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Emotional Stroop Performance in Older Adults: Effects of Habitual Worry

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Abstract

Objective—In clinically anxious individuals, selective attention to negative cues in the environment may perpetuate a vicious cycle of emotional dysfunction. However, very little is known regarding the role of negative attentional bias in anxious older adults. There is evidence that in older adults without clinical anxiety, the opposite bias (toward positive, and away from negative, emotional material) is present. We explored how these age-related changes in emotional processing interact with anxiety.

Method—Sixty older adults (age 60+) completed the emotional Stroop (eStroop) task, a widely used measure of attentional bias which requires rapid identification of the color in which neutral and emotional words are printed. Participants were stratified into high-, mid-, and low-worry groups on the basis of a self-report measure, the Penn State Worry Questionnaire.

Results—The high-worry group exhibited a bias towards threat-related words, while the low- and mid-worry groups showed a bias away from threat-related words. By contrast, the low- and mid-worry groups showed a bias towards positive words, potentially consistent with an established positivity effect in older adults; while the high-worry group showed a bias away from positive items.

Conclusion—Older adults who worry frequently exhibit a pattern of eStroop performance that is broadly consistent with the younger adult literature, suggesting that selective attention towards threat-related information may be seen as a relevant factor in older, as in younger, anxiety.

Keywords

aging; attention; generalized anxiety; emotional Stroop

Introduction

Generalized anxiety disorder (GAD) is one of the most common psychiatric conditions in adults over the age of 60 (1, 2), with estimated prevalence rates as high as 9% (1, 3). The disorder is associated with significant public health burden in late life (4, 5). Furthermore, worry, the cardinal feature of GAD (6), is associated with increased psychiatric symptoms and decreased quality of life even when diagnostic criteria for GAD are not met (7).

Younger GAD patients presented with threat-related and neutral material are prone to attend selectively to threatening information (8). Cognitive models of clinical anxiety assume that this bias exists not merely as a by-product of anxious mood, but as a central contributor to

the development and maintenance of anxiety symptomatology, by reinforcing a tendency in anxious individuals to overestimate the danger present in feared situations (9). Thus, attentional bias is conceptualized as an important causal factor in anxiety. Recently, attentional bias has become an explicit target of treatment in younger anxiety patients, with early reports suggesting a powerful benefit for ‘attention training’ interventions designed to alleviate anxiety by building a more benign attentional profile through repeated practice (10).

One of the most widely used paradigms for assessing attentional bias is the emotional Stroop (eStroop) task (e.g., 11), which requires participants to identify the color of ink in which words of varying emotional content are printed. Increased color-naming reaction times during emotional words are interpreted as an index of biased attention, reflecting a tendency for emotional information to selectively capture attention under circumstances where such information is irrelevant to the task. A recent metaanalysis of attentional bias studies, including more than 70 eStroop studies, confirmed that attentional bias is a robust phenomenon in anxious samples comprised mostly of younger adults (8).

Cognitive aging and attentional bias

The impact of aging on anxious bias has received very little attention from researchers to date. Thus, for anxious older adults, the clinical relevance of attentional bias and ‘attention training’ interventions remains unclear. Although age-related decline in inhibitory control task performance has been documented (12), this decline does not affect the processing of all information equally. In fact, when presented with positive, negative, and neutral information, non-anxious older adults show a tendency to attend more closely to, and recall more accurately, the positive material, while negative material is less likely to be attended to or recalled (13). This *positivity effect* is predicted by Carstensen’s socio-emotional selectivity theory (14), which proposes that as individuals age and ‘time left’ becomes limited, goals shift toward the maintenance of emotional well-being, leading to biases in information processing.

The *positivity effect* literature raises the intriguing and little-studied question of how age-related shifts in emotional processing might interact with anxiety in producing an anxious older adult’s attentional profile. In the only published study to test the effect of anxiety on older adult eStroop performance, Fox and Knight (15) found that older adults with high trait anxiety showed the expected threat interference effect. However, this initial study did not include analyses of positive words, leaving open the critical question of whether or not observed interference effects were valence-dependent. Furthermore, this study used a heterogeneous sample based on generic trait anxiety, meaning that it likely included individuals with divergent anxiety presentations spanning a range of diagnostic categories as well as sub-clinical anxiety. No previous study has examined eStroop performance in relation to the specific symptoms of late-life GAD, the most prevalent anxiety disorder in older adults (1) and a disorder widely linked to eStroop effects in younger samples.

