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Attentional Bias to Reminders of the Deceased as Compared With a Living Attachment in Grieving

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ABSTRACT

BACKGROUND: Grieving individuals demonstrate attentional bias toward reminders of the deceased versus neutral stimuli. We sought to assess bias toward reminders of the deceased versus a living attachment figure and to evaluate similarities and differences in the neural correlates of deceased- and living-related attention. We also sought to identify grief process variables associated with deceased-related attentional bias.

METHODS: Twenty-five subjects grieving the death of a first-degree relative or partner within 14 months performed an emotional Stroop task, using words related to a deceased or a living attachment figure, and a standard Stroop task, to identify general selective attention, during functional magnetic resonance imaging. Subjects rated word sadness, complicated grief symptoms, depression severity, attachment style, emotional pain, nonacceptance, yearning, and intrusions.

RESULTS: We identified an attentional bias to deceased-related versus living-related words, independent of age, depression severity/history, loss type, word sadness, medication use, and time since loss. Attentional bias correlated with complicated grief severity and intrusive thinking. A conjunction analysis identified joint activation in the fusiform gyrus, posterior cingulate, and temporal parietal junction across living- and deceased-related attention versus general selective attention. Insecure-avoidant attachment style correlated with decreased engagement of this network in deceased-related attention.

CONCLUSIONS: We have demonstrated an attentional bias to reminders of the deceased versus a living attachment in grieving. Overlapping neural circuits related to living- and deceased-related attention suggest that the bereaved employ similar processes in attending to the deceased as they do in attending to the living. Deceased-related attentional bias appears to be linked primarily to intrusive thinking about the loss.

Keywords: Attachment, Attention bias, Complicated grief, Fusiform, Grieving, Intrusive thinking

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During the first year following the loss of a loved one, reminders of the deceased occupy attention and provoke thinking about the loss (1). This salience has been operationalized as attentional bias, the unintentional and disproportionate allocation of attention to reminders of the deceased versus neutral stimuli, and related to the pathological grief response known as complicated grief (CG) (2–5).

It remains unclear if attentional bias to reminders of the deceased versus neutral stimuli reflects a bias to the deceased specifically or a more general process of emotional attachment seeking. Close attachment relationships evoke attention regardless of whether the individuals are living or deceased (6,7). Attentional biasing toward attachment reminders may also reflect attention toward the predominant emotions related to that attachment (8), such as sadness in the case of grieving. We therefore sought to demonstrate a bias to reminders of the deceased as compared with a living attachment and to demonstrate the independence of this bias from sadness evoked by reminders of the deceased and living attachments.

Prior studies have correlated attentional bias to CG (3,5). However, CG is an amalgam of cognitive, emotional, and functional processes related to grieving (9). Intrusive thinking, nonacceptance, yearning, and emotional pain are all core components of CG (10). People who do not accept the loss, lack control over the contents of their mind, or are overcome with pain or yearning may all demonstrate greater bias to the deceased. It is unknown which, if any, of these components demonstrates a specific relationship with attentional bias. For this reason, we tested the role of all four grief process variables, as well as CG, in attentional bias.

We next sought to determine the degree of similarity or difference in the processes underlying attention to the deceased and to a living attachment. Freud's grief work hypothesis states that the bereaved must sever their connections with the deceased during grieving in a process of decathexis that is unique to loss and grieving (11). By contrast, the attachment theory of grieving suggests that the bereaved reform and restructure their relationship with the deceased so that it may continue to exist in the postdeath reality (12–17). Accordingly, a relationship with the deceased may be maintained in much the same way that a relationship with a living attachment exists (15). This latter perspective would imply

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greater similarity between attention to the deceased and attention to living attachments.

Prior functional magnetic resonance imaging (fMRI) studies have shown increased rostral anterior cingulate and orbital frontal cortex engagement in deceased versus neutral attention in bereaved versus nonbereaved subjects, as well as altered frontal-limbic connectivity related to intrusive thinking in grieving (2,4). These findings suggest unique neural substrates for deceased-related attention. However, the comparison of neural activity across the deceased and neutral conditions may correspond to processing emotional attachments in general. It remains unclear if the bereaved would process living and deceased attachments in a similar or different way. Therefore, we used fMRI to evaluate common or separate neural circuitry underlying deceased-related versus living-related attention. The continuing bonds model, as compared with decathexis, has gained significantly greater research greater support (12–17). We therefore expected to find greater similarity rather than difference in neural correlates of living- and deceased-related attention.

We administered an emotional (8) and cognitive (18) Stroop task during fMRI to grieving subjects. The emotional conditions comprised deceased-related words and living-related words. The emotional Stroop task measures attentional bias to reminders of the deceased because it pits task instructions (i.e., respond as fast as possible) against the tendency to focus on reminders of the deceased or living attachment, which would slow reaction time (RT). It is therefore more likely to tap into control impairments characteristic of CG. The cognitive Stroop task allows for the comparison between neural activity associated with attachment-related attention in the deceased and living-related conditions and general selective attention.

METHODS AND MATERIALS

Subjects

We recruited 25 people bereaved of a first-degree relative or partner within the past 3 to 14 months. Subjects were between 18 and 65 years of age, had normal color vision, and spoke English as a first language. Subjects were recruited as part of a broader study of suicide bereavement. Recruitment was done through social media websites and contacting people listed as relatives in obituaries. Nineteen of these 25 people were bereaved of a loss by suicide while the others were bereaved of a nonsuicide death. While time since loss ranged from 3 to 14 months, no subjects were interviewed or scanned during the 12th month. This was done to avoid anniversary reactions.

