Affective Reactivity in Language: The Role of Psychophysiological Arousal

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Several studies have found that individuals with schizophrenia and their relatives, as well as healthy controls, exhibit greater language disturbance when discussing affectively negative as compared to positive or neutral topics. The goal of this study was to test the hypothesis that negative emotion impairs language production, at least in part by increasing physiological arousal. The authors had 35 healthy adults produce speech in response to affectively negative, positive, and neutral questions while the authors recorded heart rate and skin conductance. Participants displayed greater amounts of reference errors, higher heart rates, and a higher frequency of nonspecific skin conductance responses when discussing affectively negative as compared to positive or neutral topics.

A growing domain of research has been devoted to understanding the complex ways in which different aspects of emotional processing and emotional experience can both impair and facilitate a range of cognitive functions. One arena in which this can be seen is in the domain of language function. Anecdotally, individuals report greater difficulty in both producing and comprehending language when experiencing strong negative emotions. A growing number of controlled empirical studies support the idea that the evocation of negative emotions can impair language production. For example, numerous studies have found that healthy individuals, as well as individuals with disorders such as schizophrenia, demonstrate what has been called affective reactivity in language (Burbridge & Barch, 2002; Docherty, Evans, Sledge, Seibyl, & Krystal, 1994; Docherty, Hall, & Gordinier, 1998; Docherty & Hebert, 1997; Docherty, Sledge, & Wexler, 1994) and in other cognitive functions (Docherty, Grosh, & Wexler, 1996; Rhinewine & Docherty, 2002). Affective reactivity in language refers to the fact that individuals exhibit greater amounts of language disturbances when discussing negatively valenced topics than when discussing positively valenced (Docherty, Evans, et al., 1994; Docherty et al., 1998; Docherty & Hebert, 1997; Docherty, Sledge, & Wexler, 1994) or neutral topics (Burbridge & Barch, 2002). Similar patterns of affective reactivity in language are seen among individuals with schizophrenia, as found in psychiatrically healthy controls, although to a greater degree than that seen in healthy individuals (Docherty et al., 1998). The mechanisms that underlie the relationship between emotional valence, emotional reactivity, and language disturbance remain unclear, either in healthy individuals or in patients with schizophrenia. Thus, the goal of the present study was to explore one possible mechanism, namely, whether negative emotion impairs language production by means of increasing physiological arousal. To begin to address this possibility, we examined whether increases in physiological arousal co-occurred with the impairments in language production elicited by discussing topics with negative valence. Developing a better understanding of such mechanisms will shed further light on the ways in which the processing of different emotions can modify ongoing cognitive processing.

Although affective reactivity of language is found in both healthy individuals and individuals with schizophrenia, a greater amount of research on factors associated with this phenomena has been conducted in schizophrenia. For example, previous research has demonstrated that individual differences in cognitive functions such as selective attention are also correlated with the degree of affective reactivity in language in individuals with schizophrenia (Burbridge & Barch, 2002). In other words, we have found that those individuals with the worst cognitive function are also the most likely to display affective reactivity in language, though clearly more research in this area is needed. It is interesting that Docherty has also found a relationship between physiological responding and affective reactivity in schizophrenia. Individuals with schizophrenia can show either increased or reduced autonomic responding, which has added complexity to the literature on arousal in schizophrenia. However, Docherty has found that individuals with schizophrenia who show the largest magnitude startle responses in basic startle paradigms (i.e., not emotion-modulated startle) also show the greatest affective reactivity in language (Docherty & Grillon, 1995; Docherty, Rhinewine, Nienow, & Cohen, 2001). This led Docherty to suggest that affective reactivity in language is an indication of a general problem with hyperreactivity to emotional and other stimuli, among at least a subset of individuals with schizophrenia (Docherty et al., 2001). Such results also suggest a possible mechanism by which negative emotional valence might influence language and other cognitive functions, namely, that negative emotional valence might elicit at least some components of a stress response, including autonomic and/or other aspects of arousal (e.g., changes in heart rate and/or skin conductance), which are either associated with, or even lead to,

changes in neurotransmitter function (dopamine, norepinephrine). These changes in arousal and/or neurotransmitter function may in turn impair language and other cognitive functions. As discussed in more detail below, physiological arousal may be an indicator of, or even lead to, a stress response, components of which may alter cognitive function. For example, some research suggests that exposure to loud, uncontrollable noise elicits increased arousal and a stress response that alters dopamine function in prefrontal cortex and impairs working memory function in nonhuman primates (Arnsten & Goldman-Rakic, 1998). Working memory function is clearly important for language production (Daneman, 1991; Daneman & Green, 1986; Levelt, 1989; Melinder & Barch, 2003). If negative emotional valence can elicit a stress response that alters working memory function by means of alterations in dopamine function, this pathway could then lead to impairments in language production.

