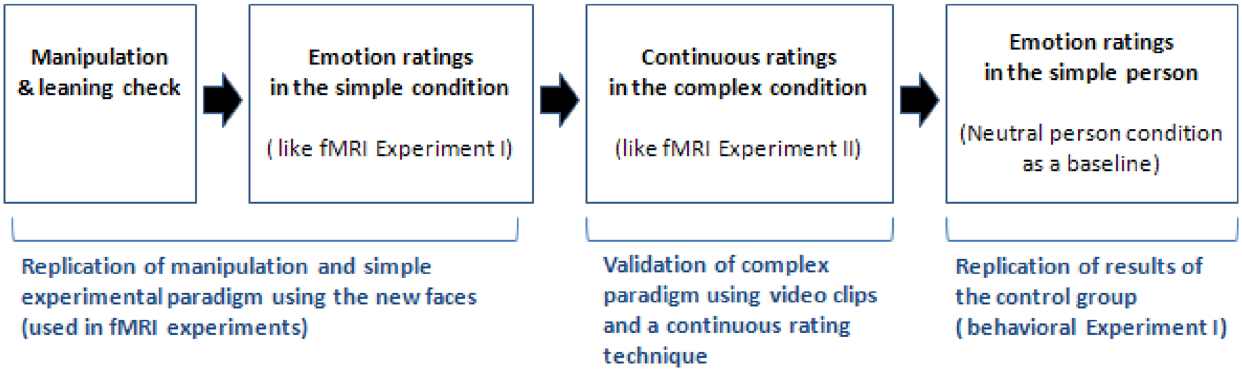

Figure 6.1 Experimental procedure in behavioral Experiment II

RESULTS

Manipulation check

Post-rating data with regard to the video clips presented during the manipulation showed that participants reported more positive emotional responses to the video clip of the good person (Valence rating: *M* = 7.29, *SD* = 1.51) than to the video clip of the bad person (*M* = 2.12, *SD* = 1.01), *t*(33) = 15.51, *p* < .001, *d* = 2.66. All participants performed the learning check accurately with over 95 % accuracy in all of the different conditions (Good person-Match condition: *M* = 98.53%, *SD* = 4.36; Good person-Mismatch condition: *M* = 97.35%, *SD* = 5.11; Bad person-Match condition: *M* = 96.18%, *SD* = 6.52; Bad person-Match condition: *M* = 98.53%, *SD* =

4.36). Consistent with behavioral Experiment I, these results indicate that participants perceived the good person as good and the bad person as bad.

Emotion ratings of *self* and *others* in the 'simple' condition and in the neutral person

A 2 Task (Self vs. Other) x 2 Person (Good vs. Bad) repeated measures ANOVA revealed a significant interaction effect, $F(1, 33) = 89.52$, $p < .001$, $\eta_p^2 = .73$ (Figure 7.1). Consistent with behavioral Experiment I, simple main effects with a Bonferroni correction for multiple comparisons showed a significant difference in the emotion ratings between *self* and *others* in both the concordant and discordant conditions (*ps* < .001). However, differences in emotion ratings between *self* and *others* appeared greater in the concordant condition than in the discordant condition. These findings suggest that participants felt more similar emotional responses to the good person than the bad person. There was also a significant difference in the emotion ratings of *self* between the concordant and discordant conditions ($p < .001$). However, this difference was not evident in the emotion ratings of *other* between these two conditions ($p = .64$). In accord with behavioral Experiment I, the reduction of one's own emotional responses to the bad person contributed to less similarity between *self* and *other* in the discordant condition.

Emotion ratings in both concordant and discordant conditions were compared to those in the neutral condition. Consistent with behavioral Experiment I results, significant differences in emotion ratings of *self* were found between the good and neutral persons, $F(1, 33) = 7.62$, $p < .01$, $\eta_p^2 = .19$, and between the bad and neutral persons, $F(1, 33) = 65.74$, $p < .001$, $\eta_p^2 = .67$ (Figure 7.1). However, there were no significant differences in emotion ratings of *others* between the good and neutral persons ($p = .46$) or between the bad and neutral persons ($p = .06$). These findings indicate that the manipulation affected the emotion ratings of *self*, but not the emotion ratings of *others*.

