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Speaking under pressure: Low linguistic complexity is linked to high physiological and emotional stress reactivity

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Abstract

What can a speech reveal about someone's state? We tested the idea that greater stress reactivity would relate to lower linguistic cognitive complexity while speaking. In Study 1, we tested whether heart rate and emotional stress reactivity to a stressful discussion would relate to lower linguistic complexity. In Studies 2 and 3 we tested whether a greater cortisol response to a standardized stressful task including a speech (Trier Social Stress Test) would be linked to speaking with less linguistic complexity during the task. We found evidence that measures of stress responsivity (emotional and physiological) and chronic stress are tied to variability in the cognitive complexity of speech. Taken together, these results provide evidence that our individual experiences of stress or 'stress signatures'—how our body and mind react to stress both in the moment and over the longer term—are linked to how complexly we speak under stress.

Keywords

cognitive complexity; cognition; stress reactivity; cortisol reactivity; language

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Imagine you are about to give an important speech; your heart races, your palms are sweaty, you feel tongue-tied, and you cannot think clearly or make sophisticated arguments. What might underlie this impaired cognitive fluidity?

A link between emotional stress and cognitive function is thought to occur, in part, because emotional stress immediately inhibits areas of the brain related to memory and complex thought, and triggers the hypothalamus–pituitary–adrenal (HPA) axis that releases stress-

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related hormones. These hormones then act back on the areas of the brain related to memory and complex thought, which have a high density of stress hormone (glucocorticoid) receptors. This can then lead to further impairment of cognition (Arnsten, 2009; Kern et al., 2008; Lupien et al., 1998; Sapolsky, Romero, & Munck, 2000; Seeman, McEwen, Rowe, & Singer, 2001). More specifically, human and animal research has shown that acute stress impairs prefontal cortex functioning (Arnsten, 2009), including reduced cognitive flexibility (Alexander, Hillier, Smith, Tivarus, & Beversdorf, 2007) and working memory (Luethi, Meier, & Sandi, 2008) during stressful speech tasks. Not surprisingly, short-term acute oral doses of cortisol are related to a reduction in verbal memory (Newcomer et al., 1999), and a meta-analysis showed that treatment with cortisol before memory retrieval impairs recall performance (Het, Ramlow, & Wolf, 2005). In addition, fMRI research has revealed the antagonistic or inverse relationship between the limbic system and prefrontal cortex activity (Taylor et al., 2008).

This pattern of effects lends support to the disruptive stress hypothesis, which argues that greater stress leads to decreasing complexity of thought (Suedfeld & Rank, 1976). More specifically, it has been theorized that when a stressor is first encountered, individuals feel alarmed and may become, to some extent, immobilized as they prepare to gather their resources and cope. This stage is hypothesized to be characterized by low complexity of thought (Suedfeld, 1992). However, once individuals have mustered their available resources, it is hypothesized that they should think in a more complex way once again. But, according to the disruptive stress hypothesis, if individuals remain at high levels of stress, they may attempt to solve their problems from a less cognitively complex perspective because the stress will disrupt and simplify their information processing (Suedfeld & Rank, 1976).

In the present research we examined if greater emotional and physiological stress would relate to less cognitive complexity while speaking. While it is of interest to understand how stress influences the complexity of thought, we were interested primarily in how thought manifests itself during a motivated performance tasks, namely in public speaking tasks. The ability to deliver a coherent narrative demands good executive functioning, and executive function is taxed under stress (Arnsten, 2009). In previous research, public speaking tasks, especially in combination with other cognitive tasks, have been found to be associated with a greater physiological stress responses (as measured through cortisol) than any other type of stressor examined (Dickerson & Kemeny, 2004). In this way, public speaking tasks are the ideal tasks to examine the possible influence of acute stress on speech patterns.

We used a relatively novel measure of complex speech, an objective linguistic-based measure of cognitive complexity based on the Linguistic Inquiry and Word Count (LIWC) software (Pennebaker & King, 1999). To analyze transcripts of speech, the program assesses the percentage of particular words that fall into one or more of over 70 categories. Using factor analysis, Pennebaker and King (1999) found four distinct patterns of these word categories, including the “making distinctions” or cognitive complexity category (Pennebaker & King, 1999; Slatcher, Chung, Pennebaker, & Stone, 2007). When speaking with greater cognitive complexity, people make more distinctions or qualifications and are less likely to group ideas together; linguistically complex speech uses more exclusive words (such as *but*, *except*, *however*, and *unless*), more tentative words (such as *maybe*, *perhaps*, *hesitant*, and *guess*), more negations (such as *never*, *neither*, *without*, and *cannot*), more discrepancies (such as *should*, *would*, *ought*, and *wish*), and fewer inclusive words (such as *with*, *also*, *plus*, and *together*).

Conceptually, linguistic cognitive complexity is similar to Suedfeld and Tetlock's (1977) concept of integrative complexity. Thinking that is reflective of high integrative complexity is flexible, complex, and open to dissonant information. In contrast, simplistic thinking is rigid, egocentric, and lacks attention to multiple perspectives. More integratively complex thinking is thought to protect wellbeing by allowing one to be more flexible and resilient in the face of life stressors (Pancer, Hunsberger, Pratt, & Alisat, 2000). Complexity of thinking tends to reduce under stress (Loewen & Suedfeld, 1992; Suedfeld, Fell, & Krell, 1998; Suedfeld & Rank, 1976). For example, integrative complexity has been found to reduce in the speech of national leaders, novelists, and scientists during times of national crisis (Porter & Suedfeld, 1981; Suedfeld, 1985). Worse health, too, has been tied to less complex thinking (Pennebaker, 1997; Pennebaker & King, 1999; Porter & Suedfeld, 1981).