All subjects were medically healthy as determined by medical history, examination, and standard blood and urine tests. Exclusion criteria were manic episode within the past year, current substance use disorder (i.e., met criteria within past 6 months), current obsessive-compulsive disorder, lifetime schizophrenia or schizoaffective disorder assessed with the Structured Clinical Interview for DSM-IV Axis I Disorders (19). Psychiatric medication use was required to be stable for 2 weeks prior to scanning. The New York State Psychiatric Institute Institutional Review Board approved this study and all subjects gave written informed consent.

Procedure

Subjects underwent a prescan interview, an MRI scan, and then a postscan interview. Both interviews always occurred within 1 week of the scan. During the prescan interview subjects presented a living person with whom they had a similar relationship as they did with the deceased. Subjects provided 15 deceased and 15 living-related words. Word valence was rated as follows: 1 (very sad), 2 (sad), 3 (neutral), 4 (happy), and 5 (very happy). To produce a sadness rating, emotion ratings were recoded as follows: 4 or 5 = 0, 3 = 1, 2 = 2, and 1 = 3. During the postscan interview subjects completed all structured interviews and questionnaires.

Measures

CG severity was measured with the Inventory of Complicated Grief (ICG) (Cronbach's α = .85) (1,20), which consists of 19 Likert-type items measuring frequency of complicated grief symptoms on a scale of 0 (never) to 4 (always). Yearning was measured by a single item asking subjects how much they yearn for their loss on a scale of 1 to 10, with 10 being the most (4,21). Emotional pain and nonacceptance were measured through the emotional pain and nonacceptance factors of the Texas Revised Inventory of Grief (emotional pain: α = .75; nonacceptance: α = .75) (22). Intrusive thinking was measured with the intrusion subscale of the Impact of Event Scale–Revised (α = .74) (23). The Impact of Event Scale–Revised is a 21-item scale measuring distress related to symptoms of posttraumatic stress in the past seven days on a scale of 0 = Not at all to 4 = Extremely. Depression severity was measured with the Center for Epidemiologic Studies Depression short scale (α = .83) (24) and the Beck Depression Inventory (α = .83) (25). Avoidant attachment style was measured with the avoidant-attachment subscale of the Adult Attachment Scale (26), on which higher scores (0–7) indicate more avoidant attachment. This scale was introduced after the start of the study and only completed by 17 subjects. The total count of major depressive episodes was determined as part of the Structured Clinical Interview for DSM-IV Axis I Disorders interview. Psychiatric medication use was coded as a binary variable indicating the presence or absence of current medication use.

Stroop Task

During the scan, subjects completed four runs of a cognitive and emotional Stroop task. Each run consisted of four blocks of words: deceased, living, congruent, and incongruent. The design for the Stroop task is presented in Figure 1. In all blocks, subjects were presented with words and instructed to identify the color of the word font as fast as possible using a right hand–held button box. Training was conducted until subjects reached 100% accuracy and speed of color-button pressing dropped to under 1 second for 10 consecutive practice trials. All 15 words were presented for 1.5 seconds and followed by a randomly jittered fixation cross averaging 2 seconds. A 10-second fixation cross was presented in between each block. Word presentation and color pairings were randomized within a block and block order was permuted across runs.

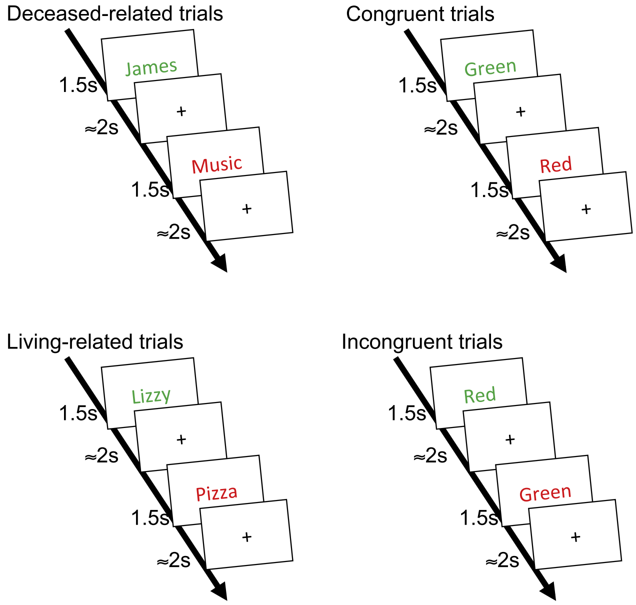

Figure 1. Design of the emotional and cognitive Stroop task. Stimuli were presented using a mixed block-event design presenting words of each condition in a unified block with intertrial jitter allowing for trial-level analyses. Deceased- and living-related trials presented reminders of the deceased and a living attachment figure provided a week before the scan by the subject. Color-congruent and color-incongruent trials comprised standard Stroop conditions.

Imaging

Blood oxygen level–dependent (BOLD) images were acquired on a GE 3T scanner (Discovery MR750; GE Healthcare, Milwaukee, WI) parallel to the anterior commissure-posterior commissure line with a T2*-weighted echo-planar imaging sequence of 45 contiguous slices (repetition time = 2000 ms, echo time = 25 ms, flip angle = 77°, field of view = 192 mm × 192 mm) of 3-mm thickness and 3 × 3 in-plane resolution. Structural images were acquired with a T1-weighted spoiled gradient sequence recording 256 slices at a slice thickness of 1 mm and in-plane resolution of 1 mm × 1 mm.