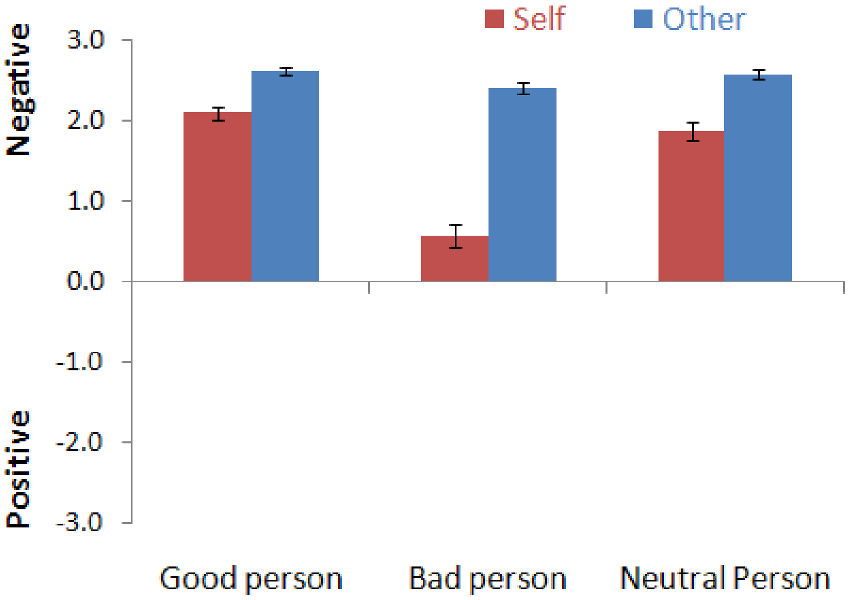

Figure 6.2 Emotion ratings of *self* and *others* in the simple experimental condition. Note. Y-axis: emotion rating scale: 3=very negative, 0=nothing or neutral, and -3=very positive.

Continuous emotion ratings in the 'complex' condition using video clips

Figure 7A and 7B shows the averages across individuals of the continuous emotion ratings of *self* and *others* in the concordant and discordant conditions, respectively. As predicted, the continuous emotion ratings showed significant differences between *self* and *others* over longer time periods in the bad person condition (1.70 to 72.00 sec: $F(1,33) = 23.55$, $p < .05$; 86.30 to 180.00 sec : $F(1,33) = 22.47$, $p < .05$) than in the good person condition (e.g., 0.05 to 16.85 sec: $F(1,33) = 12.76$, $p < .05$; 25.05 to 71.15 sec: $F\ (1,33) = 11.23$, $p < 0.05$; 129.25 to 139.55 sec: $F(1,33) = 7.93$, $p < .05$; 175.50 to 179.90 sec: $F(1,33) = 6.59$, $p < .05$).

As shown in Figure 7C and 7D, *self*-ratings between the good and bad persons were significantly different over long time periods (e.g., 3.50 to 31.55 sec: $F(1,33) = 12.09$, $p < .05$; 82.45 to 110.65 sec: $F(1,33) = 8.87$, $p < .05$; 110.75 to 141.65 sec: $F(1,33) = 8.57$, $p < .05$; 158.70 to 179.50 sec: $F(1,33) = 6.35$, $p < 0.05$). In contrast, *other*-ratings between the good and bad persons were not significantly different over any time periods. Less similarity between *self* and *others* in the bad person condition compared to the good person condition could be due to less intense *self*-ratings in the bad person condition. Specifically, there was a marginally significant Task x Person interaction in average ratings from 4.05 to 74.05 sec, $F(1,33) = 3.98$, $p = .054$, $\eta_p^2 = .11$, and a significant Task x Person interaction in average ratings from 4.05 to 74.05 sec, $F(1,33) = 8.45$, $p < .01$, $\eta_p^2 = .20$ (Figure 7.2E). Consistent with the findings from the simple experimental condition, less similar emotions between *self* and *others* were reported in the bad person condition than in the good person, which is due to less intense *self*-ratings in the bad person condition.