The eStroop is one of two attentional bias tasks that are well-validated and widely employed in studies of younger adults with anxiety (8). The other is the dot probe paradigm (16), which presents two visual stimuli simultaneously (e.g., neutral and threat-related) and then replaces one of the stimuli with a ‘dot probe’ that requires a motor response. Two previous studies using the dot probe task have found no evidence of increased attentional bias in older adults with elevated trait anxiety (15, 17), although an anxious mood induction did increase attentional bias as expected in one of these studies (15). In a more recent dot probe study, both pictures and words were used as stimuli, and each stimulus type was presented in both masked and unmasked format (18). Of these four conditions, the typical bias towards negative items in the high anxiety group was seen only in the condition using unmasked

words. These mixed findings may be attributable to the task design. Although it has been argued that the dot probe paradigm is a purer measure of visual attention than the eStroop (e.g., 19), the task provides only a 'snapshot' of attentional allocation at the moment the probe appears. Thus, results can be influenced by the experimenter's selection of an interval between emotional stimulus presentation and probe (20). The marked decreases in processing speed, and concomitant increases in inter-individual variability, that characterize older samples (21) may complicate the selection of such an interval, perhaps explaining the mixed and unexpected findings in older adult dot probe studies to date. By contrast, the eStroop is able to assess interference on whatever time frame is suited to the participant's overall processing speed. Thus, it could provide a more reliable measure of biased processing in older adults.

Aims, design, and hypotheses

The goal of the present study was to explore whether the robust eStroop findings from younger adult samples might be equally relevant in late-life GAD, using an analogue sample of older adults who frequently engage in worry. Based on the positivity effect literature, older adults reporting low or intermediate levels of worry were expected to show faster eStroop reaction times on threat trials, due to a hypothesized bias away from the processing of negative material, and slower reaction times on positive trials, when the inclination to process positive emotional meanings would become an obstacle to task completion. By contrast, it was posited that in older adults high on worry, a bias towards the processing of threat-related material would trump the positivity effect pattern. Thus, the high worry group was expected to exhibit increased reaction times to threat-related words as compared to neutral, while any pattern of interference from positive words was expected to be attenuated, or abolished entirely, in this group.

Methods

Participants

60 participants age 60 and over (mean = 67.9, range = 60–83) were recruited from an urban community in the northeast for a study of mood and attention. Flyers were placed in public venues frequented by seniors (libraries, senior centers, hospitals). On the basis of an initial phone screen, participants were excluded if they were not native English speakers; reported progressive brain disease, Alzheimer's disease, or history of stroke; were color blind; reported problematic drug or alcohol use in the 3 years prior to interview; or had any physical or motor difficulties that would impair their ability to press keys on a keyboard. After informed consent was completed, the Mini-Mental State Examination (MMSE; 22) was administered by Master's-level clinicians to ensure that gross cognitive ability was intact (score ≥ 25 ; 23) and the Wide Range Achievement Test reading subscale (WRAT-III; 24) was completed to ensure a minimum of an 8th grade reading level. Visual acuity at close distances (40 cm) was assessed with a Precision Vision Numbers Near Vision Card. Participants were allowed to wear vision-correcting glasses or contact lenses during the test, provided that they kept them on during the experimental tasks. Participants scoring below a cut-off point of .8 (20/25 vision) were excluded from participation. Two prospective participants were excluded because of inadequate near vision; all other participants met all eligibility criteria and were included in the final sample.

Procedure

Eligible participants completed a short questionnaire surveying health and demographic information. For the remainder of the session, they were seated comfortably in front of a computer screen positioned approximately one foot from the participant, at eye level. They completed the eStroop task, followed by a battery of computerized self-report symptom

questionnaires, and concluded with a series of word ratings. Participants were paid \$20 for a visit lasting roughly one hour. All procedures were approved by the Institutional Review Board.

Symptom measures

Clinical measures including the Penn State Worry Questionnaire (PSWQ; 25), the Geriatric Depression Scale (GDS; 26), and the Beck Depression Inventory (BDI; 27) were administered by computer. All symptom measures have been validated for use with older adults (28, 29).

Post hoc group assignment to the high-worry ($n = 20$), mid-worry ($n=19$), and low worry ($n = 21$, uneven n 's due to a tie score) groups were made taking the top, middle, and bottom third of scorers on the PSWQ. The PSWQ assesses the frequency, severity, and uncontrollability of worry, the cardinal feature of GAD. Thus, this procedure was intended to produce a late-life GAD analogue sample and two non-anxious control groups. Of note, 90% of participants in the high-worry group scored at or above a PSWQ score of 50, an empirically derived cut-off score that has been shown to maximize sensitivity and specificity in determining the presence of late-life GAD in a geriatric sample (30, 31). There were no statistically significant differences between the groups on a range of demographic, health-related, and cognitive variables, with one exception (household income, which was lower in the mid-worry group). Demographic and clinical characteristics of the three groups are summarized in Table 1.

