DUAL PROCESS MODELS OF DECISION MAKING: AN FMRI INVESTIGATION OF FRAMING EFFECTS AND INDIVIDUAL DIFFERENCES

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DEDICATION

I would like to dedicate this dissertation to my family and friends for their unwavering support in my undertaking of this endeavor.

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While the manifestation of decisions can be explained in several ways, dual-process models provide a unique purview into the relationship between automatic and controlled components of the decision making process. Although dichotomies in processing can be observed utilizing different experimental paradigms, framing effects provide a unique reflection of these dichotomies. Framing effects have been studied behaviorally for quite some time; however, only recently have investigators begun to examine the neurobiological basis for these effects. Additionally, as these effects mirror dual-process accounts of decision making, the examination of concurrent task demands and individual differences in the manifestation of framing effects could serve to inform dual-process models. The current studies examined two different framing paradigms in the context of experimental manipulations, perspective taking and emotional priming, which were intended to facilitate processing within the subsystems of a dual-process account of social cognition. Framing manipulations included both a previously established risky-choice framing paradigm and a novel, socially relevant attribute framing paradigm. In addition to behavioral studies, an fMRI investigation of the attribute framing paradigm was conducted to examine the neural correlates associated with the observed framing effect within the neurobiological framework of the X- and C-System model of social cognition. Finally, the current studies sought to examine the role that individual differences (e.g., personality, intelligence, need for cognition, cognitive reflection, impulsivity, and attachment style) play in susceptibility to framing phenomena. Results indicated the framing manipulations utilized in these studies were successful in eliciting a bias in decision making behavior. The effects of additional experimental manipulations were mixed, with some evidence for influences on the manifestation of the framing effects. fMRI data generally showed changes in brain activity in a manner consistent with the neurobiological divisions included within the X- and C-System model and provided preliminary evidence suggesting differences in the way frames and counterframes are processed. Individual differences, both in terms of psychological constructs and brain activity, appeared to be associated with susceptibility to framing phenomena. In total, the current series of studies provide several novel contributions to the existing literature on framing effects, and by extension, dual-process accounts of decision making.

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PRIOR PUBLICATIONS

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Schachtman, T.R., Bills, C., Ghinescu, R., Murch, K., Serfozo, P., & Simonyi, A. (2003). MPEP, a selective metabotropic glutamate receptor 5 antagonist, attenuates conditioned taste aversion in rats. *Behavioural Brain Research*, 141, 177-182.

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LIST OF ABBREVIATIONS

ACC	Anterior Cingulate Cortex
ANOVA	Analysis of Variance
AR-Anx	Attachment-Related Anxiety
AR-Avo	Attachment-Related Avoidance
BIS	Barratt Impulsivity Scale
BOLD	Blood Oxygen Level Dependent
C-system	Reflective System
CRT	Cognitive Reflection Test
dACC	Dorsal Anterior Cingulate Cortex
DLPFC	Dorsolateral Prefrontal Cortex
DMPFC	Dorsomedial Prefrontal Cortex
ECR	Experiences in Close Relationships - Revised
EPQR-E	Eysenck Personality Questionnaire Revised - Extraversion
EPQR-L	Eysenck Personality Questionnaire Revised - Lie
EPQR-N	Eysenck Personality Questionnaire Revised - Neuroticism
EPQR-P	Eysenck Personality Questionnaire Revised - Psychoticism
EPQR-S	Eysenck Personality Questionnaire Revised – Short Form
FAI	Frame Adaptation Index
FCI	Frame Consistency Index
fMRI	Functional Magnetic Resonance Imaging
FWHM	Full-Width Half-Maximum

GLM	General Linear Model
HRF	Hemodynamic Response Function
ITI	Inter-Trial Interval
LPFC	Lateral Prefrontal Cortex
LTC	Lateral Temporal Cortex
MCC	Middle Cingulate Cortex
MNI	Montreal Neurologic Institute
MPFC	Medial Prefrontal Cortex
MRI	Magnetic Resonance Imaging
MTG	Middle Temporal Gyrus
MTL	Medial Temporal Lobe
NFC	Need For Cognition Scale
OFC	Orbitofrontal Cortex
OMPFC	Orbitomedial Prefrontal Cortex
PFC	Prefrontal Cortex
PPC	Posterior Parietal Cortex
rACC	Rostral Anterior Cingulate Cortex
RAI	Response Accuracy Index
ROI	Region of Interest
RT	Reaction Time
rTMS	Repetitive Transcranial Magnetic Stimulation
SMA	Supplementary Motor Area
SPM	Statistical Parametric Map

TOM	Theory of Mind
VLPFC	Ventrolateral Prefrontal Cortex
VMPFC	Ventromedial Prefrontal Cortex
WTAR	Wechsler Test of Adult Reading
X-system	Reflexive System

CHAPTER ONE
Introduction and Literature Review

A primary goal of science is to increase the knowledge base of man with the hope that it will have some impact on the world as we know it (Glimcher, 2005). In studying the psychological constructs of thought, emotion, and behavior, researchers are presented with an opportunity to facilitate the understanding of how psychology relates to scientific advancement as a whole. In clinical psychology, an emphasis is placed on understanding how individual differences in thoughts, behaviors, and emotions influence people's everyday lives. Our daily lives are full of numerous choices that impact the stream of experiences we have over time. These choices can vary from what we decide to wear on a given day, to more complex decisions, such as how to express ourselves in an emotionally-charged social interaction. Decisions can be made consciously, such as when we decide what to eat for lunch, or more automatically, such as when our motor memory switches on the blinker when making a turn in the car. The decisions we make can also carry with them significant impacts on our lives, as would be the case if we failed to use our blinker and got into a car accident. Given the impact of everyday decision-making on quality of life, this construct represents a mechanism through which a greater understanding of human behavior and development can be achieved with implications for several disciplines (Heekeren, Marrett, & Ungerleider, 2008). While the complexity of decision-making limits broad generalizations, scientists and scholars from multiple disciplines including psychology, neuroscience, philosophy, law, economics, and biology are beginning to shed light on this topic.

Although insights from a diverse population of disciplines have impacted our knowledge of decision-making, psychology and neuroscience appear to be at the forefront of unraveling this complex topic. Indeed, the study of economics has provided theories and formulations to describe many different types of decision situations, yet in practice, these models have been unsuccessful in providing a satisfactory description of human behavior in that humans violate the principles of rationality as described by their models (Glimcher, Dorris, & Bayer, 2005; Sanfey & Chang, 2008). Knowledge generated from psychology includes a vast quantity of information on such topics as emotion, thought, and behavior with an emphasis on the human mind as the construct under investigation, while neuroscience investigates the cognitive and biological substrates of our nervous systems and how they process and organize information. The distinction between mind and brain is a topic of historical controversy including philosophical debates regarding topics such as determinism and dualism (Glimcher, 2005). At the center of these controversies are questions such as is our behavior determined by our biology and environment or do we possess the capacity to guide our lives through free will. While the current investigation does not presume to provide resolutions to such debates, it will seek to shed light on how environmental factors and individual differences may come to inform them.

DUAL-PROCESS ACCOUNTS OF DECISION MAKING

In analyzing decision making, investigators utilize different frameworks to conceptualize how information from our environment gets integrated to inform our choices. While these frameworks vary in scope, they all make attempts to describe how sensory information is translated into thought and action (Heekeren, et al., 2008). One approach to understanding the complexity of decision making comes in the form of examining the roles of distinct systems in processing information to inform choice. The distinction of subsystems of information processing can occur on many levels with different implications for scientific inquiry (Evans, 2008). Additionally, human behavior can be considered the product of the interaction and integration of processing in these systems, which may act in competition or in cooperation with each other.

The idea of multiple systems of processing has historical roots that go back over the past several hundred years (Evans, 2008). These frameworks typically include a distinction between two discrete, yet interdependent systems of processing information. For example, distinctions regarding automatic and controlled processing have been incorporated into models of information processing (Schneider & Chein, 2003), reasoning (Sloman, 1996), learning (Poldrack & Packard, 2003), and social cognition (Lieberman, 2007a; Satpute & Lieberman, 2006). In addition to those frameworks regarding automatic versus controlled processing, many additional conceptualizations exist which distinguish processing according to other dichotomous variables (Evans, 2008; Sanfey & Chang, 2008), and as such, may be referred to as dual-process models. In fact, these models exist to such an extent that it has been difficult for researchers to integrate all of the information available into a coherent overview (Evans, 2008). While proponents of these models highlight distinctions in both the characteristics and applicability of their frameworks, commonalities between the core features of these models may suggest common underlying principles among the systems they describe. Generally speaking, dual-process models posit a dichotomy between intuitive, reflexive, emotionally-driven processing and rational, intentional, logically-driven processing

(Birnboim, 2003; Epstein, 1994; Lieberman, 2007a; Salas-Auvert & Felgoise, 2003; Sloman, 1996). This having been said, some researchers express caution regarding the overgeneralization that commonalities in the scientific literature provide a uniform set of evidence for discrete systems (Evans, 2008; Glimcher, et al., 2005). Indeed, it remains unclear whether the processes described in these models exist as endpoints on a continuum or if they are distinct processes.

One of the most famous dual-process models draws a distinction between two systems of processing referred to as System 1 and System 2 (Evans, 2008; Kahneman, 2003; Kahneman & Frederick, 2002; Stanovich & West, 2000). Similar to the distinctions described above, the processes of System 1 are described as fast, parallel, automatic, effortless, associative, implicit, slowly learned, and often emotionally charged (Kahneman, 2003). System 2 processes can be described as slow, serial, rule-governed, flexible, effortful, and more likely to be consciously monitored and deliberately controlled (Kahneman, 2003). It should be noted that a major function of System 2 is to override functioning in the System 1 when its responses are contextually inappropriate, a function consistent with previous observations (McClelland, McNaughton, & O'Reilly, 1995; Miller & Cohen, 2001; Sloman, 1996). This System 1 and System 2 framework was primarily conceptualized through the observation of different heuristics which demonstrated deviations from rationality in making various judgments (Kahneman, 2003). Heuristics may be described as short-cut rules of thumb used for everyday decisions which can be less rational and subject to bias (Kahneman, 2003). One example of a heuristic is referred to as the “ratio bias.” In a study examining this effect (Denes-Raj & Epstein, 1994), individuals were given the opportunity to choose a jelly bean from two containers which held different proportions of red jelly beans. Picking a red jelly bean resulted in the participant being rewarded with one dollar. Despite having a lower proportion of jelly beans, subjects consistently chose from the container with a higher absolute number of jelly beans. Additional examples of heuristics occur when evaluating probability. Studies have shown that individuals fail to consider base rates (Kahneman & Tversky, 1973), apply statistical reasoning (Denes-Raj & Epstein, 1994; Nisbett, Krantz, Jepson, & Kunda, 1983; Pelham, Sumarta, & Myaskovsky, 1994), or even apply simple deductive logic (Tversky & Kahneman, 1983).

THE X- AND C-SYSTEM MODEL OF SOCIAL COGNITION

A distinct dual-process model was selected as the foundation for the current studies (Lieberman, 2007a; Lieberman, Gaunt, Gilbert, & Trope, 2002; Satpute & Lieberman, 2006). With its roots in social cognitive neuroscience (Lieberman, 2007b; Ochsner, 2004), this framework uniquely describes dichotomous systems of processing as they relate to phenomenon in social psychology including stereotyping, attitudes, persuasion, person perception, and mood effects. This model assumes that automatic and controlled processes are qualitatively distinct, separately evolved, and functionally interdependent; however, the creators note that their conceptualization goes beyond a mere distinction between automaticity and control. The systems are intertwined in processing environmental information to achieve socioemotional goals, but they remain distinct in that each system has a collection of qualities that are relatively absent in its respective counterpart. The first system in this dichotomy is referred to as the Refle<u>x</u>ive, or X-system. In contrast, the second system described is termed the Refle<u>c</u>tive, or C-system. The proposed characteristics of the X- and C-system are summarized in Table 1. This model is not only unique in that it characterizes a dual-process theory relevant to social constructs, but it additionally provides a neurobiological framework for the different components of its proposed systems.

With regard to the X-system, brain regions were selected for inclusion based on being actively involved in conditions that promote automatic, implicit, or unconscious processing of social information. It is also noted that brain structures included in the X-system appear to be older from an evolutionary perspective with a high prevalence in multiple species. Based on their criteria, several brain regions were nominated to the X-system including the amygdala, basal ganglia, lateral temporal cortex (LTC), ventromedial prefrontal cortex (VMPFC), and the dorsal anterior cingulate cortex (dACC). The amygdala is an almond-shaped cluster of nuclei within the medial temporal lobe. It is considered part of the limbic system and, although there is some debate about the functioning of the amygdala, it appears to be associated with processing novel and emotionally-charged stimuli, Pavlovian and fear conditioning, and automatic social cognition (Adolphs, 2010; Bechara, Damasio, & Damasio, 2003; Cardinal, Parkinson, Hall, & Everitt, 2002; Costafreda, Brammer, David, & Fu, 2008; Davis, 1992; Pape & Pare, 2010; Phelps & LeDoux, 2005). The basal ganglia is a group of nuclei at the base of the forebrain. This region includes the ventral striatum, caudate/putamen, substantia nigra, and subthalamic nucleus. These structures are known for their involvement in movement disorders, implicit learning, responding to positive affective stimuli as well as, automatic components of affect, cognition, and behavior (Brown, Schneider, & Lidsky, 1997; Grahn, Parkinson, & Owen, 2009; Graybiel, 1995; Marsden & Obeso, 1994; Utter

& Basso, 2008; Yin & Knowlton, 2006). The VMPFC comprises the ventral (bottom) and medial (middle) portion of the prefrontal cortex (PFC). The term is at times used synonymously with the orbitofrontal cortex (OFC), though some researchers make clear distinctions between these two regions with the OFC being restricted to the lower most part of the VMPFC. The VMPFC's role in social cognition is evidenced in the famous case of Phineas Gage, who after suffering damage to the prefrontal cortex, evidenced significant deficits in social cognition. Researchers have suggested that the damage caused to Gage was primarily localized in the VMPFC (Damasio, 1994). The VMPFC has additionally been associated with social intuition (Bechara, Damasio, Tranel, & Damasio, 1997), implicit gender stereotyping (Milne & Grafman, 2001), and framing susceptibility (De Martino, Kumaran, Seymour, & Dolan, 2006; Deppe, et al., 2005). The LTC consists of the lateral and inferior portions of the temporal lobe in addition to the temporal poles. In contrast to the other areas of the X-system, this area has primarily been associated with semantic rather than affective processes. For example, semantic dementia primarily affects the LTC and produces significant deficits in semantic knowledge (Garrard & Hodges, 2000; Mummery, et al., 2000); however, researchers studying this area have found it to be associated with implicit semantic processes (Crinion, Lambon-Ralph, Warburton, Howard, & Wise, 2003; Rissman, Eliassen, & Blumstein, 2003) and nonverbal decoding of facial expressions (Ambady & Rosenthal, 1992). The LTC has also been associated with sensitivity to biological motion (Allison, Puce, & McCarthy, 2000) and person familiarity in visual representations (Sugiura, et al., 2001). Although the creators of the X- and C-system framework have included the dACC in the X-system due to its apparent involvement in nonsymbolic tension processes

(Eisenberger & Lieberman, 2004), for the purposes of the current studies, the anterior cingulate cortex (ACC) will be included primarily as a C-system structure.

In contrast to the X-system, brain structures nominated to the C-system are well known for their involvement in controlled processes such as working memory, conflict detection, and episodic memory (Lieberman, 2007a; Lieberman, et al., 2002; Satpute & Lieberman, 2006). Structures in the C-system include the ACC, lateral prefrontal cortex (LPFC), posterior parietal cortex (PPC), the hippocampus and surrounding medial temporal lobe region (MTL), and the medial prefrontal cortex (MPFC). While definitions for the area encompassed by the MPFC are diverse and can include the entire medial portion of the PFC, for the purposes of this discussion, the area defined by the term MPFC will be reserved for the most anterior medial portion of the PFC. The MPFC appears to be associated with self-focused attention (D'Argembeau, et al., 2007; Gusnard, Akbudak, Shulman, & Raichle, 2001; Ochsner, et al., 2005) as well as representing the mental states of others (D'Argembeau, et al., 2007; Frith & Frith, 2003; Ochsner, et al., 2005; Saxe, 2006). Additionally the MPFC has been found to be disproportionately larger in humans than in other primates (Semendeferi, Armstrong, Schleicher, Zilles, & Van Hoesen, 2001). The LPFC comprises the lateral portions of the PFC and is involved in numerous cognitive processes that are experienced as intentional and effortful including working memory, implementation of top-down goals, episodic retrieval, inhibition, and self-control (Cabeza & Nyberg, 2000; Curtis & D'Espositio, 2004; Sakagami & Watanabe, 2007; Tanji & Hoshi, 2008; Tanji, Shima, & Mushiake, 2007). The PPC has been associated with working memory, controlled processing, logic, self-focused attention, and perspective-taking (Bucci, 2009; Cabeza & Nyberg, 2000;

D'Argembeau, et al., 2007; Gusnard, et al., 2001; Hutchinson, Uncapher, & Wagner, 2009; Kelley, et al., 2002; Ochsner, et al., 2005; Ruby & Decety, 2001; Vilberg & Rugg, 2008). The MTL, comprising the inner portion of the temporal lobe, and hippocampus were included in the C-system for their role in episodic memory (Brewer, Zhao, Desmond, Glover, & Gabrieli, 1998; Wagner, et al., 1998) as it relates to controlled processing. The ACC, as the name implies, comprises the anterior portions of the cingulate cortex. This region is included within the C-system due to its significant role in conflict detection and decision making (Botvinick, 2007; Carter & Van Veen, 2007; Walton, Croxson, Behrens, Kennerley, & Rushworth, 2007).

Consistent with the X- and C-System model, experimental paradigms have discovered coactivation of brain regions suggestive a dichotomy in systems level processing with respect to category learning (Aizenstein, et al., 2000; Rauch, et al., 1995), attitudinal prejudice (Cunningham, Johnson, Gatenby, Gore, & Banaji, 2003; Cunningham, et al., 2004; Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005), and personality (Eisenberger, Lieberman, & Satpute, 2005). In a category learning task, participants who were aware of patterns within the stimuli responded to changes in the pattern with activation in the LPFC whereas individuals who were not aware of relevant pattern showed activation in the basal ganglia, despite both groups showing a diminished reaction time in the task (Rauch, et al., 1995). In another category learning task, implicit learning resulted in activations in the LTC, whereas, explicit learning resulted in activations in the LPFC, MTL, and PPC (Aizenstein, et al., 2000). With regard to attitudinal prejudice, several studies have shown greater activity in the amygdala when viewing African American faces when compared to Caucasian faces (Cunningham, et al., 2004; Lieberman, et al., 2005). In contrast, verbally explicit processing of race-related information was associated activations in the LPFC (Cunningham, et al., 2003; Lieberman, et al., 2005). With regard to personality, extraversion is frequently associated with positive affect, whereas neuroticism is associated with negative affect and anxiety. In several studies, extroverted individuals were found to have greater working memory efficiency when compared to introverts (Lieberman, 2000; Lieberman & Rosenthal, 2001; Oya, Manalo, & Greenwood, 2004). Trait-anxiety has been associated with greater automatic interference effects (Egloff & Hock, 2001) and diminished working memory efficiency (Darke, 1988). Although no distinction is made in the context of this review, the proponents of the X- and C-system distinguish between the dACC and rostral anterior cingulated cortex (rACC), with the former being included as an X-system structure and the later being included as a C-system structure (Lieberman, 2007a; Lieberman, et al., 2002; Satpute & Lieberman, 2006). In an oddball task, investigators found that neuroticism was positively correlated with dACC responses to conflict detection and negatively correlated with the rACC responses to conflict detection (Eisenberger, et al., 2005). In contrast, these investigators additionally found that extraversion was negatively correlated with the dACC response to conflict detection, but positively correlated with the rACC, LPFC, and PPC responses to conflict detection. These results suggest that extraverts tend to emphasize C-system processing, whereas neurotics tend to emphasize components of X-system processing. Taken together, these results provide support for the coactivation of brain structures nominated to the X- and C-System model.

A central component of the X- and C-System model is that the C-system serves to override activity in the X-system when X-system responses are contextually inappropriate. Evidence for this exists with respect to emotional regulation, affect labeling, attitudinal prejudice, and implicit learning (Lieberman, 2007a; Lieberman, et al., 2002; Satpute & Lieberman, 2006). With regard to emotional regulation, studies show that greater activity in the amygdala and VMPFC occurs during passive viewing of emotionally evocative images and greater LPFC activity occurs during attempts to regulate emotion (Gross, 1998; Ochsner, Bunge, Gross, & Gabrieli, 2002). In subsequent functional connectivity analyses, these researchers found that the greater the magnitude of the LPFC response during emotional reappraisal, the smaller the response was in the amygdala and VMPFC (Ochsner, et al., 2002). Another emotional regulation technique is referred to as affect labeling. The labeling of affect may recruit C-system activity through the linguistic processing of affective stimuli. As mentioned above, amygdala activity is associated with passively viewing emotionally charged material. However, when affect labeling is introduced amygdala activity is replaced by LPFC activity (Hariri, Bookheimer, & Mazziotta, 2000; Lieberman, et al., 2007). Moreover, these studies have found functional connectivity between these regions in that greater responses in the LPFC during affect labeling are associated with weaker responses in the amygdala. Similar findings also exist with respect to implicit versus explicit attitudinal prejudice (Cunningham, et al., 2004; Lieberman, et al., 2005). Implicit Learning tasks have also found relationships between functioning in X- and C-system structures in both lesion studies in animals (Packard, Hirsh, & White, 1989) and category learning (Lieberman, Chang, Chiao, Bookheimer, & Knowlton, 2004; Poldrack, et al., 2001).

Yet another line of research that provides support for the X- and C-System model comes from the study of the Ultimatum Game (Güth, Schmittberger, & Schwarze, 1982).

In this game two players are given the opportunity to split a sum of money provided by the experimenter. One player is deemed the proposer and the other the responder. The proposer makes an offer as to how this money should be split between the two, with no restrictions on how the money is to be divided. The responder then must make a decision to accept or reject this offer. If the offer is accepted, the money is split as proposed. If the offer is rejected, then neither player receives anything. Research indicates that low offers (of 20% or less) have approximately a 50% chance of being rejected (Sanfey & Chang, 2008). It appears that when responders perceive an unfair split of the money, they reject the offer on emotional grounds, despite the potential gain of receiving some money (Pillutla & Murnighan, 1996). An fMRI investigation of the ultimatum game (Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003) showed that this effect was limited to offers from people, as unfair offers perceived to be presented by a computer were accepted more readily. Brain activations associated with unfair offers included the anterior insula (an area associated with negative emotional states), dorsolateral prefrontal cortex (DLPFC), and ACC. A relationship was found between activations in the insula and DLPFC with unfair offers that were rejected showing greater activation in the anterior insula than in the DLPFC. In contrast, unfair offers that were accepted resulted in greater activation in the DLPFC than anterior insula. In a manner consistent with the studies in this proposal, a subsequent study used repetitive transcranial magnetic stimulation (rTMS) to stimulate the DLPFC and found greater acceptance rates of unfair offers (Van't Wout, Kahn, Sanfey, & Aleman, 2005). Additionally, in a separate study, these researchers had participants view emotional videos as priming stimuli prior to engaging in the ultimatum game (Harle & Sanfey, 2007). Results showed that the emotional priming effect of viewing negatively valenced videos, resulted in a greater rejection of unfair offers by participants. Taken together, results from this series of studies provides further evidence for dual-process models of cognition as well as the foundation for the approach to the proposed studies.

The X- and C-System model contains several common characteristics with other dual-process models (Evans, 2008). Given the neuroanatomical framework of the X- and C-system model of social cognition, it provides an ideal basis for the development and examination of experimental paradigms geared towards examining dual-process accounts of decision-making. Recently, researchers have begun to examine the neurobiological correlates of framing effects, and by extension, dual-process accounts of decision-making.

FRAMING EFFECTS

A framing effect may be defined as "discrepancies between choice problems that decision-makers, upon reflection, consider effectively identical" (Kahneman, 2003). Framing effects have traditionally been viewed as deviations from rationality that are contingent on the context in which choices are presented. These effects have been studied in a variety of contexts including advertising, health care, political views, as well as several others (Levin, Schneider, & Gaeth, 1998). Different types of framing effects have been described including risky-choice, attribute, and goal framing (Levin, et al., 1998).

In the case of risky-choice framing effects, when facing a loss, individuals tend to be more risk-seeking, whereas when given a choice framed in terms of gains, individuals tend to be more conservative. The most famous and commonly cited example of risky-choice framing phenomena was called the Asian Disease Problem (Tversky & Kahneman, 1981). In this scenario, decision-makers are presented with two versions of the same problem relating to the outbreak of a new disease, detailing the potential ways that the situation could be handled. In one version of the problem ("lives saved"), outcomes are described relative to the number of lives that would be saved based on the decision choices. The second version ("lives lost") describes the number of lives that will be lost as a result of the decision choices. When presented with this problem in the lives saved version, decision makers tended to choose the option that was more conservative (i.e., ensuring that a specific number of people would be saved despite an alternative choice which held the possibility of saving more people). When presented with the lives lost version of the problem, decision makers favored the option that was more risky (i.e., taking a chance of saving more people and avoiding the sure loss of people). This effect was observed despite the probabilities in the problem being identical in terms of lives lost or saved. The framing of a decision in terms of losses or gains seems to be the critical factor in eliciting the bias observed in risky-choice framing paradigms. In summary, risky-choice framing effects reflect behavioral tendencies to make more conservative decisions in the face of a potential gain and conversely to be more risk-seeking in scenarios which include a potential loss.

