Measuring Behavioral Indices of Cognitive Processing in Children

Linda Phan
San Diego State University,
Laboratory for Language and
Cognition, 6330 Alvarado Crt Suite
208, San Diego Ca, 92102
LindaP.Phan@gmail.com

Rosemary Meza
San Diego State University
Laboratory for Language and
Cognition, 6330 Alvarado Crt Suite
208, San Diego Ca, 92102
RosemaryDMeza@gmail.com

Gwen Littlewort
University of San Diego California
Machine Perception Lab 9500,
Gilman Dr. La Jolla Ca, 92093
Gwen@mplab.ucsd.edu

Marni Bartlett
University of San Diego California,
Machine Perception Lab,
9500 Gilman Dr. La Jolla Ca, 92093
Marni@salk.edu

Judy Reilly
San Diego State University,
Laboratory for Language and Cognition,
6330 Alvarado Crt Suite 208, San Diego Ca, 92102
Reilly1@mail.sdsu.edu

ABSTRACT
The integration of verbal and nonverbal behavior is a complex interaction. Previous studies have mainly focused on understanding the development of single behaviors, and in doing so the interaction is often not apparent. By using a multi-modal coding system, the interaction among verbal and non-verbal behaviors will give us better insight into how they develop and change over time.

Author Keywords
Multi-modal, integration, verbal, non-verbal behavior, development.

INTRODUCTION
How children plan, organize their thoughts, and resolve problems has long been of interest to psychologists and educators. However, little is known about how children recruit and integrate verbal and non-verbal behavior. By using the video coding interface ELAN [1,2], we have developed a multimodal coding system that allows us to map temporal and developmental changes in patterns of verbal and non-verbal behavior, as well as how children integrate verbal and non-verbal behavior (e.g., speech and facial expression).

Our coding system will permit us to identify behavioral indices of cognitive processing in children in dyadic problem-solving contexts. Which behaviors characterize the thinking processes in children? How do such patterns of behavior change over time?

METHODS
As part of a larger study preschool (N = 12; ages 3-4yrs), school-age children (N = 12; ages 7-8yrs) and college-age adults (ages 19-35yrs, N = 12) took part in two problem-solving contexts:

1) Biographical interview—a naturalistic conversation between the participant and experimenter which provides a naturalistic sample of the participant's language abilities and use of language to address questions. From the biographical interview three question-answer sequences with varying levels of required cognitive effort were of particular interest (see Table 1).

2) Mystery box—a problem solving task in which participants are asked to identify five objects (wooden cube, triangle, cylinder, toy dinosaur, rubber duck) using only haptic input.

Both types of interactions are recorded from three angles using HD video cameras (see Figure 1).

Question	Cognitive effort
What is your name?	Low
How old are you?	Low
For children: What do you like to do at school?	High
For adults: What is your best subject and why?	High

Table 1. Input requiring varying levels of cognitive effort.

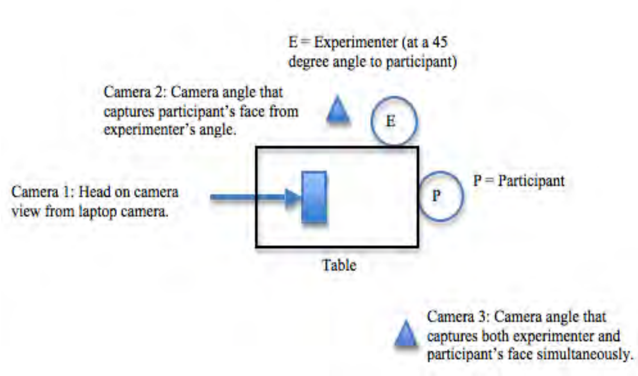

Figure 1. Top-down view of experiment set up. The three camera angles capture multiple perspectives of the interaction; multiple camera angles also allow for more accurate analysis (e.g., detecting direction of participant's eye gaze).

CODING AND ANALYSIS

In each problem-solving context, the interaction between experimenter and participant is schematized into four phases:

Interaction Schema

- <u>Input</u>: participant receives question or a mystery object
- <u>Latency</u>: period in which the participant is thinking
- <u>Answer</u>: participant gives a response
- <u>Turn surrender</u>: participants behavior after completing a response

The duration of each phase is measured and annotated in ELAN. In each interaction phase the participant's <u>Eye gaze</u>, <u>Facial Expression</u>, and <u>Speech</u> is measured as follows:

<u>Eye gaze</u>

Eye contact categories (+K = makes eye contact with experimenter; -K = no eye contact with experimenter) are adapted from Reilly and colleagues [5]. Confirmation of eye contact with experimenter was determined from two camera angles. Frequency of eye contact and gaze aversion is calculated per phase.

<u>Facial expression</u>

Facial expressions are coded during the <u>Latency</u> and <u>Answer</u> phases using the Facial Action Coding System (FACS) [3], a taxonomy based on adult facial muscle movements. The upper and lower parts of the face were coded separately to account for muscle movements in the lower face influencing muscles in the upper face and vice versa.

<u>Language</u>

Linguistic data is transcribed using the CHILDES system [4]. Speech is coded for hedges (i.e., linguistic markers of uncertainty). Both linguistic and non-linguistic data are annotated in the ELAN grid (see Figure 2).

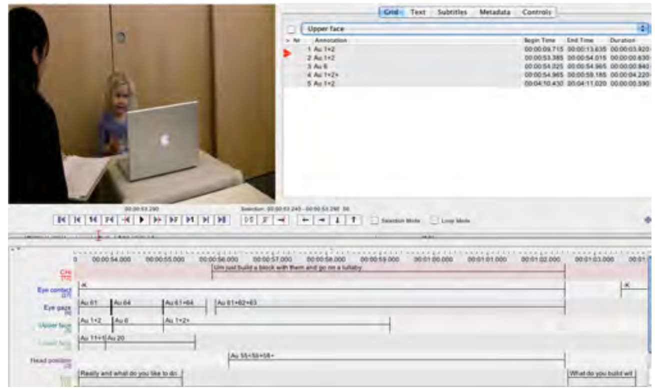

Figure 2. Example of coded verbal and non-verbal behavior in ELAN.