Emotional Stroop task

The emotional Stroop (eStroop) task was administered individually in a quiet room on a Dell GX270 computer using Inquisit software. The task required participants to indicate the color of each word presented as quickly as possible via button press. Key-press responses were used because we sought to develop and validate an eStroop task that would be useful in future neuroimaging studies, where head motion is often restricted. Words were printed in red, green, tan, or blue ink.¹ Participants responded by pressing the appropriate keyboard button using their right (red) or left (green) first finger or right (tan) or left (blue) second finger. Each trial began with a 1000 ms fixation crosshair followed by a word presentation. Words remained on screen until a response was made. Prior to the task, participants completed 100 practice trials, comprised of colored XXXXs, with corrective feedback, to overlearn response key mapping. reaction time asymptote was reached within the first 10 practice trials. To maximize effect sizes (8), the trials were presented as alternating blocks of emotional and neutral words—16 words/block, 8 blocks/run. Two runs were completed: a negative-neutral run and a positive-neutral run. The order of runs (positive or negative) and initial blocks in a run (emotional or neutral) was counterbalanced across all participants.

Stimuli

The eStroop word lists were developed for use with younger adult samples (32). The positive, negative (threat-related), and neutral word lists were matched for word length, frequency, and emotionality (positive and negative words only). The negative word list consisted of general threat-related terms (e.g., “emergency,” “cancer,” “sneer”). As older and younger adults may differ in perceptions of valenced stimuli (33), a stimulus validity check was performed following the eStroop and symptom questionnaires. Participants made valence and arousal ratings for each word by selecting a rating on a 7-point scale with verbal

¹A simpler 2-color eStroop task was completed prior to the 4-color task. This task failed to produce significant effects of group, valence, or group X valence on reaction time. See Supplemental Digital Content for further information and discussion.

anchors (e.g., “extremely pleasant,” “extremely unpleasant”) in response to two questions: “How pleasant is this word?” and “How emotionally arousing is this word?” Valence ratings confirmed that positive, negative, and neutral words were perceived as intended by participants in each group. Arousal ratings were also largely consistent with intentions. However, a group difference emerged in the arousal ratings for negative words ($F_{2,57}=3.33$, $p=.04$), which were rated more arousing by the high-worry group in comparison to the low-worry ($t_{39}=2.27$, $p=.03$) and mid-worry ($t_{37}=2.44$, $p=.02$) groups.

Data analysis

Trials with incorrect color identification responses (1.4% of all trials) were excluded prior to analysis of reaction time data. Error rates did not exceed 8% for any individual. Error rates did not differ significantly as a function of group, valence, or group X valence (p 's $> .13$). Reaction time outliers were removed using a Winsorizing procedure (34), a robust statistical technique in which the highest and lowest 1% of reaction times (across all participants) were replaced with the next highest and lowest values in the distribution of scores, respectively. This procedure resulted in a distribution of reaction times ranging from 359 to 3527 ms. For ease of interpretation and to circumvent inhomogeneity of variance obtained in the reaction time data from individual valence types, reaction time bias scores were calculated separately for each run by subtracting each participant's mean reaction time to the neutral words in a given run from his/her mean reaction time to the emotional words in the run. All significance tests were two-tailed with α set at .05.

Results

Mean Winsorized reaction times and reaction time bias scores for each group are presented in Table 1 as a function of valence. Mean reaction times averaged across all valences did not differ as a function of group ($F_{2,57}=0.47$, $p=.63$). A 3×2 ANCOVA with group (low-worry vs. mid-worry vs. high-worry) as a between-subjects variable, valence (negative run vs. positive run) as a within-subjects variable, order of blocks (emotional or neutral first) and runs (negative-neutral or positive-neutral first) as covariates, and bias scores as the dependent measure revealed a significant group X valence interaction ($F_{2,55}=6.78$, $p=.002$, partial $\eta^2=.20$; Figure 1). Within-group pairwise comparisons based on estimated marginal means showed that the high-worry group showed larger bias scores during the negative than the positive run (paired $t_{19}=2.5$, $p=.02$, $d=.76$), while the mid-worry group (paired $t_{18}=2.2$, $p=.04$; $d=.55$) showed larger bias scores during the positive than the negative run. The low-worry group showed a similar pattern to the mid-worry group, but the difference between bias scores was not significant (paired $t_{20}=2.0$, $p=.056$, $d=.47$). Between-group comparisons of estimated marginal means revealed that negative run bias scores were larger in the high-worry group than the low-worry group ($t_{39}=2.2$, $p=.03$, Cohen's $d=.67$), while the mid-worry group did not differ from the other groups (p 's $> .19$). Positive run bias scores were larger in both the low-worry group ($t_{39}=2.1$, $p=.04$; $d=.72$) and mid-worry group ($t_{37}=3.3$, $p=.002$; $d=1.00$) in comparison to the high-worry group, while the low-worry and mid-worry groups did not differ ($t_{38}=1.2$, $p=.22$; $d=.43$). The significance and pattern of the 2-way interaction (group X valence) described above was not altered by including depression scores (BDI or GDS), arousal ratings for negative words, income level, or age as additional covariates in the model.

