



Published in final edited form as:

*Evol Hum Behav.* 2012 January ; 33(1): 42–45.

## Instant messages vs. speech: hormones and why we still need to hear each other

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### Abstract

Human speech evidently conveys an adaptive advantage, given its apparently rapid dissemination through the ancient world and global use today. As such, speech must be capable of altering human biology in a positive way, possibly through those neuroendocrine mechanisms responsible for strengthening the social bonds between individuals. Indeed, speech between trusted individuals is capable of reducing levels of salivary cortisol, often considered a biomarker of stress, and increasing levels of urinary oxytocin, a hormone involved in the formation and maintenance of positive relationships. It is not clear, however, whether it is the uniquely human grammar, syntax, content and/or choice of words that causes these physiological changes, or whether the prosodic elements of speech, which are present in the vocal cues of many other species, are responsible. In order to tease apart these elements of human communication, we examined the hormonal responses of female children who instant messaged their mothers after undergoing a stressor. We discovered that unlike children interacting with their mothers in person or over the phone, girls who instant messaged did not release oxytocin; instead, these participants showed levels of salivary cortisol as high as control subjects who did not interact with their parents at all. We conclude that the comforting sound of a familiar voice is responsible for the hormonal differences observed and, hence, that similar differences may be seen in other species using vocal cues to communicate.

### Keywords

Middle childhood; Females; Oxytocin; Instant messaging; Vocal communication; Social behavior; Human evolution

## 1. Introduction

Human speech consists of both tonal cues, which are used by a number of other animals as a means of conveying emotional color, and the ability to understand and generate grammatically complex content, which is ostensibly unique to our species. When speech takes place in person, these elements are also accompanied by nonverbal cues such as visual and olfactory components that can add complex nuances to the exchange, and underlying all is the intricate cognitive network enabling humans to perceive differences in meaning depending on the identity of the speaker and their relationship with the self.

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Considerable work shows that regular social interaction is critical to both typical development (Kaufman et al., 2004) and adult health in our species (Norman et al., 2010), and given its centrality to the human experience it is likely that speech plays a role in such processes. Nonetheless, we still do not have answers to such basic questions as how speech is capable of changing the brain under species-typical behavioral circumstances or what the proximate mechanisms of such action may be. Very little work to date has examined the effects of speech on human biology, under naturalistic conditions, in real time. Without such inquiry, it is impossible to piece apart what elements of human speech are shared with other species and which are unique to our own.

Some information, however, is available. Recent work by Seltzer, Ziegler and Pollak (2010) indicates that speech between mothers and daughters is comparable to physical touch in its ability to decrease measures of salivary cortisol, a hormone that tends to increase after a challenging or stressful event, and increases urinary measures of oxytocin (OT), a hormone which appears to be associated with such phenomena as maternal–infant attachment (Uvnäs-Moberg, 1996) and other forms of affiliation between trusted individuals when relevant social cues are present (Carter, 1998; Kosfeld, Heinrichs, Zak, Fischbacher & Fehr, 2005; Razzoli, Cushing, Carter & Valsecchi, 2003; Uvnäs-Moberg, 1997; Landgraf, 2005). The current study builds off of this previous work in attempting to discern which component of speech — the content of the words used or their tonality — may be responsible for this observation.

To address this question, we compared the hormonal responses of children hearing their mother's voice with those who communicated with their mother via instant message. This paradigm allows us to eliminate the prosodic elements of a phone conversation while controlling for conversational content. If children in the instant message group fail to show a similarly striking response in terms of OT or markers of stress like salivary cortisol to those able to hear their parent over the phone, then it is likely that the prosodic, auditory component of a familiar voice is responsible for the differences in hormonal shifts between these and children not permitted to interact with their parent after a stressful event. If, however, a similar hormonal pattern is observed even when all communication is accomplished via instant message, i.e., with no vocal cues at all, then this effect might be due to the unique role of the emotional content of linguistic exchange itself, which can only be observed in humans. This would highlight quite a unique quality of our species — the ability to translate a symbol into a hormonal response. Given the ancient nature of vocal communication in other vertebrates (Bass, Gilland & Baker, 2008), however, we hypothesized that instant messaging would fall short of auditory social cues in terms of eliciting a peptide response in human children.

