SOCIOECONOMIC STATUS, AMYGDALA REACTIVITY, AND SELECTIVE ATTENTION TO THREAT

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In this study, a pathway through which low socioeconomic status (SES) might heighten risk for disorders of mood and affect via a social information-processing bias is investigated. Here, we examined whether measures of social status covary with attentional bias toward threat and with greater threat-related amygdala reactivity in a sample of healthy community volunteers. Participants were middle-aged men and women (30 – 55, M = 42.1 years; 41% female, 87% white) who participated in the second Adult Health and Behavior project (AHAB II). SES indices included objective (individuals' education and income, parental education) and subjective (individuals rated themselves and their parents on the MacArthur Scale of Subjective Social Status) indicators. Participants' attentional bias toward threat was assessed using a visual probe-detection task, utilizing angry, fearful, happy, and neutral facial expressions from the Karolinska Directed Emotional Faces stimulus set. Blood oxygenation level-dependent (BOLD) functional magnetic resonance imaging (fMRI) was employed to investigate amygdala reactivity, using facial stimuli derived from the MacArthur Network Face stimulus set. Correlational analyses failed to show any relationship between SES and attentional bias for any of the affective stimuli. Linear regression analyses accounting for age, race, and sex showed lower education ($\beta = -.116$, SE = .056, $p = .041$) and lower composite SES (fear > shapes: $\beta = -.142$, SE = .059, $p = .018$; fear > neutral: $\beta = -.122$, SE = .058, $p = .037$) associated with higher left amygdala reactivity to fearful facial stimuli. No significant relationships between SES and amygdala

reactivity were detected for the remaining SES indicators, and findings were limited only to the left amygdala relationship with fearful faces. Thus, our prediction of an inverse association between indices of social standing and heightened responses to threatening stimuli was largely unsupported by the results. Future investigations should include participants representing a broader range of age, ethnicity, and socioeconomic standing in order to more accurately characterize individuals' responses to threat. Despite the shortcomings of the current study, these findings provide initial (albeit limited) evidence that heightened neurobiological responses to threat may be associated with lower SES.

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PREFACE

"No man is an island, entire of itself." - John Donne

Many people have contributed to the completion of this dissertation, and I am extremely grateful to them all for their unwavering support and encouragement. I have been very fortunate to have worked with so many extraordinary faculty and staff members within the University of Pittsburgh Department of Psychology. First and foremost, I would like to acknowledge my primary mentor, Dr. Stephen Manuck, for his consistent dedication of time and resources, his excellent advice, and the extensive professional opportunities that he has granted throughout my graduate experience. Secondly, I want to thank Dr. Peter Gianaros for his generosity and patience during my foray into the world of fMRI. I am also thankful for the valuable conceptual contributions of dissertation committee members Dr. Dick Jennings, Dr. Anna Marsland, and Dr. Elizabeth Votruba-Drzal. Appreciation also goes to Dr. Matthew Muldoon for his constant availability and willingness to teach, and to Dr. JeeWon Cheong for volunteering her time, good humor, and statistical consultation throughout my graduate career. Finally, several members of the Behavioral Physiology Laboratory were instrumental in my completion of this and other projects throughout the years, including Dr. Serina Neumann, Janet Lower, Julie Johnson, Michael Eddy, Jackie Fury, Patrick Fisher, Brittney Gidwitz, Sydell Payne, Bryan Kostelnik, and, in particular, Dr. Janine Flory, without whose support and encouragement I may never have had the courage to pursue a career in psychology.

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1.0 INTRODUCTION

Inequalities of income, education, and other socioeconomic indicators predict diverse sources of psychiatric and physical morbidity. In addition to having a powerful influence on physical health (Adler et al., 1994), socioeconomic status (SES) is inversely associated with the experience of negative emotions and with the occurrence of emotional disorders (Gallo & Matthews, 2003; Lorant et al., 2003). Recent national estimates indicate that the most common mental disorders in the U.S. are those of anxiety and depression, with 18.1% and 6.7%, respectively, of adults suffering from anxiety disorders and major depression during a twelve-month period (Kessler et al., 2005). Depressive symptoms (Berkman et al., 1986; Craig & Van Natta, 1979; Fiscella & Franks, 1997; Ickovics, Viscoli, & Horowitz, 1997; Kaplan et al, 1987; Lynch, Kaplan, & Salonen, 1997; Salokangas & Putanen, 1998; Steele, 1978; Warheit, Holzer, & Arey, 1975) and prevalence of depressive disorders (Bruce, Takeuchi, & Leaf, 1991; Kessler et al., 1994) are related to low SES, and a similar relationship has been demonstrated for anxiety symptoms (Himmelfarb & Murrell, 1984; Weirheit, Bell, Schwab, & Buhl, 1986) and disorders (Blazer et al., 1991; Magee, Eaton, Wittchen, McGonagle, & Kessler, 1996; Wittchen et al., 1994), including panic and phobic disorders (Regier, et al., 1990; Kessler et al., 1994; Offord et al., 1994). Lower SES individuals report more emotional distress than do their higher SES counterparts (Brown, Bhrol-Chain, & Harris, 1975; Kessler & Cleary, 1980; McLoed & Kessler, 1990; Turner & Noh, 1983). The life experiences engendered by low SES may lead to higher levels and more frequent experiences of negative emotional states and moods. Negative emotionality, itself, is associated with a reduced quality of life, as well as losses in workplace productivity (Conti & Burton, 1994; Druss, Rosenheck, & Sledge, 2000; Kessler et al., 1994; Murray & Lopez, 1997). Disorders of affect are also posited to play a role in risk for early death and disability (Adler et al., 1994; Kaplan & Keil, 1993; Matthews, 1989; Taylor, Repetti, & Seeman, 1997).

In sum, negative affect appears to follow an SES gradient, with lower SES being associated with a higher prevalence of mood and anxiety disorders and symptoms (Gallo & Matthews, 2003). Here, a pathway through which low SES may heighten risk for disorders of mood and affect via a social information-processing bias is proposed. First, though, a conceptual basis for SES research is presented, followed by more detailed discussion of covarying socioeconomic circumstances and disorders of negative emotion. Next, a possible mechanism for this relationship, involving social information processing, is reviewed along with the role of the amygdala in processing social information. A model suggesting how each of these components might contribute to higher risk of mood disorders among persons of lower SES is presented. Finally, we explore whether variations in social information-processing and amygdala reactivity are associated with SES in a sample of healthy community volunteers, and whether these variations relate to measures of negative emotion.

1.1 CONCEPTUALIZATION OF SOCIOECONOMIC STATUS

Socioeconomic status (SES) has been defined as one's relative "position" in society, as reflected in access to or the accumulation of material resources or prestige (Lynch & Kaplan, 2000).

Measures of socioeconomic position indicate particular structural locations within society (Lynch & Kaplan, 2000) and attempt to quantify an individual's probability of success, i.e. "life chances". Current conceptualization of socioeconomic status relies heavily on the concept of *social class* as described in Marxist, Weberian and Functionalist sociological traditions (summarized by Lynch & Kaplan, 2000). Social class refers to groups defined by interdependent economic and legal relationships, based on an individual's position within the economy (Krieger, Williams & Moss, 1997). Relationships between classes co-define each other, and are determined by a society's connections through production, consumption and distribution of goods (Krieger, Williams & Moss, 1997). Conceptualizing class as a social relationship emphasizes how members of different social classes advance their economic and social well-being, and how the well-being of one class is linked to the deprivation of another (Krieger, Williams & Moss, 1997). Measures of social class attempt to capture these economic interactions among people, rather than identify the personal characteristics that determine an individual's position within a hierarchy.

Each sociological tradition approaches social class in a slightly different way. The Marxian definition of social class reflects stratification in relation to means of production. A social class is a group within a society where members are relatively similar in political, economic, educational, occupational, and prestige status (Lynch & Kaplan, 2000). According to the Weberian tradition, one's class position yields certain probabilities (or life-chances) of success. Society is stratified by class, status, and political power, and a lack of resources (i.e. goods, skills) places certain individuals at competitive disadvantage. The functionalist approach to stratification suggests that complex societies require stratification into sectors that are more or less valuable to social maintenance and progress. This position maintains that social inequality is necessitated by the need to preferentially reward, by money and power, individuals best qualified to occupy the positions of highest responsibility (Lynch & Kaplan, 2000). The sociological schools of thought described here maintain that macrosocial processes determine the socioeconomic prospects of individuals, with prevailing political and economic conditions generating hierarchies of social position.

The term social class refers strictly to social groups arising from interdependent economic relationships (i.e. “working class”, “managerial class”). For example, epidemiological research in many European countries draws upon social class data based on the Registrar-General’s grouping of occupations, and categorizes individuals’ structural location within the economy (Marmot, Kogevinas & Elston, 1987). Because social status in this sense is conceptualized as an ordinal variable, it cannot provide a meaningful measure of distance between adjacent occupational categories. Although the concept of socioeconomic *status* (SES) has built upon the concept of social class described in the sociological traditions of Marx, Weber, and the Functionalists, much contemporary research on social stratification addresses the hierarchical positioning of individuals inferred from a combination of measures of resources (income, wealth, assets) and prestige (attributed statuses) providing a more continuous measure of one’s standing in a social structure (Krieger, Williams, & Moss, 1997)

Methodologically, SES is commonly assessed at the level of the individual, although household and neighborhood-level indicators are also prevalent in contemporary literature. These SES indicators are related, but not fully overlapping, and they may conceivably affect health and well-being through different pathways (Gallo & Matthews, 2000). The most widely reported measures of SES are educational attainment, occupational status, income, or some combination of these measures. Although less extensively studied than income, education, or other "objective" socioeconomic indicators, individuals' perceptions of their relative social positions (often measured using a visual social ladder and termed subjective SES) have been found to predict various indices of physical and psychological morbidity (Adler, Epel, Castellazzo, Ickovics, 2000).

In sum, the intellectual traditions of Marx, Weber and the Functionalists provide a framework for research into social inequalities, and describe structural positions within society that can be measured in several ways. The concept of relative (subjective) social position also provides a new way of conceptualizing and measuring social status. Next, the evidence for a social gradient in disorders of negative mood and affect is reviewed, and the influence of stressful life events is discussed.

1.2 SES AND MOOD/AFFECTIVE DISORDERS

A consistent, inverse relationship between SES and overall rates of psychopathology has been documented over several decades of epidemiological research (Kohn, Dohrenwend, & Mirotznik, 1998). In their early review of social status and psychiatric disorders, Dohrenwend and Dohrenwend (1974) reported that 28 of 33 studies reviewed showed the highest rates of psychopathology in the lowest social stratum represented in the study sample. Similarly, a review of 20 investigations found that in 17 studies, the prevalence of psychopathology was highest among persons of the lowest compared to the highest social standing, and that across all studies, mental disorders were 2.6 times more prevalent among low SES (versus high SES) individuals (Neugebauer et al., 1980). More recently, investigations based on the Epidemiologic Catchment Area (ECA) study have found significantly higher rates of all disorders in the lowest stratum of SES (Regier et al., 1993; Williams, Takeuchi, & Adair, 1992). Here, we focus on the relationships between social status and two specific categories of major psychiatric disorder: depression and anxiety.

Major depressive disorder is characterized by the presence of depressed mood and/or a lack of interest or pleasure in most activities for at least 2 weeks, plus at least four additional symptoms, which include: change in appetite or weight, alterations in sleeping habits, fatigue, psychomotor retardation or agitation, thoughts of guilt or worthlessness, concentration difficulties, and suicidal ideation or intent (DSM-IV-TR: American Psychiatric Association, 2000). Other clinical depressive diagnoses include depressive symptoms that do not fully meet criteria for major depression, dysthymia (sub-threshold depressive symptoms that persist for 2 or more years) and minor depression. Over a 1-month period, approximately 5% of the U.S. population experiences a major depressive episode (Blazer, Kessler, McGonagle, & Swartz, 1994), and lifetime prevalence is approximately 13% (Kessler et al., 1994). Lifetime prevalence of dysthymia has been estimated at 5% (Kessler et al., 1994), and lifetime prevalence of sub-threshold depressive symptoms is approximately 23% (Horwath, Johnson, Klerman, & Weissman, 1992). Anxiety is characterized by fear or worry regarding future events or the memory of past events, though anxiety diagnoses differ in specific symptoms and situational stimuli (DSM-IV-TR: American Psychiatric Association, 2000). Diagnostic criteria for generalized anxiety disorder include excessive, uncontrollable worry for at least 6 months, plus three additional symptoms including restlessness, fatigue, difficulty thinking or concentrating, irritability, muscle tension, and difficulty sleeping. Panic disorder involves recurrent attacks of sudden intense fear that occur without an identifiable cause and that are accompanied by somatic (e.g., increased heart rate, shortness of breath, sweating) and cognitive symptoms (e.g., fear of losing control or dying). Agoraphobia involves the avoidance of environments that may trigger a panic attack, such as refusal to drive or leave one's house, and may occur in association with panic disorder. In a 1-year period, approximately 0.9% of the population meets criteria for panic disorder, whereas about 9.7% meet criteria for any phobia (Eaton, Dryman, & Weissman, 1991).

Investigations of socioeconomic predictors of depression have analyzed depressive symptoms and clinical depressive diagnoses, and typically use either well-validated structured interview assessments, such as the Diagnostic Interview Schedule (Robins, Helzer, Croughan, & Ratcliff, 1981) or the Schedule for Affective Disorders and Schizophrenia (SADS; Endicott & Spitzer, 1979), or well-validated symptom measures including the Beck Depression Inventory (BDI; Beck & Beamesderfer, 1974) or the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), though some of this research has relied on study-specific measures, sometimes composed of one or only a few questions. Much of the data documenting association of SES with affective disorders has been collected as a component of the Epidemiologic Catchment Area (ECA; Robins & Regier, 1991) and National Comorbidity Studies (NCS; Kessler et al., 1994), which involved the administration of structured psychiatric interviews to large probability samples of U.S. residents (Gallo & Matthews, 2003).

Cross-sectional evidence documents a higher prevalence of common mental disorders among lower socio-economic groups (Holzer et al, 1986; Bijl et al, 1998; Davey Smith, Hart, Blane, & Hole, 1998; Lewis et al, 1998; Muntaner et al, 1998; Weich & Lewis, 1998a). Longitudinal data suggest that low social status may be a risk factor for the development of depressive episodes (Bruce et al., 1991; Kaplan et al, 1987) and that lower SES individuals have a worse prognosis for depression (Weich & Lewis, 1998b). A recent meta-analysis demonstrated an increased likelihood (odds ratio = 1.81) of depression in the lowest versus the highest tertile of SES (Lorant et al, 2003). More specifically, 51 of the 56 studies exhibited odds ratios greater than 1.0 (ranging from 1.09 to 7.98), 35 of which reached statistical significance. In their review of studies examining the association between depression and SES, Gallo and Matthews (2003) identified nine cross-sectional investigations between depressive symptoms and SES. Of the five that examined education and social standing, two identified an inverse, linear association between depressive symptoms and SES indices (Lynch, Kaplan, & Salonen, 1997; Salokangas & Putanen, 1998). Four studies examined the relationship between income and depression. Fiscella and Franks (1997) found that the odds of reporting depressive symptoms were 1.6 – 2.0 times higher in low income (versus high income) groups, and similar inverse associations between income and depression were noted in two of the three remaining studies (Salokangas & Putanen, 1998; West, Reed, & Gildengorin, 1998). Only one identified study utilized occupation as the index of SES, and showed an inverse relation between occupational prestige and depressive symptoms (Lynch, Kaplan, & Salonen, 1997). Of four studies employing composite SES indices, three found a significant, inverse association (Ickovics et al., 1997; Steele, 1978; Warheit, Holzer, & Arey, 1975). Overall, 64% of the examined associations suggested an inverse relationship between SES and depressive symptoms, with depressive symptoms increasing linearly across gradations of declining SES.

Kessler et al. (1994) found an inverse association of education and income with prevalence of major depression in the NCS. A decade later, data from the National Comorbidity Survey Replication (NCS-R) yielded similar results, demonstrating that the 12-month prevalence of major depressive disorder was significantly elevated in those in the lowest versus the highest quartiles of education (OR = 1.9; 0-11 years vs. ≥ 16 years) and income (OR = 3.8; below poverty vs. 6 x poverty level) (Kessler & Merikangas, 2003). Kaplan, Roberts, Camacho, and

Coyne (1987) observed a prospective relationship of education and income with depressive symptoms in a nine-year follow-up of almost 7,000 residents of Alameda County, California. Unemployment at baseline (Anthony & Petronis, 1991) and lower education (Gallo, Royall, & Anthony, 1993) predicted the onset of major depression at one year follow-up of ECA participants, and another prospective analysis of ECA subjects demonstrated that individuals reporting poverty-level income had higher rates of incident major depression across a six month follow-up (Bruce, Takeuchi, & Leaf, 1991).

In sum, substantial evidence suggests that individuals of low SES have higher levels of depressive symptoms and depressive disorders. The evidence is strongest for a cross-sectional association between depressive symptoms and SES and between incident depressive disorders and SES, although studies also suggest that SES is associated with prevalent depressive disorders.

Accumulating data also suggest an inverse, linear association for social standing and anxiety symptoms and disorders. NCS investigations have identified an inverse association of education with panic (Eaton, Kessler, Wittchen, & Magee, 1994) and phobic disorders (Magee et al., 1996). Shear et al. (2006) found that respondents with low education (quartiles were 0–11, 12, 13–15, and 16+ years) were substantially more likely to have anxiety disorders (OR = 2.3) as compared to those in the highest quartile of education. Kessler et al. (1994) found that those in the lowest income quartile were twice as likely to meet criteria for an anxiety disorder as compared to those in the highest income group, and similar associations between income and prevalence of various anxiety disorders have been demonstrated in other NCS studies (Magee et al., 1996; Wittchen, Zhao, Kessler, & Eaton, 1994).

The ECA identified mixed evidence for an association between education and prevalent panic and phobic disorders (Eaton, Dryman, & Weissman, 1991) and no evidence for a relationship between education and generalized anxiety disorder (Blazer, Hughes, George, Swartz, & Boyer, 1991). A positive association between financial dependence on the government and one-year prevalence rates of generalized anxiety disorders (Blazer et al., 1991) and phobic and panic disorders (Eaton et al., 1991) was identified via data from the ECA. Similarly, Regier et al. (1993) found a significant association between a composite index of SES and one-month prevalence of panic and phobic disorders (OR = 2.43 for lowest quartile of composite SES versus highest quartile). Thus, the majority of studies document inverse associations between indicators of SES and prevalent anxiety disorders. Regarding incident anxiety disorders, poverty did not significantly predict incident panic or phobic disorders in the ECA (Bruce et al., 1991), though higher occupational prestige and more education were negatively associated with the one-year incidence of agoraphobia (Eaton & Keyl, 1990) and a lower likelihood of incident panic disorder (OR = 0.80, Keyl & Eaton, 1990). Wells, Tien, Garrison, and Eaton (1994) found that lower education was associated with higher incidence rates of social phobia over a one-year follow-up of ECA participants. Murphy and colleagues (1991) incorporated an assessment of anxiety disorders in their longitudinal study of SES and psychiatric status and found that SES did not show a clear association with incident anxiety disorders. Thus, evidence supports an association between lower levels of SES and higher levels of anxiety symptoms and prevalent anxiety disorders.

1.3 MECHANISMS

As reviewed in the preceding section, a growing body of literature suggests an association between SES and negative emotions. To the extent that social inequalities may play a causal role in these psychopathologies, the mechanisms mediating such associations remain uncertain. Although various pathways, such as genetic influences, environmental toxins, or a lack of mental health services are likely to be important, emotional correlates of SES are emphasized in the present discussion.

Substantial evidence supports a role for “social causation” in linking SES with negative cognitive-emotional factors (Gallo & Matthews, 2003), whereby it is hypothesized that heightened exposure to environmental adversity elevates risk of emotional disorders in lower SES groups (Dohrenwend, 2000; Kendler et al., 1995). Specifically, lower SES individuals experience more frequent stressful life events, such as income loss, ill health, and death of a loved one (Anderson & Armstead, 1995; Dohrenwend, 1973; McLeod & Kessler, 1990). Inhabitants of lower SES neighborhoods are more likely to report concerns regarding crime, pollution, and crowding (Aneshensel & Sucoff, 1996; Evans, 2001; Homel & Burns, 1987) and low income persons are more likely to be exposed to toxic wastes and other forms of threatening environmental conditions, relative to more affluent citizens (Environmental Protection Agency, 1977; Institute of Medicine, 1999). Low SES families experience more threatening and uncontrollable life events, such as family destabilization, violence, unstable employment, and persistent economic hardship (Bradley & Whiteside-Mansell, 1997; Gad & Johnson, 1980). Adolescents from lower SES families are more likely to perceive their neighborhood as dangerous and violent (Aneshensel & Sucoff, 1996) and to report the presence of weapons and fighting at school than their higher SES counterparts (Gallup, 1993; Sinclair et al., 1994).

Children living in poorer neighborhoods are more likely to witness street violence (Fitzpatrick & Boldizar, 1993). These adverse events have also been implicated in the onset and severity of depression (Kendler et al., 1993; Kendler, Karkowski, & Prescott, 1999; Kessler, 1997; Lewinsohn, Hoberman, & Rosenbaum, 1988; Stueve, Dohrenwend, & Skodol, 1998) and anxiety disorders (Blazer, Hughes, & George, 1987; Epstein, Fullerton & Ursano, 1998; Findlay-Jones & Brown, 1981; Joy, Probert, Bisson & Shepherd, 2000; Maes, Mylle, Delmeire & Janca, 2001).