There are several reasons to believe that negative emotion could influence language through changes in arousal. First, numerous studies have shown that eliciting emotional states, particularly negative states, can increase autonomic arousal (Simons, Betenber, & Roedema, 1999). For example, individuals tend to show larger magnitude startle responses when being exposed to negative stimuli as compared to being exposed to neutral stimuli (Bradley, Cuthbert, & Lang, 1990, 1991). In addition, individuals tend to show higher heart rates and a greater frequency of nonspecific skin-conductance responses when exposed to negative as compared to neutral stimuli (Bradley, 2000; Simons et al., 1999), particularly if the negative stimuli are highly arousing (Bradley, 2000; Simons et al., 1999). Thus, there is ample evidence that negative emotional states can increase a number of different aspects of physiological arousal.

Second, a number of studies have shown that increased autonomic arousal can impair a range of cognitive functions. For example, Yerkes and Dodson (1908) long ago articulated the well-known Yerkes-Dodson Law, which describes an inverted U-shaped relationship between arousal and cognitive task performance (Yerkes & Dodson, 1908). Research in this area has been somewhat mixed and controversial. However, a number of studies suggest that high levels of physiological arousal can impair cognitive task performance, particularly when the cognitive task is complex or novel (Anderson, 1994; Hartley & Adams, 1974; Loke, 1993; Pallack, Pittman, Heller, & Munson, 1975; Revelle, Amaral, & Turiff, 1976; Watters, Martin, & Schreter, 1997). Such results have been obtained using a number of different methods for increasing physiological arousal, including the administration of caffeine and physical exercise. There are a number of different explanations for such a relationship between physiological arousal and cognitive task performance, including the idea that increased physiological arousal reduces the amount of available cognitive resources and/or narrows the focus of attention (Humphreys & Revelle, 1984). Taken together with the relationship between emotion and physiological arousal, such research on the relationship between physiological arousal and cognitive performance suggests that it may be useful to explore increased physiological arousal as a potential mechanism by which emotional valence impairs language function.

Of course, arguing that physiological arousal can impair cognitive function raises two important issues. First, some might question whether there is a general construct of arousal that has useful explanatory power. For example, Lacey (1967) long ago called into question a generalized construct of arousal given that different putative indices of arousal (e.g., heart rate, skin conductance, respiration) do not always covary across individuals (Lacey, 1967). At the same time, however, many researchers still argue that there are meaningful and valid uses of the construct of arousal, even if there is not always a tight coupling across individuals of different indicators of changes in physiological arousal (Revelle, 1993; Revelle, Humphreys, Simon, & Gilliland, 1980). Second, it is not simply enough to say that arousal leads to changes in cognitive function. Instead, one needs to specify the mechanisms by which increasing one or more aspects of physiological arousal could alter cognitive function. One possible chain of mechanisms, suggested by Lieberman and Rosenthal (Lieberman & Rosenthal, 2001), involves the relationships among the stress response, changes in catecholamine and prefrontal cortex function, and changes in working memory/executive function. In the context of language production, this explanation might take the following form: (a) discussing negative topics elicits increased autonomic arousal as part of a more general stress response; (b) in addition to changing autonomic indicators of arousal, the stress responses leads to increases in dopamine and norepinephrine (Koob, 1999); (c) both dopamine and norepinephrine influence the function of brain regions such as the dorsolateral prefrontal cortex (Goldman-Rakic, 1995, 1996); (d) the dorsolateral prefrontal cortex supports working memory function necessary for tracking prior discourse and referential targets during language production (Barch & Berenbaum, 1996; Barch, Carter, Braver, & Cohen, 1997); (e) increases in dopamine and norepinephrine in response to stress can impair dorsolateral prefrontal cortex function (Arnsten & Goldman-Rakic, 1998; Goldman-Rakic, 1996), which in turn impairs working memory (and other prefrontally mediated cognitive function) and language production. This explanation for the influence of negative emotion on language production suggests that changes in autonomic arousal should at minimum be an indicator that this set of mechanisms is operating, but it may also be the case that changes in autonomic arousal themselves play a causal role by means of sympathetically mediated elicitation of further changes in catecholamine function.