Preprocessing

Preprocessing included slice time correction, motion correction, 120-second high-pass filter, bias field correction, skull stripping, and smoothing with a Gaussian kernel of 6 mm full width at half maximum. Functional images were registered to structural images with seven degrees of freedom and then structural images were warped to the standard Montreal Neurological Institute space using a 12° affine registration implemented in FLIRT (27). Seven degrees of freedom for the initial warp provided better registration than six degrees. Originally a nonlinear warp was also applied in FNIRT (28). However, visual inspection revealed that this registration failed for one subject and thus the linear registration was used.

Attentional Bias

RT data were analyzed using SPSS version 22 (IBM Corp., Armonk, NY). RTs were log transformed to reduce the effects of outliers. Linear mixed models included a subject-specific random intercept and run number (1–4) and trial number (1–15) as fixed covariates. Error trials were excluded.

To identify an attentional bias to deceased relative to living-related words we entered condition type (i.e., deceased related, living related) as a fixed effect predicting RT. This analysis was repeated while covarying for word-evoked sadness, age, current depression symptom severity (Beck Depression Inventory and Center for Epidemiological Studies–Depression short scale), psychiatric medication use, and the number of prior major depressive episodes.

Attentional Bias and Grief Processing

We sought to evaluate the respective relationships between attentional bias and grief process variables of emotional pain (Texas Revised Inventory of Grief), nonacceptance (Texas Revised Inventory of Grief), yearning (1–10 rating), and intrusive thinking (Impact of Event Scale–Revised), as well as general CG severity. For each variable a separate mixed effects model was calculated to test the interaction of condition type (deceased, living) and the grief process variable on RT. Significance threshold was set to $p < .01$ to Bonferroni correct for five analyses.

Neural Circuitry of Attentional Bias

BOLD signal was analyzed using FSL (29). We were primarily interested in determining whether separate or similar neural systems exist for deceased- and living-related attention. To do this we first sought to identify neural signal corresponding to deceased- and living-related attention independently. Simply identifying activity associated with deceased- and living-related trials might yield clusters involved in reading the words, but not necessarily attending to them. We therefore modeled the length of the presentation of each word at each trial (i.e., 1.5 seconds) to account for activation relating to reading and interpreting Stroop task words. A trial-level parametric regressor was then used to model RT. The first-level fMRI analysis identified the correlation between each voxel's BOLD activity and attention to the deceased or living figure as measured by the trial-level RT regressor. Subject-level fixed-effects analyses identified parameter estimates for the relationship between voxelwise BOLD activity and RT for each person condition (i.e., deceased related [BOLD × RT] or living related [BOLD × RT] across runs).

We next sought to determine the degree of similarity in neural processing of deceased- and living-related attention. A lack of difference between two conditions or simply calculating the summed average of two conditions does not indicate significant overlap in neural activity underlying both conditions (30). Significance of activation across two conditions can be determined with a conjunction analysis (30), which identifies voxels associated with condition A and condition B as compared with the variability of condition A and condition B. We therefore assessed the conjunction of voxels whose BOLD activity correlated with RT across both living- and deceased-related trials.

However, there are two confounds inherent to the approach described above. First, both equations for deceased- and living-related attention identify activity based on RT. Without comparison with another RT-based contrast we would simply identify neural activity associated with pushing buttons.

Second, both of these contrasts identify activity associated with either deceased- or living-related attention. However, it is likely that such attentional activity also incorporates general selective attention that is not specific to attachment processing.

To account for button pressing we controlled for BOLD correlation with RT to deceased-related (deceased related [BOLD × RT] > congruent [BOLD × RT]) and living-related (living related [BOLD × RT] > congruent [BOLD × RT]) trials. To account for general selective attention, we identified clusters, which were significantly more active during incongruent color-word trials as compared with congruent color-word trials. Notably, all words across both incongruent and congruent trials had the same meaning. For this reason, we did not need to incorporate RT into the contrast identifying general selective attention and therefore identified voxel clusters involved in general selective attention as follows: incongruent BOLD > congruent BOLD. As a result, the total contrast identifying deceased- and living-related attention while accounting for voxels associated with general attentional interference and for button pressing activity was the following: for deceased, (deceased related [BOLD × RT] > congruent [BOLD × RT]) > (incongruent BOLD > congruent BOLD); and for living, (living-related [BOLD × RT] > congruent [BOLD ×RT]) > (incongruent BOLD > congruent BOLD). Nuisance regressors modeled out error trials and standard six degrees of freedom motion regressors.

Separate two-sided mixed effects analyses were implemented in FSL's FLAME (29) to identify voxel clusters significantly associated with RT for deceased- and living-related trials (voxel $p < .001$, cluster $p < .05$). To compare activity between deceased- and living-related attention the contrasts described above were compared with a within-subjects t test implemented in FSL (voxel $p < .001$, cluster $p < .05$, corrected). To identify common activity in these networks we employed a conjunction analysis (voxel $p < .001$, cluster $p < .05$, corrected) (30). Regional localizations were identified using the Harvard-Oxford Cortical and Subcortical atlases (31) applied to the Montreal Neurological Institute 152 standard brain template, Brodmann areas (BAs) were identified using the Talairach Atlas (32).

RESULTS

Table 1 describes the demographic and clinical characteristics of the sample. On average the sample contained a considerable degree of grief intensity, with a wide range across levels of severity (average ICG score = 27.04, range = 1–50). Post hoc analyses confirmed that deceased- and living-related lists did not have significant differences in word length, part of speech, or language frequency (Supplement, Supplemental Table S1).