An additional socio-environmental contributor to higher prevalence of emotional disorders in lower SES individuals may be the distress stemming from perceptions of *relative* social or material disadvantage (Gianaros et al., 2007; Gallo & Matthews, 2003; Adler & Snibbe, 2003; Wilkinson, 1999). Growing evidence suggests that perception of economic deprivation or lower social standing in relation to others is associated with poorer mental health (Marmot & Wilkinson, 1999; Wilkinson, 1999). Epidemiologic evidence demonstrates that less egalitarian societies have higher rates of violence and lower quality of social relations (Wilkinson, 1999). Limited educational and occupational opportunities, along with less access to material resources, may engender perceptions of powerlessness, social exclusion, or disenfranchisement among those in lower social strata. In combination with a diminished sense of personal control, awareness of negative status-based stereotypes may heighten perceptions of discrimination in those with relatively lower educational, financial, or occupational status. Although most research on perceived discrimination has focused on racial categorization, status-based stereotypes have been documented (Feldman & Hilterman, 1974; Weeks & Lupfer, 2004) and have, in some cases, shown stronger bias effects than have racial stereotypes (Jussim, Coleman, & Lurch, 1987). Negative attitudes and beliefs regarding lower SES groups include perceptions of low SES individuals as lazy (Leahy, 1981), dishonest (Desmond, Price, Eoff, 1989) and uninterested in education (Bullock, 1999). Though few studies have investigated perceptions of SES-based prejudice, evidence for perceived mistreatment based on income level has been documented (Brown et al., 2006; Guyll et al., 2001; Matthews et al., 2005). In medical settings, low SES patients report higher rates of being discriminated against by health care providers, independent of race (Trivedi & Ayanian, 2006).

The frequency and intensity of exposure to harmful or potentially threatening situations may be crucial in the association of lower SES with negative emotions. Potentially, more frequent exposure to adverse life events, as well as perceptions of relative disadvantage, may heighten psychological distress among lower SES individuals and render them more vulnerable to negative affective states and mood disorders. This heightened exposure to stressful situations may serve to "sensitize" lower SES persons to these potential threats over time, whereby these individuals come to attend more readily to cues of possible danger. Living in a low-SES environment over a prolonged period of time has been suggested to lead a state of 'reactive responding,' characterized, in part, by chronic vigilance for threatening environmental stimuli (Taylor & Seeman, 1999), and others have reported associations between lower SES and higher "vigilance for threat" (Feldman & Steptoe, 2004).

These cognitive tendencies may, in turn, increase one's vulnerability for disorders of negative affect. Maladaptive cognitions related to information-processing have been hypothesized to play an important role in the etiology and maintenance of emotional disorders (Mogg & Bradley, 1998). Specifically, ruminative processing of thoughts related to the threat of loss or failure has been implicated in depressive disorders (Beck, 1987), while selective attention to danger-related information may enhance anxious tendencies (Eysenck, 1992). Individuals with such a vigilant attentional style may exhibit heightened sensitivity to potential dangers in the environment, which, in turn, could negatively impact mood (Bradley, Mogg, Falla, & Hamilton, 1998).

Thus far, we have conceptualized SES as playing a causal role in the development of disorders of negative affect. In contrast, some evidence supports an alternate "social selection" hypothesis, wherein negative emotions and cognitions might reduce one's likelihood of attaining or maintaining a higher social position. For example, National Comorbidity Survey respondents with early-life anxiety and mood disorders, independent of childhood SES, were significantly more likely to drop out of high school (OR's 1.4 – 1.6) as compared to those with no history of childhood psychiatric disorder (Kessler, Foster, & Stang, 1995). Others suggest that social causation and selection are not mutually exclusive explanations of the association between SES and psychiatric disorders, and may operate at different points across the life cycle (Dohrenwend et al., 1992; Lorant et al., 2003). The majority of findings, however, suggest that the social drift hypothesis is more relevant for debilitating psychiatric disorders such as schizophrenia (Dohrenwend, 1990) and substance use disorders (Kessler et al., 1995) whereas social causation processes play a more important role in the association between SES and depression and anxiety (Johnson et al., 1999). For instance, Johnson and colleagues (1999) showed childhood SES to be a strong prospective predictor of future depressive and anxiety disorders, while neither depression nor anxiety predicted downward shifts in SES in a sample of over 700 children. Another longitudinal study of adolescents found no evidence of downward shift in SES for participants with baseline diagnoses of anxiety or depression (Miech, Caspi, Moffitt, Wright, & Silva, 1999). Thus, although the origins of the association between SES and negative affect may not be clear cut, the data suggest a stronger causal role for SES-based social stressors in this relationship.

1.4 SENSITIVITY TO THREAT

Historically, threat appraisals have been investigated in a variety of clinical anxiety disorders (e.g., GAD, PTSD, social phobia, simple phobias, OCD, panic disorder) and a substantial body of literature documents selective attention to threat signals among clinically anxious and high anxious individuals (see reviews by Bar-Haim et al., 2007 and Williams, Watts, MacLeod, & Mathews, 1997). Although the evidence for an attentional bias is less robust in depressed individuals, depression has been associated with selective processing of negative information (Teasdale, 1983) and the tendency to expect negative outcomes (MacLeod & Byrne, 1996). Cognitive models postulate that individuals higher in negative affect prioritize threat stimuli over neutral or positive information, and that this vigilance for threat might result in greater generalized sensitivity for negative information.

A variety of tasks have been used to identify biases in selective attention to emotional stimuli. When subjects are asked to choose between spoken homophones (differently spelled words with identical sounds), trait anxious individuals tend to write down the threatening alternative (e.g., “die” versus “dye”) (Eysenck, MacLeod, & Mathews, 1987). Trait anxious individuals show a bias toward expectation of negative events when asked to predict sentence conclusions (Calvo & Costillo, 2001) and social phobics manifest biases in recall and recognition of negative faces (Foa et al., 2000; Hirsch & Clark, 2004; Richards et al., 2002). Muris, Luermans, Merckelbach, and Mayer (2000) demonstrated that, when exposed to both threatening and ambiguous social scenarios, children’s anxious and depressive symptoms were positively associated with frequency of threat perception and early detection of threat.

In the Modified (Emotional) Stroop color-naming task, participants are asked to name the colors in which words are printed as quickly as possible while disregarding word meaning.

Color-naming latency has been interpreted as reflecting the extent to which processing resources are allocated to the word content (Mogg & Bradley, 1998). Compared to normal controls, individuals with Generalized Anxiety Disorder (GAD) typically take longer to name the colors of threatening words than to name neutral words (Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989), and similar effects are seen in patients with panic disorder (Hope, Rapee, Heimberg, & Dombeck, 1990; McNally Riemann, & Kim, 1990). Combat veterans (McNally, Kaspi, Riemann, & Zeitlin, 1990) and rape victims (Cassiday, McNally & Zeitlin, 1992) with PTSD show slowed color naming with trauma-relevant words, relative to trauma victims without PTSD. Emotional Stroop effects have also been found in non-clinical samples of trait anxious individuals, who demonstrate slowed naming of anxiety related words when in anxious states (Richards & French, 1992; Egloff & Hock, 2001). In addition to anxious populations, interference effects during color-naming emotional words have been documented in depressed individuals (Gotlib & McCann, 1984; Gotlib & Cane, 1987; Williams & Nulty, 1986), although a bias for negative words has typically been found only if the stimuli are presented for 1000 ms or longer (Gotlib & Cane, 1987; Mogg et al. 1995; Bradley & Whiteside-Mansell, 1997; Gotlib et al., 2004; Gotlib, Krasnoperova, Yue, & Joormann, 2004). Segal et al. (1995) found an attentional bias for negative self-descriptions (participant-selected) in depressed participants, though the target words were presented for a relatively long duration (2 s). By contrast, attentional biases have typically not been found in clinical depression when negative words were shown for relatively short display times in the modified Stroop task (Neshat-Doost, Taghavi, Moradi, Yule, & Dalgleish, 1997; Mogg et al., 1993).

Numerous studies have investigated the role of selective attention to threat using a visual probe-detection task (Posner, Snyder, & Davidson, 1980), commonly referred to as the "dot-probe task". In the dot-probe task, two words, facial expressions or pictures (one emotionally valenced and one neutral) are simultaneously presented to participants in different locations on a computer monitor (top versus bottom/left versus right), after which a neutral object (the 'probe') appears in the space previously occupied by one of the two stimuli (Frewen, Dozois, Joanisse, & Neufeld, 2008).

Participants are instructed to press a response button immediately upon perceiving the probe, and response latencies on the dot-probe task are held to provide a "snapshot" of the distribution of participants' attention, with faster responses to probes presented in the attended relative to the unattended location (Koster, Crombez, Verschuere, & De Houwer, 2004). In the dot-probe paradigm, participants are required to respond to a neutral stimulus (the probe), alleviating concern that delayed latencies may result from response bias or general arousal.

Consistent evidence has shown that anxious individuals respond faster to congruent trials (probe in place of threatening stimulus) than to incongruent trials (probe in place of neutral stimulus) (Bradley, Mogg, White, Groom, & de Bono, 1999; MacLeod, Mathews, & Tata, 1986; Mogg, Mathews, & Eysenck, 1992; Horenstein & Segui, 1997; Kroeze & van den Hout, 2000), a finding which is interpreted as vigilance for threat (Bradley, Mogg, & Millar, 2000; Mogg & Bradley, 1998). For instance, individuals with GAD are faster to respond to probes that replace threat words than neutral words, in comparison with normal controls (MacLeod et al., 1986). In a study of non-clinical individuals, MacLeod and Mathews (1988) found that high trait anxious students responded more quickly to threatening words than did their low trait anxious counterparts. Koster and colleagues found that subjects' selective attention for high threat pictures increased with higher trait anxiety scores on the State Trait Anxiety Inventory (STAI) ($r = 0.42$, $p < 0.01$) (Koster, Crombez, Verschuere, & De Houwer, 2004). A meta-analysis by Bar-

Haim et al. (2007), investigating the overall effect size of the attentional bias in anxiety in 172 studies (2,263 anxious and 1,768 nonanxious individuals), found that the combined effect size of the threat-related bias was significant in anxious participants (d = 0.45) and nonsignificant in nonanxious controls. The authors reported the attentional bias to be reliable across different experimental paradigms and of comparable magnitude across different types of anxious populations (individuals with different clinical disorders, high-anxious nonclinical individuals, anxious children and adults).

Depression has also been associated with selective processing of negative information (Teasdale, 1983) and the tendency to expect negative outcomes (MacLeod & Byrne, 1996). Although the evidence for an attentional bias is less robust in depression, some investigations using the dot-probe paradigm support an attentional bias for threat-related stimuli in depressed individuals. Using relatively long durations of stimulus presentation [500 – 1000 milliseconds (ms)], Mogg, Bradley, & Williams (1995) found an attentional bias toward negative words, and Mathews, Ridgeway, & Williamson (1996) demonstrated the bias for socially threatening words (e.g. “shame”, “loser”, “stupid”). No attentional bias has been found in clinically depressed individuals when the stimuli have been masked to restrict awareness (Bradley et al., 1995; Mathews et al., 1996; Mogg et al., 1993, 1995). Thus, while attention to negatively valenced emotional stimuli may exist in both anxiety and depression, the nature and time course of attentional responses may vary.

The issue of stimulus presentation time highlights some limitations introduced by the “snapshot” view attention provided by the dot probe. Attentional bias to threat has been examined in conditions that prevented conscious perception (typically 100 – 200 ms) as well as in conditions that allowed clear awareness (500 ms or longer) (Bar-Haim et al., 2007). The issue of stimulus presentation time (i.e. supraliminal versus subliminal processing) is critical, considering that varying presentation times may yield different results. Longer asynchronies between stimulus onset and probe presentation across studies allow for multiple fixations of attention during the task, making it unclear which components of attention are responsible for the differences in response times (Weierich, Treat, & Hollingworth, 2008). For instance, one critical debate surrounds the question of whether faster responses on congruent dot probe trials result from accelerated engagement with the threat stimulus or from a difficulty to disengage from the threat. Evidence demonstrates that evaluation of emotional stimuli may occur in the absence of awareness (e.g., LeDoux, 1996; Öhman, 1993), leading some authors to propose that anxious individuals direct their attention toward threatening information during early, automatic stages of processing (Williams et al., 1988). In this scenario, abnormalities in the threat-detection mechanism of anxious individuals would result in a hypervigilant mode toward threat. In contrast, others suggest that inhibition of processing of threatening information is the core deficit in anxiety, which is reflected in avoidance of threatening stimuli (Foa & Kozak, 1986; Mogg, Bradley, De Bono, & Painter, 1997), resulting in threat-related biases in anxiety being confined to later stages of processing. Attempts to reconcile these conflicting views of attentional biases suggest that anxious individuals direct their attention *toward* threat during early, automatic stages of processing, and direct attention *away* from threat during later stages of processing (Williams et al., 1997, 1988; Amir, Foa, & Coles, 1998; Mogg et al., 1997) while others cite the *delay in disengagement* from threat stimuli as the primary attentional difference between anxious and nonanxious individuals (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Yiend & Mathews, 2001). Some investigators have addressed the problem by obtaining a more continuous measure of attention by assessing the direction and latency of eye movements to the emotional stimuli (Mogg, Millar, & Bradley, 2000).

Despite some of the drawbacks related to the dot probe task, the literature generally supports an association between variation in attentional bias for threat and negative affectivity. Low SES, by virtue of its association with chronically stressful and threatening environments, may be associated with variations in processing of threat-related information, and this cognitive correlate of SES could conceivably mediate SES associations with mood and anxiety disorders. Further research into the neural bases of selective attention to threat, discussed below, has implicated the amygdala as playing a central role in threat-related emotional processes.

1.5 THE AMYGDALA

Increased responsiveness to social threat, as reflected in individuals' tendencies to selective attention toward threatening visual stimuli, may contribute to disorders of mood and affect. It may be useful, then, to understand whether this attentional bias is mediated at the neurobiological level via a common emotional information processing mechanism. Accumulating data supports a specific role for the amygdala in the perception of threat-related stimuli in humans (Fitzgerald, Angstadt, Jelsone, Nathan, & Phan, 2006). The amygdala has been shown to respond to a variety of threatening stimuli, including pictures of physical threats (Hariri et al., 2002; Ochsner et al., 2002) and exposure to facial expressions of fear and anger (Adolphs, 1999; Adolphs, 2001; Whalen et al., 1998). The amygdala is a subcortical structure with connections to both sensory processing areas and autonomic control centers in the brain, and is thought to underlie both the detection of environmental threat and the accompanying autonomic and neuroendocrine responses to threatening stimuli (Davis & Whalen, 2001). This structure is a key component of an integrated functional network, which shares reciprocal connections with visual, auditory, somatosensory, olfactory, and taste systems via thalamic and prefrontal projections (Amaral et al., 1992; McDonald, 1998; Turner et al., 1980). The amygdala influences physiologic responses via indirect projections to various arousal systems, such as the basal forebrain cholinergic system, the brainstem cholinergic system, and the locus ceruleus noradrenergic system, each of which innervates widespread areas of the cortex (LeDoux, 2000), and may exert modulatory influences on the hypothalamic-pituitary-adrenal (HPA) axis via direct projections to the hypothalamus (Xu, Day, & Buller, 1999). Physiologic responses initiated by the amygdala may, in turn, influence cortical regions via feedback from proprioceptive and/or neuroendocrine signals (Damasio, 1994; McGaugh, Cahill, & Roozendaal, 1996).

The amygdala consists of numerous subnuclei (often referred to as the amygdaloid complex) that have distinct pathways to and from cortical and brain stem structures that may play different roles in information processing and behavior (Whalen, 1998). The regions most relevant to the processing of threat stimuli appear to be the lateral, basal, accessory basal, and central nuclei (LeDoux, 2000). The central nuclei are thought to play an important role in generating fear responses such as increased heart rate, increased respiration, and the release of stress-related hormones (LeDoux, 2000). Historically, however, most findings have been at the level of the amygdala as a whole, rather than at the level of specific nuclei (LeDoux, 2002), and substantial evidence suggests that the subnuclei of the amygdala operate in concert as a functional unit when monitoring the environment (Whalen, 1998), Thus, the amygdala will be referred to here as a distinct anatomical structure.

Functional imaging studies have demonstrated amygdala responsivity to a wide range of emotionally salient cues, including facial expressions of sadness (Wang et al., 2005; Yang et al., 2002), disgust (Adolphs et al., 1999), surprise (Kim et al., 2003), and happiness (Breiter et al., 1996; Yang et al., 2002). However, evidence suggests that the amygdala is activated more strongly in the presence of fearful and angry faces than of happy ones (Breiter et al., 1996), and consistent evidence demonstrates a particular sensitivity to threat-related signals (Adolphs, 2002; Phan et al., 2002; Phillips et al., 2003). Both lesion (Adolphs et al., 1994, 1995; Anderson & Phelps, 2001) and neuroimaging studies (Davis & Whalen, 2001) have shown that fearful responses to facial expressions are processed and largely mediated by the amygdala. Patients with amygdala damage show deficits in the perception of fearful faces (Adolphs et al., 1995; Calder et al., 1996) and detection of the emotional tone of voices (Scott et al., 1997). Amygdala responses to fearful faces have been observed in the absence of subjects' conscious awareness, with some evidence suggesting that subliminal presentations of fearful faces result in stronger amygdala activation than do freely observed stimuli (Whalen et al., 1998).

Fear is associated with situations that threaten survival, and reacting appropriately to fearful stimuli may confer a direct survival advantage (LeDoux, 1996). In humans, facial expressions of negative affect are examples of such fearful stimuli, and observation of angry or fearful faces elicits strong visceral responses, such as increased heart rate and sweating (Öhman & Soares, 1998). The amygdala is especially sensitive to social cues, such as facial expressions (Whalen, 1998). Along with greater autonomic arousal, Hariri and colleagues (2002) have demonstrated stronger amygdala responses to fearful and threatening facial expressions, as compared to nonface stimuli such as violent scenes. Thus, facial expressions are of critical importance in the processing of social and emotional information (Hariri et al., 2002), and facial stimuli, as opposed to words or threatening scenes, may represent the most useful tool for measuring amygdala reactivity to threat in social environments.

Based on its key role in the processing of negative facial expressions (Liddell et al., 2005; Morris et al., 1996; Whalen et al., 1998), the amygdala has been implicated in the etiology of affective disorders. Exaggerated amygdala reactivity to social threat (e.g., viewing harsh faces) has been implicated in social phobia (Phan et al., 2006; Stein et al., 2002; Straube et al., 2004). In comparison with control subjects, patients with PTSD have shown amygdala hyper-reactivity to threatening facial expressions (Liberzon et al 1999; Rauch et al., 2004; Shin et al., 1997). Amygdala reactivity to facial threat signals is greater among subjects scoring higher on measures of trait anxiety and neuroticism (Bishop et al., 2004; Canli et al., 2001; Etkin et al., 2004). A meta-analysis of 40 fMRI studies, comparing amygdala reactivity to threat-related stimuli of anxious participants (suffering from PTSD, social anxiety disorder, and specific phobia) versus controls, demonstrated consistent and significant heightened amygdala reactivity among anxiety-disordered individuals (Etkin & Wager, 2007). In their meta-analysis of studies investigating differences in amygdala volume in depressed versus non-depressed individuals, Hamilton, Siemer, and Gotlib (2008) found that amygdala volume was significantly lower in unmedicated depressed participants than in controls ($d = -1.24$, $p = .01$). Amygdala hyperactivity has been demonstrated in depressed patients, compared with controls, in response to emotional faces (Sheline, Barch, & Donnelly, 2001) and verbal stimuli (Siegle et al., 2002). Depressed adolescents demonstrated a significant, positive association between left amygdala activation to viewing fearful faces with depression scores ($r = 0.46$, $p = .023$) (Yang et al., 2010). In two fMRI studies of depressed patients who completed an affective priming task (outside the scanner), subjects rated neutral targets more negatively when they were primed by angry or sad faces, compared with neutral targets primed by neutral faces, and these negative bias scores positively correlated with amygdala responses to masked angry and sad faces (Dannlowski et al., 2007a; Dannlowski et al, 2007b). Thus, strong evidence suggests that amygdala hyperactivity to threat may be shared across disorders of negative affect, as documented by variation in responsivity to and bias toward potentially aversive stimuli (Yoon et al., 2007).