The goal of the present study was to determine whether discussing negative versus either positive or neutral topics in healthy individuals increased heart rate or skin conductance (as two indicators of physiological arousal) as well as reference errors. As noted above, affective reactivity in language is found in both healthy individuals and individuals with schizophrenia. Thus, studying the relationship between affective reactivity in language and physiological arousal in healthy individuals will help shed light on basic mechanisms that may mediate the influence of emotion on cognitive function and language, as well as help to generate hypotheses as to what might be influencing increased affective reactivity in language among patients with schizophrenia. To examine this question, we asked individuals to produce speech on neutral, positive, and negative topics while we measured heart rate and nonspecific skin conductance responses. We predicted that participants would show higher heart rates and a greater frequency of nonspecific skin conductance responses when discussing negative as compared to either positive or neutral topics but that heart rate and skin conductance would not differ between positive and neutral topics. We also expected to replicate the

finding that discussing negative topics would produce more reference errors than would discussing neutral or positive topics. We also examined the prediction that those participants exhibiting the most physiological reactivity would also be the ones exhibiting the most reference errors. We examined these correlations in each topic condition (positive, negative, neutral). Whereas we expected these correlations to be strongest in the negative topic condition, we nevertheless expected that heightened reference errors would be associated with heightened physiological arousal, regardless of topic of discussion.

Method

Participants

Participants were 35 healthy adults recruited from the community by means of newspaper advertisements and posted flyers. The average age was 28.7 years ($SD = 7.74$, range $= 20-48$), there were 16 men and 19 women, and 91% of the participants were Caucasian. Their average number of years educated was 17.2 ($SD = 1.7$, range $= 14-21$), and their parents' average number of years educated (as a proxy for socioeconomic status) was 16.5 ($SD = 3.3$, range $= 12-21$). Current and past history of Axis I disorders were assessed using a telephone screening measure based on the Structured Clinical Interview for *DSM–IV* Axis I Disorders screening questions for *DSM–IV* symptoms of mood, psychotic anxiety, and substance abuse disorders (First, Spitzer, Gibbon, & Williams, 1995), administered by a master's-level graduate student in clinical psychology. Participants were excluded for a lifetime history of substance dependence, any form of psychosis, or bipolar disorder. Participants were also excluded for substance abuse, major depression, or any anxiety disorder within the previous 6 months. Because we were measuring heart rate and skin conductance, participants were excluded for a variety of factors that could confound the measurement of these variables. Specifically, participants were excluded for smoking, use of psychotropic medications, high blood pressure, diabetes, anemia, asthma, hormone replacement medications (other than birth control), or thyroid disorders. Women on oral birth control medications were included if the dosage had been stable for at least 6 months. Participants were paid $10 per hour for participation. All participants signed informed consent forms prior to participation, in accordance with Washington University Human Subjects Committee guidelines.

Materials and Methods

Speech samples. Each participant was administered a structured interview consisting of 10 open-ended questions. Eight of these questions asked participants to describe an experience when they felt a particular emotion, either positive (excited, experienced a great kiss, carefree, confident) or negative (pain, angry, sad, disappointed). Each of these eight questions was in the form of "Tell me about a specific situation when you felt (experienced). . . . I want you to describe everything that happened in that situation." Two questions asked participants to describe neutral topics ("Tell me about a time when you were shopping in a store. I want you to describe everything that happened in that situation" and "Tell me about a recent trip you took in a car. I want you to describe everything that happened in that situation."). These questions were chosen from an initial sample of 30 questions: 10 negative, 10 positive, and 5 neutral. The 10 questions used in the present study were selected from the initial sample of 30 questions by asking 12 individuals (graduate students and staff) to pick 4 positive, 4 negative, and 2 neutral questions that they felt best fit the valence category and that they felt they could talk about for several minutes during an interview. The order in which the questions were asked was counterbalanced across participants. Participants were told to wait 1 min (with timing indicated by the experimenter) to respond to each question after it was asked. This was done to allow for acquisition of heart rate and skin

conductance, as described in more detail below. Participants' responses to each question were tape-recorded.

Communication disturbance ratings. The tape-recorded interviews were transcribed by one research assistant and checked for accuracy by a second research assistant. Each participant's responses to each question were then rated, using the Communication Disorders Index (CDI; Docherty, DeRosa, & Andreasen, 1996), by two trained research assistants. The CDI is a measure that codes a reference error when a spoken word or phrase obscures the meaning of the larger communication. Although the CDI provides for individual ratings of six different types of reference errors, we used a single total score in all analyses for better reliability, as the reliability of a total score is typically higher than the reliability of individual subtype scores (Docherty, DeRosa, & Andreasen, 1996). To account for potential differences in the amount of speech elicited by different question types (e.g., negative vs. positive vs. neutral), reference errors were calculated as the number of errors per 100 words of speech. The reason for this correction was to account for the possibility that a higher frequency of errors in one condition could be due to a greater amount of speech elicited by that type of question valence, and not necessarily reflect more disturbed speech. We should note, however, that there were no significant differences in the average number of words produced per question in each of the valence conditions, $F(2, 68) = 0.84$, $p > .30$. The average number of words per question was 165.0 ($SD = 82.5$) for the neutral condition, 153.0 ($SD = 64.2$) for the positive condition, and 165.1 ($SD = 71.2$) for the negative condition. Thus, we think it unlikely that differences in the amount of speech account for any obtained differences in the number of reference errors produced across valence conditions. Interrater reliability, measured using interclass correlation coefficients with the mean of the raters as the unit of reliability, was .81.

