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Application of a cognitive neuroscience perspective of cognitive control to late-life anxiety

Sherry A. Beaudreau [a,*], Anna MacKay-Brandt [b], Jeremy Reynolds [c]

[a] The Sierra Pacific Mental Illness Research, Education and Clinical Centers (MIRECC), VA Palo Alto Health Care System and Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine, United States
[b] Department of Geriatric Psychiatry, Psychiatric Institute and Division of Cognitive Neuroscience, Columbia University School of Medicine, United States
[c] Department of Psychology, University of Denver, United States

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ABSTRACT

Recent evidence supports a negative association between anxiety and cognitive control. Given age-related reductions in some cognitive abilities and the relation of late life anxiety to cognitive impairment, this negative association may be particularly relevant to older adults. This critical review conceptualizes anxiety and cognitive control from cognitive neuroscience and cognitive aging theoretical perspectives and evaluates the methodological approaches and measures used to assess cognitive control. Consistent with behavioral investigations of young adults, the studies reviewed implicate specific and potentially negative effects of anxiety on cognitive control processes in older adults. Hypotheses regarding the role of both aging and anxiety on cognitive control, the bi-directionality between anxiety and cognitive control, and the potential for specific symptoms of anxiety (particularly worry) to mediate this association, are specified and discussed.

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1. Introduction

Although cognitive deficits in older individuals with depression have been the focus of numerous investigations, studies have only begun to investigate the relationship between anxiety and cognition. A small but growing literature has suggested there is a negative relationship between late-life anxiety and cognition. A recent critical review revealed weaker cognitive performance on effortful tasks among older adults with clinically significant anxiety symptoms compared with those with minimal or no symptoms (Beaudreau & O'Hara, 2008).

Recent theories (e.g., attention control theory; Eysenck, Derakshan, Santos, & Calvo, 2007) suggest that anxiety shifts cognitive resources away from goal-relevant information toward threat-focused information, and that this reallocation of resources leads to performance differences between anxious and non-anxious adults on cognitively demanding tasks. Converging evidence from multiple studies supports these theories by associating impaired cognitive control ability with self-reported anxiety (Beaudreau & O'Hara, 2009) and anxiety status in older individuals (Broomfield, Davies, MacMahon, Ali, & Cross, 2007; Mantella et al., 2007; see Price & Mohlman, 2007 for an alternative view). The term 'cognitive control' refers to processes associated with goal-directed behavior in a mechanistic definition of 'executive functions' (Miller & Cohen, 2001). The current review examines the relationship between late-life anxiety and cognitive control from cognitive neuroscience and cognitive aging perspectives. Independent roles for aging, anxiety and their interaction are proposed.

Notably, comorbidity of anxiety and depression is widespread in the older population (Hek et al., 2011). Depressive symptoms and episodes frequently coexist with clinically significant anxiety symptoms and generalized anxiety disorder (GAD) in older age (Mackenzie, Reynolds, Chou, Pagura, & Sareen, 2011; Richardson, Simning, He, & Conwell, 2011; Wolitzky-Taylor, Castriotta, Lenze, Stanley, & Craske, 2010). The pervasiveness of co-existing late-life anxiety and depression has led to interest in combinations of these symptoms, particularly major depressive disorder (MDD) with anxiety symptoms referred to as 'anxious depression.' This review therefore encompasses late-life investigations of cognitive control in adults with GAD and anxious depression.

Studies of late-life anxiety or anxious depression and cognition that focus on cognitive control typically examine how anxious older individuals deal with the interference associated with negative emotion. Interference is generally measured in studies of anxiety by incorporating emotional content into the standard Stroop paradigm (Stroop, 1935). Resultant effects reflect the impact of negatively valenced stimuli (MacLeod & Rutherford, 1992) and

* Corresponding author at: Palo Alto VA/Stanford University School of Medicine, Department of Psychiatry, MIRECC (151Y), 3801 Miranda Avenue, Palo Alto, CA 94304, United States. Tel.: +1 650 493 5000x64119.
E-mail address: sherryb@stanford.edu (S.A. Beaudreau).

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emotional conflict (i.e., incongruence of emotion words and faces vs. congruence; Etkin, Egner, Peraza, Kandel, & Hirsch, 2006) on cognitive control. Although the literature has focused predominantly on Stroop interference associated with anxiety, the issue can be conceptualized as a more general problem of how an individual minimizes the interference caused by task-irrelevant information. A cognitive neuroscience framework may prove useful for elucidating the relationship of interference effects and cognitive control.

'Top-down processing' is a term often used interchangeably with 'cognitive control processing' to describe voluntary control of attention (Hirsch & Mathews, 2012). Deficient top-down processing has been shown to increase processing of threat information, and thus represents one possible contributor to states such as pathological worry (Hirsch & Mathews, 2012), including generalized anxiety disorder (GAD; MacLeod & Rutherford, 1992, 2004). Others have argued against such claims by suggesting that threat evaluation occurs before top-down processes could influence processing (Mogg & Bradley, 1998). Recent behavioral and imaging data suggest a role for both top-down and bottom-up processing of information during effortful tasks performed while in an anxious state (Reeck, LaBar, & Egner, 2012). Thus, complex interactions between both top-down and bottom-up processing appear to influence processing of threat-related information. Narrowing the focus of investigation to such factors allows for more precision in elucidating the relationship between late-life anxiety and cognition. For example, normal aging affects late-life cognitive processing even in the absence of anxiety, and therefore, any interactions with anxiety must be considered above and beyond the independent effects of aging.

