Facilitating Multisyllabic Productions & Assessing Sympathetic Arousal in Children with Developmental Disorders

Mariana Aparicio Betancourt[a], Laura DeThorne[a,b] & Karrie Karahalios[c]

[a]Neuroscience Program [b]Department of Speech & Hearing Science [c]Department of Computer Science, University of Illinois at Urbana-Champaign

Introduction

- Difficulty producing word and syllable combinations[4,8], in addition to difficulties with emotional regulation and unexpected responses to sensory stimuli [6], are often documented in children with autism and other developmental disorders.
- Electrodermal activity (EDA) is associated with sympathetic arousal and is known to be sensitive to cognitive and emotional states and processes. The neural mechanisms and pathways involved in mediating EDA include: 1) an ipsilateral limbic hypothalamic source, 2) a contralateral premotor basal ganglia source, and 3) a reticular formation modulating system[2].
- Recent technological advances in EDA interfaces, such as the Q sensor[1], provide the opportunity to assess children's emotional response to intervention *in situ.*
- Evidence for associated speech-language interventions and for EDA assessment in applied settings is relatively sparse and information about how children emotionally respond to interventions is essentially undocumented.

Objectives

1. To examine the effectiveness of an integrated speech-language intervention in increasing children's multisyllabic productions
2. To assess the associations between *in situ* EDA and off-line behavioral coding of emotional valence
3. To examine the association among different EDA measures

Method

Participants

Three children, all male, at the single word stage of development.

Pseudo-name	Age	Diagnosis
Pyrros	2;7	Developmental Delays
Angelo	3;0	Speech Sound Disorder
Karis	4;8	Autism Spectrum Disorder

Design

- A within-subject multiple-probe design was employed
- Thirty multisyllabic targets, outside of the child's expressive repertoire, were selected for each participant and divided into two lists (treatment v. control).
- Treatment targets were subdivided into three sets of five, treated one set at a time until mastery.
- Treatment and control targets were counterbalanced for semantic category, phonological complexity, and number of syllables.

Procedures

Intervention.
45-minute sessions, twice a week, consisting of:

1. Biosensor acclimation process
2. Drill-based **motor practice**: 5 repetition opportunities for each of five multisyllabic speech targets per session using VocSyl[3]. VocSyl is a novel software designed to provide on-line visual feedback of syllables, rate, pitch and loudness.
3. Child-centered **developmental play**: play-based strategies to model and elicit productions within naturalistic interactions.

Child practicing target words with VocSyl during the motor practice portion of the intervention.

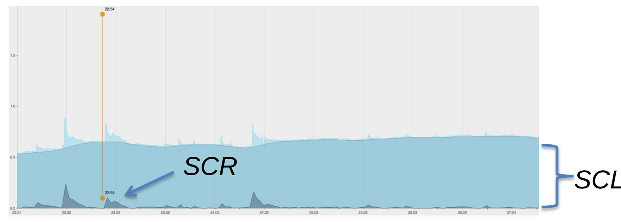
Assessment/Probe.
- Participants were assessed on all targets at five time points throughout the course of intervention via an **Object-play task** and a **Card-labeling task**.

Emotional Valence (EV) Rating.
- EV was rated once per minute based on an examiner's video review of each child's vocalizations, facial expressions and corporal gestures using a 1-5 Likert scale (1 = high negative affect, 5 = high positive affect).

EDA.
- Ag/AgCl disk electrodes, sampling rate of 8 Hz, fitted at the right wrist or ankle.
- EDA measures: skin conductance (SC) area under the curve (SC.AUC), nonspecific SC response frequency per minute (NS.SCR.freq), and NS.SCR amplitude (NS.SCR.amp).
- EDA data was collected for a total of 29, 11 and 2 treatment sessions for Pyrros, Angelo and Karis respectively. EDA analyses followed a 3-step process: 1) visual inspection of 10% of synchronized treatment sessions with EDA recordings 2) data pre-processing (cropping, manual artifact rejection, smoothing), and 3) SC decomposition into continuous phasic and tonic components using BEDA[5] and MATLAB.

Tonic and phasic components of SC data (i.e. SC level and response respectively)

SC= SCL + SCR



Analyses/Results

Objective 1

The effectiveness of the intervention was examined by comparing each child's progress on the treated v. yet to be treated treatment targets (Figure 1), and treatment v. control targets (Figure 2).