Discussion

In a sample of older adults with high worry scores, the eStroop task elicited increased reaction times on threat-related words as compared to neutral. During a positive-neutral task run, the high worry group showed a bias *away* from positive words, confirming that the interference effect seen during the negative run was not a function of generic emotional

arousal. Older adults with low and intermediate worry scores showed the opposite pattern (faster responses during threat words than neutral, and slower responses during positive words than neutral), potentially consistent with the *positivity effect* found previously in older adult samples.

Previous eStroop studies using younger anxious samples have documented bias scores roughly in the range of 20 to 45ms with an average between-groups effect size of $d = .45$ (8). Thus, our findings are broadly consistent with the extensive younger adult literature, and suggest that selective attention towards threat-related information may be seen as a relevant factor in older, as in younger, anxiety. Furthermore, these findings show that older adults' information processing is modulated by worry, a variable typically not assessed in basic cognitive neuroscience or cognitive aging research. Future research on cognitive function in late-life might benefit from consideration of this and other anxiety variables.

Optimal performance on the eStroop task requires directing visual attention toward a word while simultaneously inhibiting the processing of its emotional meaning. Although some have argued for a general decline in inhibitory control ability exhibited across the life span (e.g., (35, 36), our results confirm that any such decline does not effect the processing of all information equally. In the case of non-anxious older adults, negative information was more successfully inhibited than neutral, while positive information created the largest degree of interference. In older adults with high levels of worry, this pattern was reversed. Unexpectedly, anxious older adults exhibited not only task interference from negative material but also task facilitation during positive words as compared to neutral. Although positive material has not been widely included in studies of anxious attentional bias, a metaanalytic finding from a small group of attentional bias studies in anxious younger adults was consistent with our finding (37) and may suggest that a cognitive bias towards 'discounting the positive' is an important feature of chronic anxiety across the lifespan.

The present findings are consistent with a growing literature documenting selective attention to threat in anxious older adults (15, 18), although not all studies have been positive (17). Furthermore, the findings to date have suggested that attentional bias in late life is a fragile phenomenon that can be reversed by a range of procedural variables. Stimulus duration (masked or unmasked), stimulus modality (pictures or words), participants' mood state (neutral or negative), the specific paradigm used (eStroop or dot probe), and the severity of participant anxiety (moderate or high levels) have all been shown to influence the presence or absence of attentional bias in the limited older adult studies available to date (15, 18). It is possible that in older adults, increased heterogeneity in attentional control leads to decreased reliability of attentional bias effects across samples and experiments. Age-related changes in cognition might also complicate the conditions and time frame under which attentional bias occurs. Another possibility in reconciling the younger and older adult findings is that the ostensibly robust pattern of bias seen in the younger adult literature may suffer from a substantial "file drawer" problem that masks the true heterogeneity of findings due to publication bias. Given the severely limited literature on attentional bias in late life, many more studies of older adults will be needed before direct comparisons to the younger adult literature can be made.

Limitations

A limitation of the present study is the lack of a younger adult comparison group, which limits conclusions regarding the age-specificity of findings. The generalizability of the present findings may be limited by the use of an analogue rather than a clinical sample, and by specific older adult cohort characteristics including high overall cognitive ability and good health. Furthermore, although widely used as a measure of selective attention in the psychopathology literature, the eStroop task has been criticized for being a relatively impure

index of attentional processes. eStroop interference may best be viewed as a general index of differential processing in anxious individuals, rather than as a measure of bias localized to the visual attention system specifically. The eStroop was selected for the present study because its effects are well established in younger adults and because it provides an index of biased processing that is unlikely to be undermined by heterogeneity in older adults' overall processing speed. Future studies should incorporate multiple indices of attention to arrive at a more nuanced understanding of the nature and time course of biased processing in late-life anxiety samples.