1.6 SOCIAL STATUS AND THE AMYGDALA

It is possible that individuals of lower social status exhibit stronger amygdala responses to potential threats, as compared to those of higher SES. As reviewed previously, the heightened exposure to unpredictable and stressful events inherent in lower SES environments may lead to the development of a "vigilant" cognitive bias. This hypervigilant style may be mediated via the amygdala, which is activated by a wide variety of stressful stimuli. Experimental studies of rodents show that repeated exposure to stressful stimuli sensitizes many components of the stress response, including an increased neuronal activation within the amygdala (Buffalari & Grace, 2008). Chronic immobilization has been shown to increase spine density of basolateral amygdala (BLA) pyramidal neurons (Mitra et al., 2005; Vyas, Mitra, Rao, & Chatterji, 2002), while chronic cold exposure heightens the responses of BLA neurons to footshock (Correll et al., 2005). Buffalari and Grace (2008) demonstrated that, following long-term cold exposure (> 14 days), BLA neurons in rats exhibited increased sensitivity to novel stressors, as measured by electrophysiological response, compared to controls. Vyas et al. (2002) suggest that hormones released as a result of stress-induced amygdala activity strengthen the excitatory drive within the amygdala, thereby influencing subsequent information processing by the amygdala and its downstream targets. Further, they suggest that, in combination with a gradual stress-induced loss of higher-level (i.e. prefrontal cortex, hippocampal) inhibitory control, chronic stress could lead to a gain in excitatory control exerted by the amygdala, resulting in an abnormally high fear response. Research into the neural pathways involved in emotional processing suggests that anxiety disorders may reflect a dysregulation of fear systems of the brain (Eysenck, 1992; LeDoux, 1996). It is possible, then, that the chronic stress encountered by lower SES persons may lead to an amygdala hypersensitivity to potential dangers and, ultimately, increased likelihood of developing an affective disorder.

To date, little evidence exists to support an association between neural systems and SES-related threat sensitivity in humans. Research suggests that humans infer social dominance from aggression-related emotional expressions (Chiao et al., 2008), where facial expressions of anger are perceived as dominant and fearful expressions represent submissiveness (Hess, Blairy, & Kleck, 2000; Knutson, 1996). Increased amygdala reactivity to threat-related facial expressions may represent a neural correlate of conditioning responses to perceived socio-environmental threats. By experimentally manipulating social ranking within a perceived hierarchy, Zink and colleagues (2008) demonstrated that viewing a superior ranking individual resulted in heightened amygdala activity. In another recent fMRI study, Gianaros and colleagues (2008) examined the association of amygdala reactivity with facial expressions of negative affect in 33 healthy undergraduates, who also provided retrospective rankings of their parents' social standing as an indicator of childhood and adolescent SES. The authors report that college students with lower perceived parental social status show greater amygdala reactivity in fMRI to threatening facial expressions (Gianaros et al., 2008), independent of demographic factors, dispositional emotionality, and recent depressive and anxious symptoms. In light of the greater exposure to violence, crime, conflict, and other adverse conditions experienced by individuals from lower SES backgrounds, as well as data showing cell groups in the amygdala to demonstrate marked neural plasticity as a function of early life stress (McEwen, 2007), Gianaros et al. (2008) suggest that this heightened threat sensitivity may be due to a developmental 'embedding' of stressful early SES-related experiences. However, to our knowledge, no investigation has been conducted to determine whether these findings are similar in a population of adults' perceptions of their own social status.

1.7 CONCLUSION

Lower SES individuals experience more frequent stressful life events and are at higher risk of mood and anxiety disorders than their higher SES counterparts. Certain cognitive tendencies, including a vigilant attentional style, have been associated with negative affectivity, and this heightened sensitivity to threat may result from adverse environmental exposures, influencing the development of anxiety and mood disorders. Further, the amygdala is recognized as playing a crucial role in the processing of threat-related information. Frequent exposure to SES-related environmental stressors may result in heightened amygdala sensitivity to potential dangers (also reflected in attentional bias toward threat). Hence, amygdala reactivity to threat signals may represent a neural correlate of SES-related experiences. Thus, a predisposition toward negative affectivity, and to selectively attend toward threatening visual stimuli, may be mediated at the neurobiological level via a common information processing mechanism – specifically, increased amygdala responsiveness to social threat (Frewen et al., 2008) (Figure 1).

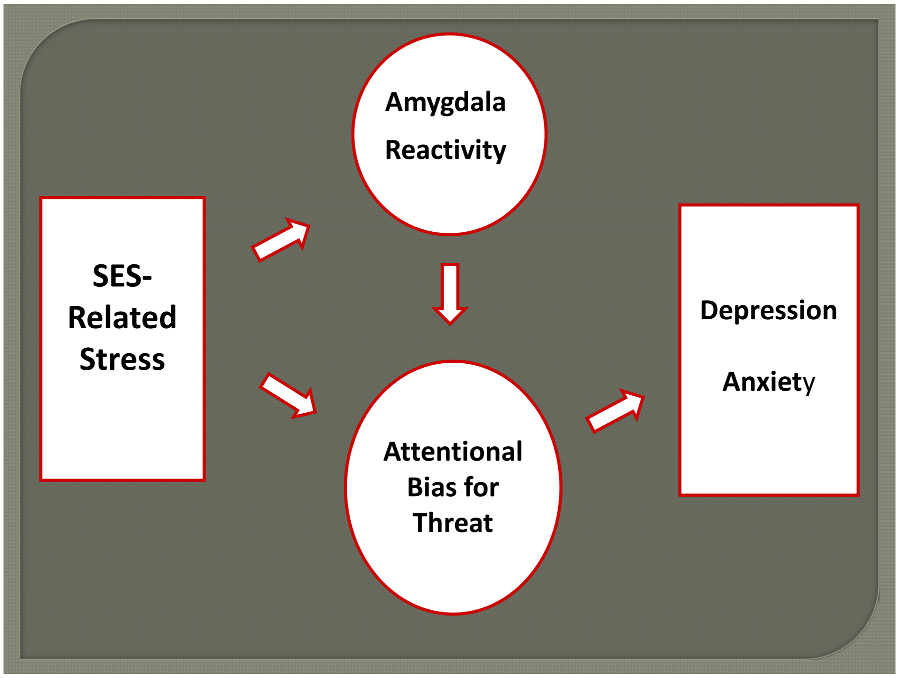


Figure 1. Potential pathway for SES influences on negative affect, via attentional bias for threat and amygdala reactivity.

1.8 PURPOSE OF THE CURRENT STUDY

Lower SES individuals are at higher risk of developing disorders of negative emotion. Despite numerous investigations of potential mediators of this relationship, the mechanisms responsible for this association remain unclear. One potential pathway for development for these disorders is the presence of a social information-processing bias, namely a vigilant attentional style, which has been associated with negative affectivity. This increased sensitivity to threat, also reflected in heightened amygdala activation, may be associated with exposure to adverse environmental conditions and may, in turn, ultimately influence the development of anxiety and mood disorders. However, little evidence exists to support this assertion. The purpose of the current study, then, is to expand this literature by examining whether measures of social status covary with sensitivity to threat and greater amygdala reactivity in a population of adult community volunteers, and whether the variation in amygdala reactivity mediates the relationship between SES and selective attention to threat. The study hypotheses are as follows:

Hypothesis One: Lower socioeconomic status will be associated with an attentional bias to threat, as reflected on a visual probe-detection task.

Hypothesis Two: Lower socioeconomic status will predict greater magnitude of amygdala response to visual threat-related stimuli presented during a functional neuroimaging task.

Hypothesis Three: Insofar as the above hypotheses are supported, amygdala reactivity to facial expressions of negative emotion will mediate (account for) the effects of low socioeconomic status on selective attention to threat.

2.0 METHODS

2.1 PARTICIPANTS

This investigation included 127 community volunteers (age range 30 – 55, M = 42.1 years; 41% female, 87% white) who participated in the second Adult Health and Behavior project (AHAB II). AHAB II is a University of Pittsburgh registry of diverse behavioral and biological measurements collected on individuals recruited (by mail solicitation) from communities of Southwestern Pennsylvania (principally Allegheny County). This protocol was approved by the University of Pittsburgh Institutional Review Board, and participants provided informed consent. Participants were excluded if they were unemployed, or if they reported a history of any of the following conditions: myocardial infarction, stroke, or cancer treatment within the past year, chronic kidney or liver disease, major neurological disorders, schizophrenia or other psychotic illness. Pregnant women were also ineligible. Individuals who reported a fear of enclosed or confined spaces, who had tattooed eyeliner, medical devices, implants, or other metal objects in or on the body that cannot be removed, or whose body habitus did not permit entry into an MR scanner were also excluded.

2.2 MEASURES

2.2.1 Socioeconomic Status

2.2.1.1 Objective SES Measures

As reviewed previously, lower SES predicts poorer mental health outcomes whether social standing is expressed as level of education, income, or a composite of these measures (Eaton, Kessler, Wittchen, & Magee, 1994; Fiscella & Franks, 1997; Gallo, Royall, & Anthony, 1993; Ickovics et al., 1997; Kaplan, Roberts, Camacho, and Coyne, 1987; Kessler & Merikangas, 2003; Salokangas & Putanen, 1998; Shear et al., 2006; West et al., 1998; Wittchen, Zhao, Kessler, & Eaton, 1994). Individuals' objective SES was indexed by two conventional indicators: 1) cumulative years of schooling; and 2) annual (pre-tax) family income, within bracketed ranges of: 1 = < $10,000; 2 = $10,000-14,999; 3 = $15,000-24,999; 4 = $25,000-34,999; 5 = $35,000-49,999; 6 = $50,000-64,999; 7 = $65,000-79,999; 8 = $80,000-94,999; 9 = $95,000-109,999; 10 = $110,000-124,999; 11 = $125,000-139,999; 12 = $140,000-154,999; 13 = $155,000-169,999; 14 = $170,000-185,000; 15 = > $185,000. As in prior reports (Manuck et al., 2005; Matthews, Flory, Muldoon, & Manuck, 2000; Manuck, Phillips, Gianaros, Flory, & Muldoon, 2010), a composite measure of objective SES was computed by averaging the standardized (z-score) values of the two index variables for each individual. This measure was then re-standardized to yield of a distribution with mean of 0.0 and SD of 1.0.

Although education and income may influence cognitive and emotional processing uniquely at each level of the social "gradient", the most striking SES effects may be seen in individuals at the lowest strata of SES (Hackman, Farah, & Meaney, 2010; Noble, McCandliss, & Farah, 2007). Thus, we thus we also converted the continuous SES variables (years of education and family income) into dichotomous indicators of lowest education (i.e. no post-secondary degree) and lowest income (i.e. less than $35,000 per year) versus those of higher education and income in the current sample.

Children from lower SES families typically suffer worse mental health outcomes than do children from higher SES families (Chen, Matthews, & Boyce, 2002), and growing evidence indicates that lower childhood SES is associated with increased risk of emotional disorders in adulthood. Children who experience socioeconomic disadvantage are more likely to develop depression or anxiety (Merikangas, 2005; Fombonne, 1995), and adults from lower SES backgrounds (i.e. parents were employed in manual occupations) demonstrate a nearly twofold increased risk of major depression, independent of adult SES (Gilman, Kawachi, Fitzmaurice, & Buka, 2002).

Considering the potential importance of childhood environment, objective data on participant's childhood SES circumstances was also examined. Participants reported both their mothers' and fathers' level of education completed by the time the participant was age 18 (range: 0 = no H.S. diploma, 1 = GED, 2 = H.S. diploma, 3 = Technical training, 4 = Some college, no degree, 5 = AS, 6 = BS, 7 = MS, 8 = MD/PhD).

2.2.1.2 Subjective SES Measures

A frequently cited correlate of low SES is the stress (or distress) that may be occasioned by heightened challenges of daily living, uncertainties of future prospect, or demoralization stemming from perceptions of relative social or material disadvantage (Gianaros et al., 2007; Gallo & Matthews, 2003; Adler & Snibbe, 2003; Wilkinson, 1999). In turn, putative stress-related dimensions of social stratification might be gauged more sensitively by subjective estimate than by conventional measures of objective SES.

The MacArthur Scale of Subjective Social Status, a visual ladder depicting ordered rungs of ascending perceived SES (Figure 2), has been shown to predict various indicators of health status and risk, including disorders of negative emotion (Singh-Manoux, Adler, & Marmot, 2003; Goodman et al., 2001) often over and above conventionally assessed SES. Work by Singh-Manoux and colleagues (2003), in which the authors predicted subjective status using a cluster of socioeconomic measures (occupation, education, income), wealth, life satisfaction measures, and psychological well being, shows that the combination of education, occupational grade, household income, feeling secure, and satisfaction with one's standard of living accounts for substantial variance associated with subjective status. Alternatively (or in addition), subjective SES ratings may capture a psychological property of relative social position that engenders greater distress or demoralization among persons who perceive themselves as disadvantaged relative to others (Operario, Adler, & Williams, 2004). However, significant associations between ladder rankings and health measures have been demonstrated upon adjustment for negative affect (Adler et al, 2000; Operario et al., 2004), and Singh-Manoux et al. (2003) demonstrate that individuals primarily reference socioeconomic parameters when assigning themselves subjective SES rankings, while potentially biasing personality characteristics (such as traits of hopelessness, optimism, or hostility) account for little additional variance in subjective SES scores (Singh-Manoux et al., 2003). Subjective SES likely reflects a "cognitive averaging" of multiple dimensions of socioeconomic circumstances, such as access to material resources, earnings and accumulated wealth, educational attainments, occupational prestige, and assessments of future prospects (Singh-Manoux et al., 2003), rendering this measure potentially a more comprehensive single-index portrayal of individuals' social position than the common socioeconomic indicators employed in most epidemiologic studies. Subjective appraisals, then, may provide a more sensitive gauge of SES-related stress than do more traditional SES indices.

Lower rankings on the MacArthur social ladder have been associated with impaired sleep and elevated heart rate (Adler et al., 2000), with an exaggerated rise in the stress-hormone, cortisol, on awakening from sleep (Wright & Steptoe, 2005) and with a non-habituating cortisol response to acute psychological stress (Adler et al., 2000). In most instances, these associations remained significant even when adjusted for correlated variation in objective SES indicators. Recently, in an fMRI investigation of 100 healthy community volunteers, lower subjective SES, independent of conventional SES measures, was found to correlate with reduced gray matter volume in the perigenual area of the anterior cingulate cortex (ACC), a brain region involved in emotional experience and the regulation of behavioral and physiological reactivity to stress (Gianaros et al., 2007). These findings suggest that subjective SES might contribute to psychiatric morbidity, in part, through neurobiologic correlates of the stress associated with lower perceived social standing. Volumetric changes in the ACC and other paralimbic brain areas have been documented in stress-related psychiatric symptomatology, such as depression (e.g., Drevets, Öngür, & Price, 1998), which is also predicted by low subjective status (Goodman et al., 2001; Singh-Manoux et al., 2003). Of potential relevance to the current study, neurobiologic correlates of subjective SES may modulate key circuitries of social information processing involved in the development of affective disorders.

Participants' individual subjective SES was assessed by asking individuals to rank themselves on the MacArthur ladder (comparison of standing compared to others in the United States; 1 = worst off to 10 = best off). Participants also used this "social ladder" to rank their perceptions of each parent's SES during the participants' childhood and adolescence (in comparison to others within the United States) prior to the participants' eighteenth birthday.

Instructions to participants were worded as follows: "Think of this ladder as representing where people stand in the United States. At the top of the ladder the people who are the best off - those who have the most money, most education and the most respected jobs. At the bottom are the people who are the worst off - who have the least money, least education, and the least respected jobs or no job. The higher up you are on this ladder, the closer you are to the people at the very top, and the lower you are, the closer you are to the people at the very bottom. Where would you place yourself on this ladder?" http://www.macses.ucsf.edu/

Figure 2. Illustration of 10-step social ladder scale used to assess subjective social status.

2.2.2 Selective Attention to Threat

2.2.2.1 Visual Probe Detection Task

Participants' attentional bias toward threat was assessed using a visual probe-detection task (Posner, Snyder, & Davidson, 1980), commonly referred to as the "dot-probe task". Twenty four actors, each expressing angry, fearful, happy, and neutral facial expressions, were selected from the Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt, & Öhman, 1998) available at http://www.facialstimuli.com. The entire KDEF Stimuli Set consists of 4900 different facial expression stimuli displayed by a variety of male and female models. An equal number of male and female models expressing the four affective conditions were used. This procedure is based on that of previous studies (Joormann & Gotlib, 2007), and evidence suggests that the use of emotional faces, rather than words, might yield more consistent results in studies of attentional biases to threat (Bradley et al., 1998; Mogg & Bradley, 2006). Happy expressions were included to determine whether predicted behavioral responses to fearful and angry faces can be attributed specifically to the threatening nature of the faces, rather than to emotional faces more generally (Cooper & Langton, 2006).

Participants were seated behind the computer at a distance of approximately 60 cm from the screen to perform the probe detection task. Participants were instructed to observe the fixation point in the center of the monitor screen. They were then presented with a series of picture pairs (facial expressions). Participants first completed a practice trial, utilizing 18 picture pairs that differ from models used in the main dot-probe task. For the main task, six blocks of 24 picture pairs ([24 angry, 24 fearful, and 24 happy expressions paired with the neutral expression of the same actor (12 female and 12 male)] were presented for a total of 144 trials (See Figure 3 for example). Each trial began with the presentation of the central fixation point for 1000 ms, immediately followed by the picture pair for 200 ms. Immediately after the offset of the two pictures, a small dot probe was presented, appearing in the location previously occupied by one of the two pictures, and participants responded by pressing one of two keyboard buttons (indicating that the probe had appeared on either the right or the left side of the screen) as quickly and accurately as possible. The inter-stimulus interval was 1000 ms, and total task time was approximately ten minutes. The pictures and dot probe were presented equally often at the right or left position and the order of trials was randomized for each participant. E-Prime software (version 2.0) was used for the programming and presentation of the probe detection task, and was programmed to randomize the presentation order for each subject and collect the response accuracy and reaction time (RT) latencies. The dependent variable in this task is latencies in milliseconds to respond to the dot probe.

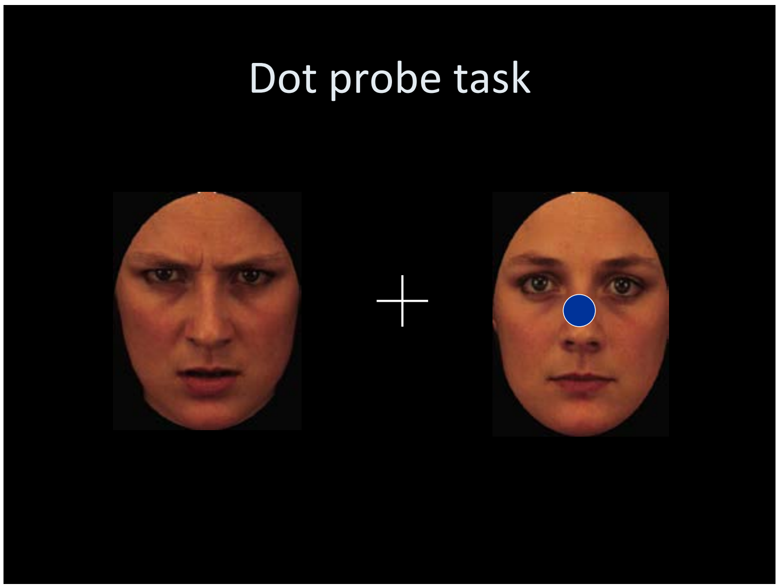


Figure 3. Example of probe/stimuli placement in dot probe task.

2.2.3 Amygdala Reactivity

2.2.3.1 Functional Magnetic Resonance Imaging

Blood oxygenation level-dependent (BOLD) functional magnetic resonance imaging (fMRI) was employed to investigate amygdala reactivity. BOLD fMRI is a noninvasive neuroimaging technique that utilizes an endogenous contrast signal associated with shifts in the relative magnetic susceptibility of oxy- and deoxy-hemoglobin resulting from activity in localized neuronal populations (Logothetis & Pfeuffer, 2004).

Participants were instructed to fast and to abstain from caffeine, tobacco products, and exercise for at least three hours and refrain from drinking alcohol and taking non-essential medication for 12 hours prior to scanning. Upon arrival to the Magnetic Resonance Research Center (MRRC - Presbyterian Hospital), eligible individuals provided written informed consent and underwent screening for contraindications for MRI scans (e.g. metallic foreign objects, pregnancy). Eligible subjects were then informed of the protocol, and the general instructions for each experimental task were reviewed. Subjects were provided with the opportunity to assess their comfort and ability to participate in the fMRI scan by entering an MRI simulator. Participants were instrumented for heart rate, and then entered the scanner. Those requiring corrective lenses were provided with MR-compatible glasses accommodating a full range of correction.

Each subject was scanned using a Siemens Allegra 3T scanner optimized for functional brain imaging. An automated shim procedure was applied to minimize possible magnetic field inhomogeneities. In-plane T2 structural images were acquired for visualization and normalization of functional imaging data. BOLD functional images were acquired using the following parameters: field of view: 200 x 200 mm; matrix size: 64 x 64 mm; repetition time: 2 seconds; echo time: 29 ms; and flip angle: 90°. Thirty-four axial-oblique slices (3 mm thick, 0 mm gap) were obtained using a gradient echo EPI sequence, oriented to the AC-PC line and encompassing the entire cerebrum and the majority of the cerebellum. All scanning parameters were selected to optimize the quality of the BOLD signal while maintaining a sufficient number of slices to acquire whole-brain data.