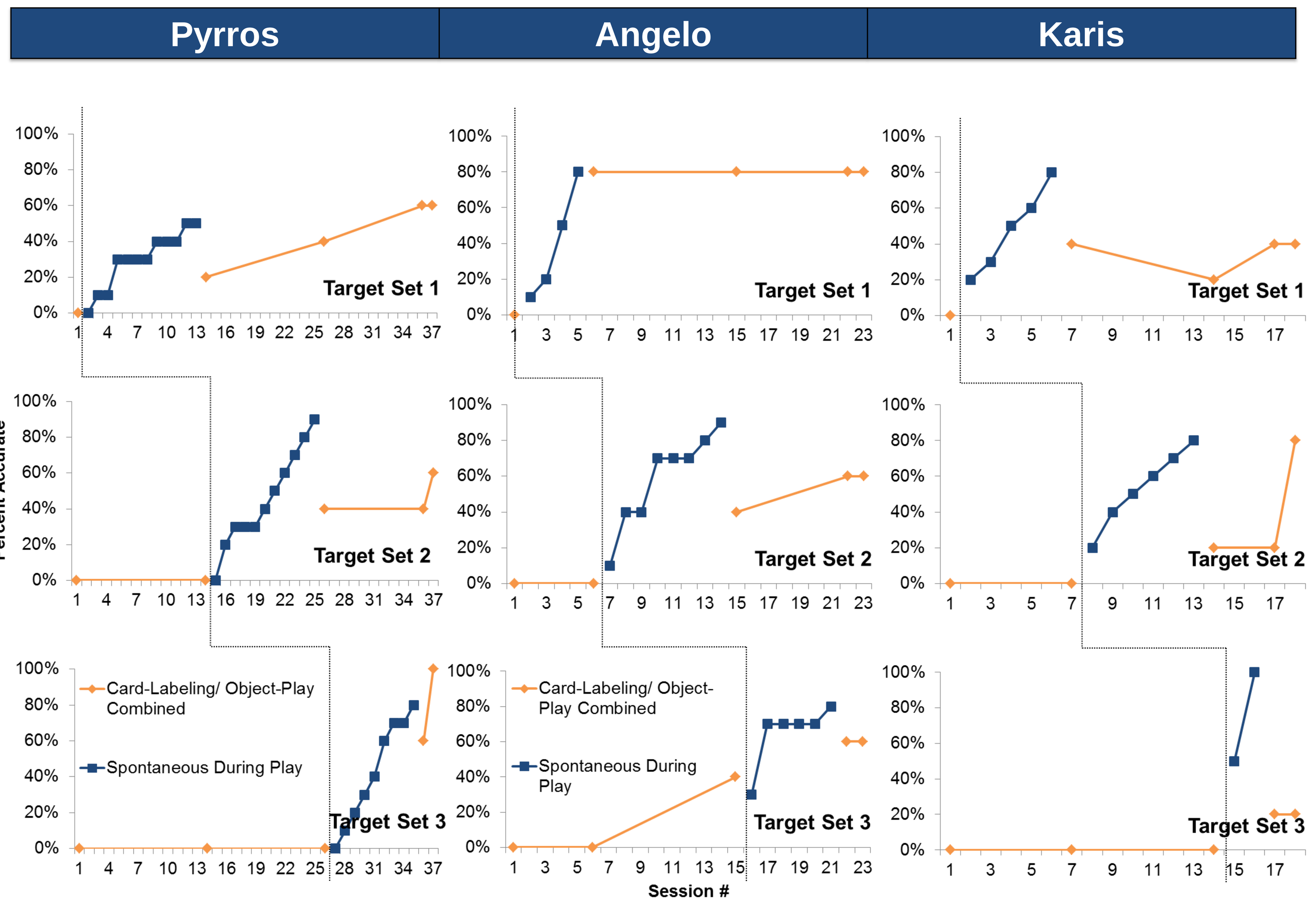


Figure 1. Combined object-play and card-labeling treatment and probe data for treatment targets for Pyrros (left panel), Angelo (middle panel), and Karis (right panel).

