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INTERHEMISPHERIC COMMUNICATION AND EMOTIONAL REACTIVITY

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ABSTRACT

Negative emotions involve right hemisphere activation, while positive emotions involve left hemisphere activation (Borod, 1992). Researchers (e.g., Galin, 1974) have further hypothesized that emotional regulation is associated with left-hemisphere activation. Thus, regulation of negative emotion would require interhemispheric communication. These studies examined whether individual differences in interhemispheric communication predicted emotional reactivity. In Study 1, participants completed the Emotional Contagion Scale (Doherty, 1997) and the Edinburgh Handedness Inventory (Oldfield, 1971), and "strong-handedness" (i.e., low interhemispheric communication) showed a positive relationship with contagion to negative emotions (e.g., fear, anger, and sadness). In Study 2, strong-handedness positively correlated with test anxiety.

INTRODUCTION

Researchers have long known that the hemispheres of the brain play different roles in the experience of emotion. Bakan (1969) and Galin (1974) suggested that the verbal, analytical left hemisphere acts to inhibit the emotion-related messages coming from the right hemisphere. This idea, predictably named the Right-Hemisphere Hypothesis (Borod, 1992), fit the logic that the left hemisphere engages in more deliberate, analytical tasks and the right hemisphere engages in more holistic, reflexive tasks (Tucker, 1981). However, at the time that this hypothesis was prominent, technological options for studying brain activity were limited to examining sensory dominance in different sides of the body (e.g., using preferences in visual or auditory fields), brain damage studies, and EEG experiments.

A competing hypothesis, the so-called Valence Hypothesis, emerged during the 1980's (Bryden, 1982; Silberman & Weingartner, 1986) and gradually accumulated support as brain imaging technology (e.g., PET Scans, fMRI) became available (Pizzagalli, Shackman, & Davidson, 2003). This hypothesis states that the neurological activation associated with an emotional response depends on the valence (i.e., positive or negative) of the emotion (Borod, 1992). Specifically, positive emotions (e.g., love or joy) typically involve left hemisphere activation, while negative emotions (e.g., anger, fear, sadness) typically involve right hemisphere activation. This arrangement seems especially adaptive because, the right posterior (i.e., parietal) region of the brain activates during threat responses and leads to increased visuo-spatial attention, vigilance, and autonomic arousal (Heller, Koven, & Miller, 2003). Thus, when threat is detected, no interhemispheric interaction is required in order to efficiently engage in the emotional processing (fear or anger) necessary to respond to the threat.

This left-positive, right-negative distinction generally has produced reliable results. The left hemisphere shows activation during approach behaviors (Davidson, 2000) and when processing reward information (O'Doherty, Kringelbach, Rolls, Hornak, & Andrews, 2001) or pleasant visual information (Canli, Desmond, Zhao, Glover, & Gabrieli, 1998). Conversely, in the same studies, the right hemisphere showed activation during avoidance behaviors and processing punishment and aversive visual stimuli.

The Development of Hemispheric Differentiation of Emotion

Fox and Davidson (1986) found some support for the Valence Hypothesis in newborns. Using EEG scans, they discovered greater left-frontal activation when newborns received a sucrose solution, which infants find pleasant. However, they found no correspondingly negative reaction to an aversive substance: citric acid. Infants showed facial disgust, but showed no increase in electrical activity of the right-frontal hemisphere. This represents a common finding in the infant literature: the left hemisphere reliably activates during positive emotions, but right-hemisphere activation is far less predictable. For instance, in multiple studies of ten-month-olds, pleasurable stimuli produced left-frontal activation, but aversive stimuli did not easily produce right-frontal activation (Davidson & Fox, 1982; Fox

& Davidson, 1988). This, despite the fact that, according to various theories of emotional development (e.g., Izard, 1991; Sroufe, 1979), children should be displaying each of the basic negative emotions by ten months of age.

Thus, while researchers have identified general patterns of hemispheric activation, these results can defy dichotomous categorization. For instance, even though positive emotions imply approach behaviors, and correspondingly, negative emotions imply avoidance behaviors, in actual practice, emotion categories and behavior categories do not always align. For example, an angry person may advance upon a target, or a sad person may feel motivated to seek others for comfort (Davidson & Fox, 1988). The neurological response also may depend upon the behavioral options available. For example, in a study that featured students reading about a tuition increase at their university, when participants read that administrators were considering the increase (i.e., it could still be prevented) rather than having already made a definite decision, the angered participants actually showed left-frontal activation (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003).