Given the immediate effects of a stressor on brain activity and on the HPA axis, as well as the disruptive stress hypothesis, we hypothesized that greater stress reactivity would relate to lower linguistic cognitive complexity. Although we hypothesized a link between stress and the cognitive complexity of speech, the causal pathway between the two is not clear. It is possible that individuals who are able to maintain high linguistic complexity while speaking under pressure may concurrently have high prefrontal cortex activity, which prevents high limbic arousal and cortisol reactivity. Conversely, high limbic arousal may cause impaired prefrontal cortex function, low linguistic complexity, and high cortisol reactivity. In turn, it is possible that the high cortisol reactivity may further impair linguistic complexity. This is feasible although peak cortisol levels do not typically occur until at least five minutes after the speech begins. Furthermore, it is possible that a history of exposure to stress leads to long-term changes in neural pathways regulating the stress response, which concurrently leads to both lower complexity and the exaggerated reactivity under pressure. Conversely, a history of better stress coping may have a positive impact on the stress response, simultaneously leading to a more adaptive physiological response to stress, higher levels of positive emotions and lower levels of negative emotions at the moment of stress, and greater linguistic cognitive complexity.

We tested our hypothesis, that stress reactivity would be linked to linguistic cognitive complexity, using lab stressors that involve talking—short verbal tasks to convey ideas to others—and operationalized stress reactivity with a number of different self-reports and physiological measurements including salivary cortisol and heart rate, both of which appear to respond somewhat similarly to the stressor: they rise in response to stress (Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004). In Study 1, we assessed linguistic cognitive complexity in a stressful discussion with a stranger. In Studies 2 and 3 we assessed response a more standardized psychosocial stressor, the Trier Social Stress task, which includes a five-minute speech (Kirschbaum, Pirke, & Hellhammer, 1993). This is a speech task optimized to be especially stressful. In Studies 2 and 3 we tested whether a greater cortisol response to Trier task would be linked to speaking with less cognitive complexity in the speech. In Study 2 we were able to assess whether both positive and negative emotional reactivity would be tied to linguistic cognitive complexity. Finally, in Study 3 we tested whether trait stress vulnerability would be related to less linguistic cognitive complexity, whereas stress resiliency (as indexed by stress-related growth), and the ability to positive reappraise stress would be related to greater linguistic cognitive complexity. In sum, we asked whether measures of physiological and psychological stress are related to variability in the cognitive complexity of speech.

Study 1: Discussion under Stress; Heart Rate, Emotional, and Autonomic Reactivity

As an initial test of our reasoning, we examined whether the way people spoke in discussions would map onto their physiological reactivity to the conversations, how stressed they became in response to the conversations, as well as their traitlike stress vulnerability (the tendency to respond to stressful situations with emotional arousal). We hypothesized that autonomic and emotional reactivity to a conversation about a stressful topic would be related to lower levels of linguistic cognitive complexity during the conversation. In addition, we hypothesized that individuals who self-reported the tendency to react strongly to stressful situations with negative emotions would also speak in a less cognitively complex way in the stressful conversation.

Method

Undergraduates (*N* = 136; 59% female; M = 20.9 years of age, *SD* = 5.0) participated in the experiment either for a $15 compensation or partial credit toward a psychology class requirement. Same-sex dyads of strangers were randomly paired, seated facing one another, and asked to report on how they typically react to stress. Next, the dyads participated in a laboratory stressor: they took turns talking about an event during the past five years that caused them a great deal of emotional suffering and pain. Before talking, they wrote about the event in order to collect their thoughts. Then, they took turns discussing the situations for up to five minutes each. For each turn, one participant was assigned to be the talker, the other the listener. Talkers were asked to describe their situation. Listeners were asked to simply listen with the goal of understanding the talker's experience, asking questions if they wished. As they discussed, only the two participants were in the laboratory room. Afterwards, the participants switched roles.

Measures

Trait emotional stress reactivity—The tendency to respond to stressful events was assessed with a unidimensional 7-item scale (α = .83), created for this research based on a subset of items from the Big Five Inventory (John, Naumann, & Soto, 2008) and the Interpersonal Reactivity Index (Davis, 1983). Questions started with the stem: "I see myself as someone who…" Highly reactive items included: "tends to lose control during emergencies," "feels apprehensive and ill-at-ease in emergencies," and "gets nervous easily." Non-reactive items included: "is pretty effective in dealing with emergencies," "is relaxed, handles stress well," "is emotionally stable, not easily upset," and "remains calm in tense situations." Participants rated their level of agreement from 1 (*disagree strongly*) to 5 (*agree strongly*).

State emotional stress—At baseline and following each discussion, participants rated how much they felt "anxious," "disturbed," "worried," "upset," and "distressed" from 1 (*did not feel at all*) to 7 (*felt very strongly*). The internal reliability of the measure was high (α =. 87).

Heart rate—Electrocardiogram (ECG) recordings, sampled at 1000 Hz, were obtained with an ambulatory monitoring system (VU-AMS) developed by the Free University, Amsterdam, The Netherlands. The leads were placed on the torso in a Lead II configuration. Baseline heart rate was calculated from five minutes of ECG data acquired 15 min after the start of the experiment while the participants were quietly filling in questionnaires. Heart rate during the speech was an average of the first five minutes of the discussion.

Linguistic cognitive complexity—We transcribed all conversations, retaining only the words of the talker and deleting any interjections made by their listening partner. The transcribed speech was analyzed with the latest version of Linguistic Inquiry and Word Count text analysis software for a linguistic measure of cognitive complexity (LIWC2007). This cognitive measure was created by summing z-scores for the LIWC categories of exclusive words, tentative words, negations, discrepancies, and subtracting the *z*-score for inclusive words. The metric for these scores is percent of words spoken, which corrects for varying discussion lengths.

The following is from a participant whose average level of linguistic cognitive complexity was *high*:

> I'm not really sure about what I want to do. So, I guess, sort of, it's, well, a lot of, of my other friends, they all know what they want to do well, not all of them but some of them, and, it sort of bothers me... Right now I guess I feel sort of lost and, not knowing what the purpose of continuous classes and doing well in them really is.

