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SHORT COMMUNICATION

Psychobiological impact of speaking a second language in healthy young men

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ABSTRACT

The use of second languages is ubiquitous in modern societies. Despite many benefits, there is also evidence for this to cause or exacerbate stress (e.g. in the form of foreign language anxiety). The aim of the present study was to examine to which extent speaking a second language increases acute psychobiological stress in a social context. A total of $N = 63$ healthy Swiss males were randomly allocated to one of two conditions: completing the Trier Social Stress Test (TSST) in Swiss German (their first language) vs. standard German (perceived as a second language). Repeated measures of self-reported stress, anxiety, salivary cortisol, and heart rate were obtained. Participants speaking standard German showed significantly larger cortisol increases in response to the TSST when compared to those speaking Swiss German ($F(1, 61) = 5.53$, $p = .022$, $eta^2 = .083$). The two groups did not differ in terms of self-reported stress and anxiety, nor in their heart rate response (all $p > .216$). This study provides initial evidence that speaking a second language in social contexts increases the cortisol stress response. Future research should explore the short- and long-term effects this may have in populations frequently using second languages (e.g. learners of a second language, migrants).

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Introduction

Speaking a second language has become an integral part of daily life for people all over the world. In the European Union, secondary school students learn 1.5 foreign languages on average in addition to their native language (Eurostat, 2012a). University student mobility is high, with over half a million of young adults enrolled at other European universities (Eurostat, 2012b), and globally, the number of migrants is currently estimated at 258 million (UN, 2017). In addition, several countries have multiple official languages and most harbor a wide variety of regional dialects or varieties of the native language. When taken together, these numbers suggest that a large proportion of the global population regularly engages in the use of a second language.

Despite the numerous benefits that come with this, there is evidence to suggest that speaking a second language may also cause stress or exacerbate stress in situations that are already highly stressful to most individuals. This is perhaps most evident in the case of foreign language anxiety, which is a common phenomenon among learners of a second language (Horwitz, Horwitz, & Cope, 1986). In addition to causing or enhancing psychological stress, using a second language may also activate stress-responsive biological systems, such as the autonomic nervous system or the hypothalamic-pituitary-adrenal (HPA) axis. However, no research has yet been undertaken to investigate the psychobiological impact of speaking a second language in social contexts.

To answer this research question, a homogenous group of healthy Swiss natives from the German-speaking part of the country was exposed to a social task known to induce an acute psychobiological stress response (the Trier Social Stress Test; TSST; Kirschbaum, Pirke, & Hellhammer, 1993). Individuals were randomly allocated to one of two conditions: performing the TSST in Swiss German vs. standard German. The situation in Switzerland resembles that of a diglossia (Ferguson, 1959), meaning that native people are trained to speak two varieties of the same language: Swiss German and standard German. While Swiss German is learned from the cradle, the specific grammar and lexicon of standard German are taught when entering the school system, and its oral use is confined to schools and universities, the military, and law courts. Thus, although Swiss and standard German are merely language varieties from a linguistic point of view, standard German shares several features of a second language. In line with this, studies have shown that nearly 80% of Swiss people endorse the statement that "standard German is the first foreign language for the Swiss" and over a third report feeling inhibited when speaking standard German (Hägi & Scharloth, 2005; Scharloth, 2005). Based on these findings, we expected that participants performing the TSST in standard German (the second language)

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would exhibit more pronounced stress responses when compared to those speaking Swiss German (the first language). More specifically, we would expect greater increases in self-reported stress and anxiety, heart rate, and cortisol concentrations in participants speaking standard German.

Methods

Participants

All participants were recruited via mailing lists of the University of Zurich and the Swiss Federal Institute of Technology. Inclusionary criteria were being at least 18 years of age, male sex (due to the confounding effects of sex steroids on stress responses), and being a native speaker of Swiss German. Exclusionary criteria were having a physical or mental illness, smoking, intake of more than three standard units of alcohol per day, and regular intake of medication. A G*Power analysis yielded a necessary sample size of $N = 60$ when assuming medium effect sizes, and when power was set at .80 and the alpha error set at 0.05. In the end, $N = 63$ participants were recruited and reimbursed with 40 Swiss Francs. The study was in line with the Declaration of Helsinki and approved by the Ethics Committee of the Canton of Zurich, Switzerland.