DISCUSSION

This behavioral experiment aimed to replicate the effectiveness of the manipulation, learning check, and simple experimental paradigm used in behavioral Experiment I using new faces in the fMRI experiments. We found similar results of manipulation, learning checks, and emotion ratings of *self* and *others* in the simple condition and the neural person condition compared to behavioral Experiment I. These results successfully replicated findings from behavioral Experiment I.

We also found similar patterns of emotion ratings of *self* and *others* in the complex conditions using video clips and a continuous rating technique. Consistent with emotion ratings in the simple condition, continuous rating results showed that there were less emotional responses (e.g., less empathic concern) to the bad person than to the good person in the complex experimental condition. In addition, there was no difference in ratings of others' emotions between the good and bad persons. These findings suggest that it is possible to generalize findings from the simple conditions to more complex, ecological conditions. This behavioral experiment successfully validated a newly developed experimental paradigm for fMRI Experiment II in complex, ecological social contexts.

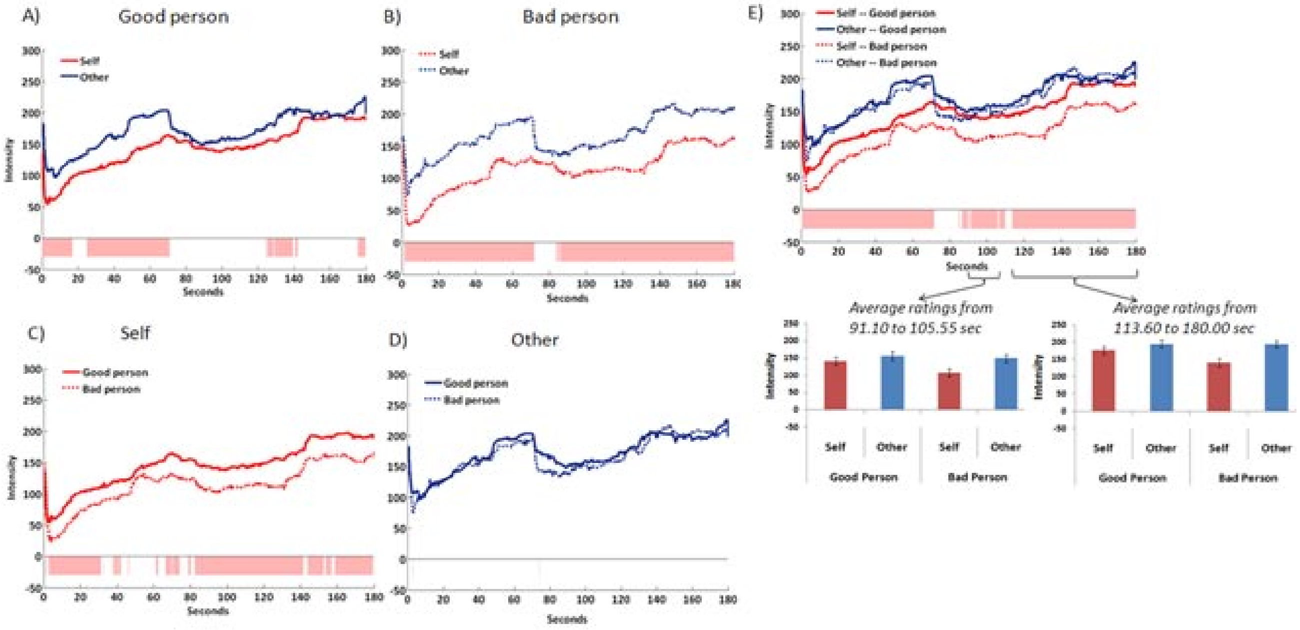

Figure 6.3 Continuous emotion rating data in the complex experimental condition: A. Continuous emotion ratings between *self* and *other* in the concordant condition. B. Continuous emotion ratings between *self* and *other* in the discordant condition. C. Continuous emotion ratings of *self* between the concordant and discordant conditions. D. Continuous emotion ratings of *other* between the concordant and discordant conditions. E. Continuous emotion ratings in the four conditions and the significant interaction of Task x Person in average ratings from 91.10 sec to 105.55 sec and from 113.60 sec to 180.00 sec. Note. A~D: x-axis = time in seconds, y-axis = negative emotion intensity (from 0: no negative emotion at all to 310: the most intense negative emotion).

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