Table 1. Sample Description

Demographic and Clinical Variables	
Age, Years	45 ± 13 (19–64)
Months Since Loss	7.96 ± 4.04 (3–14)
ICG	27.04 ± 12.99 (1–50)
CES-D	1.64 ± 0.45 (1–2.64)
BDI	8.45 ± 9.56 (0–31)
Education, Years	16.28 ± 1.96 (12–20)
Emotional Pain	3.36 ± 0.81 (1.6–4.6)
Intrusive Thoughts	2.41 ± 0.72 (1.25–3.88)
Nonacceptance	2.86 ± 1.02 (1–4.33)
Yearning	7.6 ± 2.53 (2–10)
Household Income	
>$70,000	15 (60)
$60,000–$69,000	5 (20)
$50,000–$59,000	1 (4)
$30,000–$39,000	4 (16)
Prior Depressive Episodes	
0	11 (44)
1	7 (28)
2	4 (16)
3	2 (8)
5	1 (4)
Married	11 (44)
Male	2 (8)
Psychiatric Medication Use	10 (40)

Values are mean ± SD (range) or n (%). Household income was coded with five interval levels of >$70,000, $60,000–$69,000, $50,000–$59,000, $40,000–$49,000, and $30,000–$39,000. Psychiatric medication use was coded as a binary variable corresponding to whether a subject was currently using a psychiatric medication.

BDI, Beck Depression Inventory; CES-D, Center for Epidemiological Studies–Depression; ICG, Inventory of Complicated Grief.

Attentional Bias

Errors were more common in deceased-related versus living-related (χ^2_1 = 6.52, p = .01) and incongruent versus congruent (χ^2_1 = 23.01, $p < .01$) trials. An attentional bias was evidenced by slower RT to deceased-related versus living-related words (B = 0.012, t_{2831} = 2.73, $p < .006$, 95% confidence interval [CI], 0.003 to 0.213, Cohen's d = 0.85) and to incongruent versus congruent words (B = 0.19, t_{2754} = 19.43, $p < .001$, 95% CI, 0.177 to 0.1216, Cohen's d = 6.47) (Table 2). The bias to deceased-related words persisted after controlling for the effect of time since loss, CG severity, age, Center for Epidemiological Studies–Depression short scale/Beck Depression Inventory score, number of prior major depressive episodes, suicide loss, and medication use on RT (Table 2). Supplemental Table S2 presents raw response data from the Stroop task.

Bias to Deceased Versus Sadness

A total of 42% of deceased-related and 16% of living-related trials used words with a sadness rating of sad or very sad. Estimated marginal means of sadness were the following: deceased related, 1.24 ± 0.08; living related, 0.59 ± 0.08. Deceased-related words were rated as sadder than living-related words (t_{1748} = 16.67, $p < .001$). Without modeling condition type (i.e., deceased and living-related trials), we observed a relationship between RT and trial-level sadness rating (B = 0.005, t_{2841} = 2.42, p = .01, 95% CI, 0.0009 to 0.009). When modeling condition type and sadness rating, condition remained a significant predictor of RT (B = 0.009, t_{2831} = 2.08, p = .03, 95% CI, 0.0005 to 0.0188) while sadness

Table 2. Mixed Effect Models Identifying Attentional Bias

	B	SE	*df*	*t*	*p*	95% CI	Estimate	SE
Condition								
Deceased vs. living	0.012	0.004	2831	2.73	.006	0.003 to 0.213		
Incongruent vs. congruent	0.197	0.010	2754	19.43	<.001	0.177 to 0.121		
Model Including Covariates								
Deceased vs. living	0.013	0.004	2477	2.81	.005	0.004 to 0.022		
Age	0.001	0.001	13	0.993	.339	–0.001 to 0.003		
Time since loss	0.006	0.006	13	1.008	.332	–0.007 to 0.021		
Suicide loss	0.059	0.044	13	1.330	.206	–0.037 to 0.155		
ICG score	–0.001	0.002	13	–0.363	.722	–0.006 to 0.004		
Medication use[a]	0.055	0.035	13	1.544	.147	–0.022 to 0.133		
CES-D score	0.048	0.067	13	0.708	.491	–0.098 to 0.194		
BDI score	–0.006	0.002	13	–2.999	.010	–0.011 to –0.001		
Previous MDEs	0.007	0.014	13	0.487	.634	–0.024 to 0.038		
Covariate Effects								
Residual							0.014	0.004
Subject							0.003	0.001
Run no.							0.012	0.001
Trial no.							<0.001	<0.001

Initial models tested the effect of deceased vs. living condition and incongruent vs. congruent condition on log-transformed reaction time. An additional model assessed the effect of deceased vs. living condition on log-transformed reaction time while accounting for covariates. All models included random effects for subject and fixed effects for run, and trial number.

BDI, Beck Depression Inventory; CES-D, Center for Epidemiological Studies Depression; CI, confidence interval; ICG, Inventory of Complicated Grief; MDE, major depressive episode.

[a]Binary score coding psychiatric medication use.

rating did not (B = 0.003, t_{2841} = 1.66, p = .09, 95% CI, –0.0006 to 0.008).

Grief Process Variables

Emotional pain, nonacceptance, yearning, intrusion, and ICG scores were all correlated with each other (Supplemental Table S3). Despite this correlation structure, only intrusive thinking and ICG scores displayed an interaction effect with condition (living, deceased) on RT after correcting for multiple comparisons (Figure 2, Table 3). Subjects with more intrusive thinking and higher CG severity displayed significantly greater attentional bias to deceased-related versus living-related words (Figure 2). Intrusive thinking was positively correlated with RT to deceased-related trials and less so to living-related trials (Table 3). Emotional pain, nonacceptance, and yearning did not significantly interact with condition (living, deceased) as predictors of RT (Table 3). No grief process variables exhibited a main effect on RT across conditions. Intrusive thinking did not moderate the relationship between incongruent versus congruent condition type and RT (B = 0.001, t_{2755} = 0.31, p = .76, 95% CI, −0.01 to 0.01), demonstrating the specificity of this finding to deceased-related attention.