Protocol

All participants were asked to abstain from heavy exercise within 24 h and not to eat or drink alcoholic or caffeinated beverages within 2 h before their study appointment. To account for the diurnal variation of our biological outcomes, all appointments were scheduled between 2 pm and 4 pm in the afternoon and included a resting period of 30 min to allow participants to accommodate to the laboratory environment. Participants were randomly allocated to one of two conditions: completing the Trier Social Stress Test (TSST; Kirschbaum et al., 1993) in Swiss German ($n = 33$) vs. standard German ($n = 30$). The TSST is one of the most widely employed laboratory paradigms to induce psychosocial stress. It is composed of two parts: performing a mock job interview and a mental arithmetic exercise in front of an expert committee (both parts taking 5 mins each). Repeated measures of self-reported stress, anxiety, salivary cortisol as an indicator of HPA axis activity, and heart rate as an indicator of autonomic activity was obtained (see also below).

Psychological measures

Sociodemographic information was obtained by questionnaire. Participants were asked to indicate the number of years of speaking standard German and to rate their perceived level of proficiency on a scale from 0 to 100.

Self-reported stress was measured on a visual analog scale (VAS) from 0 to 100. Self-reported anxiety was measured via the state version of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970). Both measures were first obtained after the resting period (baseline). Further measures were taken immediately before and after the TSST (+10 min).

Biological measures

Heart rate was continuously measured with an ambulatory monitor (Polar Electro Oy, Kempele, Finland). Saliva samples were collected to assess cortisol, using salivettes (IBL, Hamburg, Germany). Samples were taken after the resting period (baseline), immediately before the TSST, immediately after the TSST (+10 min), +20 min, +35 min, +60 min, and +90 min. Samples were stored at −20 °C. Cortisol was analyzed using luminescence immunoassays (IBL, Hamburg, Germany). All analyses were conducted at the biochemical laboratory of the Institute of Psychology, University of Zurich. The inter- and intra-assay variations were below 10%.

Statistical analyses

All biological parameters were checked for outliers, defined as three standard deviations (SD) below or above the sample mean. All variables deviating from a normal distribution were log-transformed (biological measures) or analyzed by means of non-parametric tests (psychological measures). To check whether our randomization was successful, the group instructed to speak Swiss German and the group instructed to speak standard German were compared in terms of sociodemographic variables, regarding their perceived level of proficiency in standard German (scale from 0–100), and regarding the number of years speaking standard German. Repeated measures ANOVAs including both pre- and post-TSST time points were calculated to determine whether the TSST induced a significant psychobiological stress response, and whether response patterns were influenced by group status. Univariate ANOVAs were subsequently computed to check whether the two groups differed in the magnitude of their psychobiological stress response, that is, in mean increases of stress and anxiety levels, cortisol, and heart rate (calculated as differences between peak values and pre-TSST values). A correction for multiple comparisons was applied using the false discovery rate – that is, the α-value was adjusted by $(n + 1)/2n$ and thus with two hypotheses being tested, only p values below .0375 were deemed to be significant (Benjamini & Hochberg, 1995). All analyses were conducted in SPSS (IBM Corp., Armonk, NY).

Results

Participant characteristics

Mean age was 24 ± 4 (range: 20–35) and mean BMI was 22 ± 3 (range: 19–27). Three-quarters of the sample were students. Correspondingly, 57% reported A levels (Matura) as their highest completed degree, 18% held a BA/BSc, and 10% held an MA/MSc. The mean number of years speaking standard German was 18 ± 4 (range: 11–30). On average, participants rated their proficiency in speaking standard German at 79 ± 16 on a scale from 0 to 100. The two experimental

groups were statistically equal regarding all sociodemographic and language competence related variables (all $p > .254$).

Self-reported stress and anxiety

Participants' ratings of their stress ($F(1.81, 110.13) = 29.69$, $p < .001$, partial $eta^2 = .327$) and anxiety levels ($F(2, 122) = 32.94$, $p < .001$, partial $eta^2 = .351$) varied significantly in response to the TSST. This means that the TSST was able to elicit a psychological stress response. However, neither response patterns (stress: $F(1.81, 110.13) = 1.02$, $p = .359$, partial $eta^2 = .016$; anxiety: $F(2, 122) = 1.07$, $p = .348$, partial $eta^2 = .017$) nor mean increases in stress and anxiety differed between participants speaking standard German versus those speaking Swiss German (stress: $M = 25.1$, 95% CI [17.987, 32.222] vs. $M = 30.5$, 95% CI [23.664, 37.245]; $F(1, 61) = 1.18$, $p = .281$, partial $eta^2 = .019$; anxiety: $M = 8.33$, 95% CI [5.575, 11.091] vs. $M = 9.35$, 95% CI [6.721, 11.980]; $F(1, 61) = .29$, $p = .595$, partial $eta^2 = .005$).