2.2.3.2 Amygdala Reactivity Paradigm

The amygdala reactivity paradigm consisted of four blocks of a perceptual face processing task. Subjects viewed a trio of faces and selected one of two faces (bottom) that was identical to a target face (top) (Figure 4). Two blocks each of affectively-laden (angry, fearful, and happy) and neutral facial expressions were employed. The order of affective and neutral face matching blocks was counterbalanced across subjects. Each of these blocks consisted of six images, three of each sex (or target affect in the affective matching blocks) presented sequentially for four seconds. All face stimuli were derived from the MacArthur Network Face Stimuli Set (Tottenham et al., 2009) available at http://www.macbrain.org/resources.htm. Within each face block, the interstimulus interval (ISI) varied between two, four, and six seconds (mean ISI = 4). This mixed trial design maximizes both the detection efficacy of sustained activity (BOLD Signal Amplitude) over entire blocks and the estimation efficacy of trial-related transient activity (modeling of hemodynamic characteristics) for individual trials (Birn, Cox, & Bandettini, 2002; Mechelli, Price, Henson, & Friston, 2003; Mechelli, Henson, Price, & Friston, 2003). Total scan time was six minutes. During imaging, subjects responded by pressing one of two buttons with their right hand, allowing for the determination of accuracy and RT. Participants' performance was monitored during all scanning trials.

Figure 4. Example of experimental stimuli presented to participants during the functional scan.

Corresponding to the use of facial expressions in the dot-probe task, reactivity to threatening (angry and fearful) faces was compared to responses to both happy and neutral faces. The inclusion of neutral face matching blocks allowed for examination of specific neural responses to affectively-laden facial expressions. The contrast of happy face matching blocks with angry and fearful faces permitted assessment of amygdala reactivity to non-threatening versus threat-related emotional faces. This paradigm also permits analyses of differential amygdala responses to angry and fearful faces, which may represent unambiguous and ambiguous threatening stimuli, respectively.

2.3 DATA ANALYSIS

The present study sought to evaluate three primary hypotheses. Prior to analysis of these specific hypotheses, data on demographic characteristics and all indices of socioeconomic status were first examined for normality. Extreme data outliers were identified and, if necessary, removed prior to applying appropriate data transformation to any non-normal variables in order to better approximate normal distribution.

In hypothesis one, lower socioeconomic status was postulated have a significant association with an attentional bias to threat. After data was inspected for errors/outliers, mean RTs for each threat-related affective condition (anger and fear) were calculated, as were mean RTs for responses to happy faces (in order to determine whether responses were threat-specific, or merely general responses to emotional facial expressions. Attentional bias scores were then calculated using a standard formula (e.g., Bradley et al., 1998). Next, correlational analyses were used to detect significant associations between attentional bias scores and continuous SES variables. Any significant correlations were further inspected by linear regression analyses, first entering the dependent variable of interest (attentional bias score) alone in the regression equation, next entering the dependent variable after adjustment for age, sex and race. Linear regression analyses were similarly employed to examine relationships between bias scores and dichotomized SES variables. Finally, these associations were explored further by adding quadratic and cubic terms to the regression equation in order to test whether a nonlinear regression model best fit the data.

Mean RTs for congruent (emotional face and probe in same location) and incongruent (emotional face and probe in different locations) trial types were calculated for each affective condition. Attentional bias scores were then calculated using a standard formula (e.g., Bradley et al., 1998):

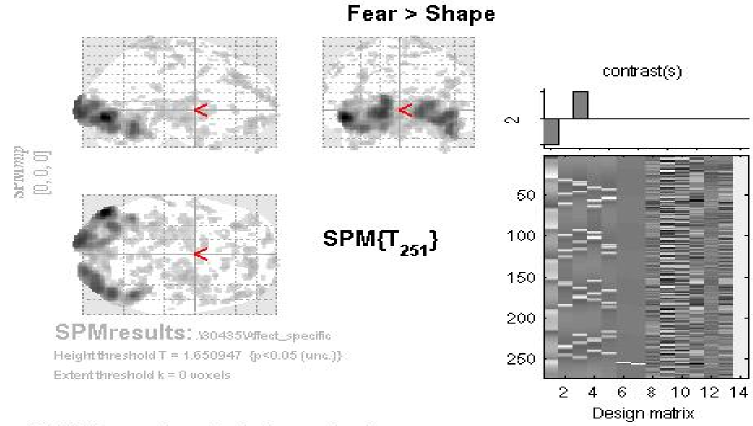
$$\text{Attentional bias score} = \tfrac{1}{2}\,[(RpLe - RpRe) + (LpRe - LpLe)]$$

In this equation, RpLe represents the participants' mean RT for all right-sided incongruent trials (i.e. trials in which the probe was on the right side and the emotional face was on the left side), RpRe represents participants' mean RT for all right-sided congruent trials, and LpRe and LpLe represent mean RTs for left-sided incongruent and congruent trials respectively. This formula calculates the "attention-capturing" quality of emotional faces by subtracting the mean probe detection times for congruent probes from the mean probe detection times for incongruent probes for both right sided and left sided presentations. Positive scores indicate faster responses to probes following emotional stimuli compared to neutral stimuli (attentional bias), negative scores indicate slower responding to probes following emotional stimuli compared to neutral stimuli (avoidance), and scores around zero indicate neither bias toward nor avoidance of emotional stimuli.

For hypothesis two, lower socioeconomic status was predicted to be related to greater magnitude of amygdala response to visual threat-related stimuli on an fMRI task. Brain imaging data were preprocessed and analyzed using Statistical Parametric Mapping (SPM8) software (http://www.fil.ion.ucl.ac.uk/spm). Images for each subject were realigned to the first volume in the time series to correct for head motion, spatially normalized into a standard stereotactic space (Montreal Neurological Institute template) using a 12 parameter affine model. These normalized images were smoothed to minimize noise and residual differences in gyral anatomy with a Gaussian filter, set at 6 mm full-width at half-maximum.

Following preprocessing, general linear models employing canonical hemodynamic response functions were used to estimate BOLD activation for each subject. In the first level of analysis, emotion-specific, within-subject contrasts were examined for each subject in order to obtain each participant’s parameter estimate for condition-specific contrasts (e.g., matching of facial stimuli; angry face matching > shape matching). SPM computes univariate t-statistics (activation in response to a condition of a given task) at every voxel in the brain to generate the individual activation parameter estimates and within-subject variances that are necessary for ‘second-level’ models in mixed-effects analyses (Mumford & Poldrack, 2007).

Predetermined condition effects at each voxel were calculated using a *t* statistic, producing a statistical contrast image for each directional comparison (angry > shapes, fear > shapes, happy > shapes, neutral > shapes, angry > neutral, fear > neutral, happy > neutral, angry > happy, fear > happy). To generate contrast images, BOLD signal changes for each condition (anger > shapes, etc.) were convolved with the default SPM hemodynamic response function. Next, task-related BOLD activation was estimated with a design matrix specifying a general linear model (GLM) that included regressors for the linear (x, y, z,) and rotational (pitch, roll, yaw) planes of movement, as well as any outliers identified via the the Artifact Detection Tool (ART; Mozes & Whitfield-Gabrieli, Neuroimaging Informatics Tools and Resources Clearinghouse, http://www.nitrc.org). The ART program is used for manual detection of global mean and motion outliers in fMRI data. After determining the threshold values for global brain activation mean, linear motion parameters, and rotational motion parameters, outliers are defined as points that exceed the threshold in at least one of these variables. These outliers are then included as covariates in the general linear model created by SPM. Linear BOLD signal drifts were removed with a high-pass filter (128 s) (see Figure 5 for example of an individual participant SPM).



Statistics: ***p-values adjusted for search volume***

set-level p	set-level c	cluster-level $p_{FWE-corr}$	cluster-level $q_{FDR-corr}$	cluster-level k_E	cluster-level p_{uncorr}	peak-level $p_{FWE-corr}$	peak-level $q_{FDR-corr}$	peak-level T	peak-level $(Z_\equiv)$	peak-level p_{uncorr}	mm mm mm
0.999	145	0.000	0.000	8115	0.000	0.000	0.000	8.89	Inf	0.000	-48 -80 -10
						0.000	0.000	6.89	6.59	0.000	-14 -104 -2
						0.000	0.000	6.34	6.10	0.000	-12 -104 8
		0.904	0.716	522	0.013	1.000	0.999	3.23	3.19	0.001	24 -10 -10
						1.000	0.999	2.85	2.83	0.002	26 -2 12
						1.000	0.999	2.64	2.62	0.004	24 -26 -4
		1.000	0.935	106	0.221	1.000	0.999	3.22	3.18	0.001	-32 36 38
		1.000	0.935	86	0.269	1.000	0.999	3.21	3.17	0.001	-34 -38 72
						1.000	0.999	2.59	2.57	0.005	-30 -46 72
		1.000	0.935	210	0.092	1.000	0.999	3.17	3.13	0.001	8 50 -18
						1.000	0.999	3.10	3.06	0.001	14 52 -12
						1.000	0.999	2.92	2.89	0.002	22 50 -14
		1.000	0.935	37	0.473	1.000	0.999	3.01	2.98	0.001	6 72 6
		1.000	0.935	147	0.153	1.000	0.999	2.98	2.96	0.002	42 60 16
						1.000	0.999	2.95	2.93	0.002	46 40 32
						1.000	0.999	2.90	2.88	0.002	48 46 26
		1.000	0.935	41	0.449	1.000	0.999	2.97	2.94	0.002	46 -16 62
		1.000	0.935	33	0.500	1.000	0.999	2.92	2.89	0.002	42 60 -10
		1.000	0.935	43	0.437	1.000	0.999	2.92	2.89	0.002	-20 66 12

table shows 3 local maxima more than 8.0mm apart

Height threshold: T = 1.65, p = 0.049 (1.000)
Extent threshold: k = 0 voxels, p = 1.000 (1.000)
Expected voxels per cluster, <k> = 75.962
Expected number of clusters, <c> = 184.86
FWEp: 4.999, FDRp: 4.912, FWEc: 8115, FDRc: 8115

Degrees of freedom = [1.0, 251.0]
FWHM = 8.7 8.7 8.4 mm mm mm; 4.3 4.3 4.2 {voxels}
Volume: 1604240 = 200530 voxels = 2357.5 resels
Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 78.97 voxels)
Page 1

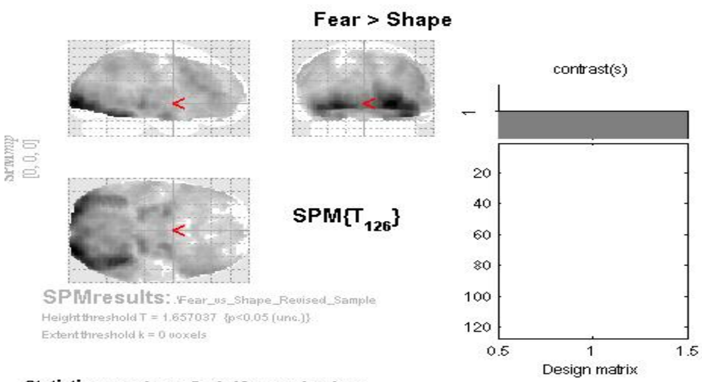
A. Glass Brain - maximum intensity projection of all activity in whole brain in response to task (i.e. presentation of fearful facial expressions), darkest areas are where t-statistics are highest

B. Level one design matrix - each row is a time point, each column is a particular stimuli (here, first column is shapes, third column is fear stimuli, columns 6-7 represent covariation for outliers, columns 9-13 represent motion parameters). Constant term (white column at end) = intercept (represents average signal intensity across a run)

C. Table of brain regions (specific locations in brain represented by MNI coordinates) significantly activated by the task.

Figure 5. Example of individual participant statistical parametric map (SPM), examining whole brain reactivity to fearful facial expressions (contrasted with reactivity to shapes).

The individual contrast images were then used in second-level mixed effects models, which accounts for both scan-to-scan and subject-to-subject variability, to determine task-specific regional responses at the group-level for the entire sample (main effects of task). Second level analysis combines all individual means and within-subject variances in order to estimate the between-subject variance and allow for group inferences. The BOLD signal change parameter estimates from the first level analysis comprise the dependent variable in the second level model. A statistical threshold of $p < 0.05$, corrected for multiple comparisons across all suprathreshold voxels [(family wise error (FWE)], was used for these whole-brain comparisons. Statistical parametric maps were generated for each participant, for each contrast of interest, expressed as t statistics at each voxel (Figure 6).



Statistics: ***p-values adjusted for search volume***

set-level p	set-level c	cluster-level $p_{FWE-corr}$	cluster-level $q_{FDR-corr}$	k_E	cluster-level p_{uncorr}	peak-level $p_{FWE-corr}$	peak-level $q_{FDR-corr}$	T	$(Z_{\equiv})$	peak-level p_{uncorr}	mm	mm	mm
1.000	20	0.000	0.000	59694	0.000	0.000	0.000	24.41	Inf	0.000	28	-94	0
						0.000	0.000	21.39	Inf	0.000	-26	-94	-4
						0.000	0.000	19.99	Inf	0.000	38	-86	-4
		1.000	0.952	172	0.219	1.000	0.284	2.91	2.86	0.002	-20	-20	44
						1.000	0.438	2.64	2.60	0.005	-18	-12	40
						1.000	0.545	2.48	2.45	0.007	-24	-6	36
		1.000	0.952	18	0.713	1.000	0.445	2.63	2.59	0.005	-12	-44	16
		1.000	0.952	18	0.713	1.000	0.489	2.56	2.52	0.006	-12	-26	64
		1.000	0.952	8	0.821	1.000	0.641	2.35	2.32	0.010	12	-26	66
		1.000	0.952	14	0.752	1.000	0.667	2.31	2.28	0.011	42	-8	32
		1.000	0.952	9	0.808	1.000	0.739	2.20	2.18	0.015	12	-44	16
		1.000	0.952	4	0.883	1.000	0.741	2.19	2.17	0.015	-20	38	48
		1.000	0.952	13	0.762	1.000	0.741	2.19	2.17	0.015	-14	-34	50
		1.000	0.952	19	0.705	1.000	0.776	2.14	2.12	0.017	14	-38	60
		1.000	0.952	3	0.903	1.000	0.787	2.12	2.10	0.018	6	58	-12
		1.000	0.952	3	0.903	1.000	0.828	2.07	2.05	0.020	2	56	-14
		1.000	0.952	13	0.762	1.000	0.835	2.06	2.04	0.021	18	50	8
		1.000	0.952	3	0.903	1.000	0.848	2.04	2.02	0.022	24	58	28
		1.000	0.952	6	0.850	1.000	0.873	1.99	1.98	0.024	28	-6	36

table shows 3 local maxima more than 8.0mm apart

Height threshold: T = 1.66, p = 0.049 (1.000)
Extent threshold: k = 0 voxels, p = 1.000 (1.000)
Expected voxels per cluster, <k> = 121.942
Expected number of clusters, <c> = 88.58
FWEp: 4.928, FDRp: 3.741, FWEc: 59694, FDRc: 59694

Degrees of freedom = [1.0, 126.0]
FWHM = 10.2 10.2 9.9 mm mm mm; 5.1 5.1 4.9 {voxels}
Volume: 1126376 = 140797 voxels = 1011.9 resels
Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 127.80 voxels)
Page 1

A. Glass Brain - maximum intensity projection of all activity in whole brain in response to task (i.e. presentation of fearful facial expressions), darkest areas are where t-statistics are highest

B. Level 2 design matrix – each row represents one participant, one column represents the one condition (have factored out any 'nuisance' variables) – in this case, the condition is the contrast between reactivity to fear faces subtracting out reactivity to shapes.

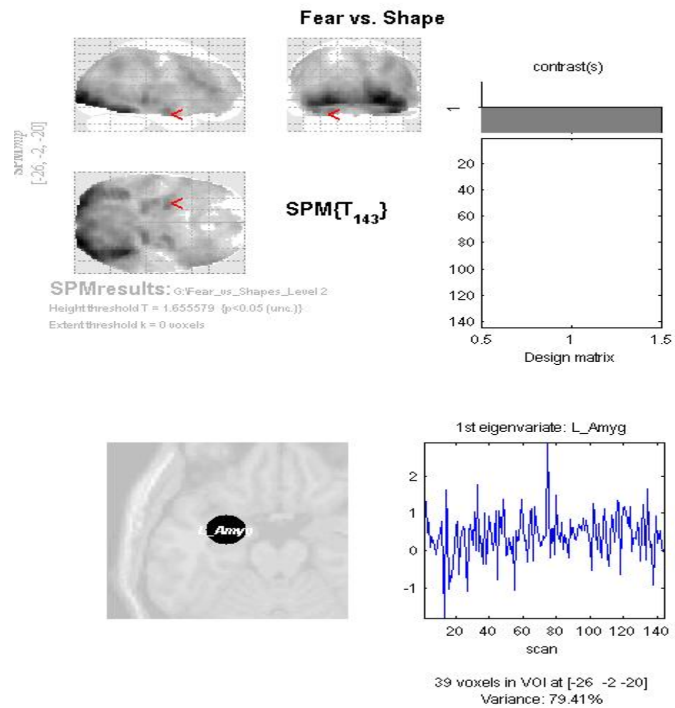
C. Table of brain regions (specific locations in brain represented by MNI coordinates) significantly activated by the task.

Figure 6. Example of second level (group map) of whole brain activity, examining whole brain reactivity to fearful facial expressions (contrasted with reactivity to shapes).

In order to target the amygdala as a region of interest (ROI), a BOLD signal time series was extracted from the left and the right amygdala for each individual. Given issues recently raised in the literature regarding the nonindependence of ROI selection from subsequent analyses (Vul et al., 2009), bilateral amygdala ROIs were pre-defined using the amygdala mask in the MarsBaR toolbox in SPM8, which derives ROIs from the Montreal Neurological Institute (MNI) single-subject template (Tzourio-Mazoyer et al., 2002). These consisted of 10 mm radius spheres centered on coordinates (left amygdala coordinates x, y, z = -26, 0, -20; right amygdala coordinates x, y, z= 24, 0, -20). Theories which posit hemispheric differences in emotion processing (Davidson, 1984; Sackeim & Gur, 1978; Sackeim et al., 1982; Schwartz, Davidson, & Maer, 1975) have raised the possibility that the left and right amygdala are differentially involved in the processing of emotional information. One such model, based on hemispheric differences associated with language, suggests involvement of the left amygdala in processing semantic material (e.g., scripts, sentences or words) and the right amygdala in processing non-semantic stimuli (e.g., faces, pictures) (Markowitsch, 1998; Phelps et al., 2001). Other models concern the temporal dynamics of amygdala responses to emotional information, wherein the right amygdala may be more engaged in the rapid detection of emotional stimuli and the left amygdala plays a more substantial role in elaborate, detailed analysis of emotional information (Glascher & Adolphs, 2003; Wright et al., 2003). Consistent with these models, evidence supports a differential role for the left and right amygdala in the processing of affective information (Atchley, Ilardi, & Enloe, 2003; Canli et al., 1998). One recent meta-analysis of 54 fMRI and PET studies reported significant differences in hemispheric lateralization, with the left amygdala being more often activated than the right amygdala, regardless of stimulus type, task instructions, or habituation rates of the left and right amygdalae (Baas, Aleman, & Kahn, 2004).

Based on these findings, we analyzed right and left amygdala responses to facial expressions separately.

Voxel-wise inferential testing was constrained to the amygdala ROIs using a statistical threshold of $p < 0.05$ with an extent threshold of 0 contiguous voxels and with individual MarsBaR ROIs used in small volume correction. A graphical representation of the resulting amygdala reactivity is provided in Figure 7. Beta values resulting from the Level 2 contrast images (left and right amygdala reactivity values) from each emotion-specific contrast for each participant were extracted from SPM. Correlation analyses of the task-related activation in the left and right amygdala were performed to determine significant associations between separate emotion-specific contrasts and SES measures. Any significant correlations were further inspected by linear regression analyses, first entering the dependent variable of interest alone in the regression equation, next entering the dependent variable after adjustment for age, sex and race. Any of the emotion-specific amygdala reactivity measures that were significantly related to SES were submitted to linear regression analyses. Using emotion-specific contrasts as dependent variables, separate hierarchical regressions were employed for all social status measures to test whether SES was associated with extracted amygdala reactivity values independent of demographic covariates. Age, sex, and race were included as covariates in all analyses. Finally, these associations were explored further by adding quadratic and cubic terms to the regression equation in order to test whether a nonlinear regression model best fit the data.



A. Glass Brain - maximum intensity projection of all activity in whole brain in response to task (i.e. presentation of fearful facial expressions), darkest areas are where t-statistics are highest

B. Level 2 design matrix - each row represents one participant, one column represents the one condition (have factored out any nuisance variables) – in this case, the condition is the contrast between reactivity to fear faces subtracting out reactivity to shapes.

C. Representation of activation values in the specific region of interest (in this case, the left amygdala) - Eigenvariates - patterns of spatio-temporal correlation, first eigenvariate time series extracted from the peak *t* value for the left amygdala

Figure 7. Example of 2nd level (group) statistical parametric map (SPM), examining left amygdala reactivity (as region of interest) to fearful facial expressions (contrasted with reactivity to shapes).

Analysis of hypothesis three was dependent upon results of hypotheses one and two. Amygdala reactivity to facial expressions of negative emotion was hypothesized to mediate (account for) the effects of low socioeconomic status on selective attention to threat. In order to examine the amygdala reactivity as a potential mediator, regression analyses would first be performed to establish that the predictor variable (SES) and the hypothesized mediator (amygdala reactivity to threat) meet appropriate steps for establishing mediation (Baron &

Kenny, 1986). The Sobel test (Sobel, 1982) would then be utilized to determine the significance of the indirect pathway between the independent variable and the dependent variable (IV-> mediator -> DV), with $z > \pm 1.96$ indicating a statistically significant pathway.