A second distinct type of framing effect has been called attribute framing (Levin, et al., 1998). Attribute framing effects reflect behavioral tendencies to endorse or select choices when they are described in terms of a relative positive attribute, and conversely, to reject choices that are described in terms of a negative attribute. The framing manipulation in attribute framing phenomena involves the inclusion of some characteristic of an object or event, which holds a different symbolic meaning (Levin, et al., 1998). The valence of the relative characteristic appears to be the key factor in eliciting an attribute framing effect. For example, imagine going to the store to buy some hamburger. When you get to the store you have a choice between two brands of hamburger. The first brand notes that their hamburger is 90% lean. The second brand describes their hamburger as 10% fat. Although identical in fat content, the manner in which the fat-content is presented would likely influence your selection of hamburger. In fact, results of an attribute framing study support this precise behavioral tendency (Levin & Gaeth, 1988). The study of attribute framing effects may hold some advantages in the systematic evaluation of framing effects. This is the case because as opposed to risky-decision framing paradigms, attribute framing paradigms are somewhat simpler in their presentation. That is to say that the framing effect is not dependent on the description of potential outcomes, rather completely based in the attribute of interest.

Finally, a third type of framing effect that has been posited is called goal framing (Levin, et al., 1998). Goal framing occurs when a message is framed in terms of potential losses or consequences rather than potential gains or benefits, resulting in greater persuasive effects. The emphasis lies in the persuasive effects of the framing manipulation. For example, investigators have found that women are more likely to engage in breast self-examination when the negative consequences of not doing so were stressed (e.g. a decreased chance of finding a tumor in the early stages) as compared to when the advantages of doing so were expressed (e.g. an increased chance of finding a tumor in the early stages) (Meyerowitz & Chaiken, 1987). In contrast to attribute framing, both versions of the frame in this example represent a positive benefit to performing the behavior. With regard to goal-framing phenomenon, the literature generally supports that messages framed in terms of potential losses or consequences are more persuasive in eliciting behavior (Levin, et al., 1998).

The distinctions between attribute, risky-choice, and goal framing phenomena underscore the overarching theme that context plays a crucial role in decision-making. Indeed, the contextual manipulations involved in these various framing paradigms have been shown to influence preferences and behavior (Levin, et al., 1998). This having been said, some methodological and interpretive considerations need to be taken into account when examining the historical findings relative to framing effects.

Although framing phenomena are primarily interpreted with respect to rationality (Kahneman, 2003; Shafir & LeBoeuf, 2002), this strategy may limit the interpretive value of findings. Indeed, it is unclear to what extent rational choice may be optimal, given the variety of differences between individuals and environments. Framing effects may hold a greater utility in contributing to psychological science through their reflection of a dichotomy in decision-relevant information processing (Kahneman & Frederick, 2007; Seger, Stone, & Keenan, 2004). While investigators of rationality have characterized framing phenomenon along the dimensions of dual-process models (Kahneman, 2003; Shafir & LeBoeuf, 2002; Sloman, 1996; Stanovich & West, 2000), previous research is somewhat lacking in the systematic evaluation of how this dichotomy is influenced by additional factors such as social contexts, individual predispositions, and dynamic environments. This is, in part, a reflection of previous limitations in design resulting in a relative reliance on between-subject measurements.

Traditionally, faming phenomena have been examined utilizing between-group designs. That is to say that one group of individuals is presented with one version of the framing stimuli and a second group of individuals is presented with the alternate version. Subsequently, the two groups are compared to each other with respect to their behavioral tendencies. While this approach represents a sound way to examine these effects, it is limited in its ability to identify how individual differences (i.e., intelligence, personality, moral values, etc.) contribute to framing phenomenon on an individual basis. This is the case because between-group designs would require the inclusion of additional groups that could be divided along the variable of interest. Additionally, this approach limits the investigation of how individuals adapt to framing phenomenon over time. That is to say that when both versions of a decision are presented, do individuals become aware of the manipulation and modify their approach to respond more rationally. Finally, between-group designs limit the extent to which framing effects can be studied utilizing methodologies that require multiple repetitions of stimuli such as fMRI. In examining the neurobiological correlates of framing phenomena, novel experimental paradigms that allow for within-subject comparisons will be necessary. In contrast to between-subjects designs, utilizing within-subjects designs allows an investigation of how other constructs reflected in task demands may interact with framing phenomena to inform choice.

Neuroanatomical Correlates of Framing Effects

Various attempts have been made to examine the role of different contextual information on decision making. While not representative of a traditional framing effect, because decision choices were framed with specific contextual information in order to examine for biased responding, a discussion of these studies appears relevant to more traditional investigations of framing phenomena. In one series of fMRI investigations of contextual framing phenomena (Deppe, et al., 2005; Deppe, et al., 2007), researchers used a paradigm most consistent with attribute framing effects. The framing manipulation used in these studies was to associate a logo from different well-known German news magazines with either an advertisement (Deppe, et al., 2007) or a headline (Deppe, et al., 2005). Although not explicitly relevant to the task at hand, it was hypothesized that the presence of the logos would influence the participants' behavior. Participants were asked to make binary attractiveness ratings for magazine advertisements and binary credibility judgments for headlines. The investigators created relative indices to examine the extent to which contextual information from the magazine logos influenced individual's ratings. In analyzing neural correlates associated with these indices, activations in the bilateral ACC were associated with susceptibility to the contextual framing manipulation for visually presented material (advertisements) and activations in the VMPFC were associated with susceptibility to framing for headlines. The authors concluded that the ACC and VMPFC are involved in the assessment of environmental information during decision making and at least partly regulate susceptibility to framing phenomenon.

An additional study investigated contextual framing in a decision making task (Mobbs, et al., 2006). In this experiment, identical faces were paired with emotionally salient contextual movies. The movies were introduced to the experimental paradigm to examine their potential contextual effect on emotional attributions of the faces. Behaviorally, faces paired with emotional movies changed the manner in which participants assigned emotions to the relevant faces. The investigators utilized fMRI to examine neural correlates of this effect and found that faces paired with emotional movies elicited activations in the bilateral temporal pole, ACC, amygdala, and bilateral superior temporal sulcus. Additionally, they found interaction effects in the amygdala with valence matching and mismatching between faces and movies, suggesting that the amygdala may act to prime the affective value of faces. With respect to positive or negative attributions, further analyses showed that positive attributions were associated with activation in the VMPFC, while negative attributions were associated with ventrolateral prefrontal cortex (VLPFC) activations. This pattern of activation was consistent with previous observations regarding positive and negative attributions (Kim, et al., 2004).

In addition to the aforementioned studies, a couple of studies have examined more traditional representations of framing effects. One recent study investigated the neural correlates of a risky-choice framing paradigm with fMRI (De Martino, et al., 2006). These investigators utilized a gambling paradigm and the framing effect was manifested by offering participants a proportion of an initial sum in terms of the amount of money lost or retained from the original amount. In addition to the option to retain a portion of the initial amount, participants additionally had the option to gamble with various probabilities of keeping the entire initial amount. Behaviorally, the results were consistent with the expectations of prospect theory. Participants chose to the option to retain money more often when the amount retained was framed in terms of gains. In contrast, when the option to retain a portion of the initial amount was framed in terms of relative losses, participants chose to gamble more frequently. When participants acted in concordance with the framing effect, activations were observed in the bilateral amygdala. Conversely, when subjects made decisions inconsistent with the framing manipulation, activations were found in the ACC and the bilateral DLPFC. These investigators additionally created a "rationality index" based on the proportion of frame consistent responding by the participants. The rationality index was used in a correlational analysis with predefined ROIs to identify brain regions that could potentially mediate susceptibility to the framing manipulation. Results showed that decreased susceptibility to the framing manipulation was associated with increased activity in the right OFC and the VMPFC.

In a subsequent fMRI study (Roiser, et al., 2009), these investigators utilized the aforementioned task to examine for potential differences in susceptibility to framing phenomenon based on genetic variations in the serotonin transporter-linked polymorphic region (5-HTTLPR), as variations have been associated with altered amygdala reactivity and a lack of prefrontal regulatory control (Heinz, et al., 2005). They hypothesized that individuals who were homozygous for the short allele of this gene would be more susceptible to the framing manipulation when compared to individuals who were homozygous for the long allele. Their results supported this hypothesis with behavioral data supporting an increased susceptibility to framing for participants homozygous for the short allele. Additionally when those with the short allele were compared to those with the long allele, neuroimaging data showed increased amygdala activity during frame consistent responding for the short allele group. Increased coupling between the ACC and amygdala was discovered during frame inconsistent responding and this effect was limited to those individuals homozygous for the long allele for 5-HTTLPR. Their results additionally replicated the findings from their previous study that activation in the OFC was associated with diminished susceptibility to their framing effect.

Taken into the context of the X- and C-system framework, the results of these studies suggest that activation in the amygdala occurs when individuals act in a manner consistent with framing manipulations. As the amygdala is included in the X-system, these results provide additional evidence that it is involved in the automatic processing component of decision making. In contrast, when individuals act in a manner that opposes the framing manipulation, activations are observed within the DLPFC and ACC, two regions included in the C-System. With regard to susceptibility to framing phenomenon, these studies suggest that the VMPFC, OFC, and ACC may mediate susceptibility to framing effects.

INDIVIDUAL DIFFERENCES AND TASK DEMANDS

As noted above, previous investigations into framing phenomenon have been limited in their ability to address the potential contributions of individual differences to framing phenomenon. When taken in the context of dual-process models, individual susceptibilities to framing phenomena may be associated with a predisposition for one type of processing over another (LeBoeuf & Shafir, 2003). While there are likely stable characteristics that result in an unbalanced reliance on the different types of processing posited in dual-process models, recent efforts to characterize constructs along such dimensions have been limited. This having been said, some studies have examined various individual characteristics that may predict susceptibility to framing (Kahneman, 2003). One of the most widely studied constructs as it relates to framing is Need For

Cognition (NFC) which identifies differences among individuals in their tendency to engage in and enjoy thinking (Cacioppo, Petty, & Chuan Feng, 1984). A relevant study found that higher NFC only predicted decreased susceptibility to framing when both corresponding decision frames were presented to individuals, thus again illustrating the importance of within-subject designs (Shafir, 1993). Other variables have been hypothesized to influence an individual's susceptibility to framing effects as well as their reliance on different types of processing. These include, but are not limited to, exposure to statistical thinking (Agnoli & Krantz, 1989), personality (Eisenberger, et al., 2005; Levin, Gaeth, Schreiber, & Lauriola, 2002), and intelligence (Stanovich & West, 2000). While these findings represent preliminary efforts to uncover how individual differences may contribute to an increased reliance on one type of processing over another, additional studies are warranted.

From a practical standpoint, understanding individual differences as they relate to dual-process models could contribute to a greater understanding of the human condition. Functional neuroimaging and psychological assessment in particular hold great promise with regard this potential. For example, a person who is impulsive because of a predilection towards automatic processing, on the surface, would be indistinguishable from an individual who is impulsive because of deficiencies in controlled processes; however, by utilizing tasks that distinguish between these two modes of processing in combination with psychological assessments and neuroimaging techniques, such a distinction may be possible. Several psychological interventions focus on the realistic evaluation of environmental cues and the suppression of irrational affective responses. Insight into the neural correlates of dual-system processing may provide additional theoretical support for these interventions, in addition to, allowing a deeper understanding of the neural phenotypes associated with various mental health disorders. Indeed, some investigators have gone so far as to posit that predilections towards one from of processing over another could be used to inform psychological treatment interventions (Salas-Auvert & Felgoise, 2003). That is to say that an individual who shows a dominance of automatic processes, may be more suited for an insight-oriented therapy given potential deficits in rational processes. In contrast, an individual who shows a strong capacity to engage controlled processes may be better served by a cognitively oriented therapy such as cognitive behavioral therapy.

In addition to individual differences that influence processing on a systems level, the investigation of concurrent task demands may shed light on what contextual factors may bolster one type of processing over another. If one imagines the dynamic environments in which decisions are made, it becomes clear that daily choices can be impacted by a variety of contextual factors. For example in providing therapy to a patient, several factors may influence how a clinician responds to a particular question from a patient. These factors could include the clinician's mood, the time during the session, what the clinician was thinking about at the time of question, nonverbal cues from the client, past knowledge of the patient, in addition to several other factors. The examination of how these various contextual factors could influence clinical decision-making could lead to a more rational and informed response from the clinician. This having been said, it is rarely the case that an individual has time to consider all of the various contextual factors that could influence a decision in a given moment; however, it does not preclude the notion that one may be able to make more informed decisions based on general factors related to processing at a systems level.

Recently, investigators have begun to speculate that reliance on different types of processing can be impacted by the use of priming, increasing cognitive load, and manipulating goals (Ferreira, Garcia-Marques, Sherman, & Sherman, 2006; Satpute & Lieberman, 2006). Indeed, studies have shown an increased reliance on heuristics when individuals are pressed for time (Finucane, Alhakami, Slovic, & Johnson, 2000), under cognitive load (Gilbert, 1991), in a good mood (Bless, et al., 1996; Eisenberg, 2000), or lacking in motivation (Pelham & Neter, 1995). As this information continues to be integrated to inform factors that influence processing at a systems level, one could imagine implications for several situations in which decision-making may be unduly biased by contextual factors.

Perspective Taking and Bias

As the current studies utilize a dual-process theory rooted in social psychology, it became ideal to develop a socially relevant attribute framing task. While the fat-content of ground beef does not appear to be based in a socially relevant context, perhaps considering personality attributes would be. As such, a simple framing paradigm was established that asks individuals to decide whether specific statements are descriptive of them or not. The framing manipulation reflected the relative presence or absence of a positive quality which is consistent with previous attribute framing phenomenon.

In an effort to elicit processing in the C-system, a perspective taking manipulation was introduced. As indicated by the name reflective in Lieberman's conceptualization (2007), it is not an intellectual leap to think that a reflecting from another individual's perspective could facilitate processing in the C-system. Self-reflection when contrasted with various control conditions reliably elicits activation in the MPFC (D'Argembeau, et al., 2007; Gusnard, et al., 2001; Ochsner, et al., 2005). Additionally individuals with damage to the MPFC experience less self-conscious emotion after engaging in inappropriate behavior (Beer, Heerey, Keltner, Scabini, & Knight, 2003). Self-reflection on emotional stimuli has also been associated with reduced activity in the amygdala (Breiter, et al., 1997; Taylor, Phan, Decker, & Liberzon, 2003). Making attributions to oneself has reliably produced activations in the MPFC as well as in the medial parietal cortex (D'Argembeau, et al., 2007; Fossati, et al., 2003; Johnson, et al., 2002; Kelley, et al., 2002; Seger, et al., 2004). In contrast to controlled processing components of self-reflection, self knowledge appears to consist of both automatic and effortful representations with automatic representations associated with activations in the VMPFC, basal ganglia, LTC, and medial parietal cortex (Lieberman, Jarcho, & Satpute, 2004). In contrast, effortful retrieval of self-knowledge appears to be associated with activity in the DMPFC and MTL (Lieberman, Jarcho, et al., 2004).

Theory of mind (TOM) is a topic which reflects the ability to represent the mental states of others (Perner & Wimmer, 1985). The ability to represent the mental states of others occurs early in the developmental process, usually by age four (Perner & Wimmer, 1985). Neuroimaging studies investigating TOM have generally shown it to be associated with activations in the dorsomedial prefrontal cortex (DMPFC) and the LTC (Frith & Frith, 2003). The LTC is thought to be sensitive to external visual cues related to others (Allison, et al., 2000; Sugiura, et al., 2001), while the DMPFC is thought to be specifically associated with overt thought regarding the internal mental state of others

(Frith & Frith, 2003). Additional areas potentially associated with TOM include the temporoparietal junction and the VLPFC (Saxe, 2006). The VLPFC specifically has been associated with inhibiting one's own experience in considering another's mental state (Samson, Apperly, Kathirgamanathan, & Humphreys, 2005; Vogeley, et al., 2001).

Recent investigations have reliably reported MPFC activity in association with making social attributions from differing perspectives (D'Argembeau, et al., 2007; Fossati, et al., 2003; Mitchell, Macrae, & Banaji, 2006; Ochsner, et al., 2005; Schmitz & Johnson, 2007). One series of fMRI studies investigated the neural correlates of making appraisals from different perspectives (Ochsner, et al., 2005). In these studies, participants were asked to endorse or reject different traits from their own perspective, the perspective of a close-other, and a non-close other. This study involved making both direct and reflected appraisals. That is to say a participant may have responded about themselves or a close other from their own perspective (direct appraisals) or in contrast they may have responded about themselves from the perspective of others (reflected appraisals). Results showed that both reflected and direct appraisals activated the MPFC, as well as, the posterior cingulate/precuneus and multiple regions of the temporal lobe spanning its superior to polar extent. Direct first-person appraisals activated the midportion of the posterior cingulate more than reflected appraisals made from either the perspective of a close or a non-close other. Reflecting on a close other's opinions about you (as compared to your own opinions of yourself) activated right OFC, insula, and parahippocampal cortex. Reflecting a non-close other's opinions about you activated middle and inferior temporal regions. Taken together, these results suggest that making appraisals from either one's own perspective or the perspective of another reliably elicits activation of the MPFC, a C-system structure. As such, it is not improbable that introducing such a manipulation to framing phenomenon could facilitate C-System activity; however, evidence from bias literature suggests that even in the context of making self-referential behaviors, individuals are still subject to bias.

Bias is likely to be closely related to the use of heuristics in decision making, although it has generally been ignored in dual-process accounts of decision making. Some researchers have come to describe what they refer to as a "bias blindspot" (Ehrlinger, Gilovich, & Ross, 2005; Pronin, 2007). This refers to an individual's tendency to lack awareness with regard to their own biases and errors in judgment. For example, a well-known form of bias is the self-enhancement (or ego-protective) bias, whereby individuals tend to see themselves in a positive light despite indications to the contrary (Ehrlinger, et al., 2005; Pronin, 2007). While individuals can detect bias in others, they appear to have less ability to do so when they are considering their own thoughts and behavior (Pronin, 2007). Given this information, it raises questions regarding whether self-reflection alone could overcome automatic processes geared toward self-favorable responding, a question which this proposal seeks to understand.

Affective Priming

In contrast to a manipulation to facilitate reflective processes, an emotional priming paradigm was utilized to facilitate reflexive processing. Affective priming is a manipulation that has been used in several experiments to influence decision-making; however, the interactions between emotional and cognitive systems related to priming manipulations are still poorly understood (Eimer & Schlaghecken, 2003). Recent studies have examined the effect of primes on risk attitudes (Erb, Bioy, & Hilton, 2002b), goal pursuit (Aarts, Custers, & Holland, 2007), and decision behavior (White, 2005). Results reliably indicate an effect of affective primes on associated behaviors within these contexts. As noted above, a study examining the ultimatum game was successful in manipulating behavioral results by utilizing an emotional priming stimulus (Harle & Sanfey, 2007). In a similar manner, one of the proposed studies will seek to utilize subliminal affective priming as a means to recruit processing in the X-System and thereby facilitate the framing effect under investigation.

OVERVIEW OF EXPERIMENTS

The current series of studies examined various types of framing effects (risky choice and attribute framing) within the context of two different task manipulations (perspective-taking and emotional priming) intended to facilitate processing at the systems level within a recent dual-process framework (Lieberman, 2007; Lieberman, et al., 2002; Satpute & Lieberman, 2006). These experiments included two behavioral studies as well as a functional neuroimaging study utilizing functional magnetic resonance imaging (fMRI). The current studies sought to replicate and expand upon a framing paradigm established by De Martino et al. (2006), as well as, to establish a novel attribute framing paradigm with developmental roots in social cognitive neuroscience. Another important goal of the current experiments was to investigate various individual differences with regard to their potential impact on susceptibility to framing effects, and by extension, predispositions towards one type of processing on a systems level. In a broader sense, the current series of studies were intended to provide additional evidence supporting the dualistic relationship between distinctive systems in the brain.

Table 1. Characteristics of the X- and C-Systems.

Reflexive or X-System	**Reflective or C-System**
Parallel processing	Serial Processing
Operates Quickly	Operates Slowly
Learns slowly	Learns Quickly
Nonreflective consciousness (nonsymbolic representations)	Reflective consciousness (symbolic representations)
Sensitive to subliminal presentations	Insensitive to subliminal presentations
Spontaneous processes	Intentional processes
Prepotent responses	Regulation of prepotent responses
Typically sensory	Typically linguistic
Outputs experienced as reality	Outputs experienced as self-generated
Relation to behavior unaffected by cognitive load	Relation to behavior altered by cognitive load
Facilitated by high arousal	Impaired by high arousal
Phylogenetically older	Phylogenetically newer
Representation of symmetric relations	Representation of asymmetric relations
Representation of common cases	Representation of special cases
	Representation of abstract concepts

CHAPTER TWO
Experiment 1: A Behavioral Study of Risky-choice Framing and Affective Priming

HYPOTHESES

Overall Goal: To investigate a risky-choice framing paradigm in the context of an affective priming manipulation intended to facilitate reflexive processing.

Question One: Will the current study replicate previous findings relative to the establishment of a framing effect as evidenced by disproportionate responding in gain and loss frames?

Hypothesis One: A statistically significant framing effect will be manifested by a disproportionate number of sure responses during gain frames when compared to loss frames.

Question Two: Will affective priming facilitate the effect of the framing manipulation as manifested by a disproportionate amount of sure responses during gain frames when compared to loss frames?

Hypothesis Two: Affective priming will significantly influence the proportion of sure responses over the course of the experiment.

Specific Hypothesis: The effect of affective priming alone will influence the proportion of sure responses across the course of the experiment with positive and negative valence primes resulting in less sure responses than neutral primes.

Specific Hypothesis: An interaction effect will occur between prime valence and frame valence with valence matching between primes and frames resulting in a larger proportion of frame consistent responses.

Question Three: Will individual differences as measured by pretest assessments be associated with susceptibility and adaptation to the risky-choice framing effect?

Hypothesis Three: Individual differences as measured by the relevant pretest measures will be correlated with susceptibility and adaptation to the framing effect.

Specific Hypothesis: Intelligence, extraversion, need for cognition, and cognitive reflection will be negatively correlated with susceptibility to the framing effect.

Specific Hypothesis: Intelligence, extraversion, need for cognition, and cognitive reflection will be positively correlated with adaption to the framing effect.

Specific Hypothesis: Neuroticism, Attachment Anxiety, and Attachment Avoidance will be positively correlated with susceptibility to the framing effect.

Specific Hypothesis: Neuroticism, Attachment Anxiety, and Attachment Avoidance will be negatively correlated with adaption to the framing effect.

DESIGN

Participants

Sixty-four undergraduate subjects were recruited from The University of Texas at Dallas. Informed consent was obtained from all subjects prior to the completion of the study tasks. Subjects received course research credits for their participation in the experiment.

Procedure

Subjects completed a questionnaire relating to demographic information including gender, ethnicity, age, years of education, and native language. Additionally, subjects were administered the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001) and completed self-report questionnaires including the Need for Cognition Scale (NFC; Cacioppo, et al., 1984), the Eysenyk Personality Questionnaire Revised-Short Form (EPQR-S; Eysenck & Eysenck, 1994; Sato, 2005), The Experiences in Close Relationships - Revised (ECR; Fraley, Waller, & Brennan, 2000), and the Cognitive Reflection Test (CRT; Frederick, 2005). These measures were chosen on the basis of both literature on framing effects and the X- and C-system framework.

The experimental design and statistical analyses were modeled off of those used by De Martino et al. (2006). The experiment was designed and run through the computer software E-Prime (Schnieder, Eschman, & Zuccolotto, 2002a; Schnieder, Eschman, & Zuccolotto, 2002b) with stimuli presented on a computer monitor and responses entered on the keyboard. After the completion of pretest measures, participants went through a brief instructional program to familiarize them with the experimental task. Subjects were told that they would not receive feedback concerning the outcomes of their decisions during the task, but would have a chance to receive a $20 gift card based on their overall performance during the experiment.

At the beginning of a trial, participants viewed a message depicting a certain starting value of money for two seconds (e.g. You receive $60). Three different starting amounts were used in the experiment ($60, $100, and $140). After being presented with the starting amount of money, subjects were given a choice between two options, a "sure" or a "gamble" option, for a period of four seconds. The sure option (appearing on the left) was presented in the Gain frame trials as an amount of money retained from the starting amount (e.g. keep $15 of $60) and in the Loss frame trials as the total amount of money lost from the starting amount (e.g. lose $45 of $60). The proportions of the starting amount that could be retained in the sure option were 25%, 50%, or 75%. The alternate gamble option (presented on the right) was identical for both frames and represented by a pie-chart depicting the probability of winning or losing the entire starting amount. The four different probabilities of winning a gamble option in a given trial were 20%, 40%, 60%, or 80%.