Cortisol

The TSST induced significant changes in cortisol levels ($F(2.15, 130.91) = 112.27$, $p < .001$, partial $eta^2 = .648$), with response patterns not differing between the two groups ($F(2.15, 130.91) = 2.10$, $p = .123$, partial $eta^2 = .033$). However, as can be seen in Figure 1, participants speaking standard German showed significantly larger mean cortisol increases when compared to those speaking Swiss German ($M = 0.98$, 95% CI [0.800, 1.166] vs. $M = 0.67$, 95% CI [0.511, 0.860]; $F(1, 61) = 5.53$, $p = .022$, partial $eta^2 = .083$).

Heart rate

Heart rate showed a significant increase in response to the TSST ($F(5.85, 356.88) = 35.17$, $p = .001$, partial $eta^2 = .366$). However, as evident from Figure 2, neither response patterns ($F(5.85, 356.88) = 0.88$, $p = .510$, partial $eta^2 = .014$) nor increases in heart rate differed between the two experimental groups ($M = 0.14$, 95% CI [0.102, 1.183] vs. $M = 0.18$, 95% CI [0.139, 0.216]; $F(1, 61) = 1.56$, $p = .216$, partial $eta^2 = .025$).

Conclusions

This is the first study to investigate the immediate psychobiological impact of speaking a second language. We report two main findings: first, healthy Swiss males performing the TSST in standard German displayed greater cortisol responses when compared to those performing the test in their first language Swiss German. Second, the two groups did not differ in terms of self-reported stress and anxiety. These results from a highly controlled and homogenous group may have important implications for individuals speaking a second language in different contexts (e.g. international communication, migration).

The main result of this study – increased biological (cortisol) stress responses in participants speaking a second language – is notable, particularly when considering that the Swiss are being taught to speak standard German fluently from early school years onwards. One might assume that the identified effect would be even more pronounced when languages are being learned later on in life. The present results can thus be interpreted as initial evidence for activation on a biological level when speaking a second language. In the short term, this may affect both language fluency (Buchanan, Laures-Gore, & Duff, 2014) and complexity (Saslow et al., 2014), as previously shown in healthy participants facing the TSST. In the long term, speaking a second language may serve as a constant minor stressor. However, findings from resilience (e.g. Bonanno, 2004) or stress inoculation research (e.g. Hammerfald et al., 2006) suggest that the vast majority of individuals are capable of dealing with stressors of mild to moderate intensity. Further experimental and longitudinal research is therefore warranted to investigate the short- and long-term consequences of second language use, and to pinpoint those individuals at risk of suffering negative consequences.

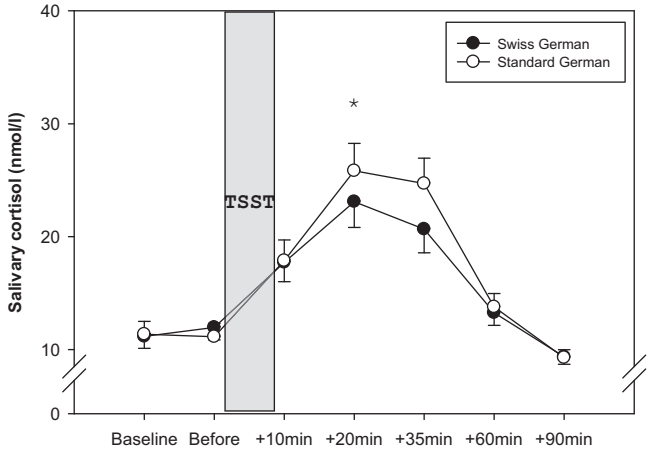

Figure 1. Cortisol concentrations during the Trier Social Stress Test (TSST) in participants speaking Swiss German (the first language) vs. standard German (the second language); while response patterns did not differ between the two groups, there was a significant difference in mean increases of cortisol; $^*p < .05$.

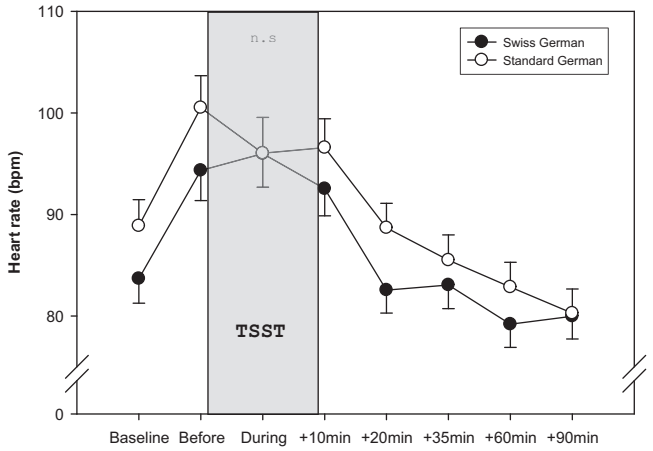

Figure 2. Heart rate during the Trier Social Stress Test (TSST) in participants speaking Swiss German (the first language) vs. standard German (the second language); no differences in either response patterns or mean increases in heart rate were observed; n.s. = not significant.