## 2. Methods

### 2.1. Subjects

We recruited 68 girls between the ages of 7.5 and 12 (mean=9.85 years, S.D.=1.08 years) to participate in a study about the hormonal effects of human speech. Participants arrived at the laboratory at 4:00 p.m. to control for circadian fluctuations of salivary cortisol, after which they signed consent and assent forms, filled out questionnaires to evaluate relationship quality between mothers and girls (Parent-Child Relationship Quality; Furman & Giberson, 1995) and rested for 30 min in order to become acclimatized to the laboratory environment. They then underwent the Trier Social Stress Test for Children (TSST-C) (Kirschbaum, Pirke & Hellhammer, 1993; Gunnar, Wewerka, Frenn, Long & Griggs, 2009) which consists of a brief preparation period followed by both verbal and math tasks performed in front of an audience trained to maintain a neutral facial expression, causing a stress response in most participants. The task lasted approximately 15 min for all components.

Afterward, children were randomly assigned to one of four experimental conditions. In the first condition, the girls were allowed direct interpersonal interaction with their parent, which included conversation, touch and visual (as well as presumably olfactory) contact ( $n=17$ ), which worked as a positive control for natural social communication in this dyad. The second group of children simply rested alone with no parental contact ( $n=17$ ), operating as a negative control. In the third group, children communicated over the phone with their mothers after the stressor but were not permitted to interact in any other way, thus limiting communication to the language content of the exchange as well as to the conveyance of auditory cues ( $n=17$ ). A third group was assigned to a task wherein they communicated via use of a private program linked between two computers in our laboratory in order to send and receive instant messages to their accompanying parent without any vocal component ( $n=17$ ). In each case except the negative control, parents were instructed to be as emotionally supportive as possible and were told that the exchange could be monitored. Interaction lasted 15 min after application of the TSST-C was complete, after which all participants watched a neutral film for 1 h in order to observe recovery back to baseline for hormonal values. At no point was any child permitted to see, hear or otherwise interact with their parent during the entire course of each subject run with the only exception taking place during the interaction period. A measure of literacy was possible via monitoring of instant message exchange from another location.

Participants who were adopted or who had experienced abuse or neglect as ascertained via Child Protective Services, direct parent report or public-access Circuit Court records were excluded from analysis. All children were screened for known history of mental or emotional problems, premature birth, use of drugs for any disorders, or other clinical histories. After completing a brief questionnaire evaluating childrens' subjective impressions of their own levels of nervousness during the task, each subject was compensated with a free toy of their choice, and accompanying mothers were provided with \$20.00 as a thank you for participating. This study was approved by the Social Sciences Institutional Review Board of the University of Wisconsin-Madison.

Hormones were measured via salivary cortisol and urinary oxytocin following the same procedures outlined in Seltzer et al. (2010). The hormonal sampling schedule is also the same (see Fig. 1).

### 3. Results

In order to control for individual variation in hormone levels, a metric of change from baseline was calculated using the difference between the samples collected at baseline and that collected 30 min after completion of the stressor. Hence, positive values indicate an increase in hormonal levels following the TSST-C, whereas negative values indicate a decrease. Analysis of variance was used in order to evaluate mean differences between the positive control, negative control, phone and instant message conditions using this adjusted metric, with a Tukey HSD test applied post hoc for salivary cortisol and urinary oxytocin.

No differences were observed between groups with respect to subjective assessment of the stressfulness of the task ( $p<.18$ ). A significant omnibus ANOVA  $F$  test was, however, obtained for cortisol change when the four experimental groups were compared ( $F(3,50)=5.48, p<.01$ ). Multiple comparisons using Tukey's HSD test revealed that change in salivary cortisol from baseline to 30 min post-stressor was similarly high (positive) between girls using instant messages to interact with their mothers and those who simply rested alone with no maternal interaction ( $p<.99$ ), whereas girls who were permitted to interact directly with their parents and those permitted to speak over the phone had comparably low (negative) levels ( $p<.99$ ). Moreover, girls in either contact group containing

vocal cues (positive control and phone) showed less change in salivary cortisol across the experimental time frame when compared to both those who rested alone ( $p<.04$  and  $p<.04$ , respectively) and instant messengers ( $p<.02$  and  $p<.02$ , respectively; see Fig. 2).