2. Cognition in normal aging

Older adulthood gives rise to notable complexity and change in emotional processing (Scheibe & Carstensen, 2010) and cognitive functioning (Bosworth & Schaie, 1999). Older adults are believed to show greater emotional wellbeing and emotional stability, increased orientation to positive stimuli (Scheibe & Carstensen, 2010), and greater complexity and differentiation of emotional response to negative stimuli than their younger counterparts (Beaudreau, MacKay, & Storandt, 2009). The extent to which these age-associated differences in emotional responses of healthy older adults applies to those with clinically significant anxiety or worry is unknown, although one recent study suggested that the age-related tendency toward a positivity bias dampens or reverses in the presence of anxiety (Price, Siegle, & Mohlman, 2012).

In contrast to positive changes associated with late-life emotional functioning, cognitive abilities decline with age. Older adults perform more poorly on a range of cognitive tasks compared with younger adults (Salthouse, 2010), with decrements corresponding to age-associated brain changes (Dennis, Kim, & Cabeza, 2008). Meta-analytic evidence suggests that age-related differences in simpler underlying processes, such as processing speed, explain some age deficits on cognitive control tasks (Verhaeghen, 2011). The impact of normal age-related cognitive changes in cognitive functioning coupled with anxiety or worry suggests that anxiety and aging pose a double jeopardy for reduced or impaired performance on measures of cognitive control.

Two cognitive aging theories propose direct mechanisms of age-associated cognitive control deficits: inhibition deficit theory (Hasher & Zacks, 1988; Lustig, Hasher, & Zacks, 2007) and goal maintenance theory (Braver & Barch, 2002; Braver & West, 2008). Inhibition deficit theory (Hasher & Zacks, 1988) posits that age-related cognitive deficits result from impaired inhibitory control of the contents of working memory in older age. These inhibitory deficits lead to increased 'mental clutter' and deficits in working memory and other complex task performance relying upon working memory processing. This theory is supported by observations of greater influence of task irrelevant information on cognitive performance among older adults compared to younger adults (Zacks, Hasher, & Li, 2000).

Goal maintenance theory posits that age-related performance deficits on tasks of cognitive control occur due to a decline in the use of context, internal representations of task-sets, or goals; and that dopaminergic dysfunction in the prefrontal cortex (PFC; potentially associated with the updating of working memory representations) accounts for this specific age-associated cognitive deficit (Braver & Barch, 2002). These competing theories, along with general speed of processing accounts (Salthouse, 2010), suggest that the cognitive control deficits observed in late-life anxiety are due to a breakdown in inhibitory control (Banich et al., 2009), a breakdown in other control processing necessary for goal maintenance, or are explained by general slowing. The ability to distinguish anxiety-related deficits from age-related deficits, or to detect their interaction, necessitates the dissociation of performance on tasks designed to assess specific cognitive mechanisms. In addition, the goal maintenance framework provides a biologically plausible account of how cognitive control deficits could occur within the PFC.

Behavioral investigations of late-life anxiety and cognitive control focus on two different but related types of anxiety—clinically significant anxiety and trait anxiety. Investigations of these variants implicate unique age-related effects of anxiety on cognitive control. Neuroimaging studies using tasks designed to measure aspects of cognitive control processes further support an age by anxiety interaction.

3. Late-life anxiety and cognitive control

Behavioral studies of clinically significant anxiety and cognitive control generally implicate increased interference on the Stroop task. Although increased interference is expected for both emotional and non-emotional versions of the Stroop task (Banich et al., 2009), Stroop performance in anxious older adults varies both by the version (emotional vs. neutral) and anxiety severity and type. Table 1 provides an overview of the results from late-life anxiety studies of cognitive control. As expected, negative emotion conditions revealed greater interference or reduced cognitive control compared with neutral emotion conditions in clinically anxious older adults. On the emotional Stroop task, older individuals with MDD with anxiety (vs. non-depressed and non-anxious controls; Broomfield et al., 2007) or high worry (vs. moderate or low worry; Price et al., 2012) demonstrated slower response times for negative words compared with neutral words. Overall, older individuals with clinical levels of anxiety, as determined by a *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text revision, American Psychiatric Association, 2000) diagnosis of GAD or MDD with anxiety, or based on elevated self-reported worry symptoms, may be predisposed to experience greater distraction to negative vs. neutral emotional stimuli.

Anxiety theories do not limit the prediction of cognitive control performance deficits to negative emotion conditions (Eysenck et al., 2007); therefore, such deficits are also expected on neutral cognitive control tasks. Higher levels of interference on the Stroop were associated with greater anxious arousal, but not associated with depressive symptoms in a sample of 102 community-dwelling older adults (Beaudreau & O'Hara, 2009). An analysis of 43 individuals with GAD indicated, however, that greater worry and greater trait anxiety were associated with *reduced* interference (Price & Mohlman, 2007). Anxious arousal and depressive symptoms were not significantly associated with Stroop performance in this sample. Differences noted between these two studies could