In order to elicit valence specific affective arousal during the experimental task, pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) were utilized as subconscious primes as these images have been used effectively to manipulate emotion in many studies. This picture set has been carefully normed for male and female participants for both emotional valence and arousal. Primes were positive, negative, or neutral in emotional valence and were selected based on normative data relating to emotional valence and arousal. Forty-eight of the pictures that were rated most positively with the highest level of arousal were selected for positive primes. Similarly, 48 images that were rated most negatively with the highest level of arousal were selected for negative frames. With regard to neutral primes, 48 images rated neutrally in emotional valence with the lowest level of arousal were selected. The priming stimuli were presented between the initial message depicting the starting amount and the second screen with response options. Forward and backward masking was utilized to minimize subjective awareness of primes (Eddy, Schnyer, Schmid, & Holcomb, 2007). Forward and backward masks were identical to each other and comprised of a square of random colored pixels. Each forward mask was presented for 253 ms, while backward masks had a duration of 53 ms. Priming stimuli were presented for 33 ms between the forward and backward masks with the total duration of the priming procedure lasting approximately 340 ms.

"Catch" trials were included to ensure that subjects remained actively engaged in the task during the experiment. In these catch trials, in both frames, expected outcomes for the sure and gamble options were unbalanced in that for half of the trials ("gamble-weighted") the gamble option was highly preferable (e.g. 95% probability of winning by taking the gamble option) and for the other half of trials ("sure-weighted") the sure option was preferable (e.g. 5% probability of winning by taking the gamble option). As in the main experimental trials, the catch trials were also presented in either a Gain or a Loss frame with the various priming stimuli. Figure 1 provides an illustration of the experimental procedure.

The experimental task was broken into six blocks of 48 randomly ordered trials (18 Gain frames, 18 Loss frames, and 12 Catch trials). All other experimental variables (prime valence, total starting amount, percentage of the initial money offered in the sure option and probability of winning a gamble) were fully balanced between the frame conditions. An inter-trial interval (ITI) period of 4 to 8 seconds (Average = 6 seconds) displayed as a fixation cross was included between trials. Subjects were given 4 seconds to respond using the numeric values "1" and "0" on a computer keyboard, pressing "1" for the sure option and "0" for the gamble option.

Data Analysis

Descriptive statistics regarding demographic, pretest and performance-based variables were calculated including means, medians, standard deviations and ranges for all subjects.

In order to assess engagement in the task, a variable was created for responses to catch trials. This variable will be referred to as the Response Accuracy Index (RAI) and was tabulated by taking the proportion of responses in catch trials in which the participant responded consistently with the weighted scenario (e.g. selecting gamble in a gamble-weighted catch trial or selecting the sure option in a sure-weighted catch trial). Values for the RAI that fell below .85 resulted in the corresponding subject's data being excluded from further analyses as it may have been reflective of a lack of engagement in the task. Responses to catch trials were not included in any of the subsequent analyses.

In addition to this exclusion criteria, reaction times (RTs) were utilized in effort to rule out individual trials where a subject may have not put forth optimal effort. This was done by calculating the mean RT and for all participants. Trials with RTs that fell two standard deviations below the group mean were excluded from subsequent analyses.

Two additional performance based variables were calculated for each subject. These included the Frame Consistency Index (FCI) and the Frame Adaptation Index (FAI). The FCI was defined by the overall proportion of trials during which participants responded in a manner consistent with the framing manipulation (i.e. choosing the sure response during a gain frame or the gamble response during a loss frame). This variable was meant to represent an individual's overall susceptibility to the framing manipulation across all experimental trials. The FAI was intended to measure adaptation to the framing effect over time. The proportion of frame consistent responses was calculated for each of the six blocks of trials in the experiment. These values were then plotted in a regression analyses and the linear slope of the relationship was extracted to represent the FAI for each subject.

A two-tailed paired *t*-test for RTs was utilized to assess for any difference in RTs between the frame conditions. This analysis was used to examine for any potential differences in difficulty across the two conditions. It was expected that no significant differences between the conditions would be revealed with respect to RT.

In order to establish the main effect of the framing manipulation, proportions of sure responses in each frame condition were calculated for individual subjects. These proportions were then entered into a two-tailed paired *t*-test in an effort to establish whether there was a significant difference in response tendencies between frames. It was expected that a difference between frame conditions would be represented in a significantly disproportionate amount of sure responses in gain frames when compared to loss frames.

The potential interaction between prime valence and frames was analyzed using a 2 X 3 repeated-measures analysis of variance (ANOVA) with the proportion of sure responses as the dependent variable. This test investigated the main effects of the framing and priming manipulations with regard to response tendencies, as well as any possible interaction effects between the two experimental manipulations. It was expected that there would be a significant interaction effect between frame valence (Gain or Loss) and prime valence (Positive, Negative, or Neutral). Further, it was expected that framing effects would be more pronounced when there was a match between frame and prime valence (i.e., loss frame/negative prime or gain frame/positive prime).

Although not a primary interest of this study, analyses were conducted to examine the effect of other variables (i.e. block, starting amount, percentage of the initial sum offered for the sure choice and probability of winning a gamble) with respect to their influence on frame consistent responding. In each case a one-way repeated-measures ANOVA was conducted with "frame consistency" as the dependent variable. The frame consistency variable was defined by the proportion of responses within each condition that were consistent with the expectations given the framing manipulation. A "frame-consistent" response would consist of a participant choosing the sure option for gain frames or choosing the gamble option for loss frames. Conversely, a "frame inconsistent" response would consist of a participant choosing the gamble option for gain frames or the sure option for loss frames. As the frame consistency variable incorporates both the frame type and the relevant behavioral response, it allowed for an investigation of these additional experimental variables with respect to their impact on frame consistent responding. With regard to block, it was hypothesized that frame consistent responding would diminish over the course of the experiment with repeated exposure to counter-frames. Larger starting amounts were expected to result in a larger proportion of frame consistent responses. With regard to the proportion of the initial sum that was offered, it was expected that when larger proportions of the initial sum were offered individuals would make more frame consistent responses. Finally, it was expected that frame consistent responding would be the highest at the intermediate probabilities of winning a gamble (40% or 60%) when compared to the extreme values (i.e. 20% or 80%).

In order to assess the relationship between individual differences and framing, the performance based variables of FCI and FAI were used as markers of framing susceptibility and adaptation, respectively. The FCI and FAI were entered into a Spearman correlational analyses exploring for potential associations with demographic variables and pretest scores. Because of the diminished range of scores associated with the CRT, its relationship with FCI and FAI was assessed using one-way ANOVAs.

Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (SPSS version 16.0, www.spss.com). Unless otherwise indicated, data reasonably met the underlying assumptions of the analyses performed. As this experiment included a large number of analyses, the potential of committing a Type I error was inflated. In order to control for this possibility, while minimizing concern for Type II error, an overall p value of .01 was adopted for all analyses. When post-hoc analyses were conducted for significant main effects, the Holm's sequential Bonferroni procedure was utilized to control for multiple comparisons.

RESULTS

A total of 64 undergraduate volunteers were enrolled in the study. Thirteen participants were excluded from the study because they were not native English speakers, as a large number of pretest measures have not been validated for use with non-native English speaking populations. Response accuracy for catch trials resulted in the exclusion of an additional four subjects from further data analysis. These individuals made decisions consistent with the weighted scenarios in catch trials less than 85% of the time. Data from the remaining 47 participants were utilized for subsequent analyses.

Of the 47 remaining participants, 23 were men and 24 were women. The average age of participants was 23.6 with an age range between 18 and 40. Participants had an average of 14.4 years of education with a range between 12 and 18. With regard to pretest scores related to cognitive constructs of interest, the average WTAR standard score was 109.60, which falls at the high end of the average range. CRT performance was highly variable, likely in association with the limited number of items on this measure. Scores on the CRT ranged between zero and three with a sample mean of 1.0. The sample mean of NFC scores was 66.4 with a range between 38 and 83. Scores on the ECR are broken down into two constructs called Attachment-Related Anxiety (AR-Anx) and Attachment-Related Avoidance (AR-Avo). The mean score for AR-Anx was 2.8 with a range between 1.1 and 5.5. The mean score for AR-Avo was 2.9 with a range between 1.1 and 5.3. Personality functioning on the EPQR-S is broken down into three constructs called Psychoticism (EPQR-P), Extraversion (EPQR-E) and Neuroticism (EPQR-N). The assessment additionally includes a validity scale called the Lie scale

(EPQR-L), which contains items reflective of denial of certain faults or flaws that are commonly endorsed by others. Individual subscale scores were converted into z scores using the normative data available in the EPQR-S manual (Eysenck & Eysenck, 1994). The mean EPQR-P z-score for the sample was .07 with a range between -1.3 and 2.6. The mean EPQR-E z-score was -.17 with a range of -2.4 to 1.2. The mean EPQR-N z-score was -.30 with a range between -2.0 and 1.6. The mean EPQR-L z-score was .06 with a range between -1.1 and 2.1. A summary of demographic and pretest data is contained in Table 2.

Prior to the calculation of performance based variables, an analysis of RT was utilized to eliminated behavioral responses for which RT fell two standard deviations below the group average (*M* = 1868.93, *SD* = 695.94). This was done in an attempt to exclude trials where an individual likely responded too quickly for the response to be reflective of thoughtful responding. As noted above, behavioral data for trials below this cutoff of 477 ms (*n* = 44, 0.4% of total) were excluded from further analyses. In addition to these trials, a total of 340 trials (3.3% of total) were excluded because subjects did not provide a response in the time allotted.

Behavioral performance-based variables were calculated for individuals based on their responses during the behavioral task. These included the FCI, FAI and RAI. The mean score for FCI was .52 with a range between .42 and .62, suggesting that some participants made frame-inconsistent responses on a majority of the trials. The mean FAI value for the sample was -.02 with a range of -.05 to .03. As noted above, the RAI was created by calculating the proportion of catch trials during which participants responded in a manner consistent with the weighted scenario (e.g. gambling when there was a 95%

chance of retaining the whole amount or electing to take a proportion of the original sum when the chance of winning the gamble was 5%). The mean RAI for the sample was .98 with a range between .88 and 1. As noted above four subjects were excluded from further analyses due to obtaining RAI values below .85, a predetermined cutoff. Sample means, medians, standard deviations and ranges for these variables are available in Table 2.

Average RT values for each frame condition were analyzed using a two-tailed paired *t*-test to assess for any potential differences in response time between the frame conditions. The results indicated that the mean RT for the Gain Frame condition (M = 1949.70, SD = 351.69) was significantly lower than the mean RT for the Loss Frame condition (M = 2021.47, SD = 357.70), $t(46) = -6.13$, $p < .001$. The eta square effect size index, η^2, was .45. The 95% confidence interval for the mean difference between the two conditions was -95.36 to -48.18. This was contrary to the hypothesis that there would be no difference in RT between the two frame conditions. A graphical depiction of RTs in each condition is presented in Figure 2.

The main effect of the framing manipulation was analyzed with a two-tailed paired *t*-test with the proportion of sure responses in each frame as the dependent variable. The frequency distribution of the overall proportion of sure responses is illustrated in Figure 3. The results indicated that the mean proportion of sure responses in the gain frame (M = .55, SD = .14) was significantly greater than the proportion of sure responses in the loss frame (M = .50, SD = .15), $t(46) = 5.74$, $p < .001$. A graphical depiction of proportions of sure responses in each condition is presented in Figure 4. The eta square effect size index, η^2, was .42. The 95% confidence interval for the mean difference between the two conditions was .03 to .07.

The effect of prime valence was of primary interest in this study, as one of the goals of the study was to facilitate processing in the X-system using subconscious emotional primes. To examine for potential interaction effects between frame condition and prime condition, a two-way repeated-measures ANOVA was conducted with the factors being prime valence and frame valence, and the dependent variable being proportions of safe responses in each condition. Consistent with the results of the previously mentioned *t*-test, results showed a significant main effect of frame condition, Wilks' $\Lambda = .58$, $F(1, 46) = 33.02$, $p < .001$, multivariate $\eta^2 = .42$. In contrast, no significant effects were found with respect to prime valence, Wilks' $\Lambda = .99$, $F(2, 45) = .30$, $p = .74$, multivariate $\eta^2 = .01$, or the interaction between prime and frame valence Wilks' $\Lambda = .99$, $F(2, 45) = .13$, $p = .87$, multivariate $\eta^2 = .01$. A graphical depiction of the proportions of sure responses in each condition is presented in Figure 5.

To investigate the other experimental conditions (e.g. starting amount, proportion of initial sum offered, probability of winning a gamble and block) with respect to their influence on framing behavior, the proportion of frame consistent responding for each condition was utilized as the dependent variable in a series of one-way repeated-measures ANOVAs. The overall distribution for frame consistent responding is shown in Figure 6.

With regard to the effect of block, the results for the ANOVA revealed a significant effect on frame-consistent responding, Wilks' $\Lambda = .25$, $F(5, 42) =$, $p < .001$, multivariate $\eta^2 = .75$. Fifteen unique pairwise comparisons were conducted among the means for each block. Nine of these pairwise comparisons were significant, controlling for familywise error rate across the fifteen tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated a linear trend with a decrease in frame consistent responding over time. A graphical depiction of proportions of frame consistent responding across blocks is presented in Figure 7.

With regard to the effect of starting amounts, the results for the ANOVA revealed a significant effect on frame-consistent responding, Wilks' $\Lambda = .63$, $F(2, 45) = 13.17$, $p < .001$, multivariate $\eta^2 = .37$. Three unique pairwise comparisons were conducted among the means for each starting amount. Two of these pairwise comparisons were significant, controlling for familywise error rate across the three tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that proportions of frame consistent responding were significantly lower for the $60 starting amount when compared to either the $100 or $140 starting amounts. No significant difference was found between the $100 and $140 starting amounts, but follow-up polynomial contrasts indicated a significant linear effect with means of frame-consistent responding increasing with larger starting amounts, $F(1, 46) = 25.58$, $p < .001$. A graphical depiction of proportions of frame consistent responding across starting amounts is presented in Figure 8.

With regard to the effect of the proportion of the initial amount that was offered, the results for the ANOVA revealed a significant effect on frame consistent responding, Wilks' $\Lambda = .65$, $F(2, 45) = 12.10$, $p < .001$, multivariate $\eta^2 = .35$. Three unique pairwise comparisons were conducted among the means for each proportion of the initial amount that was offered. All three pairwise comparisons were significant, controlling for familywise error rate across the three tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that when a larger proportion of the initial sum was offered, individuals produced a larger proportion of frame consistent responses. A graphical depiction of the proportions of frame consistent responding across proportions of starting amount offered is presented in Figure 9.

With regard to the effect of the probability of winning for the gamble choices, the results for the ANOVA revealed a significant effect on frame-consistent responding, Wilks' $\Lambda = .79$, $F(3, 44) = 3.99$, $p < .05$, multivariate $\eta^2 = .21$. Six unique pairwise comparisons were conducted among the means for each probability of winning in the gamble choice. Only one pairwise comparison was significant, controlling for familywise error rate across the six tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that the lowest probability of winning a gamble, 20%, produced significantly less frame consistent responses than when there was a 60% chance of winning. A graphical depiction of proportions of frame consistent responding across probabilities of winning in the gamble option is presented in Figure 10.

In an effort to assess how individual differences may contribute to framing susceptibility and adaptation to framing over time, Spearman correlation coefficients were computed among the pretest variables and the performance-related variables of FCI and FAI. A significant correlation was identified between FAI and AR-Anx, $r(45) = -.381$, $p < .01$. Another correlation was observed between FAI and NFC scores, $r(45) = .335$, $p < .05$; however, this correlation was not significant at the $p < .01$ level. Because of the limited number of levels of scores on the CRT, its relationship with FCI and FAI was analyzed with one-way ANOVAs. Neither the ANOVA for the FCI, $F(3, 43) = .849$,

p = .475, or the ANOVA for the FAI, $F(3,43) = 1.138$, p = .345, produced significant results.

DISCUSSION

The main goal of Experiment 1 was to investigate a risky-choice framing paradigm in the context of an affective priming manipulation intended to facilitate reflexive processing. This experiment was successful in replicating the framing effect observed by DeMartino et. al. (2006) with some notable differences. While a significant main effect of the framing manipulation was observed for the sample, not all subjects appeared to respond in a manner consistent with the framing manipulation over the course of the entire experiment, as indicated by FCI values falling below .50. The reason for this finding may be attributed to differences between the two studies such as a greater number of trials in the current study, the fMRI environment of the De Martino et al. study, or the way in which participants were rewarded for performance. In contrast to the De Martino et al. study, where participants were rewarded with a sum of money proportional to their winnings over the course of the entire experiment, the current study rewarded one participant based on their performance across the experiment. This raises the possibility that the motivational salience of individual trials may have been greater in the De Martino et al. study. An additional possibility for this difference may be related to the number of participants included in the present study. While De Martino et al. had a sample size of twenty, the current study ended with a sample size of 47. In the context of between-subjects designs, it has been reliably demonstrated that some individuals do not demonstrate a framing effect when exposed to only one frame condition (Kühberger, 1998; Mandel & Vartanian, in press). Furthermore, with exposure to counterframes, a large portion of individuals will respond in a manner consistent with their original decision (Kühberger, 1998). It is possible that the De Martino et al. study, with its limited sample size, may not have included participants who showed this response tendency while the present study did. Even in lieu of this possibility, some of the participants in the current study responded in a manner that suggested they showed a bias in response tendency that ran counter to the framing manipulation, indicating a different type of irrationality in their response tendencies (i.e. a lack of consistency in response tendencies across conditions). Again because only one participant was rewarded for their performance, it is possible that a competitive mindset may have contributed to participants adopting a different strategy across the course of the experiment, such as the one subject who chose the sure option on 100% of the trials.

An additional difference between the results obtained in this study and those obtained in the study by De Martino et al. (2006) was that RTs between the two frame conditions in this study differed significantly. De Martino et al. did not observe a difference in RTs using analyses identical to those used in this study. The difference in RTs between the two frame conditions may have been attributable to differences in difficulty between the two conditions or something implicit within the framing conditions. Some researchers describe differences in the perceived equivalence of risky-choice framing phenomena when subjects are presented with the counterframe (Mandel & Vartanian, in press). In one study, approximately 36% of individuals who participated in the study indicated that they did not believe the two frame conditions were equivalent (Mandel, 2001). As such the theoretically equivalent frames that were presented in the current study, may have been perceived and processed in an entirely different manner, contributing to difference in RTs.

With regard to the effect of priming on response tendencies during the current study, no significant effects were found. This negative result was unexpected and contrary to the proposed hypotheses. Other studies have shown success in influencing the way individuals make judgments by using emotionally laden stimuli (Aarts, et al., 2007; Erb, Bioy, & Hilton, 2002a; Harle & Sanfey, 2007; White, 2005). For example Harle and Safney (2007) showed that the emotional priming effect of viewing negatively-valenced videos, resulted in a greater rejection of unfair offers by participants in the ultimatum game. A possible explanation for this finding is that the subconscious presentation of primes was insufficient to recruit X-system activity in the current study. More overt emotional manipulations such as presenting emotional pictures at a conscious level may prove to be more successful in influencing this version of the framing effect.

The effect of block on frame consistent responding produced results consistent with hypotheses. It was expected that the proportion of frame consistent responses would diminish over time, and results seems to support such a conclusion. As framing experiments have traditionally utilized between subject designs, a smaller number of studies have presented participants with both versions of the framing paradigm within the same study. Those that have consistently found that exposure to a counterframe resulted in the majority of participants responding in a manner consistent with their behavioral response during the first frame (Kühberger, 1998). Despite this, studies with repeated exposure to counterframes such as the one conducted by De Martino et al. have shown that it is possible to maintain a framing effect over time using the right stimuli and motivation. In the current study, levels of frame consistent responding decreased over time with repeated exposure to counterframes. This supports the intuitive notion that as insight into the equivalency between frames develops, individuals tend to demonstrate more rational response tendencies; however, it should be noted that not all individuals showed a decrease in frame susceptibility over time as indicated by positive FAI values. This suggests that some individuals may have limited insight into the equivalency of frames, potentially supporting other indicators that suggest a lack of perceived equivalency of frames in risky-choice framing paradigms.

Although not a primary emphasis in this study, results showed that starting amounts, proportions of the initial sum offered in the sure option and the probability of winning in the gamble option all influenced the proportion of frame consistent responding across participants. With regard to starting amounts, results showed that higher values were associated with a larger proportion of frame consistent responses. This effect, despite being analyzed in a different manner, appeared to be consistent with the results reported by De Martino et al. (2006) as well as other studies of framing paradigms (Kühberger, 1998). With regard to proportions of the initial amount that was offered, results showed that larger offers resulted in a higher degree of frame consistent responding. Again this appeared to be consistent with the results of previous investigations (Kühberger, 1998). The probability of winning for gamble options has additionally been shown to influence the manifestation of the risky-choice framing effect. It was hypothesized that intermediate probabilities of winning (i.e. a 40% or 60% chance of winning) would result in a larger proportion of frame consistent responses than extreme probabilities of winning (i.e. 20% or 80%). In analyzing the distribution of means of frame consistent responses in each condition, the data appear to follow this trend, but the data need not be limited to experimental trials. That is to say that catch trials, not included in the analysis of frame consistency, provided further support for this hypothesis. Overall, participants responded consistently to catch trials regardless of frame condition as indicated by a sample mean RAI of .98. Taken together these results suggest that more ambiguity in the gamble option contributes to a higher susceptibility to framing effects.

With regard to the evaluation of individual differences in susceptibility to framing, the current study did not identify any individual differences that were correlated to the manifestation of the framing effect as indicated by the FCI. A significant negative correlation was identified between AR-Anx and the FAI, suggesting the possibility that higher levels of attachment related anxiety may be associated with a diminished ability to adapt to the framing effect over time. Although a positive correlation between FAI and NFC scores, this correlation did not meet the required alpha value of .01. The general lack of association between FCI, FAI, and other measurements of individual differences was unexpected, but there are some possible explanations. Firstly, the current study included a rather limited sample size, thus limiting the power to resolve differences among individuals. As noted above, not all participants achieved overall FCI values that suggested a susceptibility to the framing effect in the expected direction. As such, if the correlational analysis was limited to those that demonstrated a significant framing effect over the course of the entire experiment, as indicated by FCI values greater than .50, perhaps some individual differences may have been identified.

In total the results of Experiment 1 provide additional support for the manifestation of framing effects in risky-choice framing paradigms. The framing effect was maintained despite several experimental manipulations that had an influence on frame consistent responding. The inclusion of subconscious priming stimuli did not appear to be successful in facilitating susceptibility to the framing manipulation through the recruitment of reflexive processes, though as noted above, different task demands did influence the extent to which frame consistent responding was observed during the current experiment. Only one measurement of individual differences (AR-Anx) was significantly correlated with a performance based variable (FAI), with the absence of additional correlations potentially related to limitations in power of resolving these differences.

Table 2. Summary of descriptive statistics for demographic, pretest and performance-based variables.

Variable	Range	Median	Mean	Standard Deviation
Age	18 to 40	22	23.62	5.51
Education	12 to 18	14	14.36	1.15
WTAR	93 to 125	110	109.6	8.44
CRT	0 to 3	1	1.02	1.07
NFC	38 to 83	67	66.4	9.13
AR-Anx	1.06 to 5.50	2.56	2.79	1.18
AR-Avo	1.06 to 5.33	2.78	2.86	.95
EPQR-P	-1.31 to 2.63	-.05	.07	.96
EPQR-E	-2.44 to 1.24	.03	-.17	1.13
EPQR-N	-1.99 to 1.58	-.21	-.30	1.06
EPQR-L	-1.11 to 2.11	-.09	.06	.85
FCI	.42 to .62	.52	.52	.03
FAI	-.05 to .03	-.02	-.02	.02
RAI	.88 to 1	1	.98	.03

Note. Abbreviations in the table include: WTAR = Wechsler Test of Adult Reading; CRT = Cognitive Reflection Test; NFC = Need For Cognition; AR-Anx = Attachment-related Anxiety; AR-Avo = Attachment-related Avoidance; EPQR-P = Psychoticism; EPQR-E = Extraversion; EPQR-N = Neuroticism; EPQR-L = Lie; FCI = Frame Consistency Index; FAI = Frame Adaptation Index; RAI = Response Accuracy Index. Age and Education are reported in years. WTAR values represent standard scores. EPQR-S values represent z scores. All other variables are reported as raw scores.

Figure 1. A Sample of Counterbalanced Stimuli for the Risky-Choice Framing Experimental Task.