One important difference between Swiss German and standard German is that the latter is associated with school and public authority contexts. Speaking standard German may thus trigger connotations of performance pressure and social scrutiny, and indeed, Swiss people appear to feel inhibited when speaking standard German (Scharloth, 2005). Since it is hardly ever practiced in everyday life, speaking standard German may also enhance both subjective uncontrollability and the degree of perceived evaluation, both of which were shown to be critical constituents of any situation to provoke an HPA axis response (Dickerson & Kemeny, 2004). By contrast, previous research has shown that the autonomic nervous system responds more broadly and to any type of effort-demanding task, including physical challenges (e.g. Skoluda et al., 2015), potentially rendering it less sensitive to the incremental effects of second language use on the stress response. This could explain why speaking standard German did not exacerbate subjects' increases in heart rate in the present study.

Despite significant additional increases in cortisol, speaking standard German did not lead to higher levels of self-reported stress or anxiety during the TSST. This observation of a dissociation between psychological and biological markers of the stress response is not novel (e.g. Campbell & Ehlert, 2012; Noser, Fischer, Ruppen, & Ehlert, 2018). In the present context, these results may indicate that subjects were unaware that speaking standard German was stressful to them, which again is in line with standard German being taught from an early age onwards as one of two varieties of German that are being spoken in Switzerland. Notably, we would assume that more stress and anxiety would have been reported by populations with greater meta-cognitive awareness of foreign language speaking, such as students learning a second language (Horwitz et al., 1986), or immigrants. There is also evidence that men show greater biological (Liu et al., 2017), but often less intense psychological responses to the TSST when compared to women (e.g. Kelly, Tyrka, Anderson, Price, & Carpenter, 2008). It is therefore upon further research to test to what extent this particular finding extends to women and other populations frequently using second languages, such as learners of a second language, or migrants.

Our study offers a number of strengths. First, the fact that ours was a native sample of individuals with nearly identical language learning histories and the fact that we rigorously controlled for potential biological confounders precludes the influence of any third variables on our findings, which may be difficult to control in other samples (e.g. different degrees of pre- and peri-migratory stress in migrant samples). Second, stress was assessed in a comprehensive manner in that we used both psychological and biological measures to depict responses to the TSST. However, a number of limitations need to be considered when interpreting our findings. First, excluding women due to the confounding effects of sex steroids on stress responses means that further research is warranted to test whether speaking a foreign language contributes to stress in women. This is particularly important given that women tend to show less pronounced biological (Liu et al., 2017), but more intense psychological responses to psychosocial stress when compared to men (e.g. Kelly et al., 2008). Following from this, it is conceivable that speaking a foreign language would exacerbate psychological stress in women, while at the same time not necessarily impacting on their biological stress response. Second, as outlined above, the particular features of the present sample present with several advantages. However, despite the fact that the vast majority of Swiss people consider standard German a second language (Hägi & Scharloth, 2005), standard German is not a second language from a linguistic point of view. While we would argue that the perception of a language as non-native vs. native rather than the linguistic category it pertains to is relevant in the present context, future research is encouraged to extend our findings by comparing the effects of, for example, speaking Spanish vs. English in a homogenous group of second-generation migrants. It is to be expected that speaking a foreign language, and particularly one of different origin (eg, non-Germanic) would yield larger effects than reported in this study.

In sum, this study provides initial evidence that the use of a second language increases cortisol stress responses in a social context. Prior research has identified language-related difficulties as one of the strongest contributors to acculturation stress in migrant populations (e.g. Lueck & Wilson, 2011), and foreign language anxiety is a common phenomenon in learners of a second language (Horwitz et al., 1986). When taken together, the question thus arises as to the short- and long-term sequelae of second language use. To answer this question, future research should explore: (a) to what extent the present findings extend to other populations engaging in frequent use of second languages, and (b) to study proximal (e.g. speaking performance) and distal (e.g. chronic stress) outcomes of second language use.

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Disclosure statement

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