Likewise, a significant omnibus ANOVA was obtained for urinary oxytocin between groups ( $F(3,51)=7.46$ ,  $p<.01$ ), with post hoc comparisons showing that those children using instant messages to communicate maintained levels of OT that did not differ from OT measures in the negative control group ( $p<.99$ ). The highest levels of oxytocin were obtained from children permitted to make either direct contact or contact over the phone; these groups did not differ from one another ( $p<.97$ ) but they did differ from both the instant message ( $p<.01$  and  $p<.02$ , respectively) and negative control conditions ( $p<.01$  and  $p<.03$ , respectively; see Fig. 3).

#### 4. Conclusion

Earlier work illustrates that both physical touch and auditory cues in the form of comforting speech are capable of producing a similar release of the social peptide oxytocin in human children after a stressful event and also of reducing levels of salivary cortisol, which often increases in response to social challenge (Seltzer et al., 2010). Is the *content* of the exchange relevant, or is it the result of simply hearing a familiar and trusted voice? Put another way, are we observing a uniquely human effect that can be conveyed by our ability to read linguistic content, or are we observing something that may well be observed in many other species that use vocal cues to convey emotionally relevant information?

The present study shows that it is most likely the prosodic, auditory cues themselves that produce the hormonal effects observed, not the linguistic content of an exchange. As such, similar results may be observed in other animals using social vocalizations to communicate. There are a number of reasons why instant messages might not produce similar effects with respect to oxytocin and cortisol as physical touch or hearing a familiar and comforting voice over the phone.

First, it may be the case that written language, while rich in nuance and emotional tone, may simply be incapable of producing this type of hormonal signal in humans. Writing is a relatively recent form of human communication, with the earliest evidence of it appearing between 5000 and 6000 years ago. While many written documents are capable of transmitting an emotional signal to the literate (such as great works of literature, love notes or notice of termination from employment), vocal signaling is several hundreds of millions of years older (Bass et al., 2008). As such, it is perhaps unsurprising that, despite the power of the written word, auditory signals are better potentiators of the release of those hormones necessary for the formation of bonds, suppression of stress, mating and other behaviors critical to fitness in many species.

Another explanation for the results presented here concerns the relationship between mother and child within a specific cultural context. While many American pre-teens use text messaging to communicate with friends, communication with parents via this method may be less typical, and perhaps undesirable, to children in this age range, particularly after a stressful experience. Examination of instant messaging between female peers, however, might produce different results than those illustrated here (Brizendine, 2006).

It might also be argued that some girls have more positive relationships with their mothers or may have communicated differently with them, which may have affected the results. Relationship quality questionnaire scores, however, indicate relatively comparable relationships between subjects and their parents. To our surprise, logs of instant message transmissions reveal remarkable homogeneity in parent messages, the vast majority of which

expressed curiosity about the task (“So how did it go?”), positive emotion (“I am sure you did great!” “I love you!”) or unrelated information (“I type pretty slowly”; “So what are we going to have for dinner?”). This similarity in affect between subjects may be on account of parents being informed that their conversations could be monitored.