3.0 RESULTS

3.1 DEMOGRAPHICS

Descriptive statistics for all demographics variables are provided in Table 1. Female participants were significantly older than males (44.5 years vs. 40.6 years, $F_{1,125} = 7.86$, $p = 0.006$). Subjects included in the present analyses reported a mean subjective SES score of 6.2 ± 1.6 in the following proportions (from 2 = lowest to 10 = highest): 0.8%, 4.7%, 11.0%, 15.7%, 19.7%, 27.6%, 16.5%, 3.1%, and 0.8%. Participants averaged 17.1 ± 2.7 years of schooling (range: 10–24 years) (GED [0.8%]; completed high school [3.9%]; technical training [2.4%]; postsecondary education without degree [7.9%]; Associate's degree [4.7%]; Bachelor's degree [41.7%]; Master's or equivalent professional degree [26%]; Doctoral or doctoral-level professional degree [12.6%]). When analyzing education as a dichotomous variable, participants who did not achieve at least an associate's degree (15% of sample) were included the low education group. Mean family income was within the $50-64,999 range (6.8 ± 3.1), with the proportion of subjects falling within the 15 ranges of reported income (lowest to highest) as follows: 1.6%, 3.1%, 6.3%, 3.9%, 16.5%, 18.9%,14.2%, 9.4%, 8.7%, 4.7%, 2.4%, 2.4%, 1.6%, 0.8%, and 5.5%. The 15% of participants reporting income at or below $35,000 per year were included in the low income group for analyses of income as a dichotomous variable. All continuous SES variables were scrutinized for normality; serious departures from normality are variables for which skewness exceeds three (Curran, West, & Finch, 1996) and kurtosis exceeds 10 (DeCarlo, 1997). Skewness and kurtosis values for all SES measures fell well within acceptable ranges.

Correlational analyses were conducted to test for significant relations among demographic variables and indices of social status (Table 2). Sex was not associated with any of the individual participant SES measures, although males did report significantly lower parental education levels as compared with females (p’s $< .01$). Consistent with prior literature (Chen, Martin, & Matthews, 2006; Goodman, Huang, Schafer-Kalkhoff, & Adler, 2007), African American race was associated with lower S-SES ladder rankings ($r = -.26$, $p < .01$), fewer years of education ($r = -.18$, $p < .05$), lower family income ($r = -.20$, $p < .05$), and lower composite SES scores ($r = -.24$, $p < .01$). Whites reported significantly lower paternal education levels than did African Americans ($p < .05$). Age was positively related to higher family income and composite SES (p’s $< .05$), but was not associated with years of education or subjective SES. Older age was significantly related to lower rankings of paternal S-SES, as well as lower parental education levels (p’s $< .05$).

Across subjects, subjective SES (ladder rankings) correlated significantly with years of education ($r = .43$, $p = .001$) and income range ($r = .49$, $p = .001$), indicating that individuals earning a lower income and completing fewer years of schooling tended also to perceive themselves as holding a lower social standing than more “objectively” advantaged study participants (Table 3). Correlations between the parental education measures varied (mothers’ vs. fathers’ education level, $r = 0.65$; mothers’ vs. fathers’ S-SES, $r = 0.87$; p’s < 0.01) indicating that each indicator may provide unique information regarding the contribution of parental SES to selective attention to threat and amygdala reactivity (Table 3). Several participants’ individual SES indices were significantly and positively related to parental S-SES and parental education, with correlations ranging from .36 (father's education level with composite SES, $p < .01$) to .23 (father's S-SES with family income, $p < .01$).

3.2 HYPOTHESIS ONE

Lower socioeconomic status will be associated with an attentional bias to threat as reflected on a visual probe-detection task.

3.2.1 Reaction Time Data

Participants ($n = 127$) each completed 144 trials of the dot probe task (total responses = 18,288). Data from trials with errors and/or response time outliers (< 200ms and > 2000 ms) were removed (0.01% of trials). RTs for each emotion type were then scrutinized for normality; serious departures from normality are variables for which absolute values of skewness exceed three (Curran, West, & Finch, 1996) and kurtosis exceed 10 (DeCarlo, 1997). Skewness and kurtosis for each affective condition exceeded these values; therefore, values that deviated more than three standard deviations (SDs) from the mean RT for each affective condition were identified as extreme outliers and were removed (Curran, West, & Finch, 1996). Following removal of these outliers, skewness and kurtosis values for all measures fell within acceptable ranges. This final sample of dot probe responses ($n = 18,042$) was used for all further analyses.

In order to determine whether participants demonstrated habituation to emotional stimuli across time in the dot probe task, we subjected RTs to a repeated measures ANOVA with affect (anger, fear, happy) and block (1st through 6th) as within subjects factors. Analyses failed to reveal any habituation effects, demonstrating no significant main effect for block ($F_{5,630} = 0.38$, $p = .862$) (Figure 8), while there were significant differences in RTs between the three affective conditions($F_{2, 252} = 28.63$, $p = 0.000$)] (Figure 8). No significant affect by block interaction was detected ($F_{10,1260} = 1.66$, $p = .085$). Post hoc comparisons using the Tukey's HSD test revealed that RTs to angry stimuli (M = 392.3ms, SD = 85.4) were significantly faster ($p < .02$) than RTs to fearful faces (M = 396.7ms, SD = 86.0), while responses to happy faces (M = 405.8ms, SD = 96.9) were significantly slower than to either of the threat-related facial stimuli (p's < .001). (Figure 9).

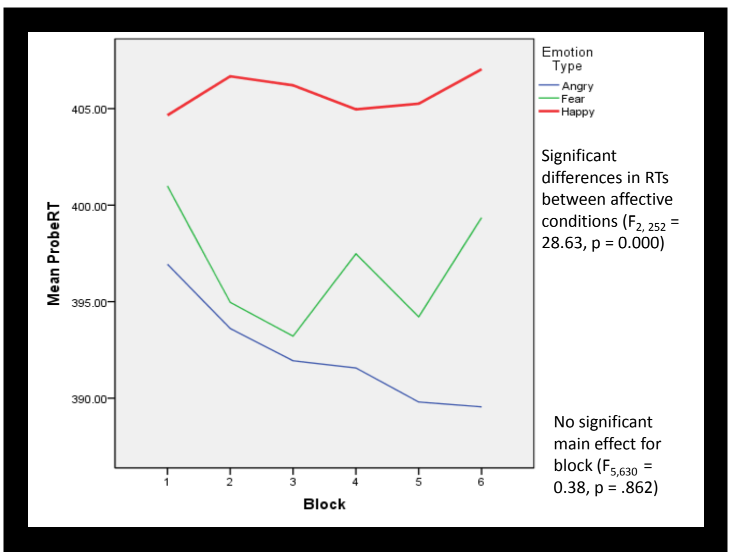


Figure 8. Dot probe reaction times (RTs) across blocks for each emotion type.

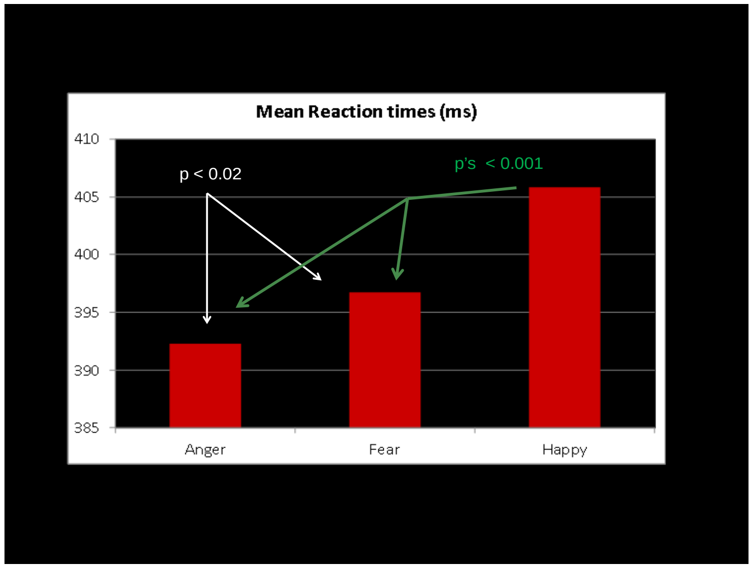
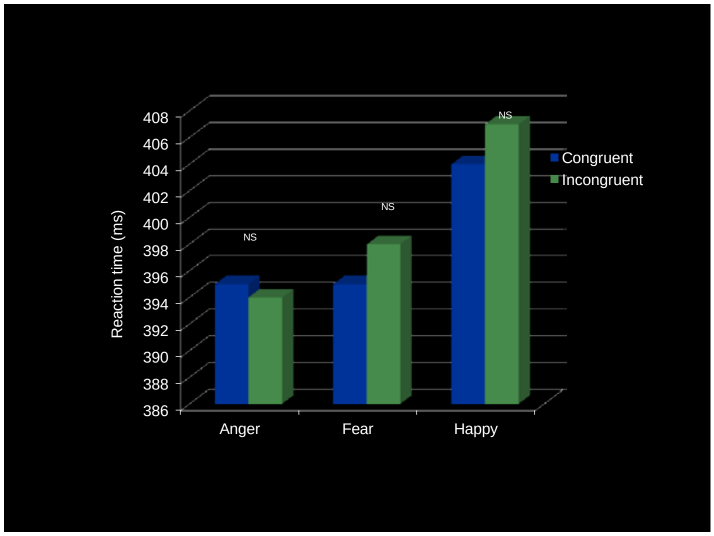


Figure 9. Dot probe mean RTs, post-hoc comparisons across emotion type.

Next, RTs were analyzed for effects of congruence using repeated measures ANOVA. There was no significant main effect of congruence ($F_{1,126} = 1.42$, $p > .05$] on participants' response latencies, nor was a significant affect by congruence interaction detected ($F_{2,252} = 0.51$, $p > .05$). Thus, participants did not appear to display an attentional bias toward any of the three types of emotional stimuli, relative to neutral stimuli, which is inconsistent with the prediction that participants would preferentially attend to threatening pictures (Figure 10).



Congruent = probe on same side of emotional facial expression
Incongruent = probe on opposite side of emotional facial expression

Figure 10. Differences between RTs for congruent versus incongruent presentation of emotional faces.

3.2.2 Attentional Bias Scores

Finally, bias scores for each subject were computed for each emotion type using the equation noted previously (Bradley et al., 1998). Bias scores for all affect types were determined to be normally distributed. Mean (SD) bias scores across participants for each emotion type were: anger: -4.9 ms (31.9), fear: 14.7 ms (54.9), happy: 2.2 ms (48.9) Repeated measures ANOVA revealed no significant difference in bias scores across blocks 1 - 6 of the dot probe task ($F_{5,630}$ = 0.64, p = .426), although there was a significant main effect of emotion type ($F_{2,252}$ = 31.62, p = 0.000). Post hoc tests (Tukey's HSD) revealed that while anger and happy bias scores did not differ significantly from one another (p = .15), both anger and happy bias scores were significantly different from fear bias scores (p's < .04) (Figure 11).

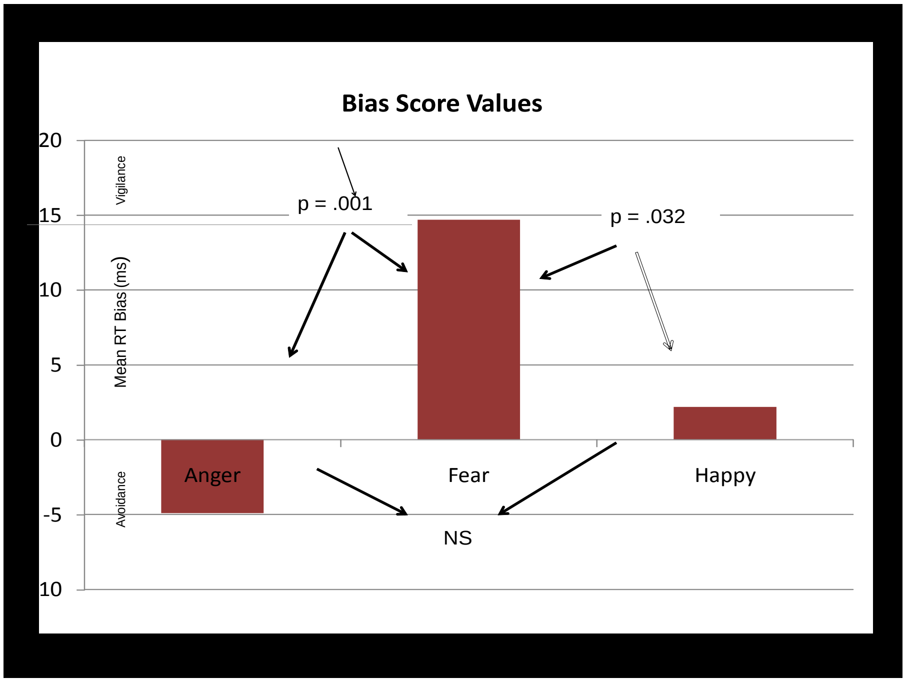


Figure 11. Comparison between mean bias scores across participants for each affective condition.

Table 4 displays the correlations between bias scores, demonstrating a significant association between fear and anger biases (r = 0.23, p < 0.01). A weaker, albeit significant, correlation was shown for fear and happy bias scores (r = 0.18, p < 0.05). No significant association was noted between anger and happy bias scores. The presence of a significant positive (orienting) or negative (avoidance) attentional bias was evaluated by performing 1-sample *t*-tests, comparing the difference from zero (zero indications absence of an attentional bias). Neither angry nor happy bias scores were significantly different from zero (anger: t = -1.73, p = 0.087; happy: t = 0.50, p = 0.615). Conversely, fear bias scores did differ significantly from zero (t = 3.02, p = 0.003) in a positive direction, signifying that participants had a significant orienting response toward fear faces.

Following the strategy employed by Schmukle (2005), Cronbach's α was used as the method for estimating the internal consistency of the bias indices. During the task, the 144 critical trials for each participant had been administered as six blocks, each containing 24 critical trials (eight anger faces, eight fearful faces, and eight happy faces each paired with a neutral face). A bias index was then calculated for each separate block for each affective condition, and internal consistency was subsequently computed based on these values. Cronbach's α was insufficient for the anger bias index (Cronbach's α = 0.42) but reached values considered sufficient (Spooren et al., 2007) for fear (Cronbach's α = 0.77) and happy (Cronbach's α = 0.72) bias scores.

3.2.3 Threat Bias and SES

Bias scores for each affective condition were examined for relationships to demographic variables (Table 5). No significant relationships were found between bias scores and sex or age. Point biserial correlations revealed a significant association between anger bias and race, suggesting greater bias toward threat among African American participants.

Correlation analyses were conducted comparing participants' bias scores for threatening emotional stimuli (angry and fearful facial expressions) with measures of individuals' objective, subjective, and parental SES. These associations are displayed in Table 5. None of these correlation coefficients reached statistical significance, indicating that no significant relationship existed between SES and threat-related bias scores. Similarly, participants' bias scores for happy facial expressions were also not related to any of the SES indices. Linear regression analyses, performed in order to examine the relationship between dichotomized SES variables and anger, fear, and happy attentional bias scores, also failed to demonstrate an association between participants' bias scores and membership in the lower versus higher income group (Table 6) or education group (Table 7).

Due to the significant relationships between race and several SES measures, race-specific analyses of the relation between attentional bias scores and SES were initially considered.

However, because the remaining number of African American participants (n = 14) was not of sufficient sample size to maintain model stability (Peduzzi et al., 1996), no race-specific analyses were conducted.

3.2.4 Results Summary for Hypothesis One

In sum, participants did not exhibit significant RT variations (i.e. no habituation) across task blocks when responding to either threat-related (angry and fearful) or happy facial expressions on a visual probe detection task. As expected, the present findings indicate that threat-related faces elicited more rapid response times than did happy facial expressions. Contrary to the study hypothesis, participants' responses to congruent probes (probe presented on same side as emotional face) elicited significantly slower RTs than did incongruent probes for angry facial expressions, while no congruency differences were noted for either fearful or happy emotional faces. Moreover, the calculated bias scores indicated an attentional bias for fearful faces only, whereas no significant bias toward or avoidance of angry faces was noted. Finally, in no case were indices of social status found to be related to attentional bias scores for any of the affective stimuli.

3.3 HYPOTHESIS TWO

Lower socioeconomic status will predict greater magnitude of amygdala response to visual threat-related stimuli on a functional neuroimaging task.

3.3.1 Analysis of fMRI Data in SPM

After ascertaining participants' activation values within the left and right amygdala for each affective condition, these values were extracted from SPM and entered into SPSS. Extracted beta values were then scrutinized for normality based on previously identified ranges (Curran, West, & Finch, 1996; DeCarlo, 1997). Skewness and kurtosis values for all amygdala reactivity measures fell within acceptable ranges.

Table 8 displays the significant BOLD fMRI responses in the amygdala for all contrasts at the whole brain peak level. Significant amygdala reactivity was found for most contrasts, although no cluster of voxels were significantly activated for the following contrasts: right amygdala activation to happy faces with shapes, left amygdala activation to angry faces with happy faces, or bilateral amygdala activation for neutral faces versus happy faces. Tables 9 – 11 display intercorrelations between right and left amygdala activation values for all contrasts in which significant activation remained upon removal of any residual activation due to amygdala responses to viewing other visual stimuli. Correlations between all facial stimuli (angry, fearful, happy, and neutral) in contrast to viewing shapes are shown in Table 9, as are correlations between all affective conditions contrasted with neutral faces (Table 10) and threat-related facial expressions with happy stimuli (Table 11). Correlations between the left and right amygdala for each condition were significant at the $p < .01$ level (anger: $r = .55$, fear: $r = .52$, happy: $r = .63$, neutral: $r = .55$). For every affective condition, beta values were significantly higher for the right amygdala than the left (p's < .01) (Table 12, Figure 12). Despite the significant associations between left and right hemispheres, evidence supports a differential role for the left and right amygdala in the processing of affective information (Alfano & Cimino, 2008; Atchley, Ilardi, &

Enloe, 2003; Baas, Aleman, & Kahn, 2004; Canli et al., 1998), precluding data reduction across the left and right amygdala.

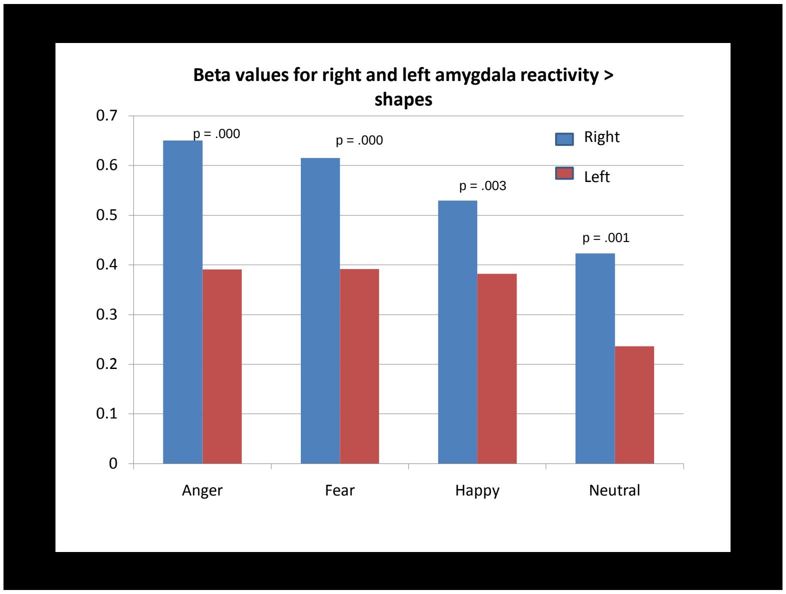


Figure 12. Comparison of right and left amygdala activation values for each affective condition > shapes.

We hypothesized that participants would exhibit significantly stronger amygdala responses to threatening faces versus non-facial visual stimuli (i.e. shapes) or to other emotional facial expressions. Beta values between amygdala reactivity to angry and fearful faces (in contrast with shapes) were compared to the beta values in contrast with neutral faces (Table 13, Figure 13), and amygdala reactivity values were consistently and significantly higher for shape contrasts, compared to neutral contrasts.

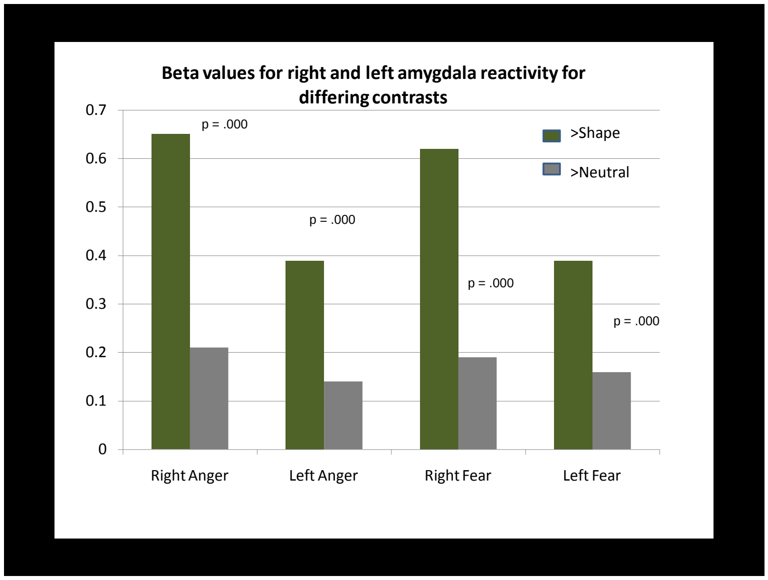


Figure 13. Comparison of amygdala activation values between contrast conditions.