The following is from a participant whose average level of linguistic cognitive complexity was *low*:

> Five years ago in a space of about a year my grandparents both died. It was, it was hard because they were together for about 60 years. They met in England and they got married after six months and moved back and, to live in America and they didn't, they were together and very inseparable ever since then. And they kind of became the sort of glue that held our whole extended family together.

Results

Linguistic cognitive complexity. We first examined average levels of linguistic cognitive complexity. As it is a measure based on z-scored variables, the values, by design, have an average of zero. The mean level of linguistic cognitive complexity in participants who spoke with the lowest cognitive complexity (lowest tertile) was −3.04 (SD = 1.22); −.16 (SD = .70) in participants who spoke with a medium level of cognitive complexity (middle tertile), and

3.20 (SD = 2.02) in participants who spoke with the highest cognitive complexity (highest tertile).

Heart rate. We next tested whether the increase in heart rate during the speech relative to the individual's baseline (i.e., greater heart rate reactivity) would be related to lower levels of linguistic cognitive complexity. We did not find evidence for this, as the correlation between linguistic cognitive complexity and heart rate during speech partialling out the effect of the heart rate during the baseline was not statistically significant, partial r = −.02, p = .789. The mean absolute increase in heart rate in response to stress was 8.43 beats per minute in participants who spoke with the lowest cognitive complexity (lowest tertile), 7.39 beats per minute in participants who spoke with a medium level of cognitive complexity (middle tertile), and 8.02 beats per minute in participants who spoke with the highest cognitive complexity (highest tertile).

We then explored whether a higher overall heart rate during the speech (without controlling for baseline heart rate) was related to lower linguistic cognitive complexity. These were related: greater heart rate throughout the entire speech was tied to lower linguistic cognitive complexity, r = −.20, p = .023. In Figure 1 we plot heart rate for participants from the three tertiles of linguistic cognitive complexity. The mean heart rate in the conversation was 93.46 beats per minute in participants who spoke with the lowest cognitive complexity (lowest tertile), 89.71 beats per minute in participants who spoke with a medium level of cognitive complexity (middle tertile), and 87.14 beats per minute in participants who spoke with the highest cognitive complexity (highest tertile). Heart rate at baseline, before the lab tasks, may in part reflect anticipation of the tasks, an inevitable flaw in obtaining true baselines in any laboratory-based research of stress reactivity.

State and trait emotional stress reactivity

Next we tested whether emotional reactivity to the stressful speech would be related to linguistic cognitive complexity. Ratings of emotional stress after the speech were related to lower linguistic cognitive complexity, with or without partialling out the effect of emotional stress rated at baseline (without controlling for baseline: $r = -.20$, $p = .023$; controlling for baseline: partial $r = -.17$, $p = .043$).

Finally we tested trait stress reactivity, whether individuals who tend to react strongly to stressful situations would speak with less cognitive complexity when talking about a stressful topic. As predicted, participants with higher trait stress reactivity spoke with less cognitive complexity under stress ($r = -.19$, $p = .024$).

Simultaneous regression

We conducted a regression analysis with the heart rate at baseline and during the discussion, baseline and post stressed emotions, as well as the self-reported tendency to react strongly to stress, all entered simultaneously. Greater heart rate reactivity (heart rate during the discussion now controlling for all other measures in the model, including baseline heart rate) continued to be related to lower linguistic complexity ($ß = -.20$, $p = .043$). Neither stressed emotions ($ß = .12$, $p = .265$) nor the self-reported tendency to react strongly to stress ($ß = -.08$, $p = .428$) continued to be related to linguistic complexity.

Discussion

These results offer initial support of the hypothesis that stressful reactions (physiological and emotional) are tied to speaking with lower levels of cognitive complexity under stress. In short, Study 1 demonstrated that linguistic cognitive complexity is linked to heart rate during the discussion, emotional distress in reaction to the discussion, and individual differences in trait stress reactivity. Follow-up analyses suggest that physiological reactions may be especially central to the impact of stress on language.

The study had a crucial limitation. Because the participants were allowed significant latitude to choose the topic of discussion, it is possible that some topics were systematically more amenable for cognitively complex language and/or less stressful to talk about. The next two studies limited the scope of the speech topic.

Study 2: Positive and Negative Emotional and Cortisol Reactivity to the Trier Social Stress Test

In Study 2, we expanded upon our previous effects to examine cortisol reactivity to a standardized stressful speech. Instead of the mild emotional stress induction in Study 1, we used a well-validated laboratory-based stressor, the Trier Social Stress Test (Kirschbaum, et al., 1993). The Trier Social Stress Test has elements of both social threat and feelings of uncontrollability, which are important for HPA axis activation (Dickerson & Kemeny, 2004). We hypothesized that participants who reacted to a stressful speech with greater cortisol and emotional distress would speak with less complexity.

According to the “Broaden-and-Build” hypothesis, positive affect helps individuals to see beyond the immediate stressor and devise alternative solutions to problems (Fredrickson, Tugade, Waugh, & Larkin, 2003). Positive emotions can thus serve to buffer people from the negative effects of stress. We hypothesized that positive emotions would be directly related to linguistic cognitive complexity during the speech.

Method

Forty-four women ($M = 27.7$ years of age, $SD = 6.5$, all European-American) participated in the health assessment and laboratory stressor, and were compensated $100. Participants arrived for a mid-afternoon session in the laboratory. Following a relaxing baseline, they provided a baseline saliva sample for cortisol measurement. Then they were told about the upcoming task: a mock job interview which required giving a 5-minute speech on their qualifications for their “Dream Job” in front of two judges who were introduced to the participants as “in-person communication experts” to increase the saliency of their feedback.[1] Participants were allowed to prepare for five minutes before a five-minute speech task. This was followed by a five-minute question and answer period and a five-minute serial-subtraction math task. This is a standardized psychosocial stressor (Kirschbaum, et al., 1993).

