Non-verbal signals from puzzled children

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Introduction
To be effective, teachers must recognize when students are in the process of “grappling” with an idea. Our study is designed to identify behavioral signals of cognitive processing across various non-verbal communication channels (e.g., facial expressions, eye gaze, gesture and prosody) and associate these with language, tasks with low and high cognitive load and dyadic interaction. Learning to coordinate this multimodal communication, especially in social situations, is important, so longitudinal studies are essential. (Begun in 2010, the LS is not analyzed here). Additional goals are to develop techniques for analyzing multimodal data; providing data for an automated tutoring system and forming the ground research for atypical populations. Gender is considered, but not reported here.

Methods for data collection and labeling

- 48 typically developing children ages 3-9 years old
- Younger group = 3-4yars and Older group = 7-8yars
- 12 adults ages 19-35 years old

Procedure: 45 minute battery of tasks. Focus on 4 tasks
- Biographical interview: Questions and answers varied in length and depth.
- Mystery box: Identify five hidden objects using only tactile perception.
- Lock box: Unlock a box when left alone with the wrong set of keys.
- Safari: a spatial puzzle: easy, moderate and very difficulty

Table 1: Input requiring increasing degrees of cognitive effort.

<table>
<thead>
<tr>
<th>Task</th>
<th>Input</th>
<th>Knowledge</th>
<th>Cognition effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biographical interview Q1</td>
<td>What is your name?</td>
<td>Low</td>
<td>Excerpt-automate</td>
</tr>
<tr>
<td>Biographical interview Q2</td>
<td>What do you like to do at school? What was your best subject and why?</td>
<td>Higher</td>
<td>Excerpt-Bi-expect, organize</td>
</tr>
</tbody>
</table>

Coding
- FACS: codes facial expressions in terms of facial muscle movement.
- CERT: automatically detects FACS; extracts frame by frame dynamics.
- ELAN: displays linguistic, facial, prosodic, and gestural codes over time.
- PRAAT: analyzes speech and phonetics.
- Linguistic transcriptions use CHILDES system, then entered into ELAN grid.

Example of multimodal coding

- Problem Solving task, 7 year old, male
- Biographical interview: Latency duration
- Lock box key contact: emerging frustration
- Cert FACS

Results – eye gaze in bio interview

Results – eye gaze – mean across subjects of count of eye contact initiation within each phase.

<table>
<thead>
<tr>
<th>Task</th>
<th>Average Latency (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Results – CERT FACS

- Mysteries box: displacement, speed and acceleration analysis of FACS in latency
- Which age group 89% ROC area
- Predicting errors 81% ROC for 8yrs
- 73% ROC for 4yrs

Developmental differences of dynamic coordination during latency

- Mystery box: displacement, speed and acceleration analysis of FACS in latency
- Which age group 89% ROC area
- Predicting errors 81% ROC for 8yrs
- 73% ROC for 4yrs

Discussion

- During the biographical interview, there is a decreasing developmental trend for latency duration for easy questions and an increase for more difficult questions with age. Eye contact during the latency phase decreases with age and is lower for more difficult questions.
- Automatic measurement of FACS shows increased nose wrinkling in mystery box latency and more social smiling during answer phase than during latency. Dynamical features of the FACS codes during latency can be used to predict whether the subject will answer correctly and whether they belong to the older or younger group.
- The persistence of subjects in the lack of frustration test can be measured by the number of attempts they make to solve the problem. All the subjects 4yrs and older trial at least one round through all the keys. Only one subject trial more than 20 times. The delay between successive attempts gets longer as the children struggle to think of a strategy.
- Whereas the younger group tend to not verbalize uncertainty, by 7 and 8 years, children use linguistic and prosodic means (might, could, may, would, can) to signal uncertainty reflecting a major cognitive advance, the ability to consider alternative hypotheses.

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References