Relationships between amygdala reactivity values and demographic characteristics are shown in Tables 14 and 15. Amygdala activation to anger faces, in contrast with shapes, was significantly higher in white versus African American participants ($r = -.17$, $p < .05$). Left amygdala activity to happy faces was significantly greater in females vs. males ($r = .20$, $p < .05$).

3.3.2 Amygdala Reactivity and SES

Correlation analyses were conducted in order to determine associations between participants' amygdala reactivity scores for angry and fearful stimuli and continuous measures of individuals' objective, subjective, and parental SES. Linear regression analyses were used to analyze whether amygdala reactivity scores were associated with dichotomized measures of income and education. These results are summarized in Tables 16 - 27. No significant associations were noted between continuous or dichotomous measures of individuals' social standing and amygdala reactivity to angry facial expressions (Tables 16 - 18). However, in regards to participants' parental SES measures, mother's education level was significantly associated with right amygdala activation to fearful facial stimuli in a positive direction (Table 19). When examining the left amygdala, participants with fewer years of education (Figure 14), lower family income, and lower composite SES scores showed greater left amygdala reactivity to fear faces (p's < 0.05) (Table 25). Membership in the low (versus high) income group was also associated with greater left amygdala activation to fear stimuli (Table 26).

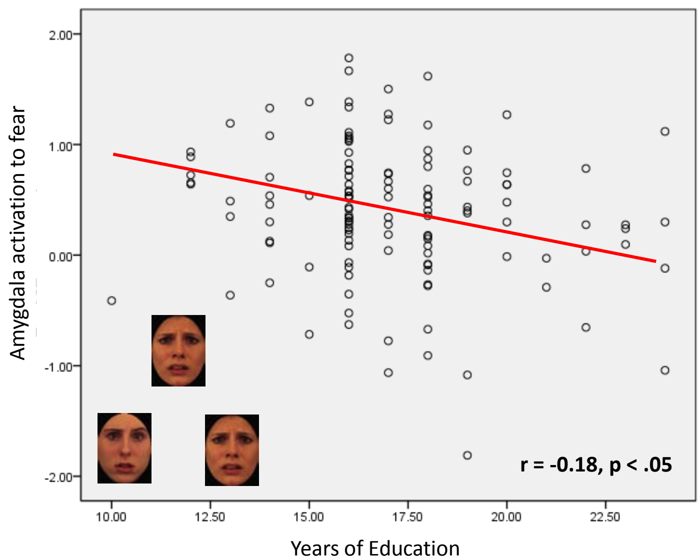


Figure 14. Inverse correlation between years of education and left amygdala activation to fearful facial stimuli (contrasted with shapes).

Next, continuous SES variables that demonstrated significant correlational associations with amygdala reactivity to fear stimuli were subjected to linear hierarchical regression analyses in order to further investigate whether SES indicators were related to greater amygdala reactivity independent of demographic covariates (age, sex, and race). As displayed in Tables 28 and 29, these associations were first examined alone and then with covariate-adjustment by entering covariates simultaneously on the first step of each regression equation. Covariates included gender (1 = male, 2 = female), age (in years), and race (1= white, 2 = African American).

Examination of participants' maternal education, using linear regression, showed higher mother's education level to predict greater right amygdala reactivity to fearful facial expressions (fear > shapes: $\beta = .079$, SE = .030, $p = .010$; fear > happy: $\beta = .042$, SE = .020, $p = .041$), a relationship which was in the opposite direction of what was expected. These relationships persisted upon adjustment for covariates (fear > shapes: $\beta = .105$, SE = .031, $p = .001$; fear > happy: $\beta = .060$, SE = .021, $p = .005$) (Table 28).

Upon further examining relationships between amygdala activity and continuous measures of individuals' objective SES (Table 29), linear multiple regression analyses showed fewer years of education to predict higher left amygdala reactivity to fearful facial stimuli, whether in contrast with shapes (Figure 15) or with neutral faces (fear > shapes: $\beta = -.112$, SE = .056, $p = .046$; fear > neutral: $\beta = -.120$, SE = .054, $p = .028$). Similarly, lower family income was associated with higher left amygdala reactivity to fearful facial stimuli (fear > shapes: $\beta = -.118$, SE = .053, $p = .028$), and lower composite SES was predictive of higher left amygdala reactivity to fearful facial stimuli, whether in contrast with shapes or with neutral faces (fear > shapes: $\beta = -.147$, SE = .055, $p = .008$; fear > neutral: $\beta = -.122$, SE = .054, $p = .025$). The relationship between years of education and left amygdala reactivity (fear > neutral) persisted after covariates were entered into the model ($\beta = -.116$, SE = .056, $p = .041$), while the association between family income and left amygdala reactivity was no longer significant. Lower composite SES continued to predict greater left amygdala reactivity to fearful facial stimuli, whether in contrast with shapes or with neutral faces, upon adjustment for covariates (fear > shapes: $\beta = -.142$, SE = .059, $p = .018$; fear > neutral: $\beta = -.122$, SE = .058, $p = .037$).

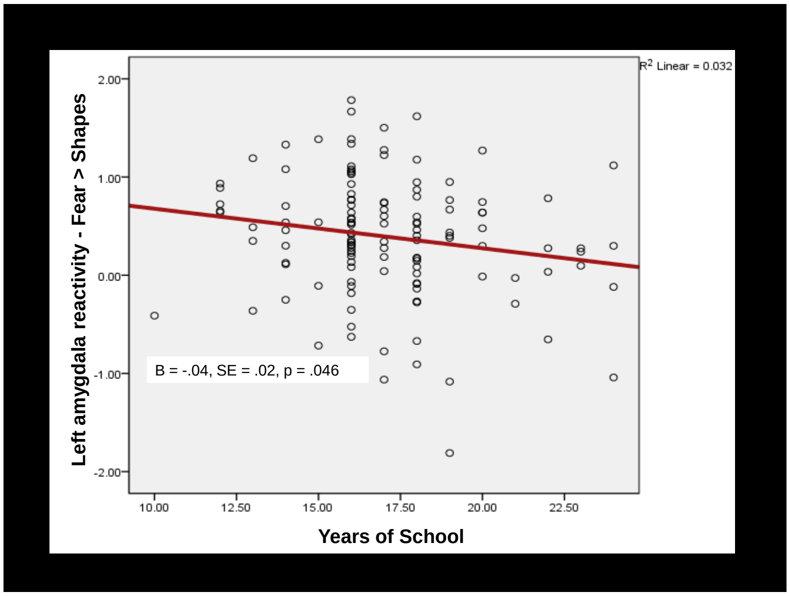


Figure 15. Linear regression model of years of education predicting left amygdala reactivity to fear faces (in contrast with shapes).

The results of an additional set of regression analyses, whereby an interaction term of SES by age was entered on Step 3, failed to demonstrate a significant interaction of SES with age (p's $< .05$). These results are not reported here. Because of the significant relationships between race and several SES measures, race-specific analyses of the relation between attentional bias scores and SES were initially considered. However, because the remaining number of African American participants ($n = 14$) was not of sufficient sample size to maintain model stability (Peduzzi et al., 1996), no race-specific analyses were conducted.

Finally, the same amygdala reactivity values that were significantly correlated with SES indices were again examined, this time by adding nonlinear terms to the regression models in order to test for linearity of the associations. These results are displayed in Tables 30 and 31. Figure 16 provides an example of a nonlinear regression model for the association of years of school and left amygdala reactivity to fear > shapes) (nonlinear: $B = -.004$, $SE = .005$, $p = .454$).

In no cases did nonlinear regression appear to provide the best explanation for the patterns observed in the data. Thus, it appears that the best fit for these was a linear model.

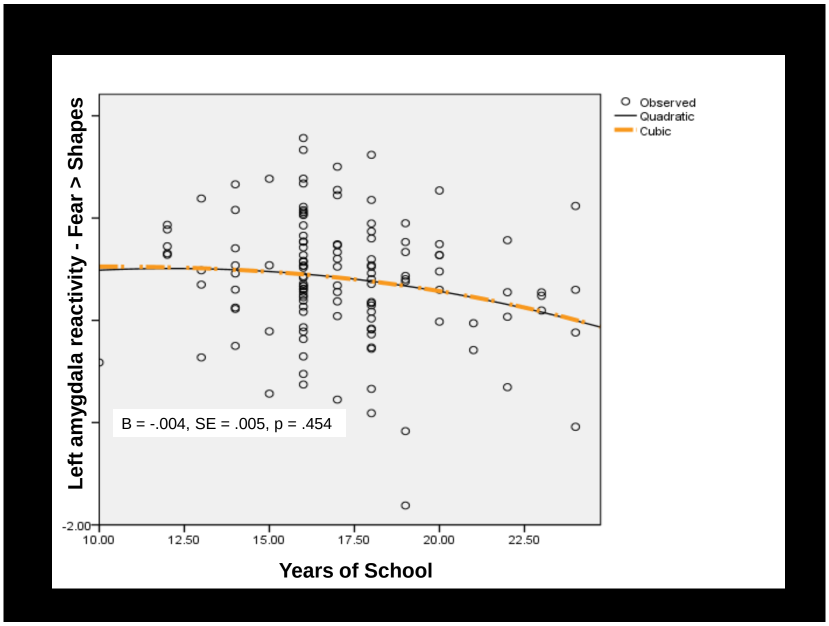


Figure 16. Nonlinear regression model of years of education predicting left amygdala reactivity to fear faces (in contrast with shapes).

3.3.3 Results Summary for Hypothesis Two

In general, participants in the current investigation exhibited stronger bilateral amygdala activation to threat-related facial expressions than to neutral facial expressions, happy facial expressions, and non-facial visual stimuli. Right-sided activation values tended to be larger than for the left amygdala for every affective condition. Left amygdala reactivity to fearful faces was negatively related to SES, whether reported as years of education, family income, or a composite of these measures. Linear regression accounted better for the relationship between amygdala reactivity and SES, as compared to a curvelinear model.

3.4 HYPOTHESIS THREE

Insofar as hypotheses 1 and 2 are supported, amygdala reactivity to facial expressions of negative emotion will mediate (account for) the effects of low socioeconomic status on selective attention to threat.

Correlational analyses were conducted to explore the relationship between attentional bias for threat and amygdala reactivity. As displayed in Tables 32 and 33, the majority of significant associations between attentional bias scores and amygdala reactivity were between ± .20 and .30. In general, attentional bias toward happy expressions was negatively related to amygdala reactivity to both fearful and happy faces, while anger bias scores tended to be positively related to amygdala reactivity to emotional faces of all types.

Sobel's test of mediation was to be used in evaluating whether amygdala reactivity scores might account for a substantial portion of the variance in the relationship between indices of social status and attentional bias scores. As seen in Table 5, however, no significant association was demonstrated between socioeconomic status and attentional bias for threat. Thus, the variables of interest did not meet criteria for testing mediation, preventing further analyses regarding this model.

4.0 DISCUSSION

Despite a well-documented inverse relationship between socioeconomic status and disorders of negative affect, the underlying mechanisms by which social inequalities impair mental health are not fully understood. In the current study, we proposed that heightened exposure to stressful life events would sensitize lower SES individuals to potential threats in the environment. To this end, three primary hypotheses were put forth. Hypothesis one of this investigation examined whether socioeconomic status is associated with attentional bias for threat as measured by a visual probe detection task. Considering the role of the amygdala in affective regulation, particularly the processing of threatening stimuli, the purpose of hypothesis two was to examine whether social status was related to amygdala reactivity to visual threat-related stimuli on a functional neuroimaging task. Assuming that hypotheses one and two were supported, hypothesis three aimed to assess whether the bias toward threatening visual stimuli might be mediated at the neurobiological level via increased amygdala responsiveness to social threat. However, results of the current study demonstrate no support for hypothesis one and extremely limited support for hypothesis two; by virtue of the limited findings for the first and second hypotheses, we were unable to test hypothesis three. In the following sections, we examine the results of each aspect of the study, detailing what might account for the lack of significant findings. Finally, more general limitations and directions for future research are discussed.

4.1 SELECTIVE ATTENTION FOR THREAT

Attention toward potential threats in the environment serves an adaptive function; i.e. to allow individuals to rapidly detect and appropriately respond to dangers (LeDoux, 1996; Bar-Haim et al., 2007). However, attentional bias toward possible threatening stimuli may also contribute to the development and maintenance of anxiety disorders (Bar-Haim et al., 2007). Substantial evidence supports an association between selective attention for threat and disorders of negative affect (Kroeze & van den Hout, 2000; Bradley et al., 1999; Horenstein & Segui, 1997; MacLeod et al., 1986; Mogg, Mathews, & Eysenck, 1992). The chronic distress engendered by membership in lower SES groups has been posited to lead to a state of heightened vigilance for threat (Taylor & Seeman, 1999; Feldman & Steptoe, 2004), and, consistent with this rationale, we predicted that lower SES would be associated with greater attentional bias to threat faces on the dot probe task. To our knowledge, this is the first study to investigate whether a relationship exists between SES and selective attention for threat using the dot probe paradigm.

4.1.1 Reaction Times to Threatening Stimuli

Overall, participants demonstrated significantly faster response times to angry and fearful facial stimuli, compared with happy facial expressions, which is consistent with past findings suggesting that humans orient fastest to threatening faces as a part of an evolved, specialized response necessary for human survival (Fox, Lester, Russo, Pichler, & Dutton, 2000; Öhman, Lundqvist, & Esteves, 2001). Mean RTs in our study were consistent with participant RTs reported in other investigations utilizing fearful/neutral and angry/neutral facial stimuli (Cooper & Langton, 2006; Lipp & Derakshan, 2005).

Participants' mean response times were used to calculate attentional bias scores (e.g., Bradley et al., 1998) toward threatening (angry and fearful) facial expressions, and attentional bias score values were in line with prior studies (Cooper & Langton, 2006; Lipp & Derakshan, 2005). Although we had expected significant attentional bias toward both types of threatening faces, participants in our sample exhibited significant bias for fear faces, but not toward angry facial expressions. These findings are consistent with Davis and Whalen's (2001) hypothesis that the threat-processing system is most reactive to ambiguous (or indirect) threat cues, and that fearful faces are more ambiguous (i.e. signify presence of danger without identifying the source) than are expressions of anger. When comparing threat bias using "high" threat pictures versus "milder" forms of threat, it has been demonstrated that high threat pictures capture attention in all individuals (Mogg et al., 2000; Wilson & MacLeod, 2003) while findings are inconsistent for mild threat presentations. These findings suggest if threat stimuli exceed a certain threshold, attentional biases will be demonstrated for all individuals (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). It is possible that the threat-salience of the pictorial stimuli used in the current study might vary by emotional condition, with fearful facial expressions representing higher threat value than the angry faces.

4.1.2 Threat Bias and SES

Socioeconomic status shapes both the types of events that individuals experience throughout their lives, as well as the individual resources utilized to respond to these events. These resources include biological characteristics, such as physical health, health behaviors, and genetic factors, psychological factors (cognitions, emotions, personality characteristics), social relationships, and financial resources (access to either preventative care or medical treatments). In this study, we hypothesized that the frequency and intensity of exposure to harmful or potentially threatening situations engendered by membership in lower social strata might render lower SES individuals more "sensitized" to cues of possible danger. Contrary to our expectations, however, we found no evidence of a significant relationship between socioeconomic status and attentional bias toward threatening stimuli on the dot probe task.

There are several potential explanations for our lack of findings regarding SES and attentional bias toward threat. Perhaps individuals' selective attention toward fearful facial expressions did not vary by SES simply because social standing does not differentially sensitize people to these specific stimuli. Although the chronic exposure to the unpredictable and stressful conditions inherent in lower SES environments could be reflected in individuals' increased vigilance and heightened sensitivity to social threats (Chen & Matthews, 2001; Repetti et al., 2002; Taylor et al., 2004; Evans & Kim, 2007), it may be that our task failed to tap into the specific type of social threat that is relevant to elucidate SES-related differences. Dickerson and colleagues (2004) suggest that lower SES individuals may experience frequent threats in the context of social "preservation", wherein stressors arise from uncertainty regarding one's social esteem or status. Lower SES individuals may experience social status threats involving social devaluation, discrimination, and rejection, essentially developing the perception of being evaluated negatively by others. Living and working in lower SES environments may contribute to diminished self-esteem, lower sense of control, and a reduced orientation toward mastery and efficacy (Amato & Zuo, 1992; McLoyd, 1998; Pearlin, Menaghan, Lieberman, & Mullan, 1981), and individuals in low socioeconomic groups report lower perceived control than those occupying higher social status (Bailis et al., 2001; Lachman & Weaver, 1998). Also, in line with the concept of stereotype threat (Steele & Aronson, 1995; Steele, Spencer, & Aronson, 2002), perceived class-based stereotypes such as laziness (Leahy, 1981), dishonesty (Desmond, Price, & Eoff, 1989) and educational disinterest (Bullock, 1999) in low SES individuals may activate the fear of being labeled as such by virtue of membership in a lower-SES group. Perhaps the experience of negative social evaluation is a more critical “threat” stimulus than what was hypothesized here - i.e., anger and/or fear as a result of living and working in potentially dangerous environments. This tendency toward fear of class-based rejection may represent a subtle (yet critical) difference from our manner of evaluating threat via angry and fearful facial stimuli on the dot probe. In this case, perhaps facial expressions representing disapproval or disgust would have represented a more salient “threat” for detecting variation in attention based on social status.

Additional exploration of the methodology used in our study may shed further light on the lack of significant findings relating SES to selective attention for threat. The dot probe paradigm has proven fairly robust in detecting selective attention for threat in clinically anxious participants (Bradley et al., 1999; MacLeod et al., 1986; MacLeod & Mathews, 1988; Mogg, Mathews, Bird, & Macgregor-Morris, 1990; Mogg, Mathews, & Eysenck, 1992; Horenstein & Segui, 1997; Kroeze & van den Hout, 2000), although not all studies of clinical groups have successfully demonstrated this bias (Gotlib et al., 2004; Bradley et al., 1997; Mogg, Bradley, de Bono, & Painter, 1997; Pineles & Mineka, 2005). However, the findings for non-clinical individuals using the dot probe are relatively inconsistent. Broadbent and Broadbent (1988) found that low anxiety and moderate anxiety subjects did not show an attentional bias, whereas highly anxious individuals directed their attention toward threatening words. A meta-analysis by Bar-Haim and colleagues (2007) found no significant attentional bias in nonanxious participants, whereas other studies report significant vigilance for threatening faces in nonanxious groups

(Cooper & Langton, 2006; Bradley et al., 1997). In regards to these inconsistent findings, Mogg et al. (2000) suggest that the dot probe task appears to provide a "relatively fragile index of anxiety-related attentional biases in non-clinical studies" (p. 1074).

Further examination of the overall validity of the dot probe task may also help to clarify our findings. Cronbach's α was used as the method for estimating the internal consistency of the dot probe task in the current investigation. Reliability was noted to be insufficient for the anger bias index (Cronbach's $\alpha = 0.42$) but reached values considered sufficient (Spooren et al., 2007) for fear faces (Cronbach's $\alpha = 0.77$). In contrast to our findings regarding consistency, Schmukle (2005) concluded that the dot probe task is an unreliable measure of attentional allocation in non-clinical samples by examining the internal consistency of two versions of the dot probe (using both verbal and pictorial stimuli). Unlike our investigation, Schmukle (2005) did not include facial photographs of human faces as stimuli. However, the author's findings raise doubts regarding the overall validity of the task as an indicator of attentional bias.

Our task did not include a baseline condition in which participants were asked to react to the dot probe when viewing neutral-neutral picture pairs. The inclusion of this condition would have provided evidence of whether differences in attentional bias resulted from vigilance toward a particular stimulus (RTs to threatening targets were faster than the neutral/neutral baseline) or avoidance of stimuli (RTs to threat stimuli slower than the baseline) (Cooper & Langton, 2006). Despite the lack of inclusion of this baseline in our investigation, prior research indicates that the stimulus presentation time for our task (i.e. 200 ms) most likely elicited attentional bias toward threat, as opposed to avoidance of threat-related stimuli. For instance, in comparing social phobics with control participants, Stevens, Rist and Gerlach (2009) demonstrated attentional bias toward angry faces at 175 ms, but not at 500 ms, on the dot probe task. Mogg, Philippot, and

Bradley (2004) found bias toward angry faces at 500 ms, but not at 1250 ms, in a similar comparison of social phobics and controls. These data suggest that relatively shorter exposure durations produce threat bias, but that attentional bias shifts toward avoidance of threat stimuli when shown for durations of 500 ms and longer. Other research has found that exposure durations of 100 ms produce attentional bias, while durations of 500 ms do not (Cooper & Langton, 2006; Holmes, Green & Vuilleumier, 2005).

