ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/303894253

Dynamical Systems Modeling of Acoustic and Physiological Arousal in Young Couples

Conference Paper · March 2016

CITATIONS
0

READS
57

7 authors, including:

Sohyun C. Han
University of Southern California
8 PUBLICATIONS **46** CITATIONS
SEE PROFILE

Daniel K Bone
University of Southern California
29 PUBLICATIONS **168** CITATIONS
SEE PROFILE

Gayla Margolin
University of Southern California
145 PUBLICATIONS **6,467** CITATIONS
SEE PROFILE

Shrikanth S Narayanan
University of Southern California
869 PUBLICATIONS **13,912** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Quantitative Methods for Dyadic Research View project

Speechlinks View project

All content following this page was uploaded by Sohyun C. Han on 10 June 2016.

The user has requested enhancement of the downloaded file. All in-text references underlined in blue are added to the original document and are linked to publications on ResearchGate, letting you access and read them immediately.

Dynamical Systems Modeling of Acoustic and Physiological Arousal in Young Couples

Theodora Chaspari, Sohyun C. Han, Daniel Bone,
Adela C. Timmons, Laura Perrone, Gayla Margolin, Shrikanth S. Narayanan
University of Southern California, Los Angeles, CA, USA

Abstract

Well-being and mental health are directly associated with relationship status particularly in the context of relatedness and support. A key factor in relationship functioning is emotional arousal. We examine the interplay between emotional arousal manifested through acoustic and physiological cues and its association to relationship satisfaction. We propose a dynamical systems model to infer the within- and across-modality as well as the between-partner relations. Our results suggest that increased emotional regulation is negatively associated with relationship satisfaction and indicate that the proposed system consists a viable framework for analyzing such multimodal interrelations within romantic partners.

Introduction

Physical and psychological well-being have been extensively associated with relationship status (Coombs, 1991; Lillard and Waite, 1995; Dush and Amato, 2005). Similarly, committed romantic relationships of young couples providing companionship and aid are related to reduced mental and physical health problems (Braithwaite, Delevi, and Fincham, 2010).

Emotional arousal has been studied in the context of family conflict, as it is associated with degraded quality of family life (Katz, Kramer, and Gottman, 1992; Gottman et al., 1995; Baucom et al., 2012b) and negative child outcomes (Gottman and Katz, 1989; Baucom et al., 2012a). However, little research has examined emotional arousal in early family environments, as well as momentary fluctuations of multiple indicators of arousal. The goal of this study is to model moment-to-moment changes of acoustic and physiological indices during conflict discussions between young couples and investigate whether their potential associations can be related to relationship outcomes.

Dynamical Systems Modeling

Dynamical systems, and particularly linear oscillators, can capture the coevolution between signals and have been previously used for studying interaction Felmlee and Greenberg (1999); Ferrer and Helm (2013); Reed, Barnard, and Butler (2015). Their benefit compared to statistical data (surface) models lies in their capability to accurately describe the underlying generative behavior of various human-derived signals. We demonstrate how a coupled linear oscillator with appropriate input can jointly model the coevolution of acoustic and physiological arousal patterns of a person, while at the same time integrate the influence of his/her partner on these measures. For this purpose, we can write the general model as follows:

$$\frac{d}{dt}\begin{bmatrix} A_x \\ P_x \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} A_x - A_x^* \\ P_x - P_x^* \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} (A_y - A_y^*) \quad (1)$$

or else

$$\frac{dA_x}{dt} = a_{11}(A_x - A_x^*) + a_{12}(P_x - P_x^*) + b_1(A_y - A_y^*)$$
$$\frac{dP_x}{dt} = a_{12}(A_x - A_x^*) + a_{22}(P_x - P_x^*) + b_2(A_y - A_y^*) \quad (2)$$

where A_x, P_x represent the acoustic and physiological arousal measures of a person, A_y the acoustic arousal index of his/her partner, and A_x^* , P_x^* , A_y^* the corresponding variables at equilibrium state. Parameters a_{11} and a_{22} capture the amount of change within the acoustic and physiological modality, while a_{12} and a_{21} represent the cross-modal influence within a person. The amount of interconnection between partners is expressed by b_1 and b_2, which capture the effect of one's acoustic features to the other's acoustic and physiological patterns. Negative values of the aforementioned parameters indicate instantaneous fluctuations towards the equilibrium, while positive terms reflect the opposite - as similarly described in (Ferrer and Helm, 2013). This suggests that the degree of self-regulation in the acoustic and physiological domain and cross-regulation between the two modalities is reflected by negative values of (a_{11}, a_{22}) and (a_{12}, a_{21}), respectively. Similarly, negative values of b1 and b2 suggest opposite patterns between one's acoustic and physiological indices compared to his/her partner's vocal arousal.

Data Description

Our data was collected as part of an ongoing study of 26 young dating couples (ages 18-25 years) engaging in a 10-minute "change discussion", during which they had to talk

Copyright © 2016, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved.