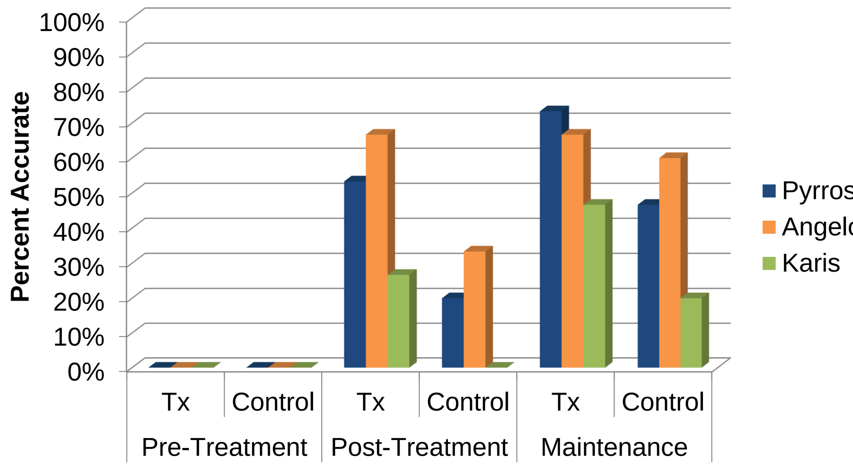


Figure 2. Accuracy of treatment (Tx) vs. control targets. Pre-, post-, and maintenance combined object-play and card-labeling probe data.

Results indicate all three children were able to spontaneously produce a majority of the treated targets during the intervention while remaining at baseline in the yet to be treated targets, with the exception of Angelo for target set 3 (Figure 1).

All participants accurately produced a higher number of treatment (27-67%) v. control (0-33%) targets post-treatment and they all either maintained or increased this difference at the five-week post-treatment maintenance session: treatment (47-73%) and control targets (20-47%); see Figure 2.

Objective 2

Associations between *in situ* EDA and off-line behavioral coding of emotional valence were examined by 1) polynomial regression for all treatment sessions and 2) mean comparisons across the two intervention conditions (i.e. motor practice (MP) and developmental play (DP)).

1) A second order polynomial provided the best fit for NS.SCR.freq as a function of EV (b = .53, p < .01) with an adjusted R^2 of .023 (F(4, 1,337) = 8.78, p < .001); and a first order polynomial (i.e. linear regression) provided the best fit as a function of time within session (b = .14, p < .001) with an adjusted R^2 of .019 (F(2, 1,339) = 13.66, p < .001). NS.SCR.freq was higher for high positive and negative affect ratings compared to neutral ratings, and increased with time.

A linear regression model provided the best fit for SC.AUC as a function of time within session (b = .20, p < .001) with an adjusted R^2 of .053 (F(2, 1,339) = 38.75, p < .001.), also increasing with time.

No other relevant significant associations were found.

2)

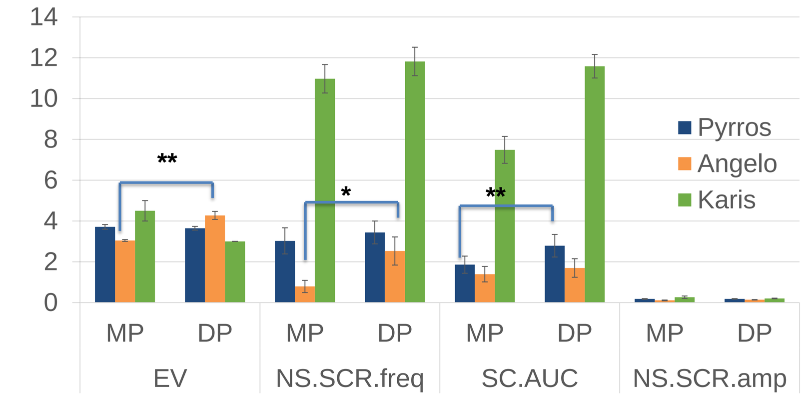


Figure 3. Emotional valence & EDA measures across conditions. Mean comparisons across motor practice and developmental play for all participants. Note. * p < .05, ** p < .01. Error bars: +/- SEM.

Objective 3

Associations among different EDA measures were examined via 3 Pearson correlations between SC. AUC, NS.SCR.freq and NS.SCR.amp.

Table 2. Correlation matrix for EDA measures during Treatment.