Measures

Cortisol reactivity—Salivary cortisol is considered a useful biomarker of the body's physiological response to stress (Hellhammer, Wüst, & Kudielka, 2009). Participants provided 2 ml of saliva into a cryovial via a plastic straw at each measurement. Saliva samples were stored immediately at −80 degrees Celsius until they were shipped overnight on dry ice to a laboratory in Dresden, Germany. Samples were analyzed for salivary cortisol (nmol/L) using a commercial immunoassay with chemiluminescent detection (IBL, Hamburg/Germany) using an EIA ELISA kit (Diagnostic System Laboratories, Webster, TX, USA). The intra-assay coefficient of variation was less than 8%. Saliva samples were taken after a relaxing 15-minute baseline. Next, the speech task was fully described and the participants met the interviewers. Two minutes into the five-minute preparation period participants provided the second saliva sample. The rest of the saliva samples were 20, 35, and 55 minutes after the participants were introduced to the stress task. According to previous research, peak cortisol responses occur between roughly 20-40 minutes after the start of an acute psychological stressor (Dickerson & Kemeny, 2004). For this study, we chose the 20 minutes post stressor as our marker of acute reactivity.

Emotional stress reactivity—Just before and after the speech participants rated how much they felt “anxious,” “upset,” “nervous,” “tense,” “distressed,” and “irritated,” from 0 (*not at all*) to 6 (*very much*). Reliability was found to be good (α = .88 at both time points).

Positive emotional reactivity—Just before and after the speech participants rated how much they felt “happy,” “interested,” “satisfied,” “pleased,” “content,” “glad,” and “inspired,” from 0 (*not at all*) to 6 (*very much*). Reliability was high (before speech: α = .85; after speech: α = .93).

Linguistic cognitive complexity—The five-minute “dream job” speech was transcribed. We retained the participants’ words, removing any comments from the judges. The transcriptions of the participants’ speeches were analyzed using LIWC. This linguistic measure of cognitive complexity was analyzed as in Study 1.

The following are from participants whose average level of linguistic cognitive complexity was *high*:

> My weakness would be that if I do not do well under pressure, but I am able to coach myself through it at certain points. Meaning that I can take deep breaths, and I am able to calm myself during high-stress situations. I am also punctual. I am extremely reliable when asked to do something or perform a task. I know that I can perform it to my best abilities.

The following are from participants whose average level of linguistic cognitive complexity was *low*:

[1]The “experts” were actually confederates trained to appear either supportive (*N* = 19; smiling, nodding, leaning forward, etc.) or unsupportive (*N* = 25; no smiling, nodding, leaning forward, etc.). Initially we expected these two conditions to induce differing levels of stress with supportive feedback aimed to reduce stress in the participants and unsupportive feedback to increase it. However, none of the results were modified by feedback condition, nor did controlling for condition significantly alter the results, so we collapsed across groups for the reported analyses.

> One of my, the weaknesses of mine would probably be my decisive skills. I have a problem with that, I know there's all these different options and it's hard for me to make the right decision so with the experience that I don't have it's kind of a fault that I haven't had all the life experiences to know what the exact right thing will be but more and more chances to know more people I'll be able to develop that a lot further and I feel that having being put in a situation where I am in charge will allow me to naturally make those decisions.

Results

Linguistic cognitive complexity—First we assessed average levels of linguistic cognitive complexity. The mean level of linguistic cognitive complexity in participants who spoke with the lowest cognitive complexity (lowest tertile) was −3.43 (*SD* = 1.40); −.37 (*SD* = 1.05) in participants who spoke with a medium level of cognitive complexity (middle tertile), and 3.82 (*SD* = 1.60) in participants who spoke with the highest cognitive complexity (highest tertile).

Cortisol. We tested our hypothesis that participants who responded to the speech task with greater cortisol reactivity would speak with lower levels of linguistic cognitive complexity. Cortisol reactivity was determined by controlling for baseline cortisol just before the stress task from cortisol 20 minutes after the onset of the stress task. There was a link between cognitive complexity during the speech and cortisol reactivity (cortisol at 20 minutes post stressor partialling out the effect of cortisol at baseline: partial r = −.43, p = .005) with greater cortisol reactivity associated with lower complexity.

We also examined the results using two-way analysis of variance with repeated measurement revealed the expected significant salivary free cortisol response to stress in the total group [time effect: F(2.56, 66.59) = 7.21, p = .001]. Figure 2 depicts the means and standard errors among groups for saliva cortisol at each time point. More importantly, a significant twoway interaction effect was obtained [linguistic cognitive complexity × time effect: F(2.56,66.59) = 3.26, p = .033], with the highest cortisol concentrations during stress in subjects who were in the lowest tertile of linguistic cognitive complexity. As can be seen in Figure 2, the mean absolute increase in salivary cortisol in response to stress was 2.05 nmol/L in participants who spoke with the lowest cognitive complexity (lowest tertile), 2.14 nmol/L in participants who spoke with a medium level of cognitive complexity (middle tertile), and −.16 in participants who spoke with the highest cognitive complexity (highest tertile).

Emotional stress reactivity. Similarly, the more participants became distressed in response to the stressor, the lower their cognitive complexity (self-reported stressful emotions after the speech partialling out the effect of self-reported stressful emotions before the speech: partial r = −.36, p = .017. Participants who spoke with the least complexity (bottom tertile) responded to the speech with marginally more stressed emotions (M = .83, SD = 1.45; within group paired t-test p = .061). Participants who spoke with the most complexity (top tertile) did not respond in this way (M = −.06, SD = .85; within group paired t-test p = .804), with a marginally significant difference between the groups at a trending level of significance (independent samples t-test p = .055).

Positive emotional reactivity. Positive emotions were positively related to greater cognitive complexity (self-reported positive emotions at after the speech partialling out the effect of positive emotions before the speech: partial r = .42, p = .005). Participants who spoke with the least complexity (bottom tertile) responded to the speech with a reduction in positive emotions (M = −.88, SD = 1.10; within group paired t-test p = .011). Participants who spoke with the most complexity (top tertile) did not respond in this way (M = .13, SD = .89; within group paired t-test p = .570), with a significant difference between the groups (independent samples t-test p = .011).