Psychophysiological variables. Heart rate and skin conductance were collected simultaneously throughout the structured interview. However, the act of producing speech can create artifacts in the heart rate and skin conductance recordings (Brownley, Hurwitz, & Schneiderman, 2000; Dawson, Schell, & Filion, 2000). Thus, as described above, a 60-s speech-free epoch was used between the time a question was asked and the time a participant responded verbally. Although heart rate and skin conductance were collected during the entire interview, we only analyzed heart rate and skin conductance acquired during this 60-s speech-free epoch. This design provided measures of heart rate and skin conductance that were not contaminated by movement artifacts but were still potentially sensitive to changes induced by the valence of the question. In addition, 2-min baseline measures of heart rate and skin conductance were acquired prior to the onset of the interview, with the participant resting quietly.

Heart rate. Heart rate was monitored on a Grass Model 7D polygraph. A Grass photoplethysmograph was attached to the subject's thumb to monitor the pulse wave. Signals were routed to a Grass 7P4 cardiotachometer to detect the rising slope of each R-spike, with the Schmitt trigger adjusted to display heart rate for each subject in beats per minute. Continuous output was obtained during the entire experiment by having the heart rate signal written on a moving strip chart. Each event occurring during the experiment was indicated on the strip chart with an event marker. Two undergraduate research assistants coded average heart rates during specific epochs (i.e., the 2-min baseline, the minute preceding the participant's response to each question) using the strip chart. Interrater reliability, measured using interclass correlation coefficients with the mean of the raters as the unit of reliability, was .99.

Skin conductance. Electrodermal activity was assessed using a Grass Model 7D polygraph. Standard Beckman Ag/AgCl surface electrodes (8 mm internal diameter) were placed on the volar surfaces of the middle phalanges of the first and third fingers of the nondominant hand (participants needed their dominant hand for the questionnaires and word ratings) using double-sided adhesive collars. Prior to attachment, these electrodes were filled with a .05 molar NaCl solution in a Unibase paste, as specified by (Fowles et al., 1981). Skin conductance was measured using a Wheat-

stone bridge, which applied a 0.5V current between the electrodes, constructed according to the design recommended by Venables and Christie (1980). Conductance voltages from the bridge circuit were passed to a Grass 7P3 low-level DC preamplifier set to the 10K circuit. Skin conductance, measured in microsiemens (μS), was acquired on a moving strip chart continuously throughout the experiment. Two trained undergraduate research assistants coded the frequency of nonspecific skin conductance responses for each question (during the 1-min epoch before the participant responded), which were judged to occur when a magnitude increase greater than 0.1 μmhos occurred. Interrater reliability, measured using interclass correlation coefficients with the mean of the raters as the unit of reliability, was .99.

Baseline Cognitive Measures

Participants were asked to complete several cognitive measures that were used to determine whether individual differences in cognitive performance had an impact on the degree of affective reactivity in language.

Vocabulary. The Vocabulary subtest of the Wechsler Adult Intelligence Scale (WAIS)—Third Edition (Wechsler, 1997) was administered as a measure of verbal intelligence. This particular subtest was chosen because it displays the highest correlation of any subtest with verbal IQ scale score ($r = .90$, Wechsler, 1997). The Vocabulary subtest was scored by a master's-level graduate student in clinical psychology.

Stroop. Our previous research found that among individuals with schizophrenia, poor performance on the Stroop task was associated with increased affective reactivity in language (Burbridge & Barch, 2002). In an attempt to replicate this finding in the present sample, we administered a single trial version of the Stroop task that included both the standard Stroop conditions (i.e., congruent, neutral, incongruent) and emotional Stroop conditions (items with either positive or negative valence). In this version, participants were administered 7 blocks of a Stroop task, in which they were asked to name the color in which each word was printed. Each block contained 32 items. In one block, half of the items were congruent (i.e., the word red written in red) and half were neutral (i.e., the word *sum* written in red). In one block all of the items were neutral. In another block, half of the items were neutral and half were incongruent (i.e., the word *red* written in blue). In four blocks, all of the items were words with emotional valence (two blocks with negative valence and two blocks with positive valence). The words in the neutral and emotional valence conditions were matched on length and frequency (Francis & Kučera, 1982). There were 16 unique items in each of the emotional conditions and 16 unique neutral items. The neutral words were from a single semantic category to eliminate semantic confounds (MacLeod, 1991). Order of block administration was counterbalanced across participants.