Neural Circuitry of Deceased- and Living-Related Attention

Activity in the lateral occipital cortex, fusiform gyrus, and temporal parietal junction correlated with RT to reminders of the deceased. Activity in similar clusters as well as a range of limbic and frontal regions correlated with RT to reminders of the living (Supplemental Figure S1, Supplemental Tables S4 and S5). However, direct comparison of neural correlates of deceased-related versus living-related RT revealed no significant differences. This lack of difference persisted when using a more lenient threshold as well (voxel $p < .05$, cluster $p < .1$).

A conjunction analysis identified common regions of activation across deceased- and living-related conditions. This analysis identified activity in lateral occipital lobe, right temporal parietal junction, occipital and temporal fusiform gyrii, and posterior cingulate associated with both deceased- and living-related attention (see Figure 3A, Table 4, for full list of regions). All of the above analyses controlled for button pressing (BOLD × congruent RT) as well as general selective attention (incongruent BOLD > congruent BOLD) as described above.

To determine the potential role of these regions in attachment processing we tested the correlation between insecure-avoidant attachment style and average activity in the conjoint network of regions associated with living- and deceased-related attention during deceased-related trials. Subjects with a more secure rather than avoidant attachment style displayed significantly greater activation of the deceased- and living-related neural circuitry during deceased-related trials (r = –.51, p = .03; Figure 3B).

We tested the correlation between time since loss and engagement of the conjoint deceased- and living-related attention network during deceased-related trials. According to the decathexis theory, engagement of the conjoint network should decrease over time as living- and deceased-related processing become less similar. According to the continuing bonds model, engagement of the conjoint network should maintain over time as the deceased continues to be processed in a similar way to a living attachment. Our findings were

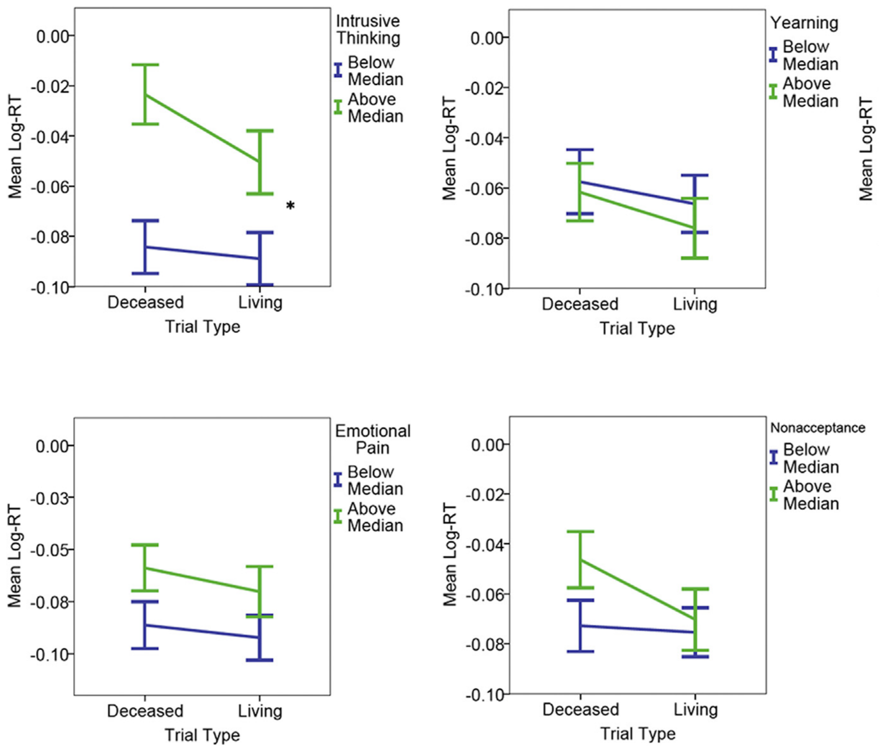

Figure 2. Intrusive thinking interacts with condition type in predicting reaction time (RT). Simple slopes display the relationship between deceased- and living-related condition and average log-transformed RT (log-RT) across high and low levels of grief process variables as well as complicated grief severity. For the sake of presentation high and low intrusive thinking, emotional pain, nonacceptance, yearning, and complicated grief are presented as above and below the respective medians of intrusions (= 2.25), emotional pain (= 3.6), nonacceptance (= 3.33), yearning (= 8), and complicated grief (= 26; Inventory of Complicated Grief). The difference between RT to deceased- and living-related conditions was greater for those subjects with high intrusive thinking as compared with low intrusive thinking. No such effect was observed for other process variables.

consistent with the latter theory, showing no correlation between conjoint activity during deceased-related trials and time since loss ($r = -.14$, $p = .49$).

General Selective Attention

A number of clusters in frontal regions showed greater activity during incongruent versus congruent trials: left inferior frontal gyrus (BA 9), middle frontal gyrus (BA 6), bilateral superior frontal gyrus (BA 6), and frontal pole (BA 10; Supplemental Figure S2, Supplemental Table S6). There were no regions that displayed greater activity for congruent versus incongruent blocks.

DISCUSSION

Grieving individuals displayed an attentional bias to reminders of a deceased as compared with living attachment independently of sadness evoked by deceased-related words, depressive symptoms and history, medication use, age, and time since loss. Attentional bias was associated with intrusive thinking and general CG severity, but not emotional pain, nonacceptance, and yearning. fMRI findings suggested more similarity rather than difference in the brain regions involved in deceased- and living-related attention as compared with general selective attention.