This returns us to the idea proposed by Bakan (1969) and Galin (1974), that another part of the brain might become active while regulating these reflexive, typically right-hemisphere responses. Both authors proposed that the analytic, left hemisphere acts as the emotional regulator, and Buck (1985) supported this idea by pointing out the major difference between humans and other animals is our capacity for language (also associated with left hemisphere activation) and this, in turn, may provide us with a greater capacity for regulating our emotions.

Beginning at about eighteen months, as verbal ability dramatically increases one's capacity for interacting with one's social environment, strategies for self-regulation increase accordingly. Children can use advanced motor skills or rudimentary verbal ability to directly manipulate or distract themselves from the source of their frustration (Grolnick, Bridges, & Connell, 1996; Mangelsdorf, Shapiro, & Marzolf, 1995). As verbal ability increases, the amount and depth of communication between a child and caregiver increases as well. Around the age of three, children begin to internalize display rules expressed by caregivers and can better suppress emotional display (Lewis, Sullivan, Stranger, & Weiss, 1989). Self-regulation strategies learned from parents often involve either mental distraction from, or contemplation of, the emotion-evoking experiences (Thompson, 1998).

Thus, consistent with the Valence Hypothesis, we would expect negative emotional responses to be associated with right hemisphere activation. However, consistent with the Right Hemisphere Hypothesis, we would expect regulation of these negative emotional states to be associated with left hemisphere activation, especially when verbal strategies are utilized.

The Current Studies

The following studies examine whether interhemispheric communication predicts our ability to regulate negative emotions. Interhemispheric communication refers to the process of transmitting messages from one hemisphere of the brain, across the corpus callosum, to the other hemisphere (Van der Knaap & Van der Ham, 2011). If the right hemisphere activates during negative emotional experiences and the left hemisphere activates during the regulation process, an individual who experiences greater interhemispheric communication may experience an increased ability to regulate his or her negative emotions, and in turn, would experience a less intense negative response. Study 1 specifically examines whether our measure of interhemispheric communication (measured by handedness scores) influences the degree to which we experience specific emotions (measured by self-reported emotional contagion scores).

STUDY 1

METHOD

Procedure

142 undergraduate psychology students (47 males and 95 females) at the University of Hawaii at Manoa completed both the Emotional Contagion Scale (Doherty, 1997) and the Edinburgh Handedness Inventory (Oldfield, 1971).

Handedness. The Edinburgh Handedness Inventory (Oldfield, 1971) lists ten tasks (e.g., opening jars), and participants indicate which hand they use to perform the task. They receive five options, each of which later receives a point value: "Always Left" (-10), "Usually Left" (-5), "No Preference" (0), "Usually Right" (5), and "Always Right" (10). Thus, scores range from -100 to 100. Individuals who perform a variety of tasks with either hand (i.e., "mixed-handers") are thought to have more efficient hemispheric interaction (Cherbuin & Brinkman, 2006). Individuals who score below 80 on the EPI (roughly half of the population) fall into this category (Christman, 1995). Thus, for this study, we measured participants on a continuum from strong-handed (either left or right) to mixed-handed. In order to obtain this measure, we calculated absolute values of handedness scores, such that participants who performed all listed tasks exclusively with their left hands (i.e., those with scores of -100) were equivalent to those who perform the tasks exclusively with their right hands (i.e., those with scores of 100). For the Handedness measure, then, higher values indicate a greater tendency to use one hand to perform tasks and less interhemispheric communication.

Emotional Contagion Scale. Emotional contagion has been defined as "the tendency to automatically mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person, and, consequently, to converge emotionally" (Hatfield, Cacioppo, & Rapson, 1992, p. 153-154). The emotional contagion that people experience during a dyadic interaction could be affected by the parts of the nervous system that initially activate this synchrony and mimicry, the feedback they receive from the person they are interacting with, or the their own self-perception (e.g., "I am scowling, so I must be angry") (Hatfield, Cacioppo, & Rapson, 1994).

For the purpose of this study, individual susceptibility to vicariously experience different emotions was measured using the Emotional Contagion Scale (Doherty, 1997). It consists of fifteen statements, three for each of the five basic emotions, as identified by Fischer, Shaver, and Carnochan (1990): Love, Joy, Anger, Sadness, and Fear. For each of the fifteen items, participants indicate the degree to which the statement applies to them (5 = "Always true of me," 1 = "Never true of me"). A sample item for the anger subscale is: "I tense when overhearing an angry argument."

According to Doherty (1997), this scale features high internal reliability as a unidimensional construct (*alpha* = .90) and as a two-factor construct with positive emotion and negative emotion scales (.82 and .80, respectively). Despite the five, three-item subscales having insufficient alpha levels, Lundqvist and Kevrekidis (2008) make a compelling argument for the validity of using a five-factor model for the scale. The Emotional Contagion Scale also has been correlated significantly with responsiveness to afferent feedback (r = .30) and facial affect mimicry (r = .25) (Doherty, 1997).