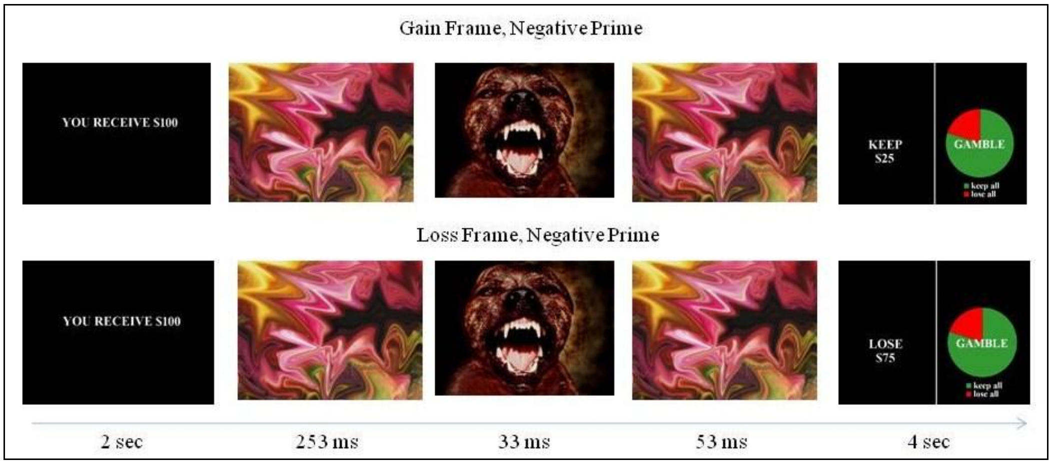
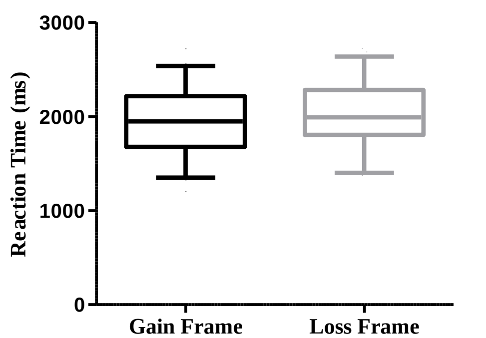


Figure 2. Reaction time by frame condition.



NOTE: Bars represent the 5th to 95th percentiles.

Figure 3. Frequency distribution of proportions of sure responses.

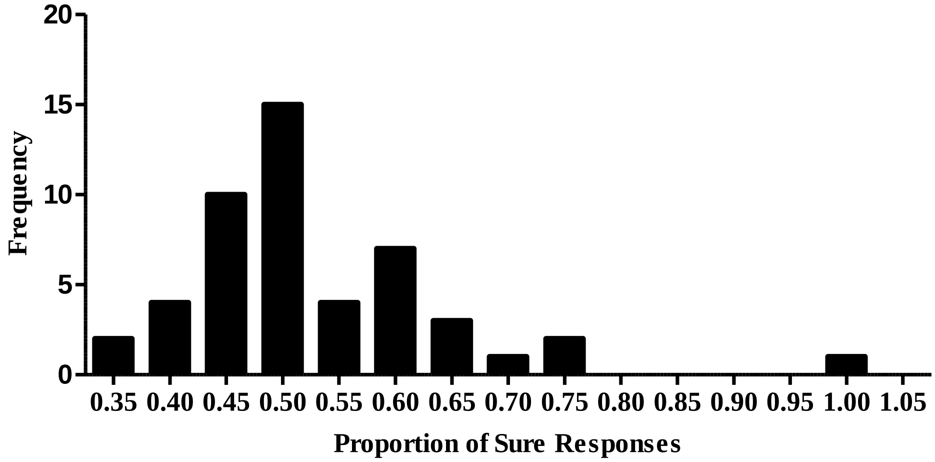
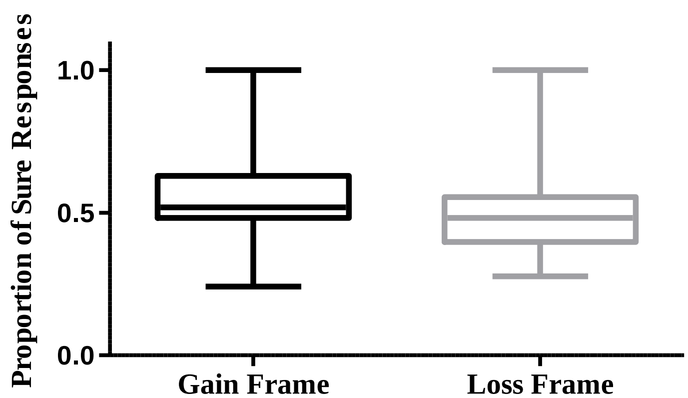
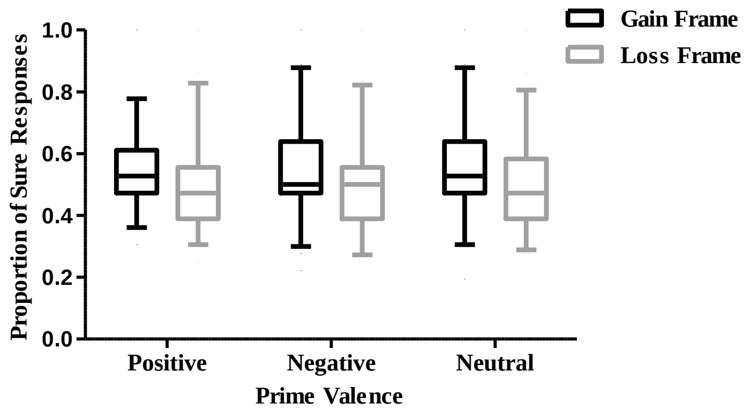


Figure 4. Proportion of sure responses by frame condition.



NOTE: Bars represent the 5th to 95th percentiles.

Figure 5. *Proportion of sure responses by frame valence and prime valence.*



NOTE: Bars represent the 5th to 95th percentiles.

Figure 6. *Frequency distribution of proportions of frame consistent responses.*

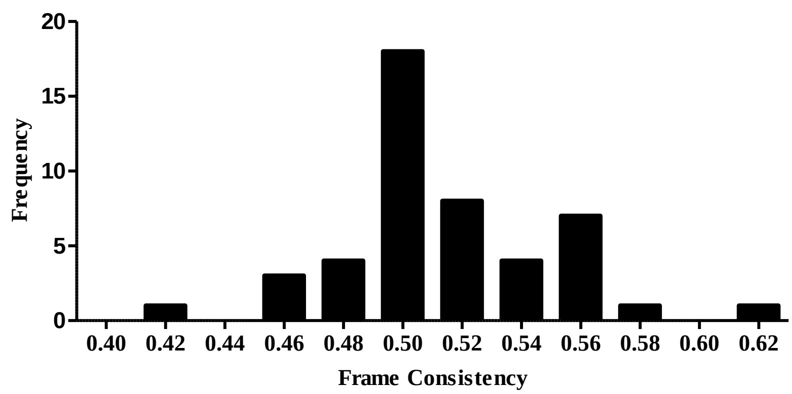
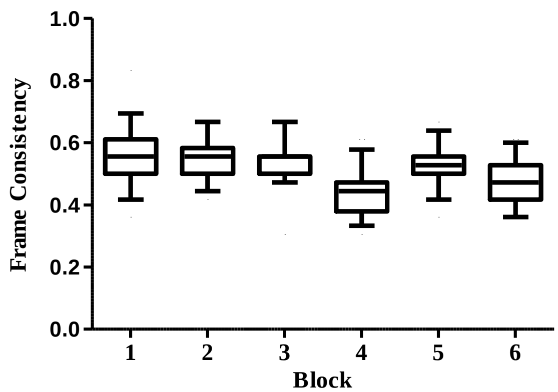
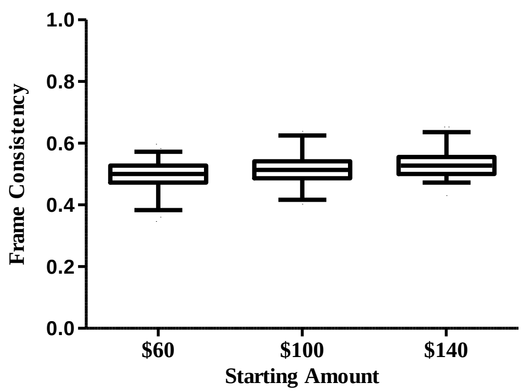


Figure 7. Proportions of frame consistent responses by block.



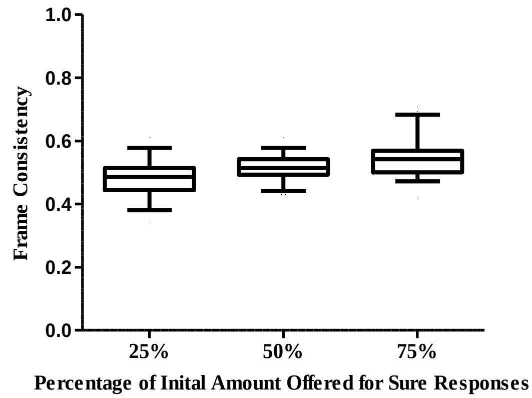
NOTE: Bars represent the 5th to 95th percentiles.

Figure 8. Proportion of frame consistent responses by starting amount.



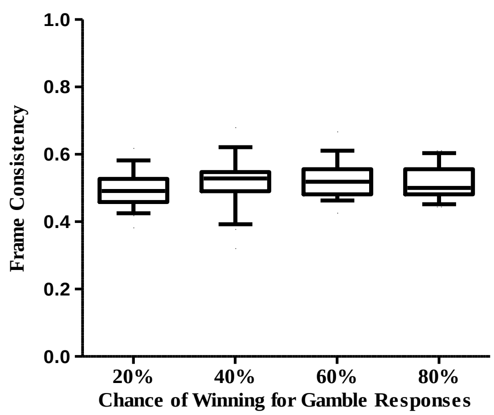
NOTE: Bars represent the 5th to 95th percentiles.

Figure 9. Proportion of frame consistent responses by the percentage of the initial amount offered for sure responses.



NOTE: Bars represent the 5th to 95th percentiles.

Figure 10. Proportion of frame consistent responses by the probability of winning for gamble responses.



NOTE: Bars represent the 5th to 95th percentiles.

CHAPTER THREE
Experiment 2: A Behavioral Study of Attribute Framing and Perspective Taking

HYPOTHESES

Overall Goal: To investigate a novel attribute framing paradigm in the context of a perspective taking manipulation intended to facilitate reflective processing.

Question One: Will the use of a novel attribute framing paradigm result in a framing effect as evidenced by disproportionate endorsement of equivalent statements framed in different terms?

Hypothesis One: A significant framing effect will be manifested by disproportionate endorsement of statements in the positive and negative frame conditions.

Question Two: Will perspective-taking influence the endorsement of equivalent statements in the context of the framing manipulation?

Hypothesis Two: The effect of perspective will influence the proportion of frame-consistent responses across the course of the experiment with reflected appraisals resulting in diminished amount of frame-consistent responses.

Question Three: Will individual differences as measured by pretest assessments be associated will susceptibility and adaptation to the attribute framing effect?

Hypothesis Three: Individual differences as measured by the relevant pretest measures will be correlated with susceptibility and adaptation to the framing effect.

Specific Hypothesis: Intelligence, extraversion, need for cognition, and cognitive reflection will be negatively correlated with susceptibility to the framing effect.

Specific Hypothesis: Intelligence, extraversion, need for cognition, and cognitive reflection will be positively correlated with adaption to the framing effect.

Specific Hypothesis: Neuroticism will be positively correlated with susceptibility to the framing effect.

Specific Hypothesis: Neuroticism will be negatively correlated with adaption to the framing effect.

METHOD

Participants

Twenty undergraduate subjects were recruited from The University of Texas at Dallas. Participants received course credits for their participation in this study. Informed consent was obtained from all subjects prior to the completion of the study tasks.

Procedure

Subjects completed a questionnaire relating to demographic information including gender, ethnicity, age, years of education, and native language. Additionally, subjects were administered the WTAR (Wechsler, 2001) and completed self-report questionnaires including the NFC (Cacioppo, et al., 1984), the Barratt Impulsivity Scale (BIS; Patton, Stanford, & Barratt, 1995), the EPQR-S (Eysenck & Eysenck, 1994; Sato, 2005), and the CRT (Frederick, 2005). These measures were chosen on the basis of both literature on susceptibility to framing effects and dual-process models of decision making.

The experiment was designed and run through the computer software E-Prime (Schnieder, et al., 2002a; Schnieder, et al., 2002b) with stimuli presented on a computer monitor and responses entered utilizing a keyboard. Following the completion of all pretest measures, subjects completed a computer task lasting approximately 45 minutes. Subjects began with an interactive instructional program detailing the experiment and providing practice on a few trials from each condition. During the experimental task, subjects were asked to rate scenarios describing personality characteristics as either descriptive or not descriptive. The stimuli consisted of statements of the percentage of time that positive attributes are present or absent, a manipulation consistent with previously described attribute framing phenomena.

With regard to the construction of stimuli, the 40 most positively rated attributes were selected from Anderson's list of personality characteristics (Anderson, 1968), the same list used in the aforementioned perspective-taking study (Ochsner, et al., 2005). Positive frames described the percentage of time that a trait was present, while negative frames described the percentage of time that a trait was absent. The relative percentage of time that a trait was present was between 51 and 90% for positive frames and 10 and 49% for corresponding negative frames. In an effort to maximize framing effects, the range of percentages was restricted in accordance with preliminary data that suggested extreme values diminished framing effects. A pseudo-random array of percentages was calculated for positive frames with ten values existing for every increment of ten percentage points within a condition. For example, in the 81-90 percentage range in the self condition, ten random percentage values within this range were assigned for the positive frame. As indicated by this example, the values of the percentages within each increment were randomly generated. Percentages for negative frames were calculated as 100-(percent in corresponding positive frame).

Subjects were asked to evaluate personality attributes from their own perspective ("self condition"), the perspective of their best friend ("best friend condition"), or the perspective of people in general ("people in general condition"). Additionally, a control condition was included during which participants simply had to decide whether the percentage values in the scenarios were greater than or less than 50%. This condition was used in an effort to assess engagement in the task as well as a control for the subsequent imaging study discussed below. Figure 11 illustrates two corresponding frames for a trial included in the self condition. The best friend and people in general conditions differed only in the first line of text (i.e. My best friend believes & People in general believe) and relative percentages involved in attributions.

The experimental task was broken down into four blocks of 80 trials. Each block was further subdivided equally between the three perspective conditions and the control condition with the order of conditions counterbalanced between blocks. Stimuli were counterbalanced to ensure that the two reciprocal frames relating to an individual attribute would not be presented in the same block of trials. An ITI period of 4 to 8 seconds (Average = 6 seconds) displayed as a fixation cross was included between trials. Subject were given six seconds to respond using the numeric values "1" and "0" on a computer keyboard. Descriptive responses were chosen using the "1" key and Not

Descriptive responses were selected using the “0” key.

Data Analysis

Descriptive statistics regarding demographic, pretest and performance based variables were calculated including means, medians, ranges and standard deviations for all subjects.

In order to assess engagement in the task, a separate variable was created for responses to control trials. As was the case in Experiment 1, this variable will be referred to as the Response Accuracy Index (RAI) and was tabulated by taking the proportion of responses in control trials during which the participant responded appropriately. Values for the RAI that fell below .85 resulted in the corresponding subject’s data being excluded from further analyses as it may have been reflective of a lack of engagement in the task. Responses to control trials were not included in any of the subsequent behavioral analyses.

In addition to this exclusion criteria, RTs were utilized in effort to rule out individual trials where a subject may have not put forth optimal effort. This was done by calculating the mean RT and for all participants. Trials with RTs that fell two standard deviations below the group mean were excluded from subsequent analyses.

Two additional performance based variables were calculated for each subject. These included the Frame Consistency Index (FCI) and the Frame Adaptation Index (FAI). The FCI was defined by the overall proportion of trials during which participants responded in a manner consistent with the framing manipulation (i.e. choosing the descriptive response during a positive frame or the not descriptive response during a negative frame). This variable was intended to represent an individual's overall susceptibility to the framing manipulation across all experimental trials. The FAI was intended to measure adaptation to the framing effect over time. The proportion of frame consistent responses was calculated for each of the four blocks of trials in the experiment. These values were then plotted in a regression analyses and the linear slope of the relationship was extracted to represent the FAI.

A two-tailed paired *t*-test for RTs was utilized to assess for any difference in RTs between the frame conditions. This analysis was used to examine for any potential differences in difficulty across the two conditions. It was expected that no significant differences between the conditions would be revealed with respect to RT.

In order to establish the effect of the framing manipulation, proportions of descriptive responses in each frame were calculated for each subject. These proportions were then entered into a two-tailed paired *t*-test in an effort to establish a significant difference between frames. It was expected that a difference between frame conditions would be represented in a significantly disproportionate amount of descriptive responding in positive frames when compared to negative frames.

Analyses were additionally conducted to examine the effect of other variables (i.e. perspective, block and percentage range) with respect to their influence on frame consistent responding. In each case a one-way repeated-measures ANOVA was conducted with "frame consistency" as the dependent variable. The frame consistency variable was defined by the proportion of responses within each condition that were consistent with the expectations given the framing manipulation. A "frame-consistent" response would consist of a participant choosing the descriptive response for positive frames or choosing the not descriptive response for negative frames. Conversely, a "frame inconsistent" response would consist of a participant choosing the not descriptive response for positive frames or the descriptive response for negative frames. As the frame consistency variable incorporates both the frame type and the relevant behavioral response, it allowed for an investigation of these additional experimental variables with respect to their impact on frame consistent responding. It was expected that reflected appraisals (best friend and people in general perspectives) would result in a lower proportion of frame consistent responding than direct appraisals (self perspective). With regard to block, it was hypothesized that frame consistent responding would diminish over the course of the experiment with repeated exposure to counterframes. With respect to the various percentage ranges, it was expected that extreme values would result in a diminished proportion of frame consistent responding.

In order to assess the relationship between individual differences and framing, the performance based variables of FCI and FAI were used as markers of framing susceptibility and adaptation, respectively. The FCI and FAI were entered into a Spearman's correlational analyses exploring for potential associations with demographic variables and pretest scores. Because of the diminished range of scores associated with the CRT, its relationship with FCI and FAI was assessed using one-way ANOVAs.

Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (SPSS version 16.0, www.spss.com). Unless otherwise indicated, data reasonably met the underlying assumptions of the analyses performed. As this experiment included a large number of analyses, the potential of committing a Type I error was inflated. In order to control for this possibility, while minimizing concern for

Type II error, an overall *p* value of .01 was adopted for all analyses. When post-hoc analyses were conducted for significant main effects, the Holm's sequential Bonferroni procedure was utilized to control for multiple comparisons.

RESULTS

A total of 20 undergraduate volunteers from The University of Texas at Dallas were recruited for this study. Volunteers received course research credits for their participation in the study. Two participants were excluded from the statistical analyses because they did not achieve a Response Accuracy of 0.85 (e.g. failing to respond correctly to 85% of control trials). Descriptive statistics were assessed with regard to demographic information, pretest measurements of individual differences and performance based variables.

Of the eighteen participants included in the analysis, there were thirteen females and five males. The ethnic composition of the group included eleven Caucasians (61%), three Hispanics (17%), one Asian (6%), and three other individuals that were a mixture of ethnicities (17%). The mean age of participants was 23.44 with an age range between 18 and 32. Participants had an average of 14.11 years of education.

With regard to pretest measurements of individual differences, performance on the WTAR ranged from between 83 to 127 (standard scores) with a group mean of 107.71 (Average range). Performance on the CRT varied between zero and three correct responses with an average of one. NFC scores ranged between 36 and 90 with a sample mean of 67. The mean BIS total score for the sample was 60.39 with a range from 42 to 78. In addition to the total score, the BIS provides subscale scores for Cognitive, Motor and Nonplanning domains of impulsivity. Scores in the Cognitive domain ranged between 9 and 22 with a sample mean of 16.06. The mean score on the Motor domain was 21.83 with a range of scores between 15 and 34. Scores on the Nonplanning domain of the BIS ranged between 12 and 28 with a mean of 22.5. As was the case in Experiment 1, individual subscale scores for the EPQR-S were converted into z-scores using the normative data available in the test manual (Eysenck & Eysenck, 1994). The mean EPQR-P z-score for the sample was .22 with a range between -1.1 and 3.2. The mean EPQR-E z-score was .60 with a range of -1.5 and 1.2. The mean EPQR-N z-score was -.47 with a range between -1.7 and 1.6. The mean EPQR-L z-score was -.25 with a range between -1.1 and 1.5. Ranges, group means, and standard deviations for these pretest variables as well as demographic information are summarized in Table 3.

Prior to the calculation of performance based variables, an analysis of RT was utilized to eliminate behavioral responses for which RT fell two standard deviations below the group average (*M* = 2809.10, *SD* = 1125.09). This was done in an attempt to exclude trials where an individual likely responded too quickly for the response to be reflective of thoughtful responding. Three trials below this cutoff of 559 ms were excluded from further analyses (<.01%). An additional 155 trials (3.7%) were excluded from analyses because participants provided no behavioral response in the time allotted.

Behavioral performance based variables were calculated for individuals based on their responses during the behavioral task. These included a FCI, FAI and RAI. The FCI was created by calculating the proportion of trials in which a participant responded consistent with the framing manipulation (e.g. choosing descriptive in a positive frame or not descriptive in a negative frame). The mean score for FCI was .64 with a range between .49 and 1. The FAI was intended to measure adaptation to the framing manipulation over time. It was calculated by taking the linear slope of the proportion of frame-consistent responses by block for each individual subject. The mean FAI value for the sample was -.06 with a range of -.18 to .01. The RAI was created by calculating the proportion of control trials during which the participants responded accurately (e.g. whether the percentage value in the sentence was greater than or less than 50%). The mean RAI for the sample was .98 with a range between 0.89 and 1. As noted above, two subjects were excluded from further analyses due to obtaining RAI values below .85, a predetermined cutoff. Sample means, medians, standard deviations and ranges for these performance based variables are available in Table 3.

Average RT values for each frame condition were analyzed using a two-tailed paired *t*-test to assess for any potential differences between the frame conditions. The results indicated that the mean RT for the positive frame condition (M = 3052.93, SD = 696.22) was significantly higher than the mean RT for the negative frame condition (M = 2480.87, SD = 480.44), $t(17) = 7.42$, $p < .001$. The eta square effect size index, η^2, was .76. A graphical depiction of RTs in each frame condition is presented in Figure 12. The 95% confidence interval for the mean difference between the two conditions was 409.36 to 734.77. This result suggests there may have been a difference in difficulty between the two frame conditions and was contrary to the proposed hypothesis which suggested no differences between the two conditions.

The main effect of the framing manipulation was analyzed with a two-tailed paired-samples *t*-test with the proportion of descriptive responses in each frame as the dependent variable. The frequency distribution of the overall proportion of descriptive responses is illustrated in Figure 13. The results indicated that the mean proportion of descriptive responses in the positive frame (*M* = .94, *SD* = .06) was significantly greater than the proportion of descriptive responses in the loss frame (*M* = .67, *SD* = .32), $t(17) = 3.37$, $p < .005$. Figure 14 provides a graphical depiction of proportions of descriptive responses in each frame condition. The eta square effect size index, η^2, was .40. The 95% confidence interval for the mean difference between the two conditions was .10 to .43.

To investigate the other experimental conditions (e.g. perspective, block and percentage range) with respect to their influence on framing behavior, the proportion of frame consistent responding for each condition was utilized as the dependent variable in a series of one-way repeated-measures ANOVAs. The overall distribution for frame consistent responding is shown in Figure 15. Three subjects achieved values at the upper extreme of the distribution, indicating a strong susceptibility to the framing manipulation for these individuals.

The effect of perspective on frame consistent responding was of primary interest in this study, as one of the goals of the study was to facilitate processing in the C-system using reflected appraisals. A one-way within-subjects ANOVA was conducted with the factor being perspective and the dependent variable being proportions of frame consistent responding in each condition. A graphical depiction of proportions of frame consistent responding in each perspective condition is presented in Figure 16. The results for the ANOVA revealed a significant effect of perspective, Wilks' $\Lambda = .51$, $F(2, 16) = 7.55$, $p < .005$, multivariate $\eta^2 = .49$. Three unique pairwise comparisons were conducted among the means for each perspective condition. Two of these pairwise comparisons were significant, controlling for familywise error rate across the three tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that frame consistent responding was diminished during reflected appraisals when compared to direct appraisals. Follow-up polynomial contrasts indicated a significant linear effect with means of frame-consistent responding decreasing with the remoteness of perspective, $F(1, 17) = 12.49$, $p < .005$.

With regard to the effect of the block, the results for the ANOVA revealed a significant effect on frame consistent responding, Wilks' $\Lambda = .33$, $F(3, 14) = 9.70$, $p < .001$, multivariate $\eta^2 = .77$. Six unique pairwise comparisons were conducted among the means for each block. Three of these pairwise comparisons were significant, controlling for familywise error rate across the three tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that frame consistent responding in block one was significantly greater than on any of the subsequent blocks. Follow-up polynomial contrasts indicated a significant quadratic effect with means of frame-consistent responding diminishing less over time, $F(1, 16) = 13.02$, $p < .005$. A graphical depiction of the proportions of frame consistent responding across blocks is presented in Figure 17.

With regard to the effect of percentage range, the results for the ANOVA revealed a significant effect on frame consistent responding, Wilks' $\Lambda = .39$, $F(3, 15) = 7.83$, $p < .005$, multivariate $\eta^2 = .61$. Six unique pairwise comparisons were conducted among the means for each percentage range. Three of these pairwise comparisons were significant, controlling for familywise error rate across the six tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated that the 31-40; 60-69 percentage range resulted in a significantly lower proportion of frame consistent responses when compared to any of the other percentage ranges. A graphical depiction of proportions of frame consistent responding across percentage ranges is presented in Figure 18.