Simultaneous regression—We conducted a regression analysis with baseline and post measures of cortisol, positive emotions, and stressed emotions all entered simultaneously. Greater cortisol reactivity continued to be related to lower linguistic complexity (*ß* = −.39, *p* = .018). The change in positive emotions also continued to be related to greater linguistic complexity (*ß* = .44, *p* = .040) but the change in negative emotions was no longer significantly tied to linguistic complexity (*ß* = −.11, *p* = .538).

Discussion

These results replicate initial support for the hypothesis that both physiological and emotional stress reactions may be tied to speaking with lower levels of cognitive complexity under stress. By using a more standardized stressful speech topic (a simulated job interview), we could better assess our question of whether reactivity to a stressful speech is related to speaking with less cognitive complexity. We found that, on average, the more participants responded to the stressful speech by feeling higher levels of positive emotions ("happy," "interested," "satisfied," "pleased," "content," "glad," and "inspired"), the higher their levels of linguistic cognitive complexity, further developing the relationship between emotion and cognitive complexity. Follow-up analyses suggest that physiological reactions and the ability to feel positive emotions during stress may be especially central to the impact of stress on language. Thus, it may be that individuals who tend to cope better with stress can speak with higher levels of cognitive complexity. In Study 3 we directly tested this hypothesis.

Study 3: Chronic Stress, Stress resilience, and Cortisol reactivity to the Trier Social Stress Test

In Study 3 we again utilized the Trier Social Stress Test (Kirschbaum, et al., 1993) to measure participants speech during a standardized, stressful speech task. We aimed to replicate Study 2's findings that greater cortisol reactivity to the speech would be related to speaking with lower cognitive complexity in the speech.

Moreover, we measured three individual difference measures: parenting burden (to tap into one important potential source of chronic stress in this sample of parents), stress-related growth (to measure how much participants have found a benefit from their stressful life situations), and coping with stress using positive reappraisal (to assess the tendency to respond to stressful situations by finding a silver lining). Given past research, we hypothesized that greater chronic stress would be related to lower levels of linguistic cognitive complexity, whereas greater stress-related growth and positive reappraisal would be tied to higher cognitive complexity. For example, greater benefit finding after stress (stress-related growth) is thought to relate to wide variety of positive health outcomes, including a healthier response to stress (Bower, Moskowitz, & Epel, 2009). Positive reappraisal is a type of cognitive restructuring that involves changing the way one thinks about a situation and selectively attending to the positive aspects of a situation. According to the revised Stress and Coping Theory (Folkman, 1997, 2008) positive reappraisal can help calm the upset caused by stress.

Method

Participants were 41 mothers from the San Francisco Bay Area (M = 37.49 years of age, SD = 5.72; 21 European-American, 9 African-American, 5 Asian-American, 3 Latina, 3 of other ethnicity) who were living with at least one biological child. The mothers varied on a measure of objective stress: some had a chronically ill child (n = 22) whereas others had a healthy child (n = 19). In all cases, controlling for chronically ill vs. healthy child did not significantly alter the results, so we discuss results collapsed across groups. The women completed self-report scales. Following a relaxing forty-minute baseline, participants provided a baseline saliva sample for cortisol measurement, and then underwent a version of the Trier Social Stress Test (Kirschbaum et al., 1993), similar to Study 2, this included a five minute preparation period, a speech, and mental arithmetic. The participants delivered a speech on a recent very stressful experience and were asked to try to emotionally relive the situation. They then conducted arithmetic for five minutes. Thirty minutes after the onset of the stressor, the participants provided another saliva sample to capture peak responses.

Measures

Cortisol reactivity—Salivary cortisol was collected and assessed as it was in Study 2. Saliva samples were taken after a relaxing 45-minute baseline. The other saliva samples were taken 30 and 60 minutes after the participants were introduced to the stress task. As mentioned above, according to previous research, peak cortisol responses occur between roughly 20-40 minutes after the start of an acute psychological stressor (Dickerson & Kemeny, 2004). For this study, we chose the 30 minutes post stressor as our marker of acute reactivity.

Stress (parenting burden)—We measured chronic stress in this sample of parents with a parenting burden with the 16-item Dislocations Scale (Gottlieb, 1988; $\alpha = .91$) which measures current and potential future stress related to taking care of one's children. Example items include: “The care you give to your child does not leave you with enough time to meet other demands” and “Your caregiving activities make it difficult to maintain your other close relationships.” We summed the items to form a total score.

Stress-related growth—We assessed stress-related growth with the 15-item Post Traumatic Growth Inventory (Tedeschi & Calhoun, 1996; $\alpha = .81$). In reference to the most stressful incident of their adult lives, participants rated how that stressful event may have led to positive consequences in several areas of their lives from 1 (I did not experience this change as a result of my crisis) to 6 (I experienced this change to a very great degree as a result of my crisis). Example items include: “I learned a great deal about how wonderful people are,” “I established a new path for my life,” and “I discovered that I’m stronger than I thought I was.”

Positive reappraisal—Positive reappraisal was assessed with the positive reappraisal subscale of a version of the Ways of Coping Questionnaire (Folkman, Lazarus, Pimley, & Novacek, 1987; $\alpha = .81$). Using a 4-point Likert scale, participants rated from 0 (*not at all*) to 3 (*most of the time*) the degree to which they used each item in coping with the most stressful situation associated with caregiving or parenting that occurred during the previous week. Example items include: “I changed or grew as a person in a good way” and “I came out of the experience better than when I went in.”

Linguistic cognitive complexity—The entire speech was transcribed, retaining only the participants’ own words and deleting the judges’ comments. Then, the transcription was analyzed using LIWC as in the previous studies.