Prior studies have related impaired grieving (i.e., CG) to biased deceased versus neutral attention (3,5). To date, it had remained unclear if CG involved general impairment in control over emotional attachment-related attention or a specific deceased-related attentional bias. We now show that a specific bias to the deceased versus a living attachment exists independently of sadness evoked by reminders of the loss. While general emotion regulation remains a relevant and important part of the grief process, our findings present deceased-related attention specifically as a unique and significant element of the grief process as well.

The bias to reminders of the deceased versus a living attachment does not appear to be driven by emotional components of grieving such as pain, word sadness, or yearning. Intrusive thinking describes a lack of control over salient thoughts, but does not explain what causes deceased-related thoughts to be salient. Once accounting for sadness, pain, and yearning, the major difference between reminders of the deceased and a living attachment is the memory of the death itself. The memory of the death may drive attention toward the deceased as compared with a living attachment. Along these lines, recent effective treatments for CG have emphasized the importance of reviewing the death event in detail, potentially habituating attentional biases to the death (33,34). One of the tasks of grieving may therefore be reducing the degree that attention is biased to memories of the death.

Table 3. Mixed Effect Models Identifying Interactions of Grief Process Variables With Attentional Bias

	B	SE	*df*	*t*	*p*	95% CI	Partial r^2
Intrusion							
Interaction[a]	0.017	0.006	2830	2.71	.006[b]	0.004 to 0.029	
Main effect[c]	0.037	0.022	23	1.68	.105	–0.008 to 0.082	
Deceased trial RT[d]	0.053	0.023	23	2.33	.02	0.006 to 0.101	.26
Living trial RT[e]	0.037	0.022	23	1.67	.10	–0.008 to 0.084	.15
Pain							
Interaction[a]	0.007	0.005	2830	1.37	.16[b]	–0.003 to 0.018	
Main effect[c]	0.012	0.215	23	0.56	.57	–0.322 to 0.056	
Deceased trial RT[d]	0.019	0.022	23	0.86	.39	–0.027 to 0.066	.05
Living trial RT[e]	0.012	0.021	23	0.58	.56	–0.031 to 0.056	.03
Yearning							
Interaction[a]	0.001	0.001	2830	1.00	.31[b]	–0.001 to 0.005	
Main effect[c]	0.001	0.006	23	0.28	.77	–0.012 to 0.016	
Deceased trial RT[d]	0.003	0.007	23	0.51	.62	–0.011 to 0.018	.05
Living trial RT[e]	0.002	0.006	23	0.30	.76	–0.012 to 0.016	.03
Nonacceptance							
Interaction[a]	0.007	0.004	2830	1.79	.07[b]	–0.001 to 0.016	
Main effect[c]	0.008	0.169	23	0.47	.64	–0.027 to 0.043	
Deceased trial RT[d]	0.015	0.017	23	0.87	.39	–0.021 to 0.052	.11
Living trial RT[e]	0.008	0.016	23	0.49	.62	–0.026 to 0.043	.05
ICG Score							
Interaction[a]	0.001	0.003	2830	2.97	.003[b]	0.003 to 0.001	
Main effect[c]	0.014	0.001	23	1.09	.28	–0.001 to 0.004	
Deceased trial RT[d]	0.002	0.013	23	1.85	.08	–0.003 to 0.005	.18
Living trial RT[e]	0.001	0.001	23	1.09	.28	–0.001 to 0.004	.09

CI, confidence interval; ICG, Inventory of Complicated Grief; RT, reaction time.
[a]Interaction of grief process variable with deceased and living condition on log-transformed RT.
[b]Original *p* values are presented but significance threshold was set to $p < .01$ to correct for five comparisons.
[c]The main effect of the grief process variable on RT across deceased- and living-related conditions.
[d]Main effect for grief process variable on RT in deceased condition only.
[e]Main effect for grief process variable on RT in living condition only.

We also sought to determine whether deceased- and living-related attention represent unique or similar processes. In prior studies, rostral anterior cingulate engagement and prefrontal-amygdala connectivity in deceased attention versus neutral attention differentiated bereaved and nonbereaved participants and correlated with intrusions, respectively (2,4). Our findings diverge, showing greater similarity rather than difference in neural processing of deceased-related versus living-related attention. The contrast between attention to deceased-related and neutral stimuli invoked in prior work may therefore display shifts in general emotional and attachment processes occurring in grieving rather than a

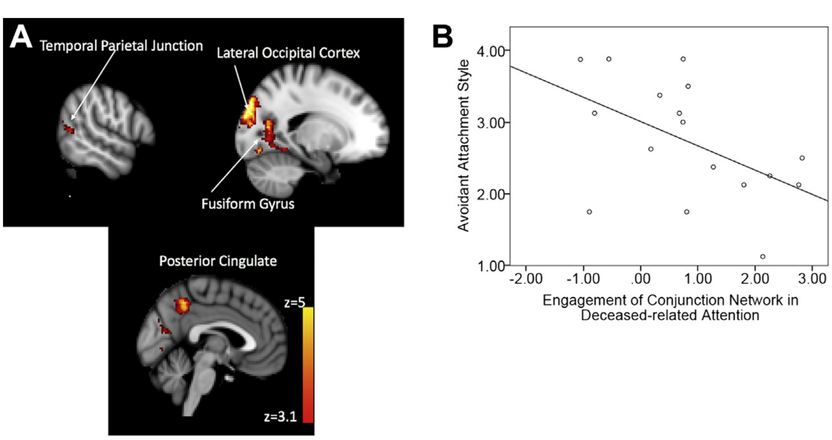

Figure 3. **(A)** Conjunction analysis of deceased and living-related attention. Activity in lateral occipital cortex, fusiform gyrus (x, y, z = 54, 31, 35), temporal parietal juncture (x, y, z = 17, 34, 30) and posterior cingulate (x, y, z = 46, 39, 44) is observed. All analyses were thresholded at voxel ($p < .001$) and cluster ($p < .05$) and controlled for button pressing, general selective attention, and word reading. **(B)** Subjects with a more secure attachment style as opposed to an avoidant attachment style showed greater engagement of the conjoint deceased- and living-related attention network during deceased related trials. Engagement of conjoint network during deceased related trials corresponds to subject level *Z* score of the correlation between blood oxygen level–dependent activity in the conjunction mask and deceased-related attention.