In an effort to assess how individual differences may contribute to framing susceptibility and adaptation to framing over time, Spearman correlation coefficients were computed among the pretest variables and the performance-related variables of FCI and FAI. A significant correlation was identified between FCI and WTAR scores, $r(16) = -.656$, $p < .005$. Another correlation was observed between FCI and NFC scores, $r(16) = -.476$, $p < .05$; however, this correlation was not significant at the $p < .01$ level. No significant correlations were identified with respect to the FAI. Because of the limited number of levels of scores on the CRT, its relationship with FCI and FAI was analyzed with one-way ANOVAs. Results indicated that the homogeneity of variances assumption was violated for the analysis with FCI. Using the Brown-Forsythe correction, an effect of CRT performance was observed, $F(3, 9.26) = 4.43$, $p = .035$; however, the significance of this effect did not meet the required alpha value of $p < .01$. The ANOVA for the FAI was not significant, $F(3, 14) = .256$, $p = .856$.

DISCUSSION

The main goal of Experiment 2 was to establish a novel attribute framing paradigm relevant to social cognition. Results indicated that participants responded in a manner consistent with the framing manipulation, disproportionately endorsing attributes framed in positive terms and rejecting attributes framed in negative terms. The observed effect appeared to be consistent with previous investigations of attribute framing (Levin, et al., 1998) and provides a unique approach to study attribute framing as it relates to other socially relevant constructs.

As was the case in Experiment 1, a significant difference in RTs was observed between the positive and negative frames with positive frames producing significantly longer response latencies. This result may provide further support that frames and counterframes are not necessarily processed in the same manner, despite intuitive notions regarding the equivalency of frames (Mandel & Vartanian, in press). The typical argument that frames and counterframes may not be equivalent is based on the ambiguity of the wording of traditional risky-choice framing problems such as the Asian Disease Problem. For example, to say that “200 people will be saved” does not communicate whether this is a minimum or maximum value. In contrast, the response options during the current study did not include the same level of ambiguity because the qualifiers “at least” and “at most” were used within the current paradigm. As such, even in lieu of less ambiguous response options, differences between response times may suggest that there is something that is more inherently different about the perception and processing of information between frames and counterframes.

A perspective taking manipulation was included in this study in an attempt to facilitate reflective processing on a systems level. While the inclusion of this manipulation was not intended to wash out the framing effect, it was hoped that taking different perspectives would influence the extent to which participants responded in a frame consistent manner. It was hypothesized that reflecting about oneself from different perspectives (reflected appraisals) would produce a diminished amount of frame consistent responding. Results supported this hypothesis in that responding from the perspective of people in general appeared to result in a smaller proportion of frame consistent responses than when responding from one's own perspective. Results additionally indicated a linear relationship between the remoteness of perspective and the proportion of frame consistent responding, suggesting that those that are less known to us may facilitate reflective processing to a greater extent. Literature on bias has reported that individuals are better at recognizing bias in others than they are about having insight into their own biases, an effect referred to as the bias blindspot (Ehrlinger, et al., 2005; Pronin, 2007). In an extensional manner, the current study additionally suggests that taking another's perspective may decrease an individual's overall susceptibility to bias. This finding is both novel and unique in that it is the first observation of such an effect within the context of framing phenomena.

As was the case in Experiment 1, the effect of block, or by extension repeated exposure to counterframes, had a significant impact on proportions of frame consistent responding over the course of the experiment. A similar relation was observed as that seen in Experiment 1 with frame consistent responding decreasing as a function of block. Results additionally indicated a quadratic relationship between block and frame consistency with the reduction in frame consistent responding diminishing over subsequent blocks. As was noted in the discussion of Experiment 1, this result appears to be consistent with literature regarding exposure to counterframes (Kühberger, 1998).

Although not a primary interest of the current study, the contextual effect of different percentage ranges was examined with respect to its influence on frame consistent responding. It was expected that frame consistent responding would diminish at the more extreme percentage ranges (i.e. 10-19; 81-90% > 20-29; 71-80% > 30-39; 61-

70% > 40-49; 51-59%). This is to say that it may be harder for individuals to say they are honest at least 90% of the time than it would be for them to say they are honest at least 60% of the time. Results showed that the 30-39; 61-70 percentage range produced a smaller proportion of frame consistent responses than all of the other percentage ranges. This relationship did not follow the proposed hypothesis and the exact nature of the relationship between this variable and frame consistent responding remains somewhat elusive.

As was the case in Experiment 1, another important goal of this study was to identify individual differences that may serve as predictors for susceptibility and adaptation to this attribute framing effect. The current study included a smaller sample size than Experiment 1 and as such was further limited in terms of power. Despite this fact, one significant negative correlation was observed between FCI and WTAR scores. This result suggests that individuals of higher intelligence may be less susceptible to framing phenomena, a finding consistent with dual-process accounts (Evans, 2008). Although not at a significant level, relationships between FCI, NFC and CRT scores were also observed. A discussion of these variables is warranted given their consistency with previous investigations of susceptibility to judgment heuristics and dual-process accounts (Evans, 2008; Kahneman, 2003; Levin, et al., 2002; M. D. Lieberman, 2007; Robyn A. LeBoeuf, 2003; Sanfey & Chang, 2008; Shafir & LeBoeuf, 2002; Stanovich & West, 2000). With regard to susceptibility to the attribute framing effect, as measured by the FCI, a negative correlation was observed with respect to NFC. High NFC scores, as a reflection of how much individuals value and engage in complex thought, have traditionally been associated with decreased susceptibility to framing phenomena;

however, some studies suggest that this is only the case when individuals were exposed to both versions of the framing manipulation (LeBoeuf, 2003). As the current study provided multiple repetitions of the frames and counterframes, it appears that the current findings may support such a notion. This having been said, it was expected that NFC scores would also be associated to adaptation to framing over time, a hypothesis that was not supported in the current study. Currently, there does not appear to be any studies that have examined the relationship between framing susceptibility and performance on the CRT; however, one of the authors who first described the observation of the framing effect suggested that possibility that this construct may be intimately tied to framing susceptibility given its reflection of intuitive versus rational thought processes (Kahneman & Frederick, 2007). As such, although the current analysis did not produce a statistically significant finding, the current study provides some preliminary data in support of this notion.

In total, Experiment 2 successful in establishing a novel and socially relevant attribute framing paradigm. The establishment of such a paradigm is both novel and unique in that it provides a framework for evaluating a socially relevant attribute framing paradigm in the context of a within subject design that could be studied using techniques such as fMRI. This study additionally included a perspective taking manipulation that was intended to facilitate C-system processes through the inclusion of reflected appraisals. Results suggested that responding from the perspective of others may indeed diminish susceptibility to framing through the recruitment of reflective processes. Given the preliminary nature of these results, additional studies are warranted to further investigate the consistency of such an effect. In addition to this perspective taking manipulation, the relative percent of time that a trait was present or absent additionally influenced the probability that an individual would respond in a frame consistent manner, thus further supporting the role of context in the manifestation of framing phenomena. As was the case in Experiment 1, individuals showed a decreased susceptibility to framing with repeated exposure to counterframes, suggesting the potential development of insight or awareness of the equivalency of frames and counterframes. Analyses of individual differences raised the possibility that framing susceptibility may change as a function of intelligence, cognitive reflection, and need for cognition.

Table 3. Descriptive statistics for demographic, pretest and performance based variables.

Variable	**Range**	**Median**	**Mean**	**Standard Deviation**
Age	18 to 32	22	23.44	4.03
Education	12 to 16	15	14.11	1.23
WTAR	83 to 127	108	107.71	12.41
CRT	0 to 3	0	1	1.19
NFC	36 to 90	71	67	14.57
BIS Total	42 to 78	62	60.39	9.88
BIS Cognitive	9 to 22	16	16.06	3.51
BIS Motor	15 to 34	22	21.83	4.84
BIS Nonplanning	12 to 28	23	22.5	3.9
EPQR – P	-1.11 to 3.16	-.05	.22	1.07
EPQR – E	-1.53 to 1.24	.88	.60	.75
EPQR – N	-1.7 to 1.58	-1.06	-.47	1
EPQR – L	-1.11 to 1.48	-.41	-.25	.76
FCI	.49 to 1	.58	.64	.16
FAI	-.18 to .01	-.06	-.06	.05
RAI	.89 to 1	1	0.98	.03

Note. Abbreviations in the table include: WTAR = Wechsler Test of Adult Reading; CRT = Cognitive Reflection Test; NFC = Need For Cognition; BIS = Barratt Impulsivity Scale; EPQR-P = Psychoticism; EPQR-E = Extraversion; EPQR-N = Neuroticism; EPQR-L = Lie; FCI = Frame Consistency Index; FAI = Frame Adaptation Index; RAI = Response Accuracy Index. Age and Education are reported in years. WTAR values represent standard scores. EPQR-S values represent z scores. All other variables are reported as raw scores.

Figure 11. Sample stimuli for counterbalanced frames for the attribute framing experiments.

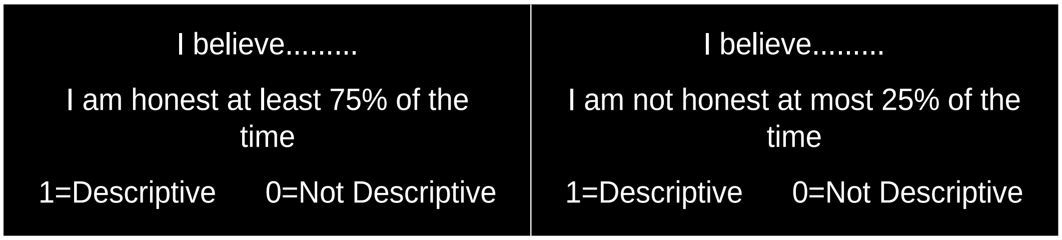
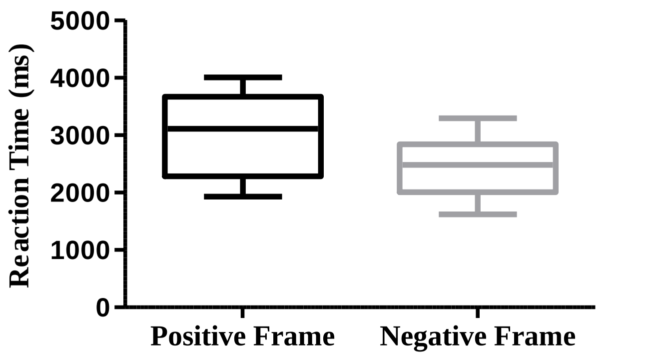


Figure 12. Reaction time by frame condition.



NOTE: Bars represent the 5th and 95th percentiles.

Figure 13. Frequency distribution of proportions of descriptive responses.

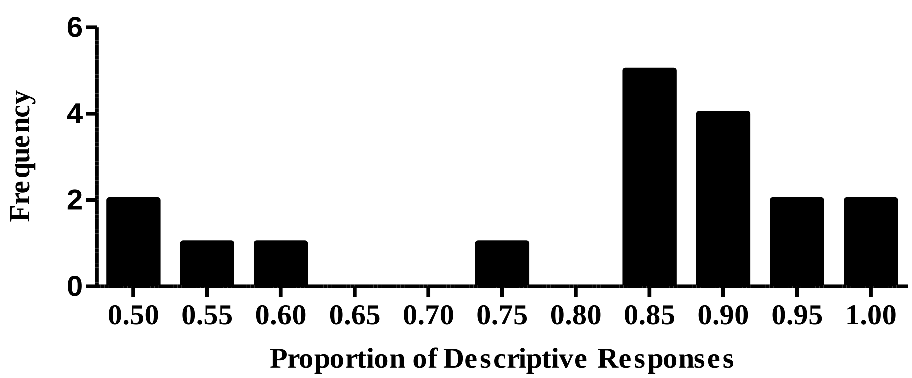
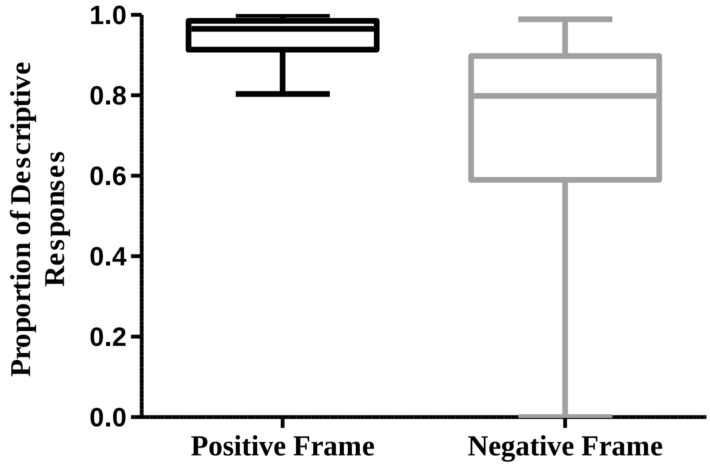


Figure 14. *Proportion of descriptive responses by frame condition.*



NOTE: Bars represent the 5th and 95th percentiles.

Figure 15. *Frequency distribution of proportions of frame consistent responses.*

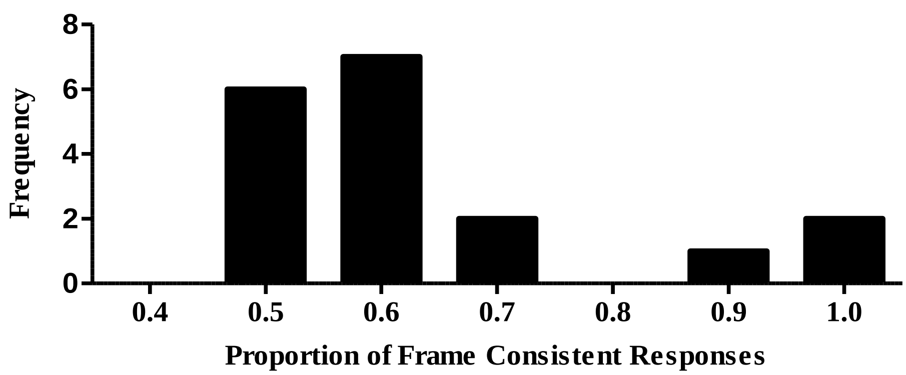
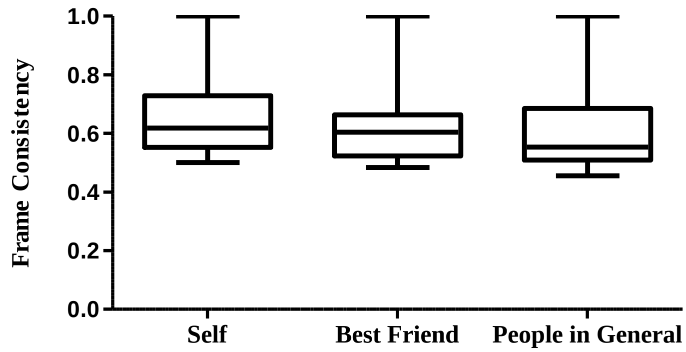
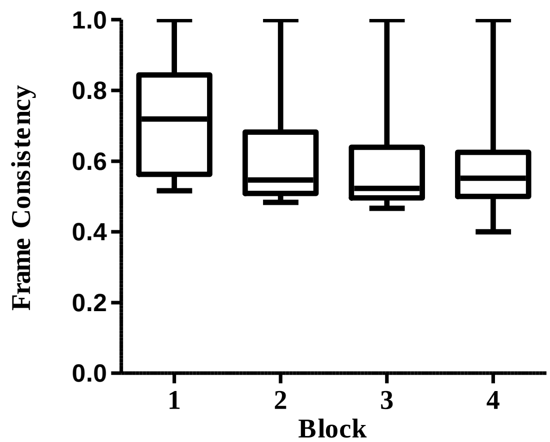


Figure 16. *Proportion of frame consistent responses by perspective condition.*



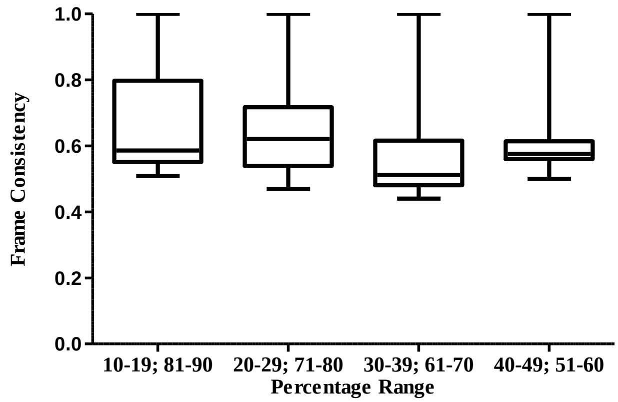
NOTE: Bars represent the 5th and 95th percentiles.

Figure 17. *Proportion of frame consistent responses by block.*



NOTE: Bars represent the 5th and 95th percentiles.

Figure 18. Proportion of frame consistent responses by percentage range.



NOTE: Bars represent the 5th and 95th percentiles.

CHAPTER FOUR
Experiment 3: An fMRI Investigation of Attribute Framing and Perspective Taking

HYPOTHESES

Overall Goal: To investigate the neural correlates of a novel attribute framing paradigm in the context of a perspective taking manipulation intended to facilitate reflective processing.

Question One: Are components of the X- and C-System model of Social Cognition activated during the attribute framing manipulation?

Hypothesis One: Frame consistent responses will be associated with activations in X-system structures when compared with frame inconsistent responses.

Hypothesis Two: Frame inconsistent responses will be associated with activations in C-system structures when compared with frame consistent responses.

Exploratory Analysis: Whole brain image analysis will be performed to investigate other areas of brain that are involved in the task.

Question Two: Will reflected appraisals recruit regions of the C-system in a manner that would diminish susceptibility to framing?

Hypothesis Three: Reflected appraisals will recruit different regions of the MPFC when compared to direct appraisals, and as such, result in a diminished framing effect.

Question Three: Will activity in the MPFC, OFC, and VMPFC be associated with susceptibility to framing?

Hypothesis Four: Activations in the MPFC will be negatively correlated with susceptibility to framing as indicated by the framing and adaptation indices.

METHOD

Participants

Twenty-one healthy adult subjects between the ages of 19 and 45 were recruited for the current study. Subjects were compensated at a rate of 10 dollars per half hour. Informed consent was obtained from all subjects prior to the completion of the study tasks.

Procedure

Subjects will complete a questionnaire relating to demographic information including sex, ethnicity, race, age, years of education, and native language. Additionally, subjects were administered the WTAR (Wechsler, 2001) and completed self-report questionnaires including the NFC (Cacioppo, et al., 1984), the EPQR-S (Eysenck & Eysenck, 1994; Sato, 2005), ECR (Fraley, et al., 2000), and the CRT (Frederick, 2005). These measures were chosen on the basis of both literature on framing effects and the X- and C-system framework. Finally, participants completed and magnetic resonance imaging (MRI) screening form that ensured they were safe to be in the MRI environment.

The experiment was designed and run through the computer software E-Prime

(Schnieder, et al., 2002a; Schnieder, et al., 2002b) with stimuli presented via an MRI compatible display and responses entered utilizing MRI compatible button boxes. Following the completion of all pretest measures, subjects completed an interactive instructional program detailing the experiment and providing practice on a few trials from each condition. This introductory program additionally discussed important considerations related to fMRI data collection such as claustrophobia and the importance of restricting movement throughout the scanning procedure. As in Experiment 2, subjects were asked to rate scenarios describing personality characteristics as either descriptive or not descriptive. The content and presentation of stimuli in this neuroimaging study was identical to the aforementioned behavioral study with one exception. In the fMRI version of the study, stimuli were broken into eight blocks of trials rather than four. The same counterbalancing procedures utilized in the behavioral study were applied to this new division of stimuli. Subjects responded using MRI compatible keypads in each hand, with the left button box being utilized for descriptive/greater than 50% responses and the right button box being utilized for not descriptive/less than 50% responses.

Behavioral Data Analysis

The analysis of behavioral data from the fMRI version of the study was similar to those utilized in the behavioral study. Briefly, descriptive statistics regarding demographic, performance based and pretest variables were calculated including means and standard deviations for all subjects. In an effort to assess engagement in the task, the RAI (as defined in Experiment 2) was tabulated and individuals with scores below .85

were excluded from further analysis due to a potential lack of engagement in the task. The group mean for RT was used to exclude responses where individuals' RTs fell two standard deviations below the group average. Performance based variables were calculated for the FCI and FAI (as defined in Experiment 2). RTs were analyzed using a two-tailed paired *t*-test to assess for potential differences between the two frame conditions. In order to establish the effect of the framing manipulation, proportions of descriptive responses in each frame were entered into a two-tailed paired *t*-test. Frame consistency (i.e. proportions of frame consistent responses) was utilized as a dependent variable in a series of one-way repeated-measures ANOVAs to examine for potential effects of perspective, block and percentage range. Because a bimodal distribution of frame consistency scores was observed during the task, ANOVAs were run for each subgroup within the sample. In order to assess for individual differences in framing susceptibility, the FCI and FAI were entered into a Spearman's correlational analyses exploring for potential associations with demographic variables and pretest scores. Because of the diminished range of scores associated with the CRT, its relationship with FCI and FAI was assessed using one-way ANOVAs. Statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (SPSS version 16.0, www.spss.com). Unless otherwise indicated, data reasonably met the underlying assumptions of the analyses performed. As this experiment included a large number of analyses, the potential of committing a Type I error was inflated. In order to control for this possibility, while minimizing concern for Type II error, an overall p value of .01 was adopted for all analyses. When post-hoc analyses were conducted for significant main effects, the Holm's sequential Bonferroni procedure was utilized to control for multiple comparisons.

fMRI Acquisition and Data Analyses

T2*-weighted echo planar images (EPI) sensitive BOLD contrasts were acquired with a Philips 3 Tesla MRI scanner using a 1-shot gradient echo- EPI sequence optimized to allow full ventral coverage including the amygdala and orbitofrontal cortex (OFC); Repetition Time (TR) = 1.5s, Echo Time (TE) = 25 ms, flip angle = 60°. Thin (3mm+.5mm gap) axial slices were obtained providing whole-brain coverage (Weiskopf, Hutton, Josephs, & Deichmann, 2006; Weiskopf, Hutton, Josephs, Turner, & Deichmann, 2007). While this sequence optimizes ventral coverage, it has also shown robust signal in dorsal areas. High-resolution MP-RAGE 3D T1-weighted scans were also acquired for anatomical localization.

Raw image data was reconstructed with distortion correction to reduce potential artifacts due to magnetic field inhomogeneities. Data were motion corrected with two iterations of a six-parameter, rigid body realignment technique and the time series of each voxel was normalized by its mean signal value to attenuate between-run scaling differences. Estimates of BOLD activity were derived with the methods for event-related fMRI data. The data analysis was performed in MATLAB using Statistical Parametric Mapping software (SPM 5, freeware distributed by the Wellcome Department of Imaging Neuroscience at www.fil.ion.ucl.ac.uk/spm/). Exploratory whole brain fMRI data analyses were initially conducted to identify functionally defined regions of interest (ROIs) for subsequent analyses.

The experiment constituted a 2x4x2 factorial design with the first factor representing the frame condition (positive frame, negative frame), the second representing the perspective condition (self, best friend, people in general, control), and the third representing the behavioral decision of each subject on a trial by trial basis during the task in the fMRI scanner (Descriptive/Greater than 50% option, Not Descriptive/Less than 50% option). With regard to whole brain image analysis, several contrasts were examined to identify brain regions involved in the task. These included Task minus Control, Positive Frame minus Negative Frame, Negative Frame minus Positive Frame, Frame Consistent minus Frame Inconsistent, Frame Inconsistent minus Frame Consistent, Direct minus Reflected appraisals and Reflected minus Direct appraisals. As was indicated above, behavioral data suggested a subdivision of groups with regard to frame consistency, and as such, some of these contrasts were also examined at the subgroup level. Because behavioral data did not suggest an effect of perspective on frame consistent responding, interaction contrasts between frame consistency and perspective were not assessed.

For whole brain analyses, voxel-wise analysis was performed using a general linear model (GLM) for autocorrelated observations. Included within the model is an empirical estimate of intrinsic temporal autocorrelation, global signal change covariates, and sine and cosine regressors for frequencies below that of the task. Hemodynamic response functions (HRFs) from the SPM5 software package were used. Subject-specific regressors of interest were assembled by convolving δ functions (corresponding to the time of onset of the choice pair for each condition) with a canonical HRF. This HRF shape was used to model blood oxygen level dependent (BOLD) responses to trial events using multiple regression. In brief, SPM performed a voxel by voxel analysis of variance for each contrast generated. A *t*-statistic was generated for each voxel, and a subsequent image map (an SPM) was displayed. Thus, for each subject, a linear contrast was used to test the relative activations associated with the conditions of interest. SPM *t*-maps (SPMs) were calculated for the relative contrasts. Resulting contrast maps reflected the differences in activation between the conditions at each voxel location.

Group analyses were performed after realignment with images normalized to the Montreal Neurologic Institute (MNI) template supplied with statistical parametric mapping software, which represents an average of 305 subjects. Functional images were smoothed using an 8 mm full-width half-maximum (FWHM) isotropic Gaussian kernel. Contrast images for each subject were submitted to a second-tier group analysis, using a one-sample *t*-test, and treating subjects as a random effect to obtain group results for the aforementioned contrasts. In all analyses, a critical *t*-value was calculated for each map based on the number of degrees of freedom, smoothness, search volume, desired cluster volume, and desired alpha value. The coordinates of each significant activation were translated into the corresponding coordinates in MNI space. The transformed MNI coordinates were used to look up grey matter correlates from the MNI atlas.