The following is from a participant whose average level of linguistic cognitive complexity was *high*:

> The rest of the week was very rough. I was upset because he did not believe my answers. And Saturday we got into another confrontation while the children where out of the car about the same incident. I tried to reassure him and tell him that I did not or had no idea why the number was in the phone book.

The following is from a participant whose average level of linguistic cognitive complexity was *low*:

> And I was half way through traffic, and this is when I was fasting, I was not drinking coffee, I dropped the kids off, I was running a little bit late and there was traffic, of course. And it was stop and go and stop and go and it was just treacherous and I was in the mini van and I was trying to get to the bridge and I got a phone call right when I got into town on my cell phone.

Results

First we assessed average levels of linguistic cognitive complexity. The mean level of linguistic cognitive complexity in participants who spoke with the lowest cognitive complexity (lowest tertile) was −2.81 (SD = 1.01); −.23 (SD = 1.09) in participants who spoke with a medium level of cognitive complexity (middle tertile), and 3.05 (SD = 1.37) in participants who spoke with the highest cognitive complexity (highest tertile).

Cortisol—We first aimed to replicate our findings from Study 2 that individuals who responded to the speech task with greater cortisol reactivity would speak with lower levels of linguistic cognitive complexity. Cortisol reactivity was determined by controlling for baseline cortisol just before the stress task from cortisol 30 minutes after the onset of the stress task. Consistent with predictions, there was an association between cognitive complexity during the speech and cortisol reactivity (cortisol at 30 minutes post stressor partialling out the effect of cortisol at baseline: partial $r = -.37$, $p = .022$), with greater cortisol reactivity associated with lower complexity.

In the overall analyses, two-way analysis of variance with repeated measurement showed a significant salivary free cortisol response to stress in the total group [time effect: $F(1.27, 30.49) = 4.90$, $p = .027$]. Figure 3 depicts the means and standard errors among groups for saliva cortisol at each time point. More importantly, a significant two-way interaction effect was obtained [linguistic cognitive complexity × time effect: $F(1.27,30.49) = 6.90$, $p = .009$], with the highest cortisol concentrations during stress in subjects who were in the lowest tertile of linguistic cognitive complexity. The mean absolute increase in salivary cortisol in response to stress was 9.92 nmol/L in participants who spoke with the lowest cognitive complexity (lowest tertile), .68 nmol/L in participants who spoke with a medium level of cognitive complexity (middle tertile), and -.83 in participants who spoke with the highest cognitive complexity (highest tertile).

Stress, stress-related growth, and positive reappraisal—Next we tested whether individuals who were under high levels of stress would speak with less cognitive complexity when talking about a stressful topic. As predicted, participants with higher chronic stress (parenting burden) spoke with *less* cognitive complexity under stress ($r = -.35$, $p = .026$). We then assessed whether individuals who found meaning and growth in their stress or who reported being able to positively reappraise their stress would speak with greater cognitive complexity under stress. As predicted, participants with higher stress-related growth ($r = .44$, $p = .006$) and a greater tendency to positively reappraise stress ($r = .38$, $p = .006$) spoke with greater cognitive complexity under stress.

Simultaneous regression—We conducted a regression analysis with baseline and post measures of cortisol as well as the measures of chronic stress, positive reappraisal, and stress-related growth. Greater cortisol reactivity continued to be related to lower linguistic complexity (ß = −.33, $p = .033$). Chronic stress was now only related to linguistic complexity at a trending level of significance (ß = −.25, $p = .092$). The tendency to positively reappraise was no longer significantly tied to linguistic complexity (ß = .16, $p = .301$). Stress-related growth continued to be related to greater linguistic complexity (ß = .33, $p = .039$).

Discussion

These results lend further support for our hypothesis that physiological reactivity to stressful situations are associated with speaking with less cognitive complexity under stress. By using a more standardized stressful speech in Studies 2 and 3, we could better assess our question of whether reactivity to a stressful speech is related to speaking with less cognitive complexity. As an extension of our previous results, we found that chronic stress (parenting burden) was related to less linguistic complexity. However, an important limitation of our findings is that in this sample of parents we examined chronic stress with a parenting burden measure, which assesses only one domain of life, whereas although the participants likely feel stress from a variety of domains of their lives. This study did extend the findings into the domain of coping as well. We found that participants with positive reactions to stress (feel that their stressful situations have enabled them to grow and can respond to stressful situations by positively reappraising the situation) were able to speak with greater complexity under stress. Follow-up analyses suggest that physiological reactions and the self-reported ability to grow in the face of stress may be especially central to the impact of stress on language.

General Discussion

We found support for our hypothesis that greater stress reactivity is linked with lower linguistic cognitive complexity across various indices of emotional and physiological reactivity. In Study 1, average heart rate during the speech was tied to less complexity, as was experiencing greater emotional stress during the discussion and trait stress vulnerability. Study 2 also found lower complexity was related to responding to the stressful task with either higher negative or lower positive emotional responses. Further, decreases in positive affect in response to the challenge showed associations with lower levels of complexity. In Studies 2 and 3, individuals who responded to a standardized speech task with greater cortisol reactivity spoke with lower complexity. In Study 3, individuals with lower levels of an index of chronic stress (parenting burden) and more resilient coping responses (more psychological growth from their stressors and more positive reappraisal), spoke using more complexity. Across all three studies, in simultaneous regressions, our measures of physiological reactivity were all consistently related to lower complexity. Positive buffers, both affect and a measure of resiliency to stress, were also independently associated with higher complexity. Negative affect was associated, but this was not independent of physiological reactivity. This is not surprising given that negative emotional reactions are often linked with or drivers of physiological reactivity, but positive aspects tend to be more independent and less correlated. Taken together, these results provide evidence that our individual experiences of stress—how our body and mind react to stress both in the moment and over the longer term—are linked to how complexly we speak under stress.