Conclusions

In summary, the present study suggests that older adults who routinely worry exhibit selective processing of threat-related material, while older adults who worry less often show a bias away from threat processing. The pattern in each group was entirely reversed when positive material was presented. Thus, the positivity effect believed to characterize emotional processing in older adults appears to be eradicated in the context of pathological levels of worry, leaving an attentional profile similar to that seen in younger adult GAD. Biased processing of emotional material may contribute to the maintenance of anxious beliefs and behaviors over time and thus may constitute an attractive target for treatment (10). Attentional bias is therefore an important and clinically relevant feature of late-life anxiety that warrants further study.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Reaction time bias scores for the negative and positive eStroop runs in older adults in the low-worry group (gray bars), mid-worry group (white bars) and high-worry group (black bars). Bias scores calculated as an individual's mean reaction time on emotional (threat or positive) trials minus his/her mean reaction time on neutral trials from the same run. Larger bias scores indicate more interference from emotional words during a given run, while bias scores less than zero indicate task facilitation during emotional words. Data represent estimated marginal means based on a group X valence ANCOVA covarying the order of blocks (emotional or neutral first) and runs (negative-neutral or positive-neutral first). Vertical bars represent SEM. Dashed lines indicate significant pairwise differences.

Table 1

Descriptive statistics, mean Winsorized reaction times, and bias scores for high-worry, mid-worry, and low-worry samples

<i>Descriptive variables</i>	High-worry (n=20)	Mid-worry (n=19)	Low-worry (n=21)
Age	67.2 (6.2)	68.5 (6.4)	68.3 (5.6)
Female	16 (80%)	12 (63%)	15 (71%)
Caucasian	16 (80%)	15 (79%)	18 (86%)
Education (years)	16.1 (4.2)	15.2 (2.7)	15.5 (2.3)
Household income (median)	\$61–75,000	\$15–30,000	\$61–75,000 ^a
Medications	2.8 (2.7)	3.3 (2.2)	2.6 (3.9)
Medical problems	1.8 (1.9)	1.8 (1.7)	1.3 (1.7)
Vision (median)	20/16	20/16	20/16
MMSE	28.8 (1.2)	28.4 (1.3)	28.6 (1.1)
WRAT reading level (median)	Post High School	Post High School	Post High School
PSWQ	56.9 (8.3)	41.1 (3.7)	28.0 (4.9) ^b
# with PSWQ 50	18 (90%)	0 (0%)	0 (0%)
BDI	11.0 (4.1)	8.5 (7.1)	4.7 (4.6) ^c
GDS	4.9 (3.4)	3.5 (3.9)	2.5 (3.5)
<i>Winsorized reaction times</i>			
Negative Run: Threat words	994.82 (192.49)	1016.63 (245.8)	1055.85 (400.0)
Negative Run: Neutral words	967.62 (207.8)	1027.43 (293.1)	1085.12 (407.7)
Positive Run: Positive words	950.04 (133.6)	1031.55 (278.7)	1058.92 (375.3)
Positive Run: Neutral words	982.32 (178.0)	987.76 (234.3)	1044.54 (355.8)
<i>Reaction time bias scores</i>			
Negative Run (threat-neutral)	27.20 (82.4)	-10.79 (85.3)	-29.27 (87.1)
Positive Run (positive-neutral)	-32.28 (73.1)	43.79 (79.6)	14.38 (56.3)

Note. Data presented as mean (SD) unless otherwise noted. Vision assessed with the Precision Near Vision Test at 40 cm distance; MMSE = Mini Mental State Exam; WRAT = Wide-Range Achievement Test, Reading subtest; PSWQ = Penn State Worry Questionnaire; BDI = Beck Depression Inventory; GDS = Geriatric Depression Scale. Bias scores calculated for each participant as the mean reaction time on all negative or positive trials minus the mean reaction for neutral trials from the same run only. Larger (more positive) bias scores indicate greater interference from emotional words, whereas negative bias scores indicate facilitation of task performance during emotional words.

^a χ^2 test comparing high-, mid- and low-worry groups: $\chi^2/df=24.0$, $p<.05$

^b ANOVA comparing high-, mid- and low-worry groups: $F_{2,57}=120.1, p<.001$

^c ANOVA comparing high-, mid- and low-worry groups: $F_{2,57}=5.4, p<.01$

No other between-group comparisons were significant.