Ten functional ROIs were identified based on group level contrasts. Selection of functional ROIs was based on task involvement as well as membership within the X- and C-system framework. Additionally, two anatomically defined ROIs, speculated to be involved in susceptibility to framing, were adapted from De Martino et al. (2006) by creating a 5 mm sphere around peak cluster activations reported in the right OFC and VMPFC. The SPM toolbox MarsBar (http://marsbar.sourceforge.net/) was utilized to obtain percent signal change estimates for each condition within a given brain region. Results from single-subject analyses were entered into a series of two-way repeated measures ANOVAs with percent signal change as the dependent variable. Frame consistency was utilized as a within subjects factor and group membership was included as a between subjects factor.

As group membership is highly reflective of susceptibility to the framing manipulation, task level activations for a brain region that showed a potential ability to differentiate between groups was utilized in a simple correlational analyses to identify neural correlates of individual differences in framing susceptibility as indicated by the FCI and FAI. Additionally, task-level activations in this brain region were analyzed with respect to pretest measures of individual differences. In an effort to maximize the power of this analysis, only pretest measures that showed a correlation with the FCI and FAI were analyzed in this correlational analysis.

Statistical analyses of ROIs were performed using the Statistical Package for the Social Sciences for Windows (SPSS version 16.0, www.spss.com). Unless otherwise indicated, data reasonably met the underlying assumptions of the analyses performed. As this experiment included a large number of analyses, the potential of committing a Type I error was inflated. In order to control for this possibility, while minimizing concern for Type II error, an overall p value of .01 was adopted for all analyses.

RESULTS

Behavioral results

A total of 21 healthy volunteers were recruited for this neuroimaging study. Two subjects were excluded from the fMRI portion of the study for medical reasons and as such their results on pretest measures of individual differences were also excluded from the statistical analyses. One subject only completed five of the eight experimental runs, but their abbreviated data set was included in all analyses. Descriptive statistics were assessed with regard to demographic information, pretest measurements of individual differences and performance-based variables.

Of the nineteen remaining participants, ten were female and nine were male. The ethnic composition of the sample included thirteen Caucasians (68%), two Hispanics (11%), two Asians (11%), one African American (5%) and one individual of another ethnicity (5%). The mean age of participants was 28.79 with an age range between 18 and 41. Participants had an average of 14.94 years of education.

With regard to pretest measurements of individual differences, performance on the WTAR ranged from between 98 and 127 (standard scores) with a group mean of 114.05 (Average range). Performance on the CRT varied between zero and three correct responses with an average of .72. NFC scores ranged between 56 and 88 with a sample mean of 69.79. Scores on the ECR are broken down into two constructs called Attachment-Related Anxiety (AR-Anx) and Attachment-Related Avoidance (AR-Avo). The mean score for AR-Anx was 2.39 with a range between 1.17 and 5.17. The mean score for AR-Avo was 2.75 with a range between 1.00 and 4.06. As was the case in Experiments 1 and 2, individual subscale scores for the EPQR-S were converted into z-scores using the normative data available in the test manual (Eysenck & Eysenck, 1994). The mean EPQR-P z-score for the sample was -.30 with a range between -1.12 and 2.63.

The mean EPQR-E z-score was .25 with a range of -1.18 to 1.24. The mean EPQR-N z-score was -.68 with a range between -1.40 and .97. The mean EPQR-L z-score was .15 with a range between -1.44 and 2.11. Means and standard deviations for these pretest variables are summarized in Table 4.

Prior to the calculation of performance based variables, an analysis of RT was utilized to eliminate behavioral responses for which RT fell two standard deviations below the group average (*M* = 2994.86, *SD* = 1089.17). This was done in an attempt to exclude trials where an individual likely responded too quickly for the response to be reflective of thoughtful responding. As noted above, behavioral data for trials below this cutoff of 817 ms were excluded from further analyses (*n* = 13, 0.3%). An additional 92 trials (2.1%) were excluded for a lack of behavioral responses.

Behavioral performance-based variables were calculated for individuals based on their responses during the behavioral task. As was the case in the previous experiments, these included a Frame Consistency Index (FCI), a Frame Adaptation Index (FAI) and a Response Accuracy Index (RAI). The FCI was created by calculating the proportion of trials in which a participant responded consistent with the framing manipulation (e.g. choosing descriptive in a positive frame or not descriptive in a negative frame). The mean score for FCI was .64 with a range between .51 and 1. The frequency distribution of FCI scores is presented in Figure 19.

In examining the distribution of the FCI across participants, a bimodal distribution of scores was observed. Given the possibility that our sample may reflect two separate distributions of individuals, analyses were run to examine whether these two populations of scores were significantly different from each other. An arbitrary FCI value of .75 was selected as a division point between the sets of scores. Using this division point for the sample, ten individuals had FCI scores below .75 (Low Framers group) and nine had scores above .75 (High Framers group). An independent-samples *t*-test was conducted to evaluate the hypothesis that the two framing groups differed significantly with respect to FCI. The test was significant, $t(17) = -12.55$, $p < .001$. The mean FCI for the Low Framers group ($M = .57$, $SD = .05$) was significantly lower than the mean for the High Framers group ($M = .91$, $SD = .07$). The 95% confidence interval for the difference in means was relatively narrow, ranging from -.40 to -.29. The eta square index indicated that 90% of the variance in FCI was accounted for by group membership. Figure 20 shows FCI distributions for each frame group. Because it appears that we observed two populations of individuals with respect to the FCI, means and standard deviations for all other variables at the subgroup level are also presented in Table 4.

Distributions of FAI and RAI did not show the same bimodal distribution that was observed with respect to FCI. The FAI was intended to measure adaptation to the framing manipulation over time. It was calculated by taking the linear slope of the proportion of frame consistent responses by block for each individual subject. The mean FAI value for the sample was -.0002 with a range of -.03 to .08. The RAI was created by calculating the proportion of control trials during which the participants responded accurately (e.g. whether the percentage value in the sentence was greater than or less than 50%). The mean RAI for the sample was .98 with a range between 0.93 and 1. No subjects were excluded from further analyses due to obtaining RAI values below .85, a predetermined cutoff. Sample means and standard deviations for these performance-based variables are available in Table 4.

Average RT values for each frame condition were analyzed using a two-tailed paired *t*-test to assess for any potential differences between the frame conditions. The results indicated that the mean RT for the positive frame condition (*M* = 2658.55, *SD* = 559.01) was significantly lower than the mean RT for the negative frame condition (*M* = 3344.40, *SD* = 653.08), $t(18) = -8.59$, $p < .001$. The eta square index indicated that 80% of the variance in RTs was accounted for by frame condition. Interestingly, this difference was in the opposite direction of the relationship observed in Experiment 2. Distributions of RTs in each frame condition are presented in Figure 21. The 95% confidence interval for the mean difference between the two conditions was -853.59 to -518.10.

The main effect of the framing manipulation was analyzed with a two-tailed paired *t*-test with the proportion of descriptive responses in each frame as the dependent variable. The distribution of proportions of descriptive responses across subjects can be seen in Figure 22. The results indicated that the mean proportion of descriptive responses in the positive frame (*M* = .93, *SD* = .07) was significantly greater than the proportion of descriptive responses in the negative frame (*M* = .47, *SD* = .35), $t(18) = 5.27$, $p < .001$. Figure 23 provides a graphical depiction of proportions of descriptive responses in each frame condition. The eta square index indicated that 61% of the variance in proportions of descriptive responses was accounted for by frame condition. The 95% confidence interval for the mean difference between the two conditions was .28 to .64.

Because scores on the variable of FCI appeared to reflect two separate groups of individuals, analyses of the other experimental conditions (e.g. perspective, block and percentage range) with respect to their influence on framing behavior, was done separately for each subgroup, rather than at the overall group level. The proportion of frame consistent responding for each condition was utilized as the dependent variable in a series of one-way repeated-measures ANOVAs for each subgroup. Because this variable collapses behavioral responses into two categories, frame consistent and frame inconsistent, it allows for the direct investigation of these variables on frame consistent responding.

To assess the effect of perspective on frame consistent responding, a one-way within-subjects ANOVA was conducted with the factor being perspective and the dependent variable being proportions of frame consistent responding in each condition. The results for the ANOVA did not reveal a significant effect of perspective for individuals in the High Framers group, Wilks' $\Lambda = .66$, $F(2, 7) = 7.55$, $p = .24$, multivariate $\eta^2 = .34$. For the Low Framers group, the results for the ANOVA also did not reveal a significant effect of perspective, Wilks' $\Lambda = .56$, $F(2, 8) = 3.11$, $p = .10$, multivariate $\eta^2 = .44$. A graphical depiction of the proportions of frame consistent responding in each perspective condition is presented in Figure 24.

With regard to the effect of the block, the results for the ANOVA did not show a significant effect on frame consistent responding for the High Framers group, Wilks' $\Lambda = .16$, $F(3, 7) = .72$, $p = .72$, multivariate $\eta^2 = .84$. For the Low Framers group, the results for the ANOVA also did not show a significant effect on frame-consistent responding, Wilks' $\Lambda = .23$, $F(3, 7) = 1.42$, $p = .42$, multivariate $\eta^2 = .77$. A graphical depiction of the proportions of frame consistent responding across blocks is presented in Figure 25.

With regard to the effect of percentage ranges, the results for the ANOVA did not reveal a significant effect on frame consistent responding for the High Framers group, Wilks' Λ = .43, $F(3, 6) = 2.64$, $p = .14$, multivariate $\eta^2 = .57$. For the Low Framers group, the results for the ANOVA revealed a significant effect on frame consistent responding, Wilks' Λ = .21, $F(3, 7) = 8.58$, $p < .01$, multivariate $\eta^2 = .79$. Six unique pairwise comparisons were conducted among the means for each percentage range. Two of the six pairwise comparisons were significant, controlling for familywise error rate across the six tests at the .05 level using the Holm's sequential Bonferroni procedure. Results indicated percentage ranges 2 (21-30%; 70-79%) and 3 (31-40%; 60-69%) were significantly lower than percentage range 1 (11-20%; 80-89%) for proportions of frame consistent responding. A graphical depiction of the proportions of frame consistent responding across percentage ranges for each group is presented in Figure 26.

In an effort to assess how individual differences may contribute to framing susceptibility and adaptation to framing over time, Spearman correlation coefficients were computed among the pretest variables and the performance-related variables of FCI and FAI. Correlations were identified between FCI and EPQR – L scores, $r(16) = .556$, $p < .05$, and WTAR scores, $r(17) = -.478$, $p < .05$; however, neither of these correlations were significant at the $p < .01$ level. With respect to the FAI, a positive correlation was observed with EPQR – E scores, $r(16) = .535$, $p < .05$, but again this correlation was not significant at the $p < .01$ level. Because of the limited number of levels of scores on the CRT, its relationship with FCI and FAI was analyzed with one-way ANOVAs. For FCI values, a significant effect of CRT performance was observed, $F(3, 14) = 6.07$, $p < .01$. The ANOVA for the FAI was not significant, $F(3, 14) = .80$, $p = .514$.

Whole Brain Neuroimaging Results

Initially, exploratory whole brain analysis was performed to identify functional ROIs that may be related to the manifestation of the framing effect in this study. Unless otherwise indicated, a minimum significance level of $p < .001$ (uncorrected) was used to analyze contrasts. MNI coordinates for peak activations are reported in the format of x, y, z in parenthesis following labels for individual clusters. Several contrasts were examined in relation to the task, the first of which was to examine task level activations with the contrast of Task minus Control. This contrast was not only examined at the overall group level, but also at the subgroup level given behavioral data that suggested a dichotomy in cognitive approaches to the task. Rendered brain images for each of these contrasts are presented in Figure 27. In examining these contrasts, it became apparent that the two subgroups of individuals within the study manifested some different patterns of brain activation in association with the task when compared to the control condition. At the overall group level, activations were observed in the bilateral posterior DMPFC/Supplementary Motor Area [SMA] (-8, 18, 64), left anterior DMPFC (-6, 48, 38), left VLPFC (-46, 16, 12), left DLPFC (-44, 14, 36), right middle cingulate cortex (MCC; 12, 22, 40), left MTL (-48, -38, 0), portions of the visual cortex, and the cerebellum. Individuals included in the Low Framers group, showed a similar pattern of activation on the task with activations in the DMPFC (-6, 28, 48), left VLPFC (-36, 28, -10), left MCC (-6, 24, 42), and portions of the visual cortex. In contrast, the High Framers group only showed task-level activations in the left VLPFC (-42, 28, 26), portions of the visual cortex, and cerebellum.

With respect to the framing manipulation, overall group level contrasts were examined to look at activations associated with each frame condition (Positive Frame minus Negative Frame; Negative Frame minus Positive Frame). A very different pattern of activation was observed for each frame condition. In the Positive Frame minus Negative Frame contrast, activations were observed in the bilateral amygdala (right: 22, -2, -12; left: -22, 8, -18), ACC (0, 18, -10), bilateral middle temporal gyrus [MTG] (right: 56, -14, -14; left -56, -18, -14), right precentral gyrus (56, -2, 12), left posterior MCC (-4, -48, 38), left angular gyrus (-44, -78, 30), and the orbitomedial prefrontal cortex (OMPFC; -2, 48, -10). The reverse contrast (Negative Frame minus Positive Frame) showed activations in the bilateral insula (right: 32, 28, 4; left: -32, 18, 2), left VLPFC (-56, 12, 24), right VLPFC/DLPFC (50, 16, 30), left posterior DMPFC/SMA (-8, 8, 54), bilateral portions of the parietal lobe (left: -34, -44, 36; right: 42, -42, 40), cerebellum (0,-68, -30) and right precuneus (28, -66, 36). Rendered images of these contrasts can be seen in Figure 28.

Next we examined the contrasts related to frame consistent and frame inconsistent responses (Frame Consistent minus Frame Inconsistent; Frame Inconsistent minus Frame Consistent). These contrasts were done for the overall group as well as for the subgroups of High Framers and Low Framers given differences in behavioral data related to this construct at the subgroup level. The Frame Consistent minus Frame Inconsistent contrast at the overall group level, showed two clusters of activation proximal to white matter areas, one near the right caudate/putamen (28, -12, 14) and another in the posterior parietal lobe (-24, -42, 52). Analysis for this contrast at the subgroup level, indicated a similar pattern of activation in the High Framers group;

however, the Low Framers group did not reveal any reliable foci of activation even at liberal significance values (e.g. $p < .01$). Figure 29 depicts activations observed at the overall group level for this contrast.

For the Frame Inconsistent minus Frame Consistent contrast, activations at the overall group level were observed in the bilateral posterior DMPFC/SMA (8, 28, 42), left anterior DMPFC (-2, 62, 26), ACC (0, 26, 22), and VLPFC (-44, 28, 12). For the High Framers group, activations were observed in the Supramarginal gyrus (52, -52, 28), right DLPFC (46, 12, 50), bilateral posterior DMPFC/SMA (-4, 18, 56), and ACC (0, 28, 22). At a slightly relaxed threshold, $p < .005$ uncorrected, a single activation in the left OMPFC (-2, 68, 2) was observed for the Low Framers group. Rendered images of these contrasts at the group and subgroup level are depicted in Figure 30.

Although no behavioral effect for perspective-taking on frame consistency was observed in this study, overall group level contrasts were examined for Direct minus Indirect appraisals and Indirect minus Direct appraisals. A more detailed analysis of additional contrasts (e.g. Self minus Best Friend, Best Friend minus Self, etc.) did not appear warranted due to a lack of behavioral data suggesting an effect of perspective taking on frame consistent responding and a wealth of pre-existing studies examining different brain activations related to responding from different perspectives. For the Reflected minus Direct contrast, a single activation was observed in the left precuneus/posterior MCC (-4, -48, 42). For the Direct minus Reflected contrast, a white matter activation was observed in the left frontal lobe (-22, 14, 26) as well as an activation in the left cerebellum (-32, -72, -38).

Region of Interest Analyses Results

As noted above, the results of whole brain analyses were used to identify functional ROIs for subsequent analyses. Ten functional regions were selected based on their involvement in the task as well as their relationship with the X- and C-system framework. In addition, two anatomically defined ROIs (centered on peak voxel MNI coordinates as a 5mm sphere) were adapted from a previous study that examined a risky-choice framing paradigm (De Martino et al., 2006). With respect to proposed C-system structures, functional ROIs included the bilateral posterior DMPFC/SMA, left anterior DMPFC, ACC, left OMPFC, left DLPFC, and left VLPFC. Functional ROIs for the X-system included the left and right amygdala. The right OFC and VMPFC, as defined by De Martino et al. (2006), appeared to overlap with X-system structures, based on the X- and C-system model of social cognition (Lieberman, 2007a). While De Martino et al. found that these areas were positively correlated with rationality in their study (i.e. decreased susceptibility to framing phenomenon), the design of their study utilized a risky-choice framing paradigm that contained no social or attribute information. As such, mediation of rationality within these brain regions may be unique to non-social framing stimuli such as gambling paradigms. Nonetheless, as the De Martino et al. study was the first to examine the neural correlates of a traditional framing paradigm, their potential involvement in this task was evaluated during the ROI analyses. Additionally, the left and right insula were included in the analysis due to their association with emotionally-laden social stimuli and a previous study which suggested the insula may play a part in reflexive processing (Sanfey, et al., 2003).

Percent signal changes estimates for each experimental condition were calculated using Marsbar (http://marsbar.sourceforge.net/). These values were utilized as the dependent variable in a series of twelve 2 X 2 repeated measures ANOVAs with frame group as a between subjects factor and frame consistency (e.g., frame consistent responses or frame inconsistent responses) as a within subjects factor. Images of all ROIs can be seen in Figure 31. The general hypothesis for these analyses was that an increase in activation of C-system structures would be observed when participants responded in a manner inconsistent with the framing condition, while X-system structures would show the opposite trend.

C-system Structures

The functional ROI for the left DLPFC (-44, 14, 36) was taken from the Task minus Control contrast at the significance level of $p < .00005$ (uncorrected). The results of the ANOVA showed a significant main effect of frame consistency, with frame inconsistent responses being associated with increases in activation in this region, Wilks' $\Lambda = .53$, $F(1, 17) = 15.05$, $p < .001$, multivariate $\eta^2 = .47$. No significant effect of frame group was observed, $F(1, 17) = .01$, $p = .77$. The interaction between frame group and frame consistency was also observed, Wilks' $\Lambda = .77$, $F(1, 17) = 5.17$, $p < .05$, multivariate $\eta^2 = .33$, but not at the required alpha level. A graphical depiction of these results is contained in Figure 32.

The ROI for the left VLPFC (-46, 16, 12) was taken from the Task minus Control contrast at the $p < .00005$ (uncorrected) significance level. The results of the ANOVA showed a significant main effect of frame consistency, with frame inconsistent responses being associated with increases in activation in this region, Wilks' $\Lambda = .18$, $F(1, 17) =$

76.96, $p < .001$, multivariate $\eta^2 = .82$. No significant effect of frame group was observed, $F(1, 17) = 1.93$, $p = .18$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .22$, $F(1, 17) = 60.13$, $p < .001$, multivariate $\eta^2 = .78$. A graphical depiction of these results is contained in Figure 33.

The functional ROI for the left anterior DMPFC (-6, 48, 38) was taken from Task minus Control contrast at the $p < .00005$ (uncorrected) level of significance. The results of the ANOVA showed a significant main effect of frame consistency, with frame inconsistent responses being associated with increases in activation in this region, Wilks' $\Lambda = .43$, $F(1, 17) = 22.88$, $p < .001$, multivariate $\eta^2 = .57$. No significant effect of frame group was observed, $F(1, 17) = .00$, $p = .99$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .55$, $F(1, 17) = 13.95$, $p < .005$, multivariate $\eta^2 = .45$. A graphical depiction of these results is contained in Figure 34.

The functional ROI for the bilateral posterior DMPFC/SMA (8, 28, 42) was taken from the overall group level Frame Inconsistent minus Frame Consistent contrast at the $p < .00005$ (uncorrected) significance level. Results of the ANOVA showed a significant main effect of frame consistency, with frame inconsistent responses being associated with increases in activation in this region, Wilks' $\Lambda = .18$, $F(1, 17) = 79.53$, $p < .001$, multivariate $\eta^2 = .82$. No significant effect of frame group was observed, $F(1, 17) = .26$, $p = .62$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .36$, $F(1, 17) = 30.60$, $p < .001$, multivariate $\eta^2 = .64$. A graphical depiction of these results is contained in Figure 35.

The functional ROI for the left OMPFC (-2, 68, 2) was defined from the Frame

Inconsistent minus Frame Consistent contrast for the low framers group at the significance level of $p < .005$ (uncorrected), the results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .99$, $F(1, 17) = .02$, $p = .89$, multivariate $\eta^2 = .01$. An effect of frame group was also observed, $F(1, 17) = 5.91$, $p < .05$; but not at the alpha level required for significance. The interaction between frame group and frame consistency approached significance, Wilks' $\Lambda = .80$, $F(1, 17) = 4.30$, $p = .054$, multivariate $\eta^2 = .20$. A graphical depiction of these results is contained in Figure 36.

The functional ROI for the ACC (0,26, 22) was defined from the overall group level Frame Inconsistent minus Frame Consistent contrast at the $p < .001$ (uncorrected) significance level. The results of the ANOVA showed a significant main effect of frame consistency, with frame inconsistent responses being associated with increases in activation in this region, Wilks' $\Lambda = .28$, $F(1, 17) = 42.49$, $p < .001$, multivariate $\eta^2 = .71$. No significant effect of frame group was observed, $F(1, 17) = .30$, $p = .59$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .78$, $F(1, 17) = 4.95$, $p < .05$, multivariate $\eta^2 = .23$, but not at the required alpha level. A graphical depiction of these results is contained in Figure 37.

X-system Structures

The functional ROI for the left amygdala (-16, -8, -18) was taken from the Positive minus Negative contrast at the $p < .001$ (uncorrected) significance level. The results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .96$, $F(1, 17) = .64$, $p = .44$, multivariate $\eta^2 = .04$. No significant effect of frame group was observed, $F(1, 17) = .04$, $p = .84$. The interaction between frame group and frame consistency was also not significant, Wilks' $\Lambda = .91$, $F(1, 17) = 1.72$, $p = .21$, multivariate $\eta^2 = .09$. A graphical depiction of these results is contained in Figure 38.

The functional ROI for the right amygdala (28, 4, -22) was taken from the Positive Frame minus Negative Frame contrast at the $p < .001$ (uncorrected) significance level. The results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .97$, $F(1, 17) = .51$, $p = .49$, multivariate $\eta^2 = .03$. No significant effect of frame group was observed, $F(1, 17) = 1.04$, $p = .32$. The interaction between frame group and frame consistency was also not significant, Wilks' $\Lambda = .99$, $F(1, 17) = .11$, $p = .75$, multivariate $\eta^2 = .01$. A graphical depiction of these results is contained in Figure 39.

The functional ROI for the left insula (-32, 18, 2) was defined from the Negative Frame minus Positive Frame contrast at the $p < .001$ (uncorrected) significance level. The results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .85$, $F(1, 17) = 3.09$, $p = .10$, multivariate $\eta^2 = .15$. No significant effect of frame group was observed, $F(1, 17) = .08$, $p = .77$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .66$, $F(1, 17) = 8.71$, $p < .01$, multivariate $\eta^2 = .34$. A graphical depiction of these results is contained in Figure 40.

The functional ROI for the right insula (32, 28, 4) was taken from the Negative Frame minus Positive Frame contrast at the $p < .001$ (uncorrected) significance level. The results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .90$, $F(1, 17) = 1.83$, $p = .19$, multivariate $\eta^2 = .10$. No significant effect of frame group was observed, $F(1, 17) = 1.74$, $p = .21$. The interaction between frame group and frame consistency was significant, Wilks' $\Lambda = .65$, $F(1, 17) = 9.30$, $p < .01$, multivariate $\eta^2 = .35$. A graphical depiction of these results is contained in Figure 41.

As noted earlier, the ROI for the VMPFC was defined as a 5 mm sphere surrounding the MNI coordinates for the peak activation (-4, 34, -8) reported in De Martino et al. (2006). The results of the ANOVA did not show a significant main effect of frame consistency, Wilks' $\Lambda = .99$, $F(1, 17) = .03$, $p = .87$, multivariate $\eta^2 = .01$. No significant effect of frame group was observed, $F(1, 17) = .66$, $p = .43$. The interaction between frame group and frame consistency was also not significant, Wilks' $\Lambda = .99$, $F(1, 17) = .07$, $p = .80$, multivariate $\eta^2 = .01$. A graphical depiction of these results is contained in Figure 42.

As noted earlier, the ROI for the right OFC was defined as a 5 mm sphere surrounding the MNI coordinates for the peak activation (24, 30, -10) reported in De Martino et al. (2006). The results of the ANOVA showed a main effect of frame consistency, with frame inconsistent responses being associated with decreases in activation in this region, Wilks' $\Lambda = .38$, $F(1, 17) = 27.31$, $p < .0001$, multivariate $\eta^2 = .61$. No significant effect of frame group was observed, $F(1, 17) = 1.07$, $p = .32$. The interaction between frame group and frame consistency was not significant, Wilks' $\Lambda = .98$, $F(1, 17) = .31$, $p = .59$, multivariate $\eta^2 = .02$. A graphical depiction of these results is contained in Figure 43.