Previous research on cognitive complexity has found that individuals who speak with more cognitive complexity or with aspects of complexity (such as greater use of exclusive words) are more likely to be telling the truth (Newman, Pennebaker, Berry, & Richards, 2003), to be older (Pennebaker & Stone, 2003), to be more likely to spend time discussing shared information (Dzindolet, Stover, & Pierce, 2005), as well as to have better health (Pennebaker, 1997; Pennebaker & King, 1999; Porter & Suedfeld, 1981). Integrative complexity, a concept similar to cognitive complexity, has been tied to greater intelligence (Suedfeld & Coren, 1992), creativity, openness, and need for cognition, as well as lower levels of authoritarianism, dogmatism, power motivation, and need for closure (Suedfeld & Tetlock, 2001). In addition, as hypothesized by the disruptive stress hypothesis, integrative complexity reduces under stress; it is lower in the speech of leaders, novelists, and scientists during times of crisis (Porter & Suedfeld, 1981; Suedfeld, 1985). The present research have extended knowledge about complexity into the realm of the quintessential motivated performance task, public speaking, which elicits marked physiological reactions, making it an ideal task to test the idea that stress can influence complexity of thought and speech.

Although compelling, the present research leaves open several questions. The observational design of the studies prevents assessing the potential causality of such a observed “reactivity-complexity” association, but taken together, these results provide evidence that our individual experiences of stress—how our body and mind react to stress both in the moment and over the longer term—are linked to how complexly we speak under stress. Moreover, we were primarily interested in the effects of cognitive complexity when speaking about a stressful topic. As such, we did not examine how cognitive complexity when speaking about a relaxing topic might be related to emotions or physiology. In addition, although we were interested in spoken cognitive complexity, effects may also occur when writing about a stressful topic. For example, how might chronic stress reactivity influence writing; would students’ e-mails decrease in complexity around exams and increase during vacations? Future research might also examine if stress reduction techniques, such as meditation or learning to increase one's experience of positive affect, could lead to increases in linguistic cognitive complexity when under stress. Another limitation of this research is that for Studies 2 and 3 we examined women only. Future research will need to examine if these specific effects extend to men as well, although our results from the mixed gender group of Study 1 suggest that the results will hold across genders.

Overall, despite these limitations and outstanding questions, these initial studies suggest that the way in which the way we speak may be integrally tied to the short-term and long-term effects of our physiological and psychological reactions to stress.

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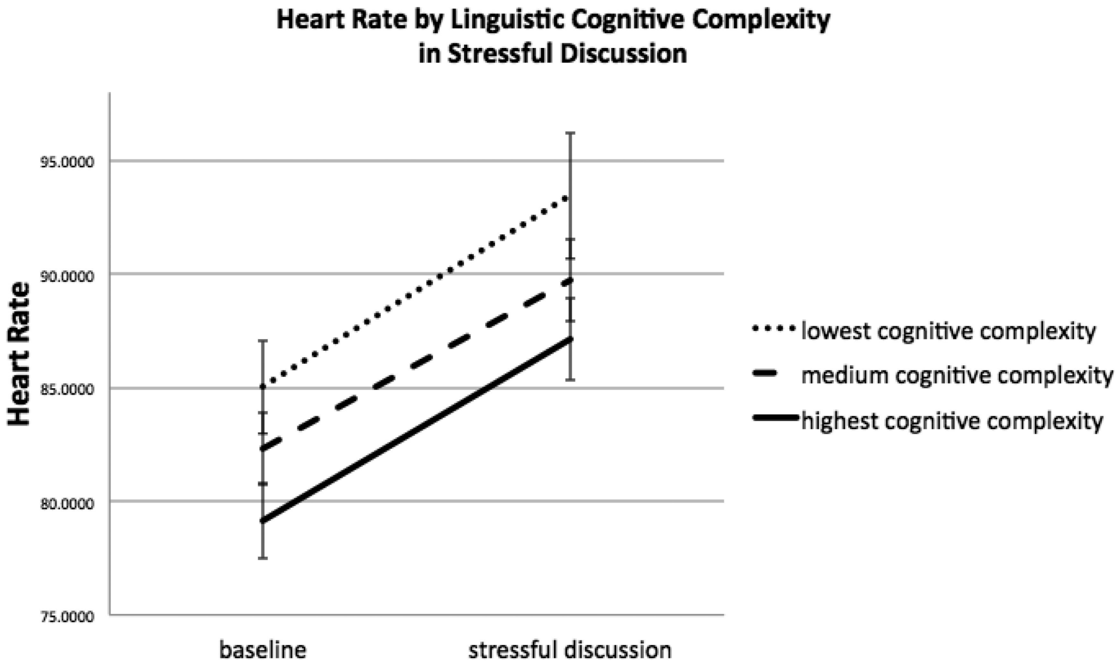

Figure 1.

Heart rate reactivity to stressful discussion (Study 1), by tertiles of linguistic cognitive complexity.