Table 4. Clusters Conjointly Associated With Deceased- and Living-Related Attention

Region	Voxels	*Z* Score	x	y	z
Posterior Cingulate Gyrus	45	3.41	48	42	56
Cuneal Cortex	536	3.53	43	23	50
Intracalcarine Cortex	552	3.40	45	27	41
Inferior Lateral Occipital Cortex	14	3.22	17	32	42
Superior Lateral Occipital Cortex	1221	3.61	40	22	49
Lingual Gyrus	536	3.42	48	29	34
Middle Temporal Gyrus	31	3.34	17	35	40
Occipital Fusiform Gyrus	41	3.44	48	24	30
Occipital Pole	800	3.66	45	17	48
Precuneous Cortex	674	3.45	45	35	54
Supracalcarine Cortex	80	3.61	46	30	44
Temporal Occipital Fusiform Cortex	65	3.48	58	38	30

deceased-specific neural substrate. However, differences between our findings and those of prior studies may also reflect differences in the samples (suicide bereaved, 3–14 months postloss), tasks (i.e., counting Stroop task or color Stroop task) and analyses (event or block design, cluster-forming thresholds).

Our fMRI neuroanatomical data revealed significant conjoined activity rather than differential activity associated with attention to deceased- and living-related stimuli. This activity was located in the lateral occipital cortex and the fusiform gyrii, part of the face- or person-processing networks (35); right temporal parietal junction, which has been linked to theory of mind (36); and posterior cingulate, a part of the default mode network (37). Notably these neural findings were unique from a set of regions associated in this study and in others with general selective attention (38). The similarity between neural correlates of deceased- and living-related attention suggests that to some extent the bereaved attend to the deceased the same way that they attend to a living attachment. This is consistent with the continuing bonds theory of grieving, which suggests a continued evolving relationship between the bereaved and the deceased (12–17).

People with insecure-avoidant attachment styles, who invest less emotional connection in their relationships, showed reduced neural activity in the conjoined deceased- and living-related attention network. The neural activity identified in this study may correspond to the emotional connection between people's bereaved and their living and deceased attachments. Nevertheless, the correlation between neural activity and attachment style may also reflect separate processes (i.e., memory) engaged more or less by insecurely attached people. Future studies should incorporate a nonattachment other-person condition to more definitively identify the role of attachment processing in deceased-related attention.

Limitations

Future studies with larger sample sizes could better parse the effect of suicide bereavement versus general grieving on attentional bias. Similarly, this sample had a limited number of men and could not assess the role of sex. Furthermore, the lack of association between emotional pain and yearning and attentional bias may also reflect limited power due to a smaller sample size. We interpret attentional bias as deriving from nonemotional sources, having controlled for pain, sadness, and yearning. However, we did not measure anger, resentment, or bitterness, which may also contribute to bias.

Future Work

Future work can test the causal role of attentional bias to the deceased on grief outcomes. Specifically computerized attentional bias interventions can be implemented to foster greater control over thoughts of loss. Future studies can also directly measure memories of the death to determine if they play a role in attentional bias and grief resolution. Finally, incorporation of a nonattachment control figure would better delineate the degree that attachment processing contributes to underlying deceased- and living-related attention.

Conclusions

We found an attentional bias to the deceased versus a living attachment figure that was associated with greater intrusive thinking and general CG severity, but not emotional components of grief such as sadness, pain, and yearning. These findings suggest that memories of the death itself may drive bias to the deceased versus a living figure. Despite the presence of a bias to the deceased versus a living figure, neural findings indicated similarity in the underlying processes subserving deceased- and living-related attention. Taken together, these findings suggest that one of the tasks of grieving is to employ control over deceased-related thoughts and maintain a continued bond with the deceased, similar to that which exists with a living attachment.