In sum, our hypothesis that selective attention to threat would be related to SES was not supported. On the whole, interpretation of our visual probe detection task findings is limited. Considering the questions of task validity, uncertainty regarding whether response times represent attentional bias toward threatening faces or avoidance of threats, and the prior inconsistent findings when using the dot probe task with non-anxious populations, it is reasonable to question whether utilization of the dot probe task provided an insufficient test of our first study hypothesis. However, it is also possible that the problems do not lie in use of the dot-probe methodology specifically, but in the type of stimuli presented when attempting to elucidate SES-based differences in the allocation of attention.

4.2 AMYGDALA REACTIVITY TO THREAT

Substantial evidence shows lower SES individuals more likely to experience stressful life events than those of higher social status. Low SES individuals are disproportionately exposed to community-level violence, crime, and crowding (Aneshensel & Sucoff, 1996; Evans, 2001; Fitzpatrick & Boldizar, 1993; Homel & Burns, 1987). Relative to higher SES youth, adolescents from lower SES families are more likely to perceive their school (Gallup, 1993; Sinclair et al.,

1994) and their neighborhood as dangerous and violent (Aneshensel & Sucoff, 1996). Being witness to or victimized by high levels of neighborhood, school, or home violence is associated with poor emotion regulation and maladaptive processing of social information (McDonald *et al.*, 2007; Schwartz, & Proctor, 2000). Chen, Cohen and Miller (2010) found that children from lower-SES backgrounds reported higher levels of family stress and greater perceptions of threat compared with children of higher social status, and others have suggested that socioeconomic status is related to a state of heightened vigilance for threat (Taylor & Seeman, 1999; Feldman & Steptoe, 2004).

The human amygdala is thought to be a key component of the neural circuitry that evaluates the meaning and importance of social information (LeDoux, 2000), and consistent evidence demonstrates a particular sensitivity to threat-related facial expressions (Adolphs, 2002; Phan, Wager, Taylor, & Liberzon, 2002; Phillips et al., 2003). Considering the role of the amygdala in threat-related processes, in combination with the heightened exposure to threat experienced by lower SES individuals, we predicted that lower SES would be associated with greater amygdala response to threat-related facial expressions on an fMRI task. To our knowledge, this is only the second investigation to examine whether a relationship exists between SES and amygdala reactivity.

4.2.1 Amygdala Reactivity to Facial Stimuli

Comparable to the extant literature (Hariri et al., 2002; LeDoux, 2000; Whalen, 1998), we found that presentation of threatening emotional stimuli elicited significant amygdala activation. It was hypothesized that amgydala responses to threatening stimuli would be greater than to either non-facial visual stimuli (shapes) or to nonthreatening facial expressions (neutral and happy faces).

Consistent with these expectations, results of the current study did show greater amygdala responses to fearful and angry faces than to other visual stimuli. Overall, amydgala activation values for face-matching (independent of affective valence of the facial expression) were significantly higher than values elicited during shape-matching tasks. Moreover, presentation of threatening faces generally resulted in significantly higher amygdale reactivity than did non-threat (happy or neutral) faces.

4.2.2 Amygdala Reactivity and SES

We found very limited support for a relationship between SES measures and amygdala reactivity to threatening faces. No significant associations were noted between any measures of social standing and amygdala reactivity to angry facial expressions. With respect to fearful faces, after controlling for demographic covariates, regression analyses showed significant associations between fewer years of education and higher left amygdala reactivity, in contrast with neutral faces. Similarly, lower composite SES was significantly associated with left amygdala reactivity to fearful facial stimuli, whether in contrast with shapes or with neutral faces, upon adjustment for covariates. Maternal education was also associated with amygdala reactivity to fear faces, albeit in the opposite direction of what was expected. The few findings showing lower SES related significantly to heightened amygdala reactivity were limited to fearful faces and would not have survived correction for multiple comparisons. In sum, our prediction of an inverse association between indices of social standing and amygdala reactivity to threatening stimuli was largely unsupported by the results.

There are several potential explanations for our lack of findings regarding SES and amygdala reactivity toward threatening facial stimuli. Perhaps individuals' neural responses toward fearful facial expressions did not vary by SES because amygdala sensitization to these specific stimuli is not conditioned by SES. As noted previously, lower SES has been associated with reduced self-esteem and lower perceived control (Amato & Zuo, 1992; Bailis et al., 2001; Baum et al., 1999; Lachman & Weaver, 1998; McLoyd, 1998; Pearlin et al., 1981), and awareness of negative status-based stereotypes may heighten perceptions of discrimination in those with relatively lower educational, financial, or occupational status (Brown et al., 2006; Feldman & Hilterman, 1974; Guyll et al., 2001; Matthews et al., 2005; Weeks & Lupfer, 2004). In line with these findings, lower SES individuals may demonstrate greater bias toward indicators of social *rejection*, rather than examples of more overt threats represented by facial expressions depicting a more global, nonspecific threat. In this case, an examination of brain structures other than the amygdala might be more conducive to detecting SES-related threats to social connection. For instance, the anterior cingulated cortex (ACC) and the right ventral prefrontal cortex (RVPFC) show heightened activation in response to perceptions of being socially excluded (Eisenberger, Lieberman, & Williams, 2003).

However, although it is possible that the amygdala is not involved in SES-related detection of social threats, prior evidence regarding amygdala reactivity and SES suggests otherwise. Zink and colleagues (2008) found that viewing a superior ranking individual resulted in heightened amygdala activity, and Gianaros et al. (2008) found that college students with lower perceived parental social status demonstrated heightened amygdala reactivity in fMRI to threatening facial expressions, as compared to those rating their parents as having higher SES. Thus, our findings are not consistent with the prior, albeit limited, findings regarding SES and amygdala activity. Perhaps, then, the lack of a significant association between social standing and amygdala reactivity in our investigation could be a result of methodological constraints.

For instance, although we achieved at least 90% amygdala coverage during the fMRI task for participants in the current sample, it is possible that some signal loss (due to a placement error while in the scanner) may have resulted in a reduction in sensitivity to activity within the amygdala. It is possible that, with more comprehensive amygdala coverage, a more valid representation of amygdala activity would have emerged. Nonetheless, the overall results demonstrating activating effects of threatening emotional stimuli on the amygdala in our participants suggests that, to some extent, the methodology used in the current investigation was adequate.

4.3 LIMITATIONS

In addition to the limitations noted in the previous sections, our findings should be interpreted with caution in light of several other constraints. Most relevant is the limited variability in the SES indicators within the study sample. Participants in the current investigation were recruited from a common geographic location (southwestern Pennsylvania), and were predominantly middle-aged, white, and relatively well-educated. The ability to determine valid SES-related variation in amygdala reactivity and attentional bias scores was likely affected by the sample's limited range of socioeconomic status. The current sample was highly educated, with 80% of participants having earned at least a Bachelor's degree and only 6% of participants reporting their highest educational achievement as being a high school diploma. In contrast, approximately 23% of the current U.S. population are college graduates (U.S. Census Bureau, 2010). According to recent statistics, approximately 45% of U.S. households report incomes equal or greater than $50,000 per year (U.S. Census Bureau, 2007), whereas 70% of participants in our sample reported being at or above this income level. Only 11% of study participants reported incomes of less than $25,000 per year. Together, the distributions of income and education indicate the absence of socioeconomic disadvantage in any significant proportion of the current sample. The inclusion of participants across a broader range of age, ethnic diversity, and socioeconomic standing may have resulted in a more valid characterization of individuals' responses to threat.

The comprehensiveness of the SES measures used in this investigation also bears consideration. Although education and income are widely used indices of SES, the inclusion of an occupational indicator might have more thoroughly encompassed additional dimensions of SES. In addition, the inclusion of a community SES measure could have served as a more precise indicator of the chronic stress hypothesized to play a role in linking SES to sensitization toward potential threats.

The inconsistent results between samples in the dot probe literature are also cause for concern, as is the lack of information regarding reliability of the task with various populations. To date, two investigations have reported poor reliability for the original dot probe task (Schmukle, 2005; Staugaard, 2009), though both studies used nonclinical samples of university students. In contrast, much of the literature supporting use of the dot probe for detecting bias for threat derives from studies of clinically anxious populations. Considering these inconsistencies, the inclusion of additional measures of attentional allocation, such as the Modified Stroop task, may have been a beneficial addition to the study. Also, participants may demonstrate attentional biases to more specific stimuli than the generic facial expressions used here, and it may be noted that some researchers employ verbal or visual stimuli that individuals self-identify as most relevant to their perceptions of threat (Amir et al., 2009).

In sum, results from the present study must be considered preliminary, as few studies have similarly examined the relationship between socioeconomic status and threat-related responses. Thus, findings must be replicated in future investigations before firm conclusions can be drawn regarding the significance of social status in explaining individual differences in attentional bias toward threat. Despite these shortcomings, however, our findings provide initial (albeit quite limited) evidence that heightened neurobiological responses to threat may be associated with lower SES.

4.4 ATTENTION TO THREAT, SES, AND DISORDERS OF NEGATIVE AFFECT

The aim of this investigation was to test for the existence of a relationship between SES and attention toward threatening stimuli. The conceptual basis for the current study was, in part, aimed at evaluating whether this association might operate as a link between social status and disorders of negative affect. However, in light of the limited findings in the current study, the association between lower social status and heightened risk for mood disorders may operate via a pathway separate from what was hypothesized here. Several potential mechanisms that may link social status to disorders of negative affect are discussed in this section.

It is possible that social threats do play a role in linking SES to disorders of depression and anxiety, albeit in a different manner than the social information processing mechanism hypothesized here. Children growing up in lower SES families experience more threatening and uncontrollable life events, such as family dissolution and household moves (Bradley & Whiteside-Mansell, 1997, Gad & Johnson 1980), and the chronic strain associated with persistent economic hardship and familial instability may contribute to diminished self-esteem and a low sense of personal control (Amato & Zuo 1992, Dohrenwend, 1990, Pearlin et al. 1981). Lower childhood SES has been associated with development of a pessimistic explanatory style (Finkelstein et al., 2007) suggesting that cognitive patterns linked to social origins may be carried throughout the life course. Some evidence indicates that these cognitive tendencies may operate as mediators of the relationship between SES and depression/anxiety. Deardorff, Gonzales, and Sandler (2003) found that generalized perceptions of control partially mediated a relationship between stressful events and depression in inner-city adolescents and children, and Chou and Chi (2001) showed that sense of personal control similarly mediated a relationship between recently experienced stressful life events and depression.

Speculation for a direct biological link between SES and disorders of negative affect stems from substantial evidence documenting an inverse relationship between SES and health, with individuals lower in SES experiencing higher rates of all-cause morbidity and mortality than individuals of higher social position. Considering the known links between negative affect and several medical illnesses, including diabetes, coronary artery disease, stroke, cancer, and Parkinson's disease (Anda et al., 1993; Barefoot & Schroll, 1996; Cassano & Fava, 2002; Kubzansky et al., 1997), it is possible that physical illness may play a role in the higher prevalence of depression and anxiety in lower SES groups. Also, considerable evidence supports a relationship between social status and health-impairing behaviors, including smoking (Adler, Boyce, Chesney, Folkman, & Syme, 1993; Bailis, Segall, Mahon, Chipperfield, & Dunn, 2001; Connolly & Kesson, 1996; Zang & Wynder, 1998), increased alcohol consumption (Bailis et al., 2001), lack of exercise (Adler et al., 1993; Ford et al., 1991; Evenson et al., 2002) and obesity (Sobal & Stunkard, 1989), behaviors which have been linked to heightened risk of affective disorders (Boden, Fergusson, & Horwood, 2010; Merikangas & Gelernter, 1990; Nurnberger, Foroud, Flury, Meyer, & Wiegand, 2002; Teychenne, Ball, & Salmon, 2010; Onyike et al., 2003). In addition, low SES individuals are more frequently exposed to pathogens and carcinogens (Adler et al., 1993), and some evidence indicates associations between exposure to hazardous chemicals and depression (Stallones & Beseler, 2002; Reif et al., 2003). Finally, evidence indicates that members of lower socioeconomic status groups use preventive health services less frequently (Adler et al., 1993) and tend to underuse or delay mental health treatment (U.S. Department of Health and Human Services, 1999) than do those of higher SES. Hence, physical illness, unhealthy behaviors, hazardous environmental conditions, and lack of treatment and/or preventative resources may serve as key links between SES and disorders of negative affect.

4.5 FUTURE DIRECTIONS

Despite the lack of support for our study hypotheses, the challenge of addressing socioeconomic disparities in mental health remains an important concern, and additional studies are needed to address limitations of available research. Prior evidence suggests that neuroimaging studies remain a fruitful area for continued study of the association between SES and negative affect. Socioeconomic disadvantage in children is associated with delayed development of the prefrontal cortex, which may result in later neurocognitive deficits (D'Angiulli, Herdman, Stapells, & Hertzman, 2008) that could, in turn, confer disadvantages in educational abilities and attainments. Slavich et al. (2010) noted that increases in tumor necrosis factor-alpha, in response to exposure to a social stressor, were associated with heightened activity in the dorsal anterior cingulate cortex and anterior insula, brain regions that have previously been associated with processing rejection-related distress and negative affect (Slavich, Way, Eisenberger, & Taylor, 2010). Lower subjective SES, independent of conventional SES measures, has been associated with with reduced gray matter volume in the perigenual area of the anterior cingulate cortex (ACC), a brain region involved in emotional experience and the regulation of behavioral and physiological reactivity to stress (Gianaros et al., 2007). Also, in addition to measuring the activation and/or volume of specific brain structures, the use of functional connectivity analysis may shed additional light on whether interactions between neuronal systems differ on the basis of social status. Future studies using neuroimaging techniques should prospectively investigate the role of both childhood and adulthood SES, including the role of community SES, on structural and functional brain alternations. Studies incorporating larger, more diverse samples are warranted. Prospective studies that include multiple assessments of SES, biological factors, and psychosocial variables will be important to address issues of timing and causality.

As evidence accumulates regarding the specific causes of social disparities in mental health disorders, research regarding interventions targeting those of lower socioeconomic standing remains an important strategy for reducing these inequalities. In addition to behavioral and cognitive therapeutic strategies and pharmacologic interventions, new methods for treating depression and anxiety are necessary. Despite the lack of findings relating SES to selective attention to threat, recent work using a modified version of the dot-probe task for the treatment of anxiety disorders make this task worthy of further study. Through repeated exposure to emotional stimuli (e.g. fearful or angry facial expressions) cognitive behavioral modification (CBM) is designed to alter a specific pattern of processing selectivity. Amir, Beard, Burns, and Bomyea (2009) reported the success of an extended CBM program, designed to reduce attentional bias to threat, in attenuating the symptoms of GAD, and Schmidt, Richey, Buckner, and Timpano (2009) presented similar results in participants with generalized social anxiety disorder.

Vulnerability to mood disorders is most likely a product of a complex interaction of individual and environmental factors. Social cognitive resources, by influencing how events are perceived, may exacerbate or ameliorate the behavioral and physiological responses to stress that lead to social gradients in mental health. However, although individual therapeutic interventions to manage mental health issues are worthy of continued study, psychosocial resources alone are unlikely to resolve issues of mental health disparities. Many researchers argue that attention should be directed toward fundamental causes of status-based differences in mental health, including inequitable distribution of wealth, restricted access to quality education, and concentrated poverty (Gallo & Matthews, 2003). Recent work emphasizes promoting cleaner and safer living environments (Vlahov & Galea, 2002), improving access to quality medical and mental health care for disadvantaged groups (Weech-Maldonado, Dreachslin, & Dansky, 2002), and reducing societal income inequalities (Kaplan, 2000). Risk-stratification based on socioeconomic position may enable health care professionals to target these interventions where they are needed most. School programs may promote resilience to stressful social events by incorporating components to reduce pessimism and increase optimism (Gillham & Reivich, 1999) or to minimize cognitive biases (Chen & Matthews, 2001) possibly reducing the psychological toll of socioeconomic disadvantage.

APPENDIX A

Table 1. Demographic characteristics for all participants.

Variable	Mean (SD) or %
Sex (% female)	41
Race (% white)	87
Age (years)	42.1 (7.8)
Married (%)	56
Smoker (% current)	12
Subjective SES (range 2 – 10)	6.2 (1.6)
Years School (9 – 24)	17.1 (2.7)
Family Income (1 – 15)	7.1 (3.2)
Mother's S-SES (2 – 10)	5.7(1.8)
Father's S-SES (2 – 10)	5.7(1.9)
Mother's Education (0 - 9)	3.6 (2.2)
Father's Education (0 - 9)	4.1 (2.8)

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 = < $10,000; 2 = $10,000-14,999; 3 = $15,000-24,999; 4 = $25,000-34,999; 5 = $35,000-49,999; 6 = $50,000-64,999; 7 = $65,000-79,999; 8 = $80,000-94,999; 9 = $95,000-109,999; 10 = $110,000-124,999; 11 = $125,000-139,999; 12 = $140,000-154,999; 13 = $155,000-169,999; 14 = $170,000-185,000; 15 = > $185,000. Subjective SES (S-SES): Individual's ranking of self in comparison to others in the U.S. - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother's and Father's S-SES: Participant ranking of PARENT'S socio-economic status (U.S. comparison),during childhood/adolescence - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother/Father education level achieved/completed before subject turned 18 yoa: (0 = no H.S. diploma, 1 = GED, 2 = H.S. diploma, 3 = Tech training, 4 = Some college, no degree, 5 = AS, 6 = BS, 7 = MS, 8 = MD/PhD 9 = unknown).

Table 2. Correlations between participants' demographic characteristics and socioeconomic indices.

	Sex **r**	**Race** **r**	**Age** **r**
Subjective SES	-.115	**-.261****	.039
Years School	-.017	**-.182***	.106
Family Income	-.090	**-.198***	**.187***
Composite SES	-.068	**-.239****	**.185***
Mother's S-SES	-.120	-.037	-.017
Father's S-SES	-.111	-.055	**-.195***
Mother's Ed. Level	**-.291****	-.090	**-.195***
Father's Ed. Level	**-.328****	**-.212***	**-.215***

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 = < $10,000; 2 = $10,000-14,999; 3 = $15,000-24,999; 4 = $25,000-34,999; 5 = $35,000-49,999; 6 = $50,000-64,999; 7 = $65,000-79,999; 8 = $80,000-94,999; 9 = $95,000-109,999; 10 = $110,000-124,999; 11 = $125,000-139,999; 12 = $140,000-154,999; 13 = $155,000-169,999; 14 = $170,000-185,000; 15 = > $185,000. Composite SES: re-standardized mean of z-score values of individual's years of education and family income of the two index variables for each individual. Subjective SES (S-SES): Individual's ranking of self in comparison to others in the U.S. - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother's and Father's S-SES: Participant ranking of PARENT'S socio-economic status (U.S. comparison),during childhood/adolescence - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother/Father education level achieved/completed before subject turned 18 y.o.: (0 = no H.S. diploma, 1 = GED, 2 = H.S. diploma, 3 = Tech training, 4 = Some college, no degree, 5 = AS, 6 = BS, 7 = MS, 8 = MD/PhD 9 = unknown).

*P < .05, **P < .01, † = point biserial correlation

Table 3. Relationships between all indicators of socioeconomic status.

	Years Education r	**Family Income** r	**Composite SES** r	**Subjective SES** r	**Mother S-SES** r	**Father S-SES** r	**Mother's Ed. Level** r	**Father's Ed. Level** r
Years Education	1							
Family Income	**.265****	1						
Composite SES	**.784****	**.806****	1					
Subjective SES	**.431****	**.508****	**.591****	1				
Mother's S-SES	**.313****	-.030	.173	**.252****	1			
Father S-SES	**.308****	.063	**.230****	**.293****	**.865****	1		
Mother's Ed. Level	**.288****	**.278****	**.357****	**.294****	**.358****	**.364****	1	
Father's Ed. Level	**.265****	**.302****	**.358****	.168	**.412****	**.490****	**.652****	1

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 = < $10,000; 2 = $10,000-14,999; 3 = $15,000-24,999; 4 = $25,000-34,999; 5 = $35,000-49,999; 6 = $50,000-64,999; 7 = $65,000-79,999; 8 = $80,000-94,999; 9 = $95,000-109,999; 10 = $110,000-124,999; 11 = $125,000-139,999; 12 = $140,000-154,999; 13 = $155,000-169,999; 14 = $170,000-185,000; 15 = > $185,000. Composite SES: re-standardized mean of z-score values of individual's years of education and family income. of the two index variables for each individual. Subjective SES (S-SES): Individual's ranking of self in comparison to others in the U.S. - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother's and Father's S-SES: Participant ranking of of PARENT'S socio-economic status (U.S. comparison),during childhood/adolescence - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother/Father education level achieved/completed before subject turned 18 yoa: (0 = no H.S. diploma, 1 = GED, 2 = H.S. diploma, 3 = Tech training, 4 = Some college, no degree, 5 = AS, 6 = BS, 7 = MS, 8 = MD/PhD 9 = unknown).

*P < .05, **P < .01

Table 4. Intercorrelations of attentional bias scores.

	Anger Bias Score **r**	**Fear Bias Score** **r**	**Happy Bias Score** **r**
Anger Bias Score	1	-----------	-----------
Fear Bias Score	**0.231****	1	-----------
Happy Bias Score	0.104	**0.182***	1

*P < .05, **P < .01

Table 5. Relationship of covariates and continuous SES indices with attentional bias scores.