Neural Correlates of Individual Differences

As the left OMPFC was the only brain region that appeared to differentiate between groups of subjects, it was identified as the most likely candidate to be associated with individual differences in frame susceptibility and adaptation. Task level percent signal change in this region was utilized in a simple Spearman correlational analysis with FCI and FAI. As individual differences on pretest measures were associated with the FCI and FAI (CRT, EPQR-E, EPQR-L, WTAR), they were additionally entered into the correlation matrix. Although NFC was not correlated with framing susceptibility in this study, it was additionally included in the correlation analysis given its negative correlation with frame susceptibility in Experiment 2 and literature associating it with framing susceptibility and adaptation (LeBoeuf & Shafir, 2003). Correlations were identified between task level percent signal change in the left OMPFC and FCI, $r(17) = -.491$, $p < .05$, NFC scores, $r(17) = .682$, $p < .005$, and WTAR scores, $r(17) = .648$, $p < .005$; however, only the correlations with the WTAR and NFC were significant at the $p < .01$ level. As was the case in previous analyses, the relationship between CRT scores and percent signal change in the left OMPFC was analyzed using a one-way ANOVA. Results of this analysis did not show a significant effect, $F(3, 14) = 2.34$, $p = .12$.

DISCUSSION

The results of the current study were successful in replicating the socially-relevant attribute framing effect observed in Experiment 2. This provides additional support regarding the ability of this paradigm to reliably produce an effect of the framing manipulation in a manner consistent with that observed in previous investigations of attribute framing (Levin, et al., 1998). As was the case in Experiment 2, participants chose the descriptive response more in the positive frame than they did in the negative frame. Notably, results identified two subgroups of individuals that differed greatly with respect to their susceptibility to framing with some participants responding in a frame consistent manner on nearly all the experimental trials. Given this significant difference in response styles, these two groups were analyzed independently with respect to the other experimental manipulations as well as with regard to the neuroimaging data. As one of the goals of this study was to identify individual differences in susceptibility to framing phenomena, and by extension differences in processing at the systems level, this division between participants proved to be quite fortuitous.

As was the case in both of the previous experiments, a significant difference in RTs between the two frame conditions was observed. It is of note that the difference in RTs observed in this study was in the opposite direction of that observed in Experiment 2 with responses in negative frames showing greater response latencies than those in the positive frame. Additional differences between frame conditions were also observed with respect to the neuroimaging data. When compared to negative frame condition, the positive frame condition showed activations in the bilateral amygdala, ACC, bilateral MTG, right precentral gyrus, left posterior MCC, left angular gyrus, and OMPFC. In contrast, the negative frame condition showed activations in the bilateral insula, left VLPFC, right VLPFC/DLPFC, left posterior DMPFC/SMA, bilateral portions of the parietal lobe, cerebellum, and right precuneus. Although there does not seem to be a precedent for such a finding, in combination with the significant differences in RTs observed across all experiments, these results provide preliminary data suggesting significant differences in the perception and processing of intuitively equivalent decision frames.

In terms of the analysis of behavioral data related to the additional experimental manipulations, neither the High Framers group nor the Low Framers group showed that the perspective taking manipulation impacted frame consistent responding over the course of the experiment. This was in contrast to the findings observed in Experiment 2 and difficult to explain given the lack of relevant studies examining such a context effect. One possible explanation for this result relates to the statistical power of the analyses employed. By breaking up the sample into two groups, the sample size for each analysis was extremely small, thus limiting statistical power to resolve differences as sample size is intimately tied to the power of a statistical test. Notably, the absence of an effect of perspective on frame consistent responding limited the applicability of an investigation of the neural correlates of the potential interactions between perspective and frame conditions in the subsequent neuroimaging analyses.

With regard to adaptation to framing, the current analyses did not support an effect of block on frame consistent responding for either the Low Framers or High Framers group. This result was highly unexpected, given the results of Experiments 1 and 2 as well as a wealth of other studies showing diminished susceptibility to framing phenomena with exposure to counterframes (Kühberger, 1998). One possible explanation for this null result again may be related to the diminished statistical power associated with small sample sizes. This result also called into question the utility of using the FAI as a measure of individual differences given the absence of a group level effect. Nonetheless, the FAI was included in the analysis of individual differences with the hope that some individuals may have demonstrated an adaptation to the framing effect over time.

With regard to the contextual influence of percentage ranges on frame-consistent responding in the current study, results were expected to follow the pattern observed in experiment 2. The relevant analyses for the current study only showed an effect of percentage range for the Low Framers group. For this group, results indicated that the 21-30; 70-79 and 31-40; 60-69 percentage ranges produced a significantly lower proportion of frame consistent responses when compared to the 11-20; 80-89 percentage range. This effect appeared to be generally consistent with the effect observed in Experiment 2; however, the exact nature of the relationship between these constructs remains somewhat elusive.

Whole brain neuroimaging analyses suggested that the two subgroups identified with respect to their susceptibility to framing differed significantly with regard to brain activations during the task. Consistent with studies of self-reflection including perspective taking (D'Argembeau, et al., 2007; Ochsner, et al., 2005), overall group level contrasts for the task over the control condition revealed activations in the DMPFC. Interestingly, when task level activations were examined at the subgroup level, a very different pattern of results was observed between groups. While the Low Framers group showed patterns of activation similar to those seen at the overall group level, the High Framers group showed no significant activations in the DMPFC. The reason for this difference is unclear, but as the MPFC has been associated with self-reflection, it raises the question of the extent to which these participants were engaged in such a behavior during the task. Interestingly, when examining the Frame Inconsistent minus Frame Consistent contrast for the High Framers group, activations in the DMPFC were observed, suggesting that individuals in the High Framers group may have been engaged in self-reflection to a greater extent when they made frame inconsistent responses. ROI analyses additionally supported this notion, showing a significant difference in percent signal change in regions of the DMPFC when participants made decisions that were inconsistent with the framing manipulation. Moreover, the difference in percent signal change appeared to be greater for the High Framers group than the Low Framers group as indicated by a significant interaction effect. Taken together, these results suggest that reflective processing, as indicated by activations in the DMPFC, may contribute to more controlled aspects of social cognition.

In addition to the DMPFC, other regions appeared to be associated with reflective processing, as indicated by increases in activations in these regions when participants made decisions that were inconsistent with the framing manipulation. These included the ACC and regions of the left LPFC. The ACC has been consistently associated with conflict monitoring and inhibition of prepotent response biases (Botvinick, 2007; Carter & Van Veen, 2007; Walton, et al., 2007). Additionally, this region has been implicated in framing susceptibility during other investigations of framing phenomena (De Martino, et al., 2006; Deppe, et al., 2007). In a similar manner, the LPFC has been associated with top-down control over prepotent responses and emotionally-driven stimuli (Curtis & D'Espositio, 2004; Sakagami & Watanabe, 2007; Tanji & Hoshi, 2008; Tanji, et al., 2007), including framing phenomena (De Martino, et al., 2006) and the Ultimatum Game (Sanfey, et al., 2003). Taken together, these results provide additional support for the role of these structures in reflective processes at a systems level.

With regard to X-system structures, the current study was less successful in identifying changes in activation associated with reflexive processing. It was expected that these regions would show increased activations when participants made decisions in a manner consistent with the framing manipulation, but no such difference was observed for a majority of the areas analyzed. No significant differences in activation in response to the frame consistency of responses were revealed in the VMPFC, bilateral amygdala, or bilateral insula; however, one brain region, the right OFC, did show a significant decrease in activation when participants made responses in a frame inconsistent manner. This region showed this effect in a manner that was consistent across groups, as indicated by the absence of an interaction effect. Although activity in this region was previously associated with a diminished susceptibility to framing effects (De Martino, et al., 2006), the task utilized to elicit framing effects consisted of a risky-choice framing paradigm consistent with Experiment 1. This provides support for notions that different types of framing effects may be manifested and processed in different ways (Levin, et al., 1998). Indeed, attribute framing effects have been noted to deviate from the predictions of Prospect Theory, a theoretical basis for the observation of risky-choice framing paradigms (Kahneman, 2003). Additionally, within the context of the X- and C-system formulation of social cognition, this region is expected to be involved in more reflexive processing (Lieberman, 2007a). As the aforementioned study utilized a gambling paradigm relatively devoid of social stimuli, the lack of socially relevant inputs to the decision-making process may in part help explain this difference. Although this difference may be accounted for by either differences in social-relatedness or something inherently different between attribute and risky-choice framing effects, the current study posits a role for the right OFC in the reflexive processing of socially relevant information.

As noted above, one of the major goals in this study was to examine individual differences as they relate to the manifestation of framing phenomena. With regard to behavioral data, two separate groups were identified with respect to their susceptibility to the attribute framing manipulation, as indicated by significant differences on the FCI. With regard to behavioral results, increased performance on the CRT was associated with a diminished susceptibility to the framing manipulation. In fact, no individuals in the High Framers group achieved any correct responses on this measure. As noted in the discussion of Experiment 2, the CRT is a relatively new measure and as such has not been studied with respect to its contribution to frame susceptibility; however, the current study suggests that the CRT may be an ideal screening tool to identify individuals with a diminished susceptibility to framing phenomena. In the current study, an additional negative correlation was observed between the FCI and WTAR scores, though this effect was not significant at the $p < .01$ level. Intellectual functioning has consistently been associated with the controlled components of dual process models, with higher intellectual function relating to an increased efficiency in controlled processes (Evans, 2008). As such, this preliminary result provides additional support for such findings. Although it was also not significant at the $p < .01$ level, the EPQR-L scale was positively correlated to FCI values. This preliminary result is both interesting and unique in that validity scales such as the EPQR-L are sometimes interpreted with respect to psychological insight with elevations on these types of scales suggesting a diminished level of psychological insight. The concept of psychological insight has not previously been investigated with respect to framing phenomena, but this finding suggests that insight may play a role in the manifestation of framing effects. Finally a positive correlation was observed between EPQR-E scores and FAI, though again this correlation was not significant at the $p < .01$ level. This effect was unexpected as a previous study indicated that extraversion was related to greater efficiency in reflective processes (Eisenberger, et al., 2005).

In addition to psychometrically-measured individual differences, one brain region, the left OMPFC, appeared to show an ability to predict susceptibility to framing. This was the only brain region analyzed which appeared to show a difference in activity between the High Framers and Low Framers. Additionally, results of a simple correlational analysis showed that task level activations in this region were associated with the FCI, NFC, and WTAR scores; however, only the positive correlations with the WTAR and NFC were significant following the correction for multiple comparisons. Interestingly, the region of the left OMPFC that was identified in this study was very similar in location to a region that has previously been associated with intellectual functioning (Gong, et al., 2005). These results suggest that activity in the left OMPFC may be related to susceptibility to framing effects, potentially being mediated through individual differences in intelligence and enjoyment of complex thought.

Table 4. Descriptive statistics for demographic, pretest and performance based variables.

Variable	**Low Frame Group** (N=10)	**High Frame Group** (N=9)	**TOTAL** (N=19)
Age	27.5 (6.27)	30.22 (8.83)	28.79 (7.50)
Years of Education	15.90 (2.47)	13.75 (1.58)	14.94 (2.34)
WTAR	119.30 (7.32)	108.22 (7.65)	114.05 (9.22)
CRT	1.44 (1.13)	0 (0)	0.72 (1.07)
NFC	72.50 (9.63)	66.78 (4.38)	69.79 (7.97)
EPQR-P	-0.43 (0.95)	-0.16 (1.11)	-0.30 (1.01)
EPQR-E	-0.26 (1.01)	0.77 (0.55)	0.25 (0.95)
EPQR-N	-0.76 (0.78)	-0.60 (0.87)	-0.68 (0.81)
EPQR-L	-0.18 (0.68)	0.47 (1.00)	0.15 (0.89)
AR-Anx	2.51 (1.14)	2.26 (0.72)	2.39 (0.95)
AR-Avo	2.91 (0.98)	2.56 (0.86)	2.75 (0.91)
RAI	0.97 (0.03)	0.98 (0.02)	0.98 (0.02)
FCI	0.56 (0.05)	0.91 (0.07)	0.73 (0.19)
FAI	-0.01 (0.02)	0.01 (0.03)	-0.00 (0.03)

Note. Abbreviations in the table include: N = number of participants; WTAR = Wechsler Test of Adult Reading; CRT = Cognitive Reflection Test; NFC = Need For Cognition; AR-Anx = Attachment-related Anxiety; AR-Avo = Attachment-related Avoidance; EPQR-P = Psychoticism; EPQR-E = Extraversion; EPQR-N = Neuroticism; EPQR-L = Lie; FCI = Frame Consistency Index; FAI = Frame Adaptation Index; RAI = Response Accuracy Index. Age and Education are reported in years. WTAR values represent standard scores. EPQR-S values represent z scores. All other variables are reported as raw scores. Values represent means with standard deviations in parenthesis.

Figure 19. Frequency distribution of proportions of frame consistent responses.

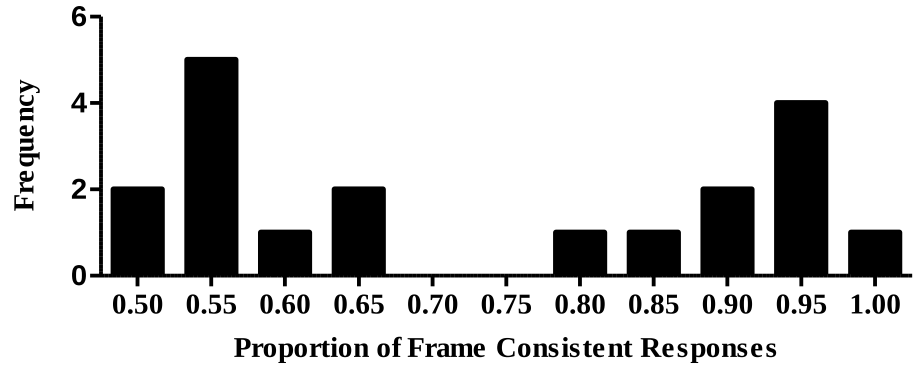
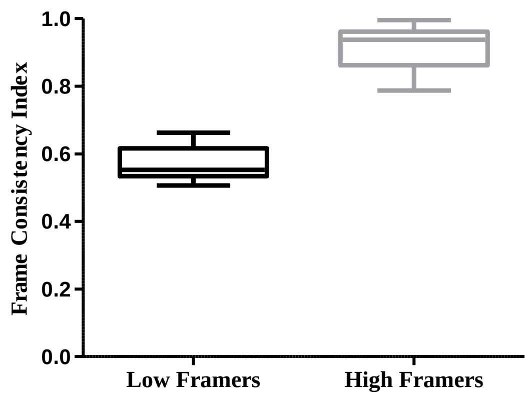
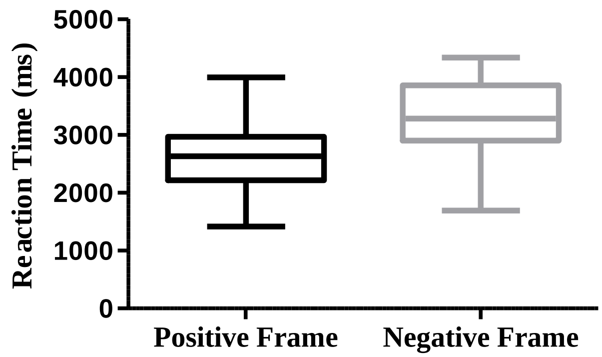


Figure 20. Proportions of frame consistent responding by frame group.



NOTE: Bars represent the 5th and 95th percentiles.

Figure 21. *Reaction times by frame condition.*



NOTE: Bars represent the 5th and 95th percentiles.

Figure 22. *Frequency distribution for proportions of descriptive responses.*

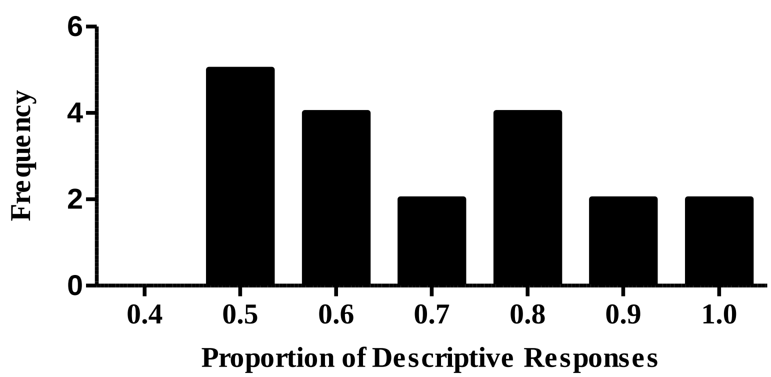
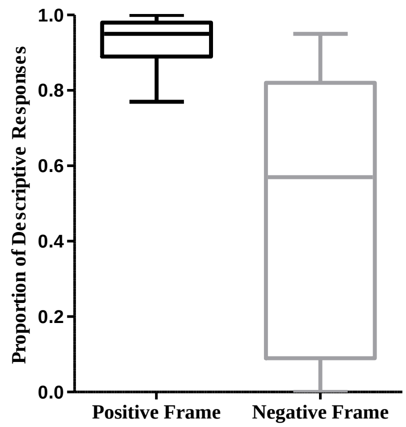
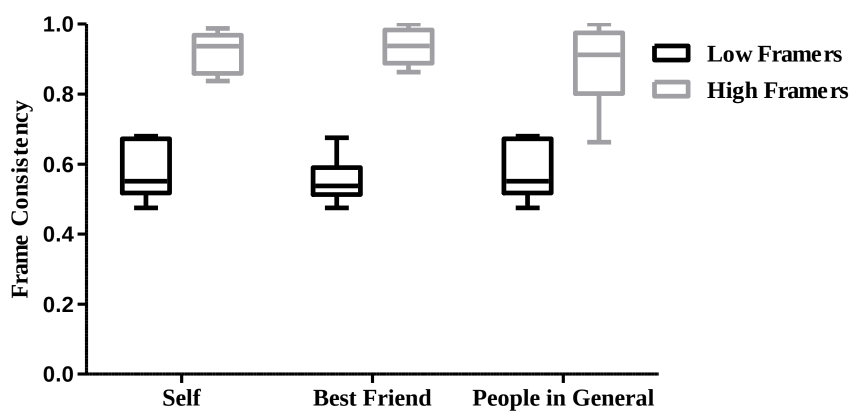


Figure 23. *Proportion of descriptive responses by frame condition.*



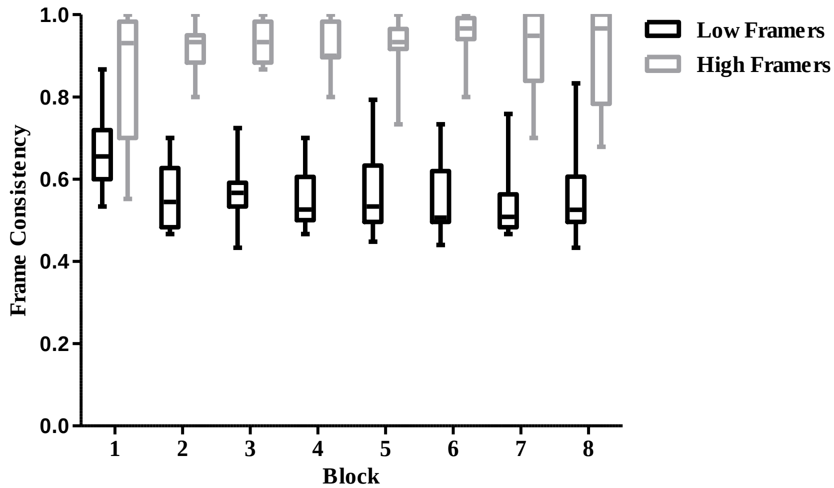
NOTE: Bars represent the 5th and 95th percentiles.

Figure 24. *Proportion of frame consistent responses by perspective condition.*



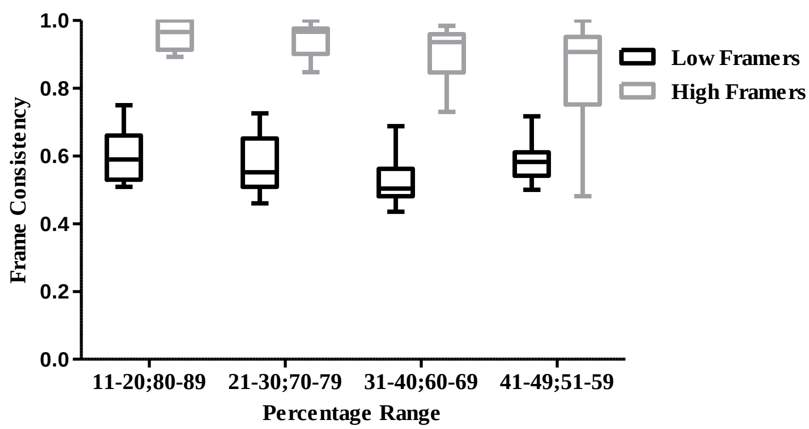
NOTE: Bars represent the 5th and 95th percentiles.

Figure 25. *Proportion of frame consistent responses by block.*



NOTE: Bars represent the 5th and 95th percentiles.

Figure 26. *Proportion of frame consistent responses by percentage range.*



NOTE: Bars represent the 5th and 95th percentiles.

Figure 27. *Rendered group level images for the Task minus Control contrast.*

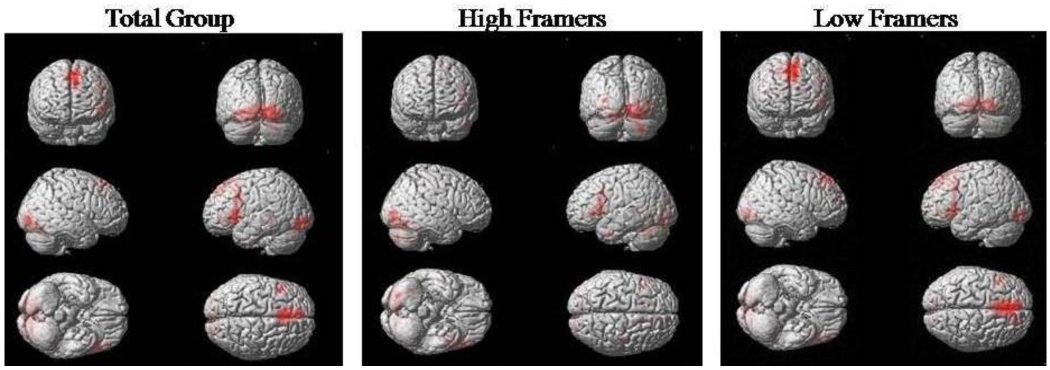


Figure 28. Rendered images for the Positive minus Negative and Negative minus Positive contrasts at the overall group level.

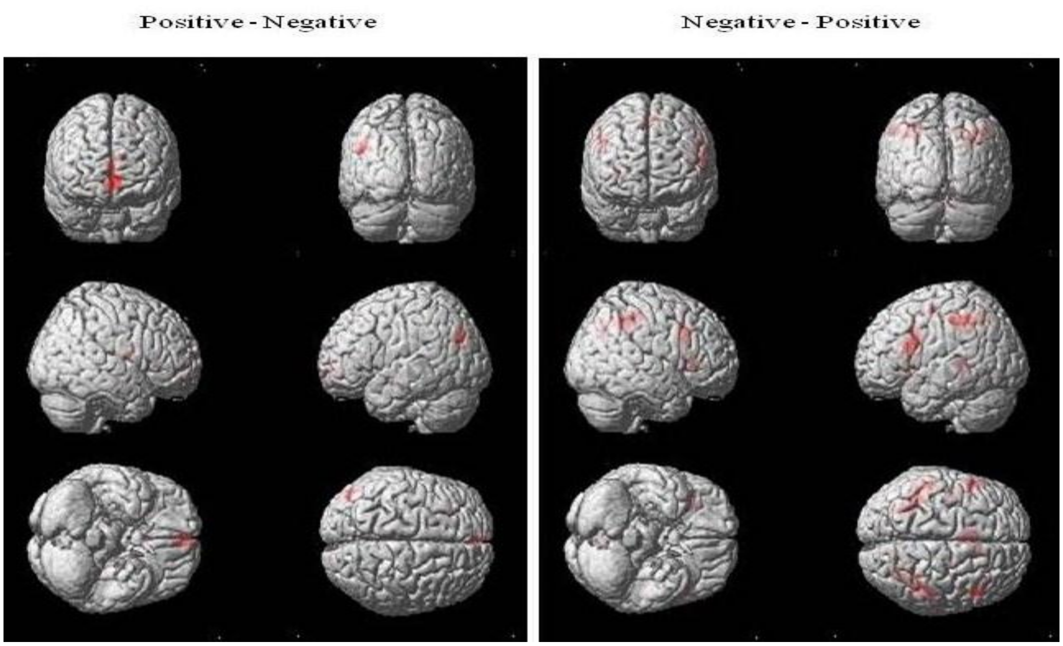


Figure 29. Images of activations observed for the Frame Consistent minus Frame Inconsistent contrast at the overall group level.