Word ratings. As described above, the questions designated as eliciting either negative, positive, or neutral emotions were chosen on the basis of norming data. However, to obtain some evidence as to whether participants in the present study perceived the questions as tapping into different emotional topics, each participant was asked to rate the critical words used in the interview for arousal and valence using the Self-Assessment Manikin (SAM; Lang, 1980). The SAM system consists of two dimensions, a positive/negative scale and an arousal/calm scale. Both dimensions are rated on a 5-point scale: $1 = most\ positive\ or\ most\ aroused$, $3 = neutral$ *for both dimensions*, $5 = most\ negative\ or\ most\ calm$. This rating task was always completed after the interview, with the words presented in a different random order for each participant. The participants were asked to respond on the basis of the way the words made them feel, not just on the basis of the semantic meaning of the words or the way the participants thought others might feel about the words. Although by no means a perfect measure, we collected these word ratings as one means of determining whether the participants were actually experiencing a change in emotional state as a function of discussing topics with putatively different valence.

Data Analysis

Because of an equipment malfunction, data for heart rate were missing for 1 participant, data for skin conductance were missing for another participant, and data for the Stroop task were missing for 2 participants. To allow us to analyze the full sample of participants, these missing data points were replaced by the mean of the sample. Kolmogorow-Smirnov tests indicated that the language ($ps = .09-.92$), heart rate ($ps = .79-.99$), and skin conductance ($ps = .2-.69$) variables were normally distributed. Thus, parametric statistics were used to analyze the data. For the Stroop data, medians for correct responses were used in analyses examining response times (RTs).

Results

We began by examining the participants' word ratings of the topics used in the interview to confirm that participants differentiated between the negative and positive words used in the questions. To do so, we conducted dependent-sample t tests on the valence and arousal ratings. These analyses indicated that participants rated the negative words as significantly more negative than the positive words, $t(34) = 271.4$, $p < .001$ [NEG = 4.2 (0.5); POS = 1.6 (0.5)]. However, there were no differences in how subjectively arousing participants rated the negative versus the positive words, $t(34) = 0.1$, $p > .5$ [NEG = 2.6 (0.5); POS = 2.5 (0.8)]. Thus, these analyses confirm that participants perceived the negative topics as having more negative valence than the positive topics.

We next examined whether the reference errors, heart rate, or skin conductance differed across the three question conditions. To do so, we used a multivariate analysis of variance (MANOVA), with emotional valence (neutral, positive, negative) as a within-subject factor. This MANOVA indicated a significant main effect of emotional valence, $F(6, 29) = 2.82$, $p < .05$. This significant effect was followed up with two planned orthogonal contrasts for each of the dependent variables. This first contrast compared the negative condition to both the positive and neutral condition simultaneously (contrast weights $= 1, -.5, -.5$) and the second contrast compared the positive and neutral conditions to each other (contrast weights $= 0, 1, -1$). The contrasts comparing the negative to the positive/neutral conditions were significant for reference errors, $F(1, 34) = 6.4$, $p < .05$, heart rate, $F(1, 34) = 5.1$, $p < .05$, and skin conductance, $F(1, 34) = 4.7$, $p < .05$. However, the contrasts comparing the positive to the neutral condition were not significant for reference errors, $F(1, 34) = 0.02$, $p > .8$, heart rate, $F(1, 34) = 0.7$, $p > .40$, or skin conductance, $F(1, 34) = 0.3$, $p > .60$. As shown in Table 1, reference errors, heart rate, and the frequency of nonspecific skin conductance responses were highest in the negative condition but relatively similar in the positive and neutral conditions.

We next examined whether individual differences in reference errors, heart rate, or skin conductance were associated with each other in any of the valence conditions. In the positive valence condition, there were no significant correlations among the reference, heart rate, and skin conductance variables ($-.13 > r < .14$). However, in the neutral condition, there was a significant positive correlation between reference errors and heart rate ($r = .31$, $p < .05$). Skin conductance was not correlated with either reference errors ($r = .03$, $p > .40$) or heart rate ($r = .04$, $p > .40$) in the neutral condition. A similar pattern was found in the negative

Table 1
Reference Errors, Heart Rate, and Skin Conductance in the Three Valence Conditions