Variable	**Bias Score r (Pearson)**		
	Anger	**Fear**	**Happy**
Sex (% female)	-0.16 †	0.01 †	-0.02 †
Race (% white)	**0.20*** †	0.10 †	-0.01 †
Age (years)	0.06	0.09	-0.05
Subjective SES	-0.11	0.03	0.09
Years School	0.09	0.13	0.11
Family Income	-0.01	0.08	-0.10
Composite SES	-0.01	0.10	0.13
Mother's S-SES	0.08	0.03	-0.06
Father's S-SES	-0.05	0.01	-0.03
Mother's Education Level	-0.06	-0.01	-0.02
Father's Education Level	-0.02	-0.12	0.03

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 = < $10,000; 2 = $10,000-14,999; 3 = $15,000-24,999; 4 = $25,000-34,999; 5 = $35,000-49,999; 6 = $50,000-64,999; 7 = $65,000-79,999; 8 = $80,000-94,999; 9 = $95,000-109,999; 10 = $110,000-124,999; 11 = $125,000-139,999; 12 = $140,000-154,999; 13 = $155,000-169,999; 14 = $170,000-185,000; 15 = > $185,000. Composite SES: re-standardized mean of z-score values of individual's years of education and family income. of the two index variables for each individual. Subjective SES (S-SES): Individual's ranking of self in comparison to others in the U.S. - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother's and Father's S-SES: Participant ranking of of PARENT'S socio-economic status (U.S. comparison),during childhood/adolescence - Scale 1-10 (1=bottom of ladder, people who are the worst off, 10=top of ladder, people who are the best off). Mother/Father education level achieved/completed before subject turned 18 yoa: (0 = no H.S. diploma, 1 = GED, 2 = H.S. diploma, 3 = Tech training, 4 = Some college, no degree, 5 = AS, 6 = BS, 7 = MS, 8 = MD/PhD 9 = unknown).

*P < .05, **P < .01, † = point biserial correlation

Table 6. Linear regression analyses, covarying for age, sex, and race, examining relationships between dichotomized family income and attentional bias scores.

	Anger Bias Score			**Fear Bias Score**			**Happy Bias Score**		
	B	**SE B**	**p**	**B**	**SE B**	**p**	**B**	**SE B**	**p**
Age	.318	.371	.393	.430	.660	.516	-.256	.595	.667
Sex	-10.899	5.780	.062	-.430	10.292	.967	-.603	9.270	.948
Race	8.778	4.928	.077	10.626	8.776	.228	-1.040	7.904	.896
Low vs. High Family Income	-13.870	7.843	.079	18.293	13.966	.193	-10.435	12.578	.408

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 (low) = < $35,000, 2 (high) = ≥ $35,000

Table 7. Linear regression analyses, covarying for age, sex, and race, examining relationships between dichotomized education and attentional bias scores.

	Anger Bias Score			**Fear Bias Score**			**Happy Bias Score**		
	B	**SE B**	**p**	**B**	**SE B**	**p**	**B**	**SE B**	**p**
Age	.312	.378	.412	.511	.671	.448	-.373	.600	.535
Sex	-11.197	5.849	.058	-.448	10.381	.966	-.191	9.286	.984
Race	10.091	4.909	.042	8.334	8.712	.341	.814	7.793	.917
Low vs. High Education	-6.015	7.885	.447	-1.629	13.993	.908	10.225	12.517	.414

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Education coded as: 1 (low) = < Associate's Degree, 2 (high) = ≥ Associate's degree or higher.

Table 8. Significant BOLD fMRI responses in the amygdala for all contrasts – whole brain peak level.

Contrast	MNI coordinates (x, y, z)	Cluster size	*T* score	*P* value
Anger > Shapes				
L. amygdala	-24, -6, -18	39	10.26	0.001
R. amygdala	22, -2, -20	38	10.78	0.001
Fear > Shapes				
L. amygdala	-22, -2, -20	39	9.56	0.001
R. amygdala	24, -2, -20	38	10.37	0.001
Happy > Shapes				
L. amygdala	-26, -2, -20	39	7.19	0.001
R. amygdala	No suprathreshold clusters			
Neutral > Shapes				
L. amygdala	-28, -2, -20	39	3.87	0.001
R. amygdala	22, 0, -18	38	8.31	0.001
Anger > Neutral				
L. amygdala	-26, -4, -20	34	3.23	0.001
R. amygdala	26, -2, -20	23	3.40	0.002
Anger > Happy				
L. amygdala	No suprathreshold clusters			
R. amygdala	28, 0, -20	26	2.84	0.003
Fear > Neutral				
L. amygdala	-24, -4, -18	28	3.54	0.001
R. amygdala	26, -6, -18	38	4.70	0.001
Fear > Happy				
L. amygdala	-28, -4, -18	30	2.06	0.021
R. amygdala	24, -2, -20	21	2.94	0.002
Neutral > Happy				
L. amygdala	No suprathreshold clusters			
R. amygdala	No suprathreshold clusters			

Note. Coordinates represent voxels in the amygdala with the most significant magnitude and spatial extent.
All reported statistical values are derived from a second-level random effects analysis using an uncorrected threshold of P < 0.05. L amygdala coordinates pre-set at -26, 0 ,-20; right amygdala coordinates pre-set at 24, -2, -20, extent threshold = 0, 10 mm amygdala sphere

Table 9. Intercorrelations between right and left hemisphere amygdala activation values for all affective conditions in contrast with reactivity to shapes.

	L Anger r	R Anger r	L Fear r	R Fear r	L Happy r	R Happy r	L Neutral r	R Neutral r
L Anger	1	-	-	-	-	-	-	-
R Anger	**.553****	1	-	-	-	-	-	-
L Fear	**.291****	.150	1	-	-	-	-	-
R Fear	**.203***	**.577****	**.521****	1	-	-	-	-
L Happy	**.330****	**.311****	**.591****	**.447****	1	-	-	-
R Happy	**.267****	**.573****	**.355****	**.668****	**.627****	1	-	-
L Neutral	**.414****	**.308****	**.391****	**.309****	**.278****	**.180***	1	-
R Neutral	**.205***	**.459****	**.260****	**.538****	**.253****	**.515****	**.548****	1

*P < .05, **P < .01

Table 10. Intercorrelations between significant right and left hemisphere amygdala activation values for threatening stimuli in contrast with reactivity to neutral facial expressions.

	L Anger r	**R Anger r**	**L Fear r**	**R Fear r**
L Anger	1	-	-	-
R Anger	**.409****	1	-	-
L Fear	**.359****	.095	1	-
R Fear	**.190***	**.511****	**.487****	1

*P < .05, **P < .01

Table 11. Intercorrelations between significant right and left hemisphere amygdala activation values for threatening stimuli in contrast with happy facial expressions.

	R Anger r	**L Fear r**	**R Fear r**
R Anger	1	-	-
L Fear	.046	1	-
R Fear	**.333****	**.472****	1

*P < .05, **P < .01

Table 12. Comparison of right and left amygdala activation values for each affective condition > shapes.

	Right **Mean (SD)**	**Left** **Mean (SD)**	**Statistic**	**p**
Anger	.65 (.77)	.39 (.55)	$t_{126} = 4.49$	.000
Fear	.62 (.75)	.39 (.61)	$t_{126} = 3.70$	.000
Happy	.53 (.69)	.38 (.53)	$t_{126} = 3.03$	.003
Neutral	.42 (.67)	.24 (.59)	$t_{126} = 3.49$	.001

Table 13. Comparison of amygdala activation values between contrast conditions.

	>Shapes **Mean (SD)**	**>Neutral** **Mean (SD)**	**Statistic**	**p**
Left Anger	.39 (.55)	.14 (,61)	$t_{126} = 4.65$	.000
Right Anger	.65 (.77)	.21 (.84)	$t_{126} = 6.92$	.000
Left Fear	.39 (.61)	.16 (.60)	$t_{126} = 4.74$	.000
Right Fear	.62 (.75)	.19 (.69)	$t_{126} = 7.14$	.000

Table 14. Relationship of demographic characteristics and right amygdala reactivity values.

Variable	Right Amygdala Activation to Angry Faces r (Pearson)			Right Amygdala Activation to Fear Faces r (Pearson)		
	Shapes	**Neutral**	**Happy**	**Shapes**	**Neutral**	**Happy**
Sex (% female)	-0.03 †	-0.01 †	0.06 †	0.04†	0.07†	0.16†
Race (% white)	**-0.17*** †	-0.13 †	-0.11 †	-0.07†	0.01†	0.02†
Age	0.02	0.04	-0.06	0.09	0.14†	0.05†

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.
*P < .05, **P < .01, † = point biserial correlation

Table 15. Relationship of demographic characteristics and right amygdala reactivity values.

Variable	Left Amygdala Activation to Angry Faces r (Pearson)		Left Amygdala Activation to Fear Faces r (Pearson)		
	Shapes	**Neutral**	**Shapes**	**Neutral**	**Happy**
Sex (% female)	0.10†	0.08†	0.07†	0.07†	**0.20***†
Race (% white)	-0.10†	-0.02†	0.04†	0.10†	0.07†
Age	-0.16	0.03	-0.06	0.05	-0.04

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.
*P < .05, **P < .01, † = point biserial correlation

Table 16. Relationship between continuous SES indices and right amygdala activation to angry facial expressions.

Variable	**Right Amygdala Activation to Angry Faces** **r (Pearson)** **Shapes**	**Neutral**	**Happy**
Subjective SES	0.03	-0.02	0.08
Years School	0.02	-0.01	0.06
Family Income	0.08	0.11	0.15
Composite SES	0.07	0.07	0.13
Mother's S-SES	-0.02	-0.15	-0.06
Father's S-SES	-0.01	-0.11	0.04
Mother's Education Level	.073	-.049	-.012
Father's Education Level	0.05	-0.03	-0.02

*P < .05, **P < .01

Table 17. Linear regression - association between dichotomized income and right amygdala activation to angry facial expressions.

Right Amygdala Activation to Angry Faces									
	Shapes			Neutral			Happy		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	.006	.009	.546	.005	.010	.630	-.007	.007	.330
Sex	.036	.143	.803	.044	.158	.783	.188	.110	.089
Race	-.239	.120	.049	-.107	.133	.423	-.127	.092	.170
Low vs. High Family Income	-.200	.193	.302	.063	.214	.769	.122	.148	.412

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 (low) = < $35,000, 2 (high) = ≥ $35,000

Table 18. Linear regression - association between dichotomized education and right amygdala activation to angry facial expressions.

	Right Amygdala Activation to Angry Faces								
	Shapes			Neutral			Happy		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	.004	.009	.669	.006	.010	.554	-.006	.007	.405
Sex	.044	.143	.758	.041	.158	.794	.182	.110	.099
Race	-.223	.122	.071	-.129	.135	.340	-.138	.093	.143
Low vs. High Education	.035	.194	.857	-.154	.214	.474	-.031	.149	.837

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Education coded as: 1 (low) = < Associate's Degree, 2 (high) = ≥ Associate's degree or higher.

Table 19. Relationship between continuous SES indices and right amygdala activation to fearful facial expressions.

Variable	**Right Amygdala Activation to Fear Faces r (Pearson)**		
	Shapes	**Neutral**	**Happy**
Subjective SES	-.004	-.010	.044
Years School	.093	.133	.160
Family Income	-.020	.037	.000
Composite SES	.044	.105	.098
Mother's S-SES	.132	.004	.113
Father's S-SES	.066	-.034	.120
Mother's Education Level	**.265****	.112	**.180***
Father's Education Level	.142	.024	.078

*P < .05, **P < .01

Table 20. Linear regression - association between dichotomized income and right amygdala activation to fearful facial expressions.

Right Amygdala Activation to Fear Faces									
	Shapes			**Neutral**			**Happy**		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	.013	.009	.165	.013	.008	.113	.000	.006	.959
Sex	.002	.140	.990	.041	.129	.749	.169	.094	.077
Race	-.130	.118	.273	-.021	.108	.847	.021	.079	.795
Low vs. High Family Income	-.376	.189	.050	-.172	.173	.323	-.036	.127	.777

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 (low) = < \$35,000, 2 (high) = ≥ \$35,000

Table 21. Linear regression - association between dichotomized education and right amygdala activation to fearful facial expressions

Right Amygdala Activation to Fear Faces									
	Shapes			**Neutral**			**Happy**		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	.009	.009	.317	.012	.008	.165	.000	.006	.950
Sex	.017	.142	.902	.048	.129	.708	.170	.094	.073
Race	-.087	.121	.475	.003	.110	.980	.036	.080	.652
Low vs. High Education	.176	.193	.364	.112	.174	.522	.113	.128	.379

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Education coded as: 1 (low) = < Associate's Degree, 2 (high) = ≥ Associate's degree or higher.

Table 22. Relationship between continuous SES indices and left amygdala activation to angry facial expressions.

Variable	**Left Amygdala Activation to Angry Faces r (Pearson)**	
	Shapes	**Neutral**
Subjective SES	-.057	-.086
Years School	-.013	.003
Family Income	-.012	.043
Composite SES	-.015	.030
Mother's S-SES	.017	-.085
Father's S-SES	.010	-.059
Mother's Education Level	-.038	-.074
Father's Education Level	.014	-.042

*P < .05, **P < .01

Table 23. Linear regression – association between dichotomized income and left amygdala activation to angry facial expressions.

Left Amygdala Activation to Angry Faces						
	Shapes			Neutral		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-.008	.007	.237	.001	.008	.854
Sex	.135	.103	.194	.089	.116	.444
Race	-.080	.086	.359	-.029	.098	.767
Low vs. High Family Income	-.109	.139	.435	-.054	.157	.732

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 (low) = < $35,000, 2 (high) = ≥ $35,000

Table 24. Linear regression – association between dichotomized education and left amygdala activation to angry facial expressions

Left Amygdala Activation to Angry Faces						
	Shapes			Neutral		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-.009	.007	.193	.001	.007	.875
Sex	.139	.103	.179	.092	.116	.430
Race	-.076	.088	.390	-.032	.099	.748
Low vs. High Education	-.021	.140	.882	-.050	.157	.750

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Education coded as: 1 (low) = < Associate's Degree, 2 (high) = ≥ Associate's degree or higher.

Table 25. Relationship between continuous SES indices and left amygdala activation to fearful facial expressions.

Variable	**Left Amygdala Activation to Fear Faces**		
	r (Pearson)		
	Shapes	**Neutral**	**Happy**
Subjective SES	-0.05	-0.09	-0.10
Years School	**-0.18***	**-0.20***	-0.09
Family Income	**-0.20***	-0.12	-0.10
Composite SES	**-0.23****	**-0.20***	-0.12
Mother's S-SES	0.15	0.01	0.02
Father's S-SES	0.12	0.02	0.03
Mother's Education Level	0.07	0.03	-0.09
Father's Education Level	0.03	-0.03	-0.06

*P < .05, **P < .01

Table 26. Linear regression – association between dichotomized income and left amygdala activation to fearful facial expressions.

	Left Amygdala Activation to Fear Faces								
	Shapes			**Neutral**			**Happy**		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-.003	.007	.635	.004	.007	.609	-.006	.005	.246
Sex	.092	.113	.417	.072	.111	.519	.187	.075	.014
Race	.039	.094	.681	.080	.093	.392	.089	.063	.160
Low vs. High Family Income	**-.439**	**.152**	**.004**	**-.335**	**.150**	**.027**	-.037	.101	.712

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Family Income (per year) coded as: 1 (low) = < $35,000, 2 (high) = ≥ $35,000

Table 27. Linear regression – association between dichotomized income and left amygdala activation to fearful facial expressions.

	Left Amygdala Activation to Fear Faces								
	Shapes			Neutral			Happy		
Variable	**B**	**SE**	**p**	**B**	**SE**	**p**	**B**	**SE**	**p**
Age	-.007	.007	.380	.002	.007	.824	-.006	.005	.187
Sex	.111	.116	.342	.087	.113	.444	.188	.075	.013
Race	.057	.099	.565	.085	.096	.382	.104	.064	.103
Low vs. High Education	-.063	.158	.688	-.127	.153	.409	.109	.101	.282

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American. Education coded as: 1 (low) = < Associate's Degree, 2 (high) = ≥ Associate's degree or higher.

Table 28. Linear regression – association between mother's education and right amygdala activation to fearful faces.

	Right Amygdala Fear vs. Shapes			**Right Amygdala Fear vs. Happy**		
	B	**SE B**	**P**	**B**	**SE B**	**P**
Step 1						
Mother's Education	**.079**	**.030**	**.010**	**.042**	**.020**	**.041**
Covariate Adjusted						
Age	.010	.009	.240	.000	.006	.951
Sex	.136	.138	.326	.263	.093	.006
Race	-.045	.113	.691	.019	.076	.800
Step 2						
Mother's Education	**.105**	**.031**	**.001**	**.060**	**.021**	**.005**

B reflects the estimated difference in amygdala activation associated with a 1 SD increase in Education.
Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.

Table 29. Linear regression - Predictors of left amygdala activation to fear faces

	Left Amygdala Fear > Shapes			**Left Amygdala Fear > Neutral**			**Left Amygdala Fear > Happy**		
	B	**SE B**	**P**	**B**	**SE B**	**P**	**B**	**E B**	**P**
Model 1a									
Years School	.112	**.056**	**.046**	**.120**	**.054**	**.028**	.036	.037	.341
Model 2a									
Family Income	**.118**	**053**	**.028**	.073	.052	.167	.041	.036	.254
Model 3a									
Composite SES	**-.147**	**.055**	**.008**	**-.122**	**.054**	**.025**	-.049	.037	.187
Model 1b									
Age	.005	.007	.521	.003	.007	639	.006	.005	.254
Sex	.098	.115	.394	.073	.112	.515	.186	.075	.014
Race	.028	.098	.777	.059	.095	.538	.084	.064	.192
Years School	.104	.058	.073	**-.116**	**.056**	**.041**	.020	.038	.592
Model 2b									
Age	.003	.008	.690	.003	.007	.642	-.005	.005	.279
Sex	.075	.116	.522	.064	.114	.575	.183	.076	.017
Race	.018	.099	.858	.071	.097	.469	.084	.065	.194
Family Income	-.018	.057	.060	-.067	.056	.233	-.005	.037	.676

Model 3b									
Age	-.002	.008	.788	.005	.007	.479	-.005	.005	.303
Sex	.071	.115	.538	.052	.112	.642	.182	.076	.018
Race	-.005	.099	.963	.040	.097	.679	.079	.065	.227
Composite SES	**-.142**	**.059**	**.018**	**-.122**	**.058**	**.037**	-.024	.039	.540

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.

Table 30. Nonlinear regression - predictors of amygdala activation to fearful faces.

	Right Amygdala Fear vs. Shapes			**Right Amygdala Fear vs. Happy**		
	B	**SE B**	**P**	**B**	**SE B**	**P**
Quadratic Term						
Mother's Education	.106	.068	.120	.031	.047	.503
Cubic Term						
Mother's Education	-.061	.052	.242	.005	.036	.894

B reflects the estimated difference in amygdala activation associated with a 1 SD increase in Education.
Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.

Table 31. Nonlinear regression - predictors of left amygdala activation to fear faces.

DV:	**Left Amygdala Fear > Shapes**			**Left Amygdala Fear > Neutral**			**Left Amygdala Fear > Happy**		
	B	**SE B**	**P**	**B**	**SE B**	**P**	**B**	**SE B**	**P**
Quadratic Term									
Years School	-.028	.038	.454	-.031	.036	.400	-.039	.025	.116
Family Income	.066	.037	.080	.061	.037	.104	-.010	.025	.702
Composite SES	.042	.038	.271	.037	.038	.324	-.009	.026	.741
Cubic Term									
Years School	.032	.029	.266	.061	.028	.030	.028	.019	.143
Family Income	-.030	.032	.351	-.067	-.020	.538	.008	.022	.711
Composite SES	-.011	.027	.672	.025	.026	.347	.003	.018	.849

Sex coded 1 = Male, 2 = Female. Race coded 1 = Caucasian, 2 = African American.

Table 32. Correlations between attentional bias scores and amygdala reactivity values to threatening facial expressions.

	L Anger > Shapes	**L Anger > Neutral**	**R Anger > Shapes**	**R Anger > Neutral**	**R Anger > Happy**	**L Fear > Shapes**	**L Fear > Neutral**	**L Fear > Happy**	**R Fear > Shapes**	**R Fear > Neutral**	**R Fear > Happy**
Anger Bias (ms)	.104	-.120	.012	-.108	-.052	**.191***	-.041	.100	.087	-.024	.113
Fear Bias (ms)	.092	.036	.112	.033	-.024	.037	.014	-.046	.062	.007	-.094
Happy Bias (ms)	.102	-.003	.021	.095	**.235****	**-.233****	**-.278****	.011	-.174	-.087	-.018

*P < .05, **P < .01

Table 33. Correlations between attentional bias scores and amygdala reactivity values to happy and neutral facial expressions.

	L Happy > Shapes	**R Happy > Shapes**	**L Neutral > Shapes**	**R Neutral > Shapes**
Anger Bias	**.249****	.063	**.232****	.125
Fear Bias	.135	.164	.020	.049
Happy Bias	**-.296****	**-.241****	.097	-.102

*P < .05, **P < .01

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