RESULTS

Results suggest that there are significant developmental differences in patterns of behavior in problem-solving contexts. Such that, patterns of eye gaze in older children are similar to those of the adults; however, it seems that younger children are not using gaze patterns in the same manner (see Figure 3). Furthermore, the degree of cognitive effort that is required to solve a problem also influences patterns of eye gaze in children. During high cognitive demand, adults and older children showed similar gaze patterns by averting their gaze from the experimenter; however, younger children continued to make eye contact with the experimenter suggesting that they are using the adult in the situation as a social reference. The integration of language and speech suggests that when discussing a response that has positive affective content, both younger and older children will display a positive facial expression. However, when recounting events of negative affective content, older children are more likely to show positive facial expression suggesting that they are masking negative affect (see Figure 4 & 5). Moreover, in a problem-solving context, older children and adults are able to use language (i.e., linguistic markers that reflect varying levels of certainty) to reflect the cognitive ability of understanding dual perspectives; whereas younger children's answers were short and concise (see Table 2).

Object	Younger child	Older child	Adult
Cylinder	A circle.	This one is still a building block except it's like I forgot what the name is…cylinder. Cylinder?	It's like a round stick it's shaped like a chapstick but it's a block.

Table 2. Example of an older child and adult using linguistic hedges to indicate uncertainty.

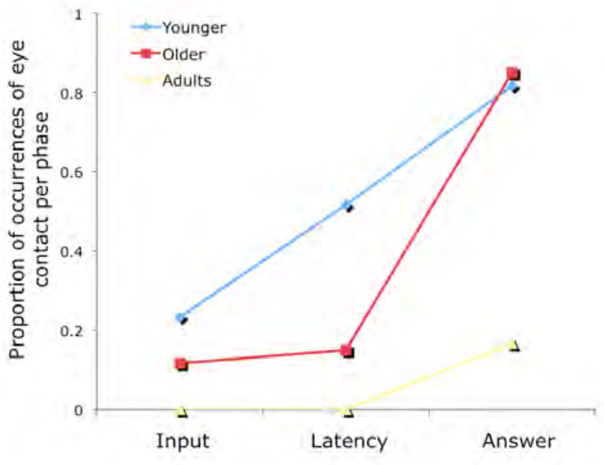

Figure 3. Proportion of eye contact made by each age group during the mystery box task.

Older Group

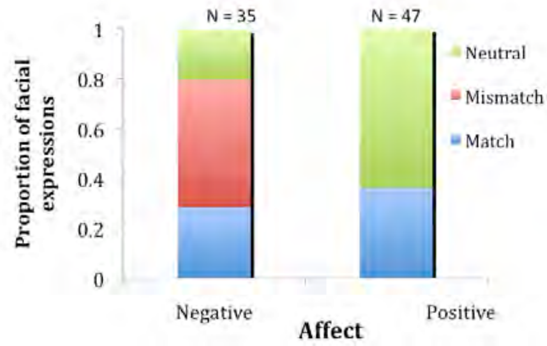

Figure 5. The older group is more likely to show positive affect that is consistent with linguistic content than negative. Also, they are more likely than the younger group to mask negative linguistic content by displaying positive affect.

Younger Group

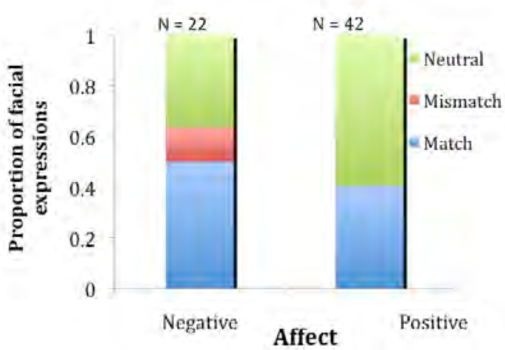

Figure 4. The younger group is more likely to show positive affect that is consistent with linguistic content then they are to show negative affect

DISCUSSION

By characterizing patterns of behaviors and seeing how these patterns temporally integrate in problem-solving contexts we are able to better understand the child as a problem-solving agent. The developmental picture that emerges is a complex interaction of multiple modalities. This would not have been so evident if we had only focused on a single behavior or modality. Using a multi-modal coding system allows us to see patterns of behavior and the complex interactions that arise from their integration.

REFERENCES

1. Brugman, H., & Russel, A. Annotating Multimedia/ Multi-modal resources with ELAN. In: *Proceedings of LREC 2004, Fourth International Conference on Language Resources and Evaluation*, (2004), 2065-2068.

2. Crasborn, O., & Sloetjes, H. Enhanced ELAN functionality for sign language corpora. In: *Proceedings of LREC 2008*, Sixth International Conference on Language Resources and Evaluation, (2008), 39-43.

3. Ekman, P., & Friesen, W. The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica*, *1* (1969), 49-98.

4. McWhinney, B. & Snow, C.E. The Child Language Data Exchange System. *Journal of Child Language*, *12* (1985), 271-296.

5. Reilly, J.S., M.L. Mcintire, and H. Seago. Affective prosody in American Sign Language. *Sign Language Studies*, *75* (1992), 113-128.

6. Wertsch, J., McName, G., & McLane, J. The adult-child dyad as a problem-solving system. *Child Development*, *51* (1980), 125-1221.