	Valence condition					
	Mean			Standard deviation		
Variable	Neutral	Positive	Negative	Neutral	Positive	Negative
Reference errors (errors per 100 words)	2.43	2.46	2.99	1.21	1.17	1.79
Heart rate (beats per minute)	79.26	79.71	80.34	11.75	11.96	12.26
Nonspecific skin conductance responses (frequency)	2.03	2.22	2.5	1.56	1.75	1.5

valence condition, with a trend toward a positive correlation between reference errors and heart rate ($r = .24$, $p = .08$) but no significant correlations between skin conductance and either reference errors ($r = -.03$, $p > .40$) or heart rate ($r = .11$, $p > .20$). We next examined whether individual differences in these baseline physiological variables affected the degree of affective reactivity displayed by participants. To create affective reactivity scores for reference errors, heart rate, and skin conductance, we conducted regressions for each of these variables separately, and scores in the neutral condition were used to predict scores in the negative valence condition. The residuals from these regressions were then used as a measure of affective reactivity. The baseline measures of heart rate and skin conductance were not significantly correlated in the expected direction with any of the measures of affective reactivity ($-.32 < r < .001$).

The analyses presented above indicated that, in comparison to the positive and neutral valence conditions, the negative valence condition was associated with increased reference errors, heart rate, and skin conductance. However, the correlational analyses did not suggest strong relationships between individual differences in reference errors and either heart rate or skin conductance. An additional question is whether the increase in language errors in the negative condition is primarily associated with the increase in physiological arousal or whether some aspect of negative valence has an influence on references errors over and above the influence of arousal. To address this question, we conducted an analysis of covariance, with reference errors as the dependent measure, valence condition as a within-subjects factor, and both heart rate and skin conductance as varying covariates (Page, Braver, & Mac-Kinnon, 2003). This analysis indicated that the main effect of condition remained significant even after accounting for the changes in heart rate and skin conductance that occurred across conditions, $F(2, 66) = 4.0$, $p < .05$.

We next examined whether either of the cognitive measures (WAIS Vocabulary, Stroop) was associated with the severity of reference errors. As described above, because of an equipment malfunction, 2 participants did not have Stroop data. For the Stroop, we examined three measures: (a) Stroop interference (incongruent RT − neutral RT), (b) negative interference (negative RT − neutral RT), and (c) positive interference (positive RT − neutral RT). We did not include errors in the incongruent condition because there was a very low error rate and relatively little variance ($M = 2.6\%$, $SD = 6.6\%$). As expected, participants demonstrated the typical Stroop interference effect, with slower RTs in the incongruent condition ($M = 724.2$, $SD = 142.9$) as compared

to the neutral condition ($M = 597.1$, $SD = 95.1$), $F(1, 34) = 117.46$, $p < .01$. As is sometimes found in healthy young adults (MacLeod, 1991), we found a reverse facilitation effect, with RTs slower in the congruent condition ($M = 632.8$, $SD = 117.1$) than in the neutral condition, $F(1, 34) = 13.48$, $p < .01$. We did not find that RTs were significantly slower in either the negative ($M = 602.9$, $SD = 115.2$) or positive ($M = 600.3$, $SD = 103.3$) word blocks as compared to the neutral word blocks, $F(1, 34) = 0.41$, $p > .66$. As shown in Table 2, performance on the Stroop task was associated with reference errors. Similar to our previous results, Stroop interference was significantly associated with the severity of reference errors in the negative condition and in the neutral condition. Further, Stroop interference was significantly correlated with affective reactivity such that a greater amount of interference was associated with more affective reactivity. As shown in Table 2, neither negative nor positive interference was associated with reference errors. The WAIS Vocabulary scores were not significantly correlated with reference errors in any of the valence conditions (all $ps > .25$).

Discussion

The results of the present study once again provide evidence that language production demonstrates negative affect reactivity. Specifically, we found that participants produced more reference errors when responding to questions designed to elicit negative valence as compared to questions designed to elicit either positive or neutral valence. More important, we also found that participants

Table 2
Correlation Between Stroop Task Performance and Reference Errors

Condition	Stroop interference (incongruent RT − neutral RT)	Negative interference (negative RT − neutral RT)	Positive interference (positive RT − neutral RT)
Neutral	.30*	.16	.21
Positive	.21	.01	−.02
Negative	.43**	.10	.20
Affective reactivity	.31*	.008	.09

Note. Affective reactivity scores for reference errors were the residuals of a regression using reference errors in the neutral condition to predict reference errors in the negative condition. RT = response time.
* $p < .05$, one-tailed.   ** $p < .01$, one-tailed.

displayed higher heart rates and a higher frequency of nonspecific skin conductance responses during the negative, as compared to positive and neutral, condition. Further, we found some evidence for relationships between individual differences in reference errors and physiological arousal, at least in terms of heart rate. Taken together, these results are consistent with the hypothesis that one mechanism by which negative valence impairs language production is through an increase in physiological arousal. However, we also found that the increase in reference errors in the negative, as compared to positive and neutral, conditions remained significant even after accounting for the increases in heart rate and skin conductance that occurred in the negative valence condition. This result suggests that although one factor influencing language errors may be an increase in physiological arousal, other factors associated with negative valence may also be contributing to an increase in language errors.