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REFERENCES

1. Zisook S, Shear K (2009): Grief and bereavement: What psychiatrists need to know. World Psychiatry 8:67–74.

2. Arizmendi B, Kaszniak AW, O'Connor MF (2016): Disrupted prefrontal activity during emotion processing in complicated grief: An fMRI investigation. Neuroimage 124:968–976.
3. Maccallum F, Bryant RA (2010): Attentional bias in complicated grief. J Affect Disord 125:316–322.
4. Freed PJ, Yanagihara TK, Hirsch J, Mann JJ (2009): Neural mechanisms of grief regulation. Biol Psychiatry 66:33–40.
5. O'Connor MF, Arizmendi BJ (2014): Neuropsychological correlates of complicated grief in older spousally bereaved adults. J Gerontol B Psychol Sci Soc Sci 69:12–18.
6. Liu Y, Ding Y, Lu L, Chen X (2017): Attention bias of avoidant individuals to attachment emotion pictures. Sci Rep 7:41631.
7. Vandevivere E, Braet C, Bosmans G, Mueller SC, De Raedt R (2014): Attachment and children's biased attentional processing: evidence for the exclusion of attachment-related information. PLoS One 9:e103476.
8. Williams JM, Mathews A, MacLeod C (1996): The emotional Stroop task and psychopathology. Psychol Bull 120:3–24.
9. Prigerson HG, Shear MK, Jacobs SC, Reynolds CF 3rd, Maciejewski PK, Davidson JR, *et al.* (1999): Consensus criteria for traumatic grief. A preliminary empirical test. Br J Psychiatry 174:67–73.
10. Shear MK, Simon N, Wall M, Zisook S, Neimeyer R, Duan N, *et al.* (2011): Complicated grief and related bereavement issues for DSM-5. Depress Anxiety 28:103–117.
11. Freud S, Rieff P (2008): General Psychological Theory: Papers on Metapsychology, 1st Touchstone paperback ed. New York, NY: Touchstone.
12. Shear K, Shair H (2005): Attachment, loss, and complicated grief. Dev Psychobiol 47:253–267.
13. Bowlby J (1980): Attachment and Loss. New York, NY: Basic Books.
14. Klass D, Silverman PR, Nickman SL (1996): Continuing Bonds: New Understandings of Grief. Washington, DC: Taylor & Francis.
15. Schuchter SR, Zisook S (1993): The Course of Normal Grief. Cambridge, UK: Cambridge University Press.
16. Klass D (1997): The deceased child in the psychic and social worlds of bereaved parents during the resolution of grief. Death Stud 21:147–175.
17. Bonanno GA, Kaltman S (1999): Toward an integrative perspective on bereavement. Psychol Bull 125:760–776.
18. Stroop JR (1935): Studies of interference in serial verbal reactions. Doctoral Thesis, George Peabody College for Teachers, Vanderbilt University, Nashville, TN.
19. First M, Spitzer R, Gibbon M, Williams J (1995): Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I/P, Version 2.0). New York, NY: Biometrics Research Department, New York State Psychiatric Institute.
20. Prigerson HG, Maciejewski PK, Reynolds CF 3rd, Bierhals AJ, Newsom JT, Fasiczka A, *et al.* (1995): Inventory of Complicated Grief: A scale to measure maladaptive symptoms of loss. Psychiatry Res 59:65–79.
21. O'Connor MF, Wellisch DK, Stanton AL, Eisenberger NI, Irwin MR, Lieberman MD (2008): Craving love? Enduring grief activates brain's reward center. Neuroimage 42:969–972.
22. Futterman A, Holland JM, Brown PJ, Thompson LW, Gallagher-Thompson D (2010): Factorial validity of the Texas Revised Inventory of Grief-Present scale among bereaved older adults. Psychol Assess 22:675–687.
23. Baumert J, Simon H, Gundel H, Schmitt C, Ladwig KH (2004): The Impact of Event Scale–Revised: Evaluation of the subscales and correlations to psychophysiological startle response patterns in survivors of a life-threatening cardiac event: an analysis of 129 patients with an implanted cardioverter defibrillator. J Affect Disord 82:29–41.
24. Irwin M, Artin KH, Oxman MN (1999): Screening for depression in the older adult: Criterion validity of the 10-item Center for Epidemiological Studies Depression Scale (CES-D). Arch Intern Med 159:1701–1704.
25. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J (1961): An inventory for measuring depression. Arch Gen Psychiatry 4:561–571.
26. Fraley R, Davis K (1997): Attachment formation and transfer in young adults' close friendships and romantic relationships. Personal Relationships 4:131–144.
27. Jenkinson M, Bannister P, Brady M, Smith S (2002): Improved optimization for the robust and accurate linear registration and motion correction of brain images. Neuroimage 17:825–841.
28. Andersson JLR, Jenkinson M, Smith S (2007): Non-linear registration, aka spatial normalisation. FMRIB Technical Report TR07JA2. Available at: https://www.fmrib.ox.ac.uk/datasets/techrep/tr07ja2/tr07ja2.pdf. Accessed May 6, 2013.
29. Woolrich MW, Jbabdi S, Patenaude B, Chappell M, Makni S, Behrens T, *et al.* (2009): Bayesian analysis of neuroimaging data in FSL. Neuroimage 45:S173–S186.
30. Nichols T, Brett M, Andersson J, Wager T, Poline JB (2005): Valid conjunction inference with the minimum statistic. Neuroimage 25:653–660.
31. Desikan RS, Segonne F, Fischl B, Quinn BT, Dickerson BC, Blacker D, *et al.* (2006): An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest. Neuroimage 31:968–980.
32. Lancaster JL, Woldorff MG, Parsons LM, Liotti M, Freitas CS, Rainey L, *et al.* (2000): Automated Talairach atlas labels for functional brain mapping. Hum Brain Mapp 10:120–131.
33. Boelen PA, Prigerson HG (2007): The influence of symptoms of prolonged grief disorder, depression, and anxiety on quality of life among bereaved adults. Eur Arch Psychiatry Clin Neurosci 257:444–452.
34. Shear MK (2010): Complicated grief treatment: The theory, practice and outcomes. Bereave Care 29:10–14.
35. Nagy K, Greenlee MW, Kovacs G (2012): The lateral occipital cortex in the face perception network: An effective connectivity study. Front Psychol 3:141.
36. Krall SC, Rottschy C, Oberwelland E, Bzdok D, Fox PT, Eickhoff SB, *et al.* (2015): The role of the right temporoparietal junction in attention and social interaction as revealed by ALE meta-analysis. Brain Struct Funct 220:587–604.
37. Leech R, Sharp DJ (2014): The role of the posterior cingulate cortex in cognition and disease. Brain 137:12–32.
38. Peterson BS, Skudlarski P, Gatenby JC, Zhang H, Anderson AW, Gore JC (1999): An fMRI study of Stroop word-color interference: Evidence for cingulate subregions subserving multiple distributed attentional systems. Biol Psychiatry 45:1237–1258.