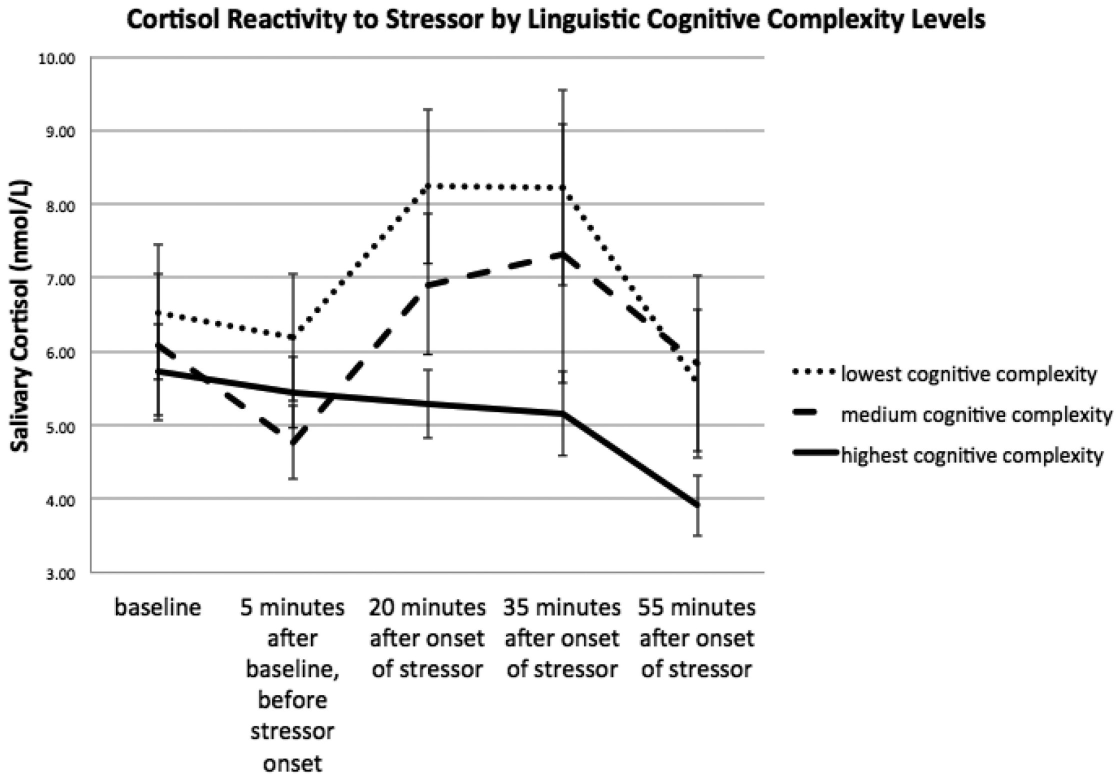

Figure 2.

Mean salivary free cortisol concentrations (± SEM) during psychosocial stress exposure (Trier Social Stress Test; Study 2). Results are shown by tertiles of linguistic cognitive complexity during the speech task of the Trier Social Stress Task.

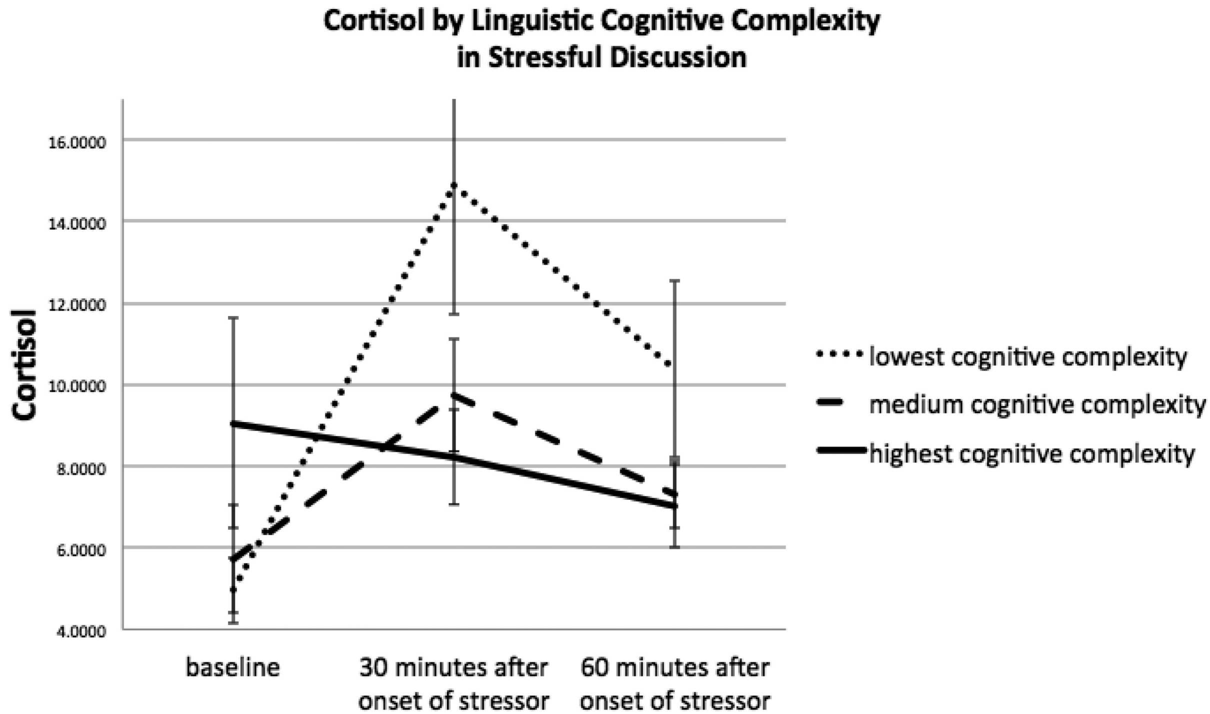

Figure 3.

Mean salivary free cortisol concentrations (± SEM) during psychosocial stress exposure (Trier Social Stress Test; Study 3). Results are shown by tertiles of linguistic cognitive complexity during the speech task of the Trier Social Stress Task.

Table 1

Outcome Variables	Linguistic Cognitive Complexity in Stressful Speech/Discussion
Study 1	
Physiology: Heart rate reactivity to speech	−.02
Physiology: Heart rate during the speech	−.20*
State: Stressed emotional reactivity to speech	−.17*
Trait: Self-reported tendency to react strongly to stress	−.19*
Study 2	
Physiology: Cortisol reactivity to speech	−.43*
State: Stressed emotional reaction to speech	−.36*
State: Positive emotional reaction to speech	.42**
Study 3	
Physiology: Cortisol reactivity to speech	−.37*
Trait: Parenting burden	−.35*
Trait: Stress-related growth	.44**
Trait: Positive reappraisal	.38**

Note:

Pearson correlations for reactivity results are partial correlations: post measures correlated with linguistic cognitive complexity, partialling out the effect of baseline measures.

* $p < .05$

** $p < .01$ for Pearson correlations.