Table 1: *Pearson's correlation values between relationship satisfaction scores and dynamical system parameters.*

		Female	Male
Within-modality	$\mathbf{a_{11}}$	-0.48 (0.16)	0.66 (0.05)
	$\mathbf{a_{22}}$	-0.04 (0.90)	-0.57 (0.09)
Across-modalities	$\mathbf{a_{12}}$	-0.55 (0.1)	-0.18 (0.62)
	$\mathbf{a_{21}}$	-0.21 (0.56)	0.24 (0.51)
Across-partners	$\mathbf{b_1}$	-0.68 (0.05)	-0.58 (0.08)
	$\mathbf{b_2}$	0.33 (0.35)	0.13 (0.72)

Parentheses denote p-values.

to each other about things in their relationship that could be different. One of the partners from ten of these couples participates in a multi-wave longitudinal study, during which he/she had also visited the laboratory approximately five years before as a youth. Participants completed the Relationship Satisfaction Questionnaire (adapted from the Quality of Marriage Index; (Norton, 1983)) concerning the degree of satisfaction in various areas of the relationship.

Each conflict discussion was manually segmented in talk turns, each bounded by consecutive speaker transitions. For vocal arousal, we used a combination of pitch (F0), voice intensity and the ratio of high-to-low frequency energy (HF500), the latter serving as a voice quality index (Bone, Lee, and Narayanan, 2014). The physiological arousal measure included the frequency of skin conductance responses (SCR), because of its relation to various psychophysiological constructs (Dawson, Schell, and Filion, 2007). Mean SCR frequency was computed over the starting points of two consecutive talk turns.

Results

Our results (Table 1) indicate that relationship satisfaction is negatively associated with vocal self-regulation (a_{11}) and physiological-to-vocal cross-regulation (a_{12}) in females, and physiological self-regulation (a_{22}) in males. Couples with higher relationship satisfaction tend to depict opposite patterns of vocal arousal (b_1), e.g. one shows reduced vocal arousal after his/her partner's highly-aroused turn. These are consistent with previous findings concerning the interconnection between negative emotions and high arousal (Baucom et al., 2012a) and suggest the usefulness of the proposed framework for modeling and interpreting the coevolution of multiple modalities within a person and their association with the interacting partner.

Conclusions

In this study, we proposed a dynamical systems model to quantify the interplay between acoustic and physiological arousal in young couples. We further examined the validity of our approach, which indicates that decreased self-regulation within and across modalities is present in couples with low relationship satisfaction. The consistency of this finding to the existing literature suggests the usefulness of the proposed model for analyzing relations of various emotional indices within and across partners.

Acknowledgments

This work was funded by National Science Foundation (GRFP DGE-0937362) and National Institute of Health.

References

Baucom, B.; Saxbe, D.; Ramos, M.; Spies, L.; Iturralde, E.; Duman, S.; and Margolin, G. 2012a. Correlates and characteristics of adolescents' encoded emotional arousal during family conflict. *Emotion* 12(6):1281.

Baucom, B.; Weusthoff, S.; Atkins, D.; and Hahlweg, K. 2012b. Greater emotional arousal predicts poorer long-term memory of communication skills in couples. *Behaviour research and therapy* 50(6):442–447.

Bone, D.; Lee, C.; and Narayanan, S. 2014. Robust unsupervised arousal rating: A rule-based framework withknowledge-inspired vocal features. *IEEE Transactions on Affective Computing* 5(2):201–213.

Braithwaite, S.; Delevi, R.; and Fincham, F. 2010. Romantic relationships and the physical and mental health of college students. *Personal Relationships* 17(1):1–12.

Coombs, R. 1991. Marital status and personal well-being: A literature review. *Family relations* 97–102.

Dawson, M.; Schell, A.; and Filion, D. 2007. 7 The Electrodermal System. *Handbook of psychophysiology* 159.

Dush, C., and Amato, P. 2005. Consequences of relationship status and quality for subjective well-being. *Journal of Social and Personal Relationships* 22(5):607–627.

Felmlee, D., and Greenberg, D. 1999. A dynamic systems model of dyadic interaction. *The journal of mathematical sociology* 23(3):155–180.

Ferrer, E., and Helm, J. 2013. Dynamical systems modeling of physiological coregulation in dyadic interactions. *International Journal of Psychophysiology* 88(3):296–308.

Gottman, J., and Katz, L. 1989. Effects of marital discord on young children's peer interaction and health. *Developmental psychology* 25(3):373.

Gottman, J.; Jacobson, N.; Rushe, R.; and Shortt, J. 1995. The relationship between heart rate reactivity, emotionally aggressive behavior, and general violence in batterers. *Journal of family psychology* 9(3):227.

Katz, L.; Kramer, L.; and Gottman, J. 1992. Conflict and emotions in marital, sibling, and peer relationships. *Conflict in child and adolescent development* 122–149.

Lillard, L., and Waite, L. 1995. 'Til death do us part: Marital disruption and mortality. *American Journal of Sociology* 1131–1156.

Norton, R. 1983. Measuring marital quality: A critical look at the dependent variable. *Journal of Marriage and the Family* 141–151.

Reed, R.; Barnard, K.; and Butler, E. 2015. Distinguishing emotional coregulation from codysregulation: An investigation of emotional dynamics and body weight in romantic couples. *Emotion* 15(1):45.

View publication stats