Emotional contagion was chosen for this study because, as a reflexive response, it provides a relatively pure emotional experience in the sense that it requires minimal context. In fact, it only requires exposure to someone else experiencing strong emotion and the ability to recognize the emotion. We will examine emotional contagion using the five subscales and in terms of positive emotions versus negative emotions. Higher Emotional Contagion Scale scores imply greater contagion and a more powerful emotional experience.

Hypotheses. We predicted that greater interhemispheric communication (indicated by lower Handedness scores) would be associated with less contagion of negative emotion. We also predicted that Handedness would not correlate with contagion of positive emotions because (1) positive emotions and regulation both are associated with left hemisphere activation and (2) the need to regulate positive emotions is typically less pressing than the need to regulate negative emotions.

RESULTS

We conducted linear regressions using Handedness ($M = 78.47$, $SD = 20.61$, for the current sample) as the predictor variable and the five subscales of the Emotional Contagion Scale as outcome variables. Handedness was a marginally significant predictor for Sadness, $t\ (141) = 1.88$, $beta = .16$, $p < .07$, such that mixed-handed participants reported less contagion to sadness than strong-handed participants. Handedness significantly predicted Anger, $t\ (141) = 2.24$, $beta = .19$, $p < .05$, such that mixed-handed participants reported less contagion to anger than strong-handed participants. Handedness also significantly predicted Fear, $t\ (141) = 2.05$, $beta = .17$, $p < .05$, such that mixed-handed participants reported less contagion to fear than strong-handed participants.

Handedness failed to significantly predicted Happiness or Love scores on the Emotional Contagion Scale. However, as with the previous analyses, Handedness was positively related to both variables, such that mixed-handed participants reported less contagion than strong-handed participants.

Overall, Handedness significantly predicted Negative Emotions (i.e., Anger, Fear, and Sadness), $t\ (140) = 2.57$, $beta = .21$, $p < .05$, such that mixed-handed participants reported less contagion to negative emotions than strong-handed participants. Handedness failed to significantly predict the self-reported experience of Positive Emotions (i.e., Love and Happiness).

DISCUSSION

Handedness significantly predicted susceptibility for two of the three negative emotions (Fear and Anger), served as a marginally significant predictor for the other negative emotions (Sadness), and did not significantly predict positive emotions. We anticipated this general pattern of results because positive emotions and emotional regulation both involve left hemisphere activation, and thus, do not require interhemispheric communication, whereas emotional regulation and negative emotion are associated with activation in opposite hemispheres. Also, when one experiences negative emotions, one tends to be more motivated to regulate them than would be the case with positive emotions.

Handedness did not predict Sadness as strongly as it did Anger and Fear. One qualitative difference between these emotions is that Anger and Fear both require a more immediate regulatory response than Sadness (not always, but unlike sadness, anger and fear often involve the interpretation of threat from the environment). Perhaps efficient interhemispheric communication is more vital for regulating threat-based emotions.

An obvious weakness of Study 1 is that its low external validity; the emotional measure involved a retroactive self-report. Study 2 examined the ability of interhemispheric communication to predict test anxiety. We asked participants how much anxiety they were experiencing before taking an in-class exam for an upper-level psychology course. We also controlled for how well they thought they did on the exam, since we anticipated that outcome expectation might influence anxiety.

STUDY 2

METHOD

Procedure

160 undergraduate psychology students (96 females and 64 males) at Keimyung University in South Korea first completed the Edinburgh Handedness Inventory (Oldfield, 1971), and scores were calculated as described in Study 1. Then, on the day of a psychology midterm exam later in the semester, they completed a pair of additional items. They answered the first question, "How much anxiety are you feeling right now?" (1 = "None at all," 7 = "A great deal"), right before the exam. They answered the second question, "How well do you think you did on this exam?" (1 = "Very poorly," 7 = "Very well"), after completing their exam. We will refer to this last variable as "expected performance."

RESULTS

Based on the ability of Handedness to predict fear contagion in Study 1, we expected Handedness to show a significant positive relationship with test anxiety. We entered Handedness ($M = 71.02$, $SD = 27.38$, for the current sample) as a predictor variable in a linear regression, along with scores on the expected performance variable and their actual percent scores on the test. Self-reported anxiety was the outcome variable ($M = 4.70$, $SD = 1.65$). Only Handedness proved to be a significant predictor of test anxiety, $t\ (157) = 2.03$, $beta = .16$, $p < .05$, with strong-handed individuals showing more test anxiety.