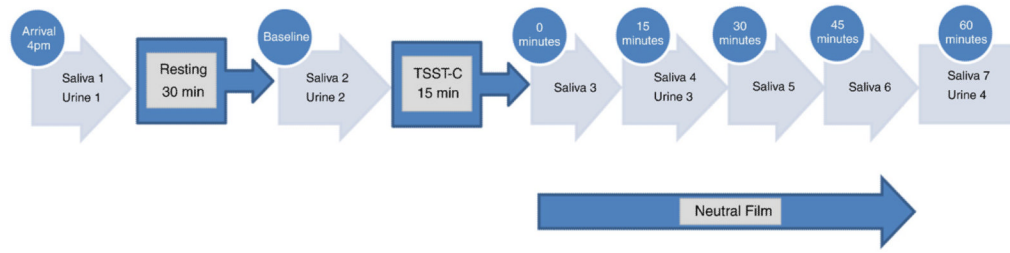
Finally, higher levels of cortisol in instant messengers may also be explained by the observed gap between mothers and girls in terms of both speed and proficiency with the interface, with children often far outpacing their parents. It may be the case that children’s bona fide attempts to solicit comforting via instant message were therefore unsuccessful, unsatisfying or provided an additional source of stress as measured by both high cortisol and lower measures of urinary OT.

Instant messaging is an effective means of conveying information, and doing so through electronic media is particularly popular among young Americans. Indeed, similar forms such as Facebooking and texting have replaced phone calls as the most popular methods of conveying information from a distance in many social circles. Due to the prevalence of this type of communication in society, it is worth noting that it does not appear to fulfill all of the same biological functions as other types of social exchange, such as vocal communication and in-person interactions. In terms of stress mediation and OT release, instant messaging is no substitute for spoken language or direct, interpersonal interaction between mothers and daughters in middle childhood.

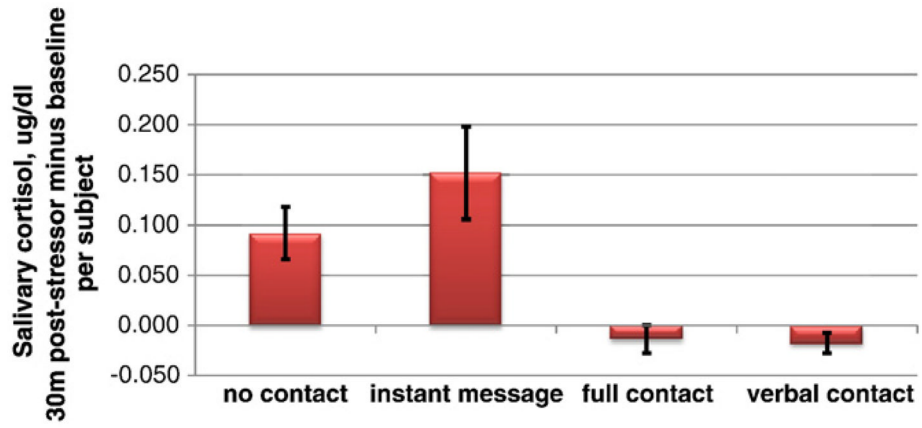
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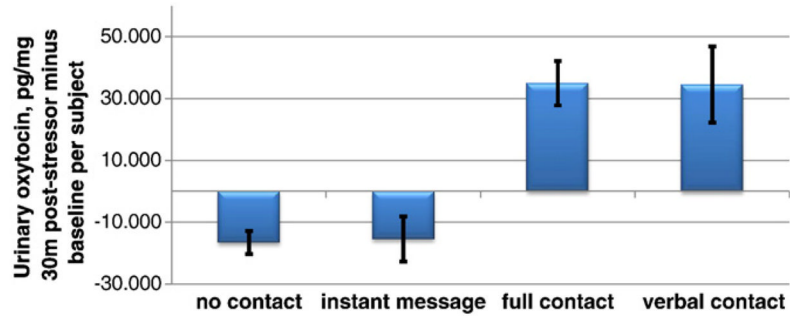


**Fig. 1.**  
Experimental time course.



**Fig. 2.** Salivary cortisol levels are comparable between children communicating via instant messaging and those who do not communicate with their accompanying parent at all following a laboratory stressor.





**Fig. 3.** Urinary oxytocin in girls using instant messages to communicate via instant message is also similar to that in girls who have no interaction with their parents at all and is unlike the higher levels observed in girls able to touch or hear the sound of their parents' voice. Urinary oxytocin is pg/mg creatinine.