As discussed previously, Docherty and colleagues have suggested that affective reactivity in language and other cognitive functions is part of a more general increase in responsivity to emotional (particularly negative stimuli) and other stimuli in at least some individuals with schizophrenia (Docherty et al., 2001). Our results are clearly consistent with the hypothesis that affective reactivity in language is associated with physiological reactivity even among healthy individuals. However, we did not find that baseline levels of physiological arousal were associated with the degree of affective reactivity, either in language or physiology. On the surface, one might think that this result is inconsistent with Docherty's findings that increased basic startle amplitudes are associated with increased affective reactivity in language (Docherty & Grillon, 1995; Docherty et al., 2001). However, it is important to note that startle amplitudes are a response to a specific stimulus, whereas our baseline measures were simply resting measures that did not involve a response to any specific stimulus. Thus, as noted by Docherty, it may specifically be responsivity to stimuli that is predictive of affective reactivity, rather than resting levels of physiological arousal. Further research in both healthy individuals and individuals with schizophrenia is needed to clarify the parameters of responsivity and arousal that may be related to affective reactivity.

As noted in the introduction, a long history of research has shown that increased physiological arousal can impair various types of cognitive functions, including selective attention and working memory (Anderson, 1994; Hartley & Adams, 1974; Loke, 1993; Pallack et al., 1975; Revelle et al., 1976; Watters et al., 1997). As such, our results are consistent with the hypothesis that emotion can serve to increase physiological arousal and thus impair cognitive function. However, our results are correlational and cannot establish causality. For example, it is possible that an aspect of emotional processing other than increased heart rate and skin conductance is mediating the influence on language, but that heart rate and skin conductance simply tend to covary with whatever this other aspect might be and are not causally related in and of themselves. As described above, we found that increases in reference errors remained significant even when accounting for the changes in physiological arousal that occurred in the negative condition. This finding seems to indicate that something about negative valence that is not captured by increased physiological arousal may be contributing to language dysfunction. As noted in the introduction, it is possible that changes in autonomic arousal

are an indication that other processes are occurring (e.g., changes in neurotransmitter function) that are themselves the causal mechanisms that lead to changes in cognitive function and language production. One way to address this issue would be to directly manipulate physiological arousal during language production, both in healthy individuals and in individuals with schizophrenia. In prior research, this has been done in various ways, including by administering caffeine and by asking individuals to exercise prior to performing cognitive tasks. If increasing arousal during language production elicited an increase in reference errors, analogous to that seen when discussing negative topics, such results would provide further evidence consistent with the hypothesis that negative valence impairs language production by means of an increase in physiological arousal. However, if it is some other aspect of emotional processing, then we would not expect that increased physiological arousal through "nonemotional" means would have the same impact on language production as that found in the present study.

Similar to our previous research in individuals with schizophrenia (Burbridge & Barch, 2002), we again found that worse Stroop task performance was associated with increased affective reactivity in language, even among healthy controls. Thus, our findings extend the findings of Burbridge and Barch (2002) by demonstrating that the language of healthy individuals (as well as individuals with schizophrenia) with worse selective attention contains more disturbance overall and is more vulnerable to increased disturbance when responding to questions that elicit a negatively valenced response. These results add to a growing literature suggesting that there may be a role for selective attention in regulating the influence of affective arousal on language and other cognitive functions. If so, then populations with deficits in selective attention, such as individuals with schizophrenia, may show larger affective reactivity effects because they are less able to modulate or inhibit emotional aspects of stimuli if they are not task relevant, potentially interfering with their ability to attend to task-relevant information.

As described in the introduction, we have hypothesized that increasing physiological arousal may be leading to changes in language production by means of changes in working memory and/or attention. This hypothesis focuses on an impairing influence of negative emotion/content on cognitive function and language processing. However, recent research suggests that emotional activation can have both impairing and facilitatory influences, depending on the nature of the emotion and the type of cognitive process involved (Gray, 2001, 2002; Gray & Braver, 2002; Gray, Braver, & Raichle, 2002). For example, recent research by Gray and colleagues suggests that negative (withdrawal) emotions can have impairing influence on verbally based working memory processes but facilitatory effects on nonverbal (i.e., spatial) working memory processes (Gray, 2001, 2002; Gray & Braver, 2002; Gray et al., 2002). In contrast, Gray has shown that positive (approach) emotions can facilitate verbal working memory but impair spatial working memory. Gray has hypothesized that such results may be mediated by the brain regions activated by different emotional states and cognitive tasks. Davidson and colleagues have shown in a number of studies that approach motivation states lead to relatively greater left frontal activation than right frontal activation, whereas withdrawal motivation states lead to relatively greater right frontal activation than left frontal activation (David-