DISCUSSION

Study 2 replicated the finding that greater interhemispheric communication (operationalized by Handedness scores) was associated with greater intensity of one's subjective emotional experience (operationalized by self-reported test anxiety). This relationship between handedness and negative emotion fits the hypothesis that interhemispheric communication facilitates effective emotional regulation of negative emotional experiences. Alternative explanations for the results could be that, instead of strong-handedness being associated with weaker regulatory ability, strong-handed people may experience greater physiological arousal to an emotional state than mixed-handed people or may be more aware of their own physiological arousal. However, Greenberg and Vandekerckhove (2008) argue that all emotions are regulated in that our behavioral, attentional, and perceptual tendencies dictate the situations we expose ourselves to and how we interpret those situations. In other words, we are constantly utilizing some sort of regulation process whenever we have an emotional experience. That being said, a more direct test of the primary hypothesis (that greater interhemispheric communication leads to greater regulatory ability) is certainly in order.

The next step in this line of research would involve participants engaging in an emotion-eliciting task and asking half of the sample to regulate their emotional states in order to see whether mixed-handed individuals are superior regulators while using specific strategies, or whether strong-handed controls are just more emotionally reactive. Although it would be inappropriate to use such a design to examine test anxiety, perhaps one could use something like the stressful anagram task described in a study by MacLeod and others (2002).

A final implication of these studies is methodological. Handedness is an easily calculated individual difference worth accounting for in emotional regulation research. Further, much of the research examining the link between hemispheric laterality and emotion has featured only strongly right-handed participants.

However, if this emotional regulation system differs based on interhemispheric communication, more comprehensive analyses should be conducted. Given that the field of psychology stresses the necessity of diverse populations of participants and warns against overgeneralizations, it seems appropriate that these theories of functional neurology would account of the other half of the population.

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APPENDIX A

Handedness Inventory

Please indicate your preference in the use of hands for each of the following activities/objects by placing a check in the appropriate column

	Always Left	Usually Left	No Preference	Usually Right	Always right
Writing					
Drawing					
Spoon					
Open jars					
Toothbrush					
Throwing					
Broom (upper hand)					
Scissors					
Knife					
Striking a match					

Is your mother left-handed?

Is your father left-handed?

APPENDIX B

Emotional Contagion Scale

This is a scale that measures a variety of feelings and behaviors in various situations. There are no right or wrong answers, so try very hard to be completely honest in your answers. Results are *completely confidential.* Read each question and indicate the answer which best applies to you. Please answer each question very carefully. Thank you.

Use the following key:

5 = Always true of me

4 = Often true of me

3 = Usually true of me

2 = Rarely true of me

1 = Never true of me

____ 1) If someone I'm talking with begins to cry, I get teary-eyed.

____ 2) Being with a happy person picks me up when I'm feeling down.

____ 3) When someone smiles warmly at me, I smile back and feel warm inside.

____ 4) I get filled with sorrow when people talk about the death of their loved ones.

____ 5) I clench my jaws and my shoulders get tight when I see the angry faces on the news.

____ 6) When I look into the eyes of the one I love, my mind is filled with thoughts of romance.

____ 7) It irritates me to be around angry people.

____ 8) Watching the fearful faces of victims on the news makes me try to imagine how they might be feeling.

____ 9) I melt when the one I love holds me close.

____ 10) I tense when overhearing an angry argument.

____ 11) Being around happy people fills my mind with happy thoughts.

____ 12) I sense my body responding when the one I love touches me.

____ 13) I notice myself getting tense when I'm around people who are stressed out.

____ 14) I cry at sad movies.

_____ 15) Listening to the shrill screams of a terrified child in a dentist's waiting room makes me feel nervous.

APPENDIX C

Table 1. *Correlation Table of Variables Used in Study 1*

	1	2	3	4	5	6	7	8
1.Handedness	1.00							
2. Sadness	.16	1.00						
3. Anger	.19	.41	1.00					
4. Fear	.17	.48	.50	1.00				
5. Love	.08	.27	.23	.15	1.00			
6. Happiness	.09	.33	.32	.35	.42	1.00		
7. Negative	.21	.82	.77	.82	.27	.42	1.00	
8. Positive	.10	.35	.32	.28	.87	.82	.40	1.00

APPENDIX D

Table 2. *Correlation Table of Variables Used in Study 2*

	1	2	3	4
1. Handedness	1.00			
2. Expected Performance	-.04	1.00		
3. Actual Performance	-.04	.25	1.00	
4. Anxiety	.16	-.14	-.09	1.00

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