		SC.AUC	NS.SCR.freq	NS.SCR.amp
NS.SCR.freq	Pearson Correlation	.852**	1	.482**
	Sig. (2-tailed)	.000		.001
	N	42	42	42
NS.SCR.amp	Pearson Correlation	.442**	.482**	1
	Sig. (2-tailed)	.003	.001	
	N	42	42	42
SC.AUC	Pearson Correlation	1	.852**	.442**
	Sig. (2-tailed)		.000	.003
	N	42	42	42

**. Correlation is significant at the 0.01 level

Conclusions

- This study provides descriptive evidence that a multimodal integrated speech-language intervention led to modest gains in children's production of spoken multisyllabic targets.
- EDA assessment in applied settings offers promise in improving supports and services for individuals with limited verbal skills. It may be useful in understanding of feelings and intentions (Figure 4) helping support learning and social interaction.

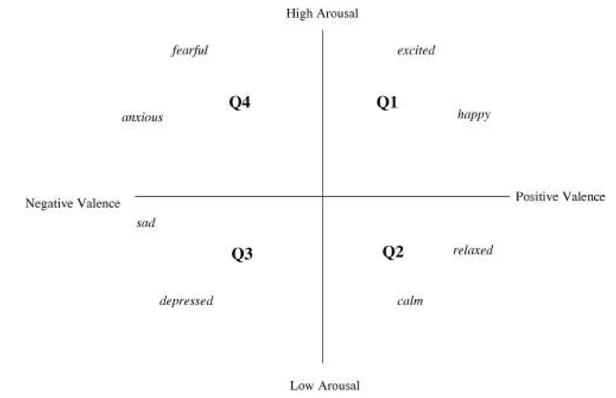


Figure 4. The Affect Grid[7]. Words in each of the quadrants indicate possible locations of specific affective states.

- The association between SC.AUC and other EDA measures is largely undocumented. Results indicate SC.AUC and NS.SCR.freq may be mediated by similar psychophysiological or neurological sources.

References

1. Affectiva, Inc. (2012) .*Q sensor 2.0*. Retrieved from http://www.affectiva.com/q-sensor/.
2. Boucsein, W. (1993/2012). *Electrodermal activity* (2nd ed.). New York, NY: Springer.
3. Hailpern, J., Karahalios, K., DeThorne, L., & Halle, J. (2010). *VocSyl: Visualizing syllable production for children with ASD and speech delays*. Extended abstracts of ACM's SIG ACCESS Conference. Orlando, FL.
4. Highman, C., Hennessey, N., Sherwood, M., & Leitao, S. (2008). Retrospective parent report of early vocal behaviours in children with suspected childhood apraxia of speech (sCAS). *Child Language Teaching and Therapy, 24*(3), 285-306.
5. Kim, J., Snodgrass, M., Pietrowicz, M., Karahalios, K. & Halle, J. (2013, November). *BEDA: Visual analytics for behavioral and physiological data*. Paper to be presented at the Workshop on Visual Analytics in Healthcare, Washington DC, MD.
6. Qi, C.H. & Kaiser, A. P. (2004). Problem behaviors of low-income children with language delays: An observational study. *Journal of Speech, Language, and Hearing Research, 47*, 595-609.
7. Russell, J. A., Weiss, A. & Mendelsohn, G.A. (1989). Affect Grid: A single-item scale of pleasure and arousal. *Journal of Personality and Social Psychology, 57*(3), 493-502.
8. Tager-Flusberg, H., et al. (2009). Defining spoken language benchmarks and selecting measures of expressive language development for young children with autism spectrum disorders. *Journal of Speech, Language, and Hearing Research, 52*, 643-652.

Acknowledgments

This project was funded by Autism Speaks (#5744), the University of Illinois Research Board, the Goldstick Family Fellowship, the Department of Speech & Hearing Science and the Graduate Program in Neuroscience. We are appreciative of all participating families, as well as assistance from Jennifer Kim, and the Child Language & Literacy Lab, particularly: Paulina Mitra, Ellen Boque, Lauren Ragins, Monique Kammo, Emily Zimmerman, Kathy Dejmek and Kori Zorina.

Contact: Mariana Aparicio Betancourt at aparici2@illinois.edu

Poster presented at the Society for Neuroscience Conference, San Diego, California (2013, November).