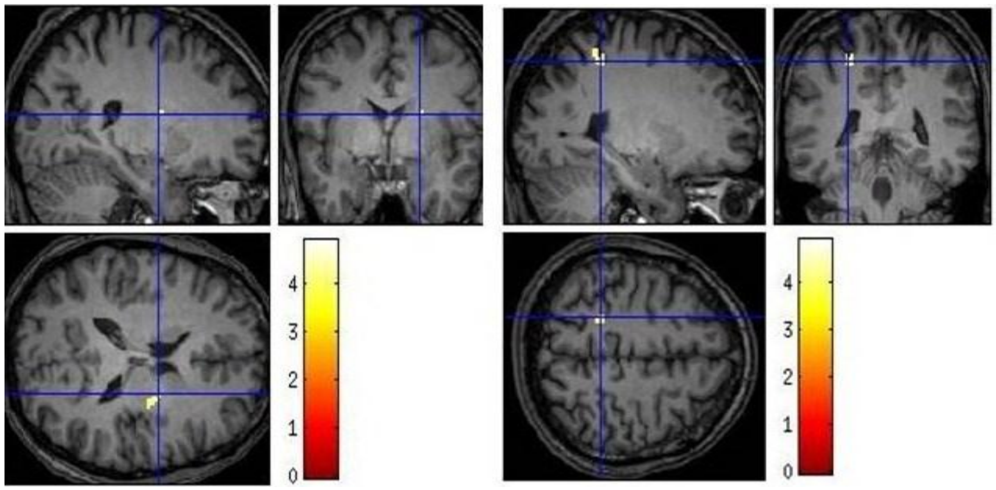


Figure 30. Rendered images of the Frame Inconsistent minus Frame Consistent contrast at the group and subgroup level.

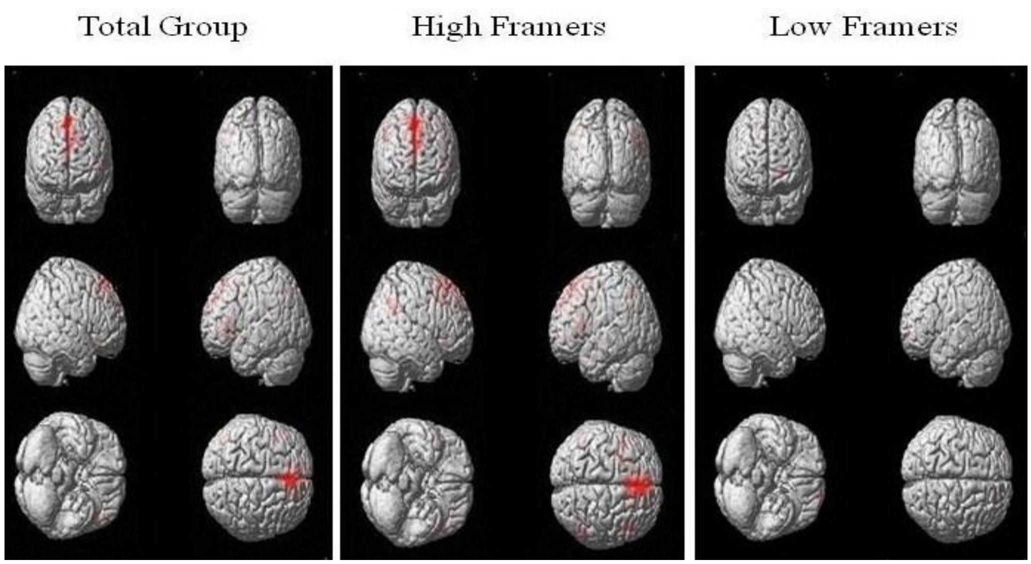


Figure 31. *Regions of interest.*

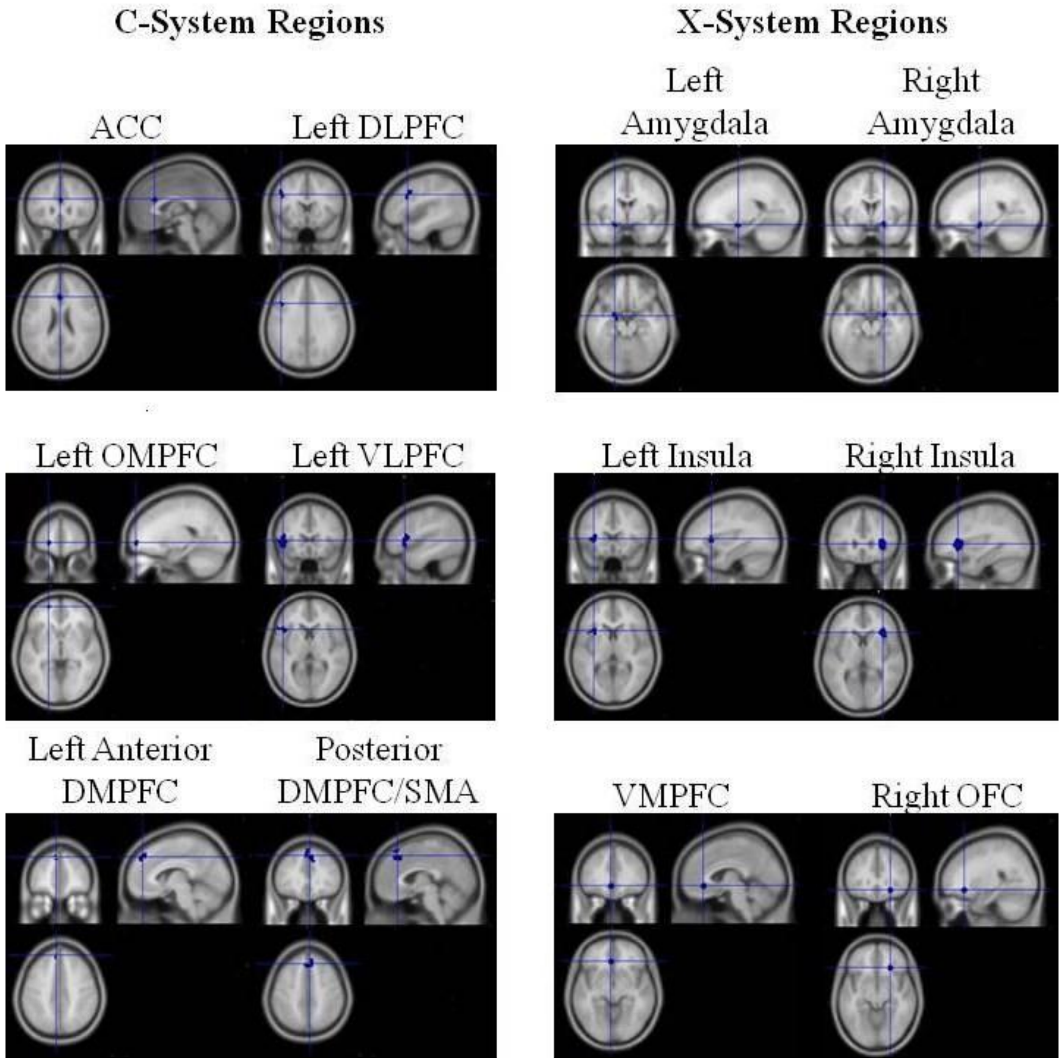
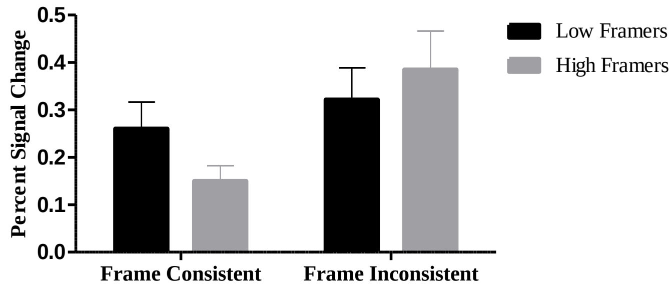


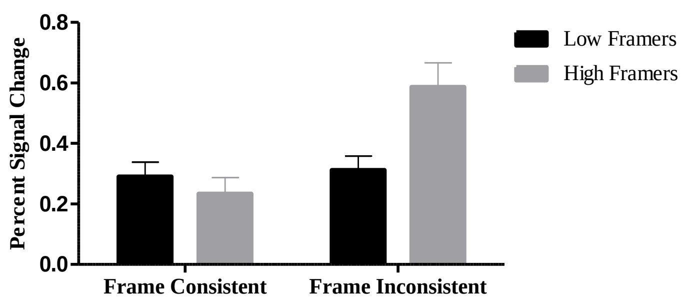
Figure 32. Percent signal change in the left DLPFC by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	4.73	0.0362
Frame Consistency	13.77	0.0012
Frame Group	0.35	0.7673
Subjects (matching)	66.4075	0.0023

Note: Bars represent standard error from the mean

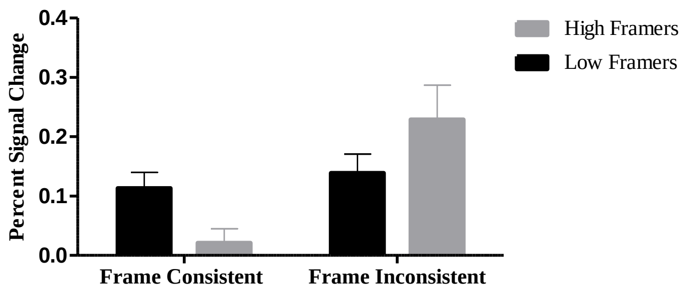
Figure 33. Percent signal change in the left VLPFC by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	14.98	< 0.0001
Frame Consistency	19.17	< 0.0001
Frame Group	6.48	0.1819
Subjects (matching)	56.8374	< 0.0001

Note: Bars represent standard error from the mean

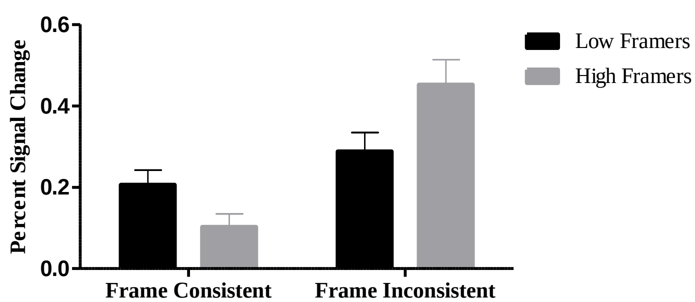
Figure 34. Percent signal change in the left anterior DMPFC by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	12.31	0.0016
Frame Consistency	20.20	0.0002
Frame Group	0.00	0.9850
Subjects (matching)	54.0496	0.0058

Note: Bars represent standard error from the mean

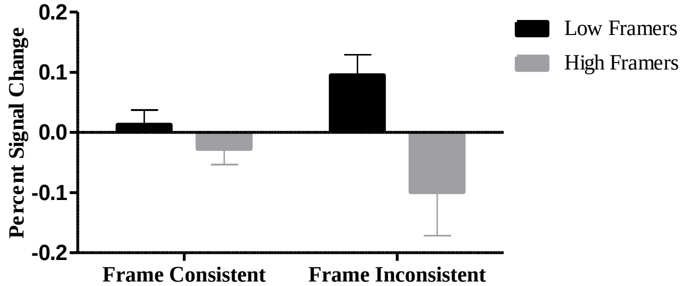
Figure 35. Percent signal change in the bilateral posterior DMPFC/SMA by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	13.51	< 0.0001
Frame Consistency	35.12	< 0.0001
Frame Group	0.69	0.6166
Subjects (matching)	45.3371	0.0003

Note: Bars represent standard error from the mean

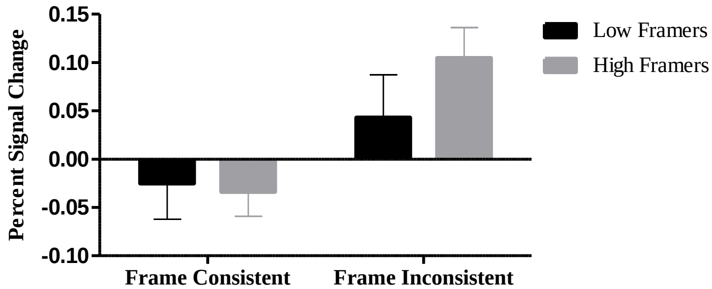
Figure 36. Percent signal change in the left OMPFC by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	7.24	0.0536
Frame Consistency	0.03	0.8934
Frame Group	16.52	0.0264
Subjects (matching)	47.5060	0.1531

Note: Bars represent standard error from the mean

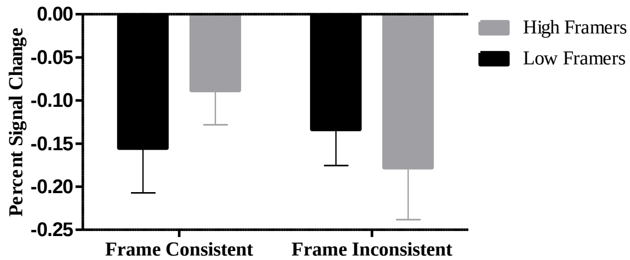
Figure 37. Percent signal change in the ACC by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	2.19	0.0400
Frame Consistency	18.78	< 0.0001
Frame Group	1.25	0.5911
Subjects (matching)	70.8889	< 0.0001

Note: Bars represent standard error from the mean

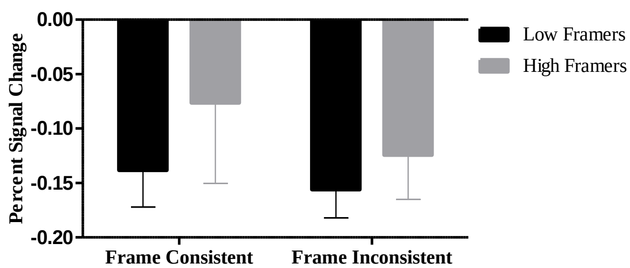
Figure 38. Percent signal change in the left amygdala by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	3.57	0.2074
Frame Consistency	1.32	0.4367
Frame Group	0.14	0.8417
Subjects (matching)	59.8092	0.1443

Note: Bars represent standard error from the mean

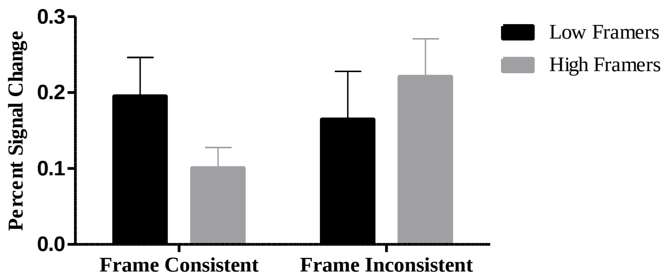
Figure 39. Percent signal change in the right amygdala by frame consistency and frame group.



Source of Variation	% of total variation	P value
Interaction	0.30	0.7480
Frame Consistency	1.44	0.4848
Frame Group	2.92	0.3211
Subjects (matching)	47.4645	0.5082

Note: Bars represent standard error from the mean

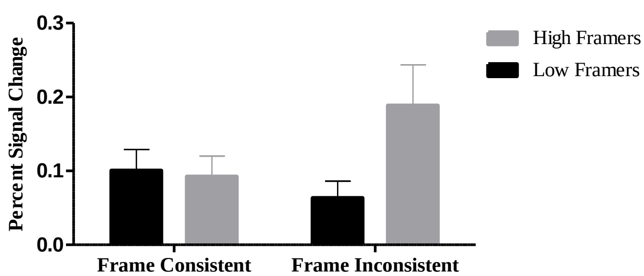
Figure 40. *Percent signal change in the left insula by frame consistency and frame group.*



Source of Variation	% of total variation	P value
Interaction	5.98	0.0089
Frame Consistency	2.12	0.0967
Frame Group	0.39	0.7767
Subjects (matching)	80.2022	0.0001

Note: Bars represent standard error from the mean

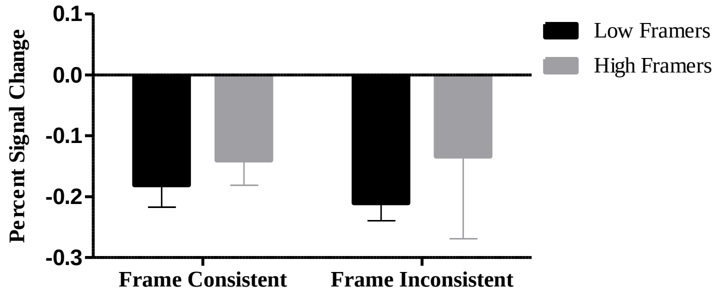
Figure 41. *Percent signal change in the right insula by frame consistency and frame group.*



Source of Variation	% of total variation	P value
Interaction	8.88	0.0072
Frame Consistency	1.75	0.1937
Frame Group	6.82	0.2048
Subjects (matching)	66.7175	0.0028

Note: Bars represent standard error from the mean

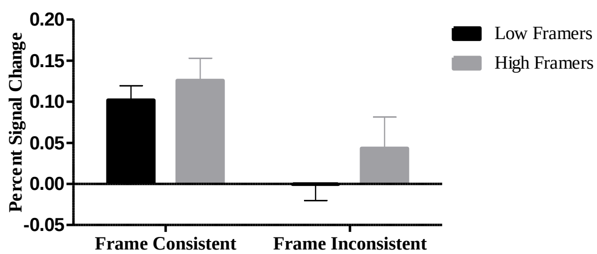
Figure 42. *Percent signal change in the VMPFC by frame consistency and frame group.*



Source of Variation	% of total variation	P value
Interaction	0.19	0.7999
Frame Consistency	0.07	0.8720
Frame Group	1.96	0.4268
Subjects (matching)	50.2317	0.4554

Note: Bars represent standard error from the mean

Figure 43. *Percent signal change in the right OFC by frame consistency and frame group.*



Source of Variation	% of total variation	P value
Interaction	0.29	0.5850
Frame Consistency	25.52	< 0.0001
Frame Group	3.42	0.3165
Subjects (matching)	54.5234	0.0075

Note: Bars represent standard error from the mean

CHAPTER FIVE
General Discussion

The current series of studies investigated two different types of framing effects in attempt to gain insight into dual-process models of decision making. Specifically, the current studies were designed from the framework of the X- and C-system of social cognition (Lieberman, 2007a; Lieberman, et al., 2002; Satpute & Lieberman, 2006). Each of the framing effects studied included an experimental manipulation expected to facilitate processing in one system within the X- and C-system dichotomy. Experiment 1 included a subconscious affective priming procedure in an attempt to facilitate reflexive processing in the context of a previously established risky-choice framing paradigm (De Martino, et al., 2006). Experiments 2 and 3 included a perspective taking manipulation in an attempt to facilitate reflective processing in a novel attribute framing paradigm which asked participants to rate scenarios regarding how often a positive trait was present or absent. Experiment 1 appeared to be unsuccessful in facilitating reflexive processing in that no effect of subconscious primes was observed on response tendencies. With regard to Experiments 2 and 3, results were mixed. In Experiment 2, results showed a main effect of perspective on frame consistent responding with reflected appraisals resulting in a diminished amount of frame consistent responding over the course of the experiment. In contrast, Experiment 3, which was nearly identical to Experiment 2, showed no such effect. While Experiment 2 provides some preliminary evidence that concurrent task demands can indeed influence processing at a systems level, the negative results of Experiments 1 and 3 suggest that the influence of such manipulations may be variable. This having been said, additional task parameters such as the probability of winning a gamble or the percentage of time a trait was present or absent, did significantly influence the extent to which framing effects were manifested across the course of these experiments. Given these findings as well as those related to previous investigations of framing phenomena (Kühberger, 1998), it appears that introducing task manipulations in a systematic way within investigations of framing paradigms may hold some utility in unraveling relative contributions to processing at a systems level.

Each of the three studies described above showed a significant framing effect in that participants responded differentially to response options based on the contextual frame of the problem. While individual frames and their counterparts have traditionally been interpreted as being effectively identical in terms of their meaning, the current series of studies raise concern regarding this notion. Indeed, other researchers have speculated that the decision frames presented in framing paradigms may not be perceived as identical upon reflection (Mandel & Vartanian, in press). In the current series of studies, differences between the processing of frames were observed with respect to RTs and the brain regions that were active during the processing of each frame. As such, the intuitive equivalency of frames may not be supported by the way in which frames are processed by individuals during decision making.

Another novel finding of the current studies relates to behavioral and cognitive adaptation to framing effects with repeated exposure to counterframes. While the analysis of framing studies has shown that framing effects are diminished with exposure to counterframes (Kühberger, 1998), the current studies appear to be the first to systematically evaluate adaptation to framing effects with several repeated exposures to counterframes. Two of the three current studies showed a significant decrease in frame-consistent responding over the course of the experiment, but it is of note that the main effect of the framing manipulation remained significant even in light of this behavioral adaptation. Nonetheless, in examining adaptation to framing over time, not all participants showed a similar decrease in frame consistent responding over the course of the experiment. This observation raises additional questions regarding the mediation of such an effect. In other words, why do some people seem to gain insight into the framing manipulation and adapt their behavior accordingly while others do not? Although individual differences related to this question were examined in the current study, results were generally unsuccessful in identifying variables that may dispose someone to adaptation to this effect over time.

Experiment 3 is one of a handful of studies that have examined the neural correlates of framing effects (De Martino, et al., 2006; Deppe, et al., 2005; Deppe, et al., 2007; Mobbs, et al., 2006; Roiser, et al., 2009). Results indicated that the sample included two subpopulations of individuals, one that was highly susceptible to the framing manipulation and another that was less susceptible to the framing manipulation. Interestingly, these individuals showed different areas of brain activation during the task, most notably in the DMPFC. With regard to the neural correlates specifically associated with the framing manipulation, the results of the ROI analyses indicated that frame inconsistent responses were associated with increased activity in the ACC, left LPFC, and DMPFC. In contrast, results indicated that frame consistent responses were associated with increased activity in the right OFC. Notably, differences in activation in a majority of these regions appeared to be most pronounced in those that were most susceptible to the framing phenomenon. These patterns of activation appear to be representative of those that would be expected given the X- and C-system model with the ACC, LPFC, and DMPFC being included in the reflective system and the OFC being included in the reflexive system.

A final goal of the current studies was to examine the extent to which individual differences contribute to susceptibility to framing phenomena, and by extension, processing at a systems level. In total, the current series of studies provided some insight into which variables may be most related to framing susceptibility; however, they were less successful in establishing individual differences that may be associated with adaptation to framing effects over time. It is of note that the sheer quantity of measures utilized in this study, in combination with small sample sizes, limited the power of the current studies to resolve individual differences related to framing susceptibility. Of the measures utilized in these studies, the CRT, NFC, and WTAR scales appeared to hold the most promise in identifying individuals who are less susceptible to framing effects. All of these measures tap primarily into cognitive functioning and as such may suggest that cognitive measures are more useful in revealing differences with respect to framing susceptibility. While aspects of personality functioning, attachment, and impulsivity were assessed with respect to their contribution to framing susceptibility, these measures did not appear to be very sensitive to resolving individual differences.

Perhaps one of the most interesting findings of Experiment 3 was that task level activity in the left OMPFC was negatively correlated with frame susceptibility and positively correlated with NFC and WTAR scores. The OMPFC is an interesting and complex brain region that receives input from all five sensory modalities (Carmichael & Price, 1995). Additionally, regions of the OMPFC are densely connected with many other brain regions including the basal ganglia, amygdala, and other prefrontal areas (Carmichael & Price, 1995; Kringelbach, 2005; Ongur & Price; 2000). The OMPFC appears to be involved in a wide variety of processes including sensory integration, learning, prediction, emotional processing and decision making (Krawczyk, 2002; Kringelbach, 2005). Given its location, functional involvement and connectivity to other brain regions, the OMPFC may contribute to the motivational and affective aspects of decision making, potentially mediating the interface between emotion and cognition. Additionally, this region has repeatedly been implicated in susceptibility to framing effects (De Martino, et al., 2006; Deppe, et al., 2005; Roiser, et al., 2009). As noted in the discussion of Experiment 3, this region was very similar in location to a region that has previously been associated with intellectual functioning (Gong, et al., 2005). The current results provide preliminary evidence that the OMPFC may be related to framing susceptibility through its association with intelligence and need for cognition.

Despite the novel contributions of these studies, they had several limitations. With regard to statistical power, all of the current studies were limited by small sample sizes. This was especially the case in Experiment 3, where the subdivision of the overall sample resulted in a sample size of ten or less in each group. Furthermore, the samples for Experiments 1 and 2 included only university undergraduates, thus raising the possibility that results may not generalize to different populations. Given the large numbers of variables assessed in each study, an alpha level of $p < .01$ was adopted for all analyses, potentially washing out effects that would have been significant otherwise. Additionally, the inclusion of multiple task manipulations may have resulted in significant interactions between these variables that were not assessed in the current analyses.

In conclusion, the current series of studies provided several novel findings with respect to the manifestation of framing effects on a behavioral and neurobiological level. Additionally, these studies successfully established a socially relevant attribute framing paradigm that can be studied utilizing techniques such as fMRI. Results appeared to be generally consistent with past investigations of framing phenomena and begin to shed light on how framing effects may serve to inform dual-process accounts of decision making. In terms of individual differences, the current studies support results from previous investigations and suggest that cognitive measures of individual differences may be more effective at distinguishing between individuals who are less susceptible to framing. Although these studies have provided some initial insight into framing effects as a reflection of dual-process accounts of decision making, additional research is warranted to further elaborate the utility of this approach. Additionally, continued efforts to unravel the contributions of individual differences to the manifestation of framing phenomena, and by extension processing on a systems level, could help to inform our understanding of how individuals make decisions in the context of the wide variety of contexts that they will inevitably experience throughout their lives.

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