son, 1995, 1998, 1999). In addition, numerous studies have shown that verbal cognitive tasks (e.g., working memory, episodic memory) lead to relatively greater left inferior frontal activation than right inferior prefrontal activation but that nonverbal cognitive tasks lead to relatively greater right inferior prefrontal activation than left inferior prefrontal activation (Braver et al., 2001; D'Esposito et al., 1998). As such, Gray has argued that emotional and cognitive processes that activate the same brain regions/ hemispheres (e.g., left frontal for both verbal working memory and approach motivation; right frontal for both nonverbal working memory and withdrawal motivation) lead to facilitatory effects of that emotion on cognitive processing but that emotional and cognitive processes that activate different brain regions/hemispheres (e.g., right frontal for withdrawal motivations combined with left frontal for verbal working memory) can lead to impairing effects of emotion on cognitive processing. Such a hypothesis leads to a potential alternative explanation for the negative influence of negative emotions on reference processes that we obtained. Specifically, one might argue that these results reflect another example of negative emotional states impairing verbal processes and that this effect is mediated by reliance on different brain regions rather than increases in physiological arousal generated by negative emotional states. However, if this hypothesis were true, one might expect to find that positive emotions actually improve reference production, as the Gray results would suggest that positive/approach states should have a facilitatory effect on verbal processes. However, we did not find any evidence that individuals made significantly fewer errors in the positive topic condition as compared to the neutral topic condition. However, it is possible that the lack of difference between the positive and neutral conditions might reflect floor effects (e.g., low error rates, even in the neutral condition). As such, it would be interesting to further examine this hypothesis in future research by using a language production paradigm that elicits a greater number of errors, even in the neutral condition.

An important question to be addressed is the degree to which the results of the present study shed light on the mechanisms that lead to affective reactivity of language and other cognitive functions in schizophrenia. For example, the degree of language impairment found in the negative valence condition as compared to the positive and neutral conditions was relatively small in the healthy controls in the present study. This degree of impairment may not have been noticeable to a naïve conversation partner or as severe as that found in schizophrenia. However, the controlled conditions used in the present study likely elicited much milder negative responses than those that can occur in real-world situations. Given that we still found significant effects even with relatively mild stimuli, it seems likely that much stronger and more apparent changes in language production occur in real-word situations that elicit much stronger negative emotional reactions. Second, the fact that healthy controls showed enhanced physiological arousal when responding to negatively valenced questions does not necessarily mean that individuals with schizophrenia show the same pattern of enhanced arousal. However, there is evidence that at least some individuals with schizophrenia may show enhanced physiological responding (Kring & Neale, 1996), and there is much evidence to suggest that individuals with schizophrenia have vulnerable cognitive systems (Barch, 2003; Burbridge & Barch, 2002). As such, the possibility that individuals with schizophrenia have either enhanced physiological responses to emotionally evocative stimuli

or cognitive systems that are particularly vulnerable to the effects of arousal seems reasonable to pursue in future research.

In summary, in the present study we demonstrated that negative valence increased reference errors, heart rate, and skin conductance when individuals produced language. These results are consistent with the hypothesis that one mechanism by which negative valence impairs language production is by means of an increase in physiological arousal. The current results suggest important avenues for research in both healthy individuals and individuals with schizophrenia. As noted above, it will be important to determine whether increasing physiological arousal through "nonemotional" means has the same impact on language production as increasing arousal through emotional paradigms. Second, it will be important to try to directly measure the changes in cognitive processes that may be mediating the influence of increased arousal on language production. Third, our results suggest that it will be important to examine physiological arousal during language production in individuals with schizophrenia to determine whether these individuals also show higher physiological arousal levels when discussing negative, as compared to positive or neutral, topics. In addition, it will be important to examine whether individuals with schizophrenia show greater affective reactivity in physiology than do healthy individuals. If so, such a result might help explain why individuals with schizophrenia demonstrate larger affective reactivity effects in language than do healthy controls. The existing research on physiological responses to emotion in schizophrenia is somewhat mixed, with some studies suggesting stronger physiological responses across the board, regardless of affective content (Kring & Neale, 1996), and others making no such suggestion (Curtis, Lebow, Lake, Katsanis, & Iacono, 1999). Thus, in future research, it will be important to examine parameters such as heart rate and skin conductance specifically during language production in individuals with schizophrenia.

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