

Child Selection of Learning Methods: A Corpus Based on Real-World Data

Heikki Ruuska
Shizuoka University
Johoku 3-5-1
Hamamatsu, Japan
+81-53-478-1486
hruuska@acm.org

Shinya Kiriya
Shizuoka University
Johoku 3-5-1
Hamamatsu, Japan
+81-53-478-1471
kiriya@inf.shizuoka.ac.jp

Yoichi Takebayashi
Shizuoka University
Johoku 3-5-1
Hamamatsu, Japan
+81-53-478-1486
takebay@inf.shizuoka.ac.jp

ABSTRACT

We are running a parent-child learning project for constructing a multimodal child behavioral corpus. It is based on a learning environment where children and their parents regularly attend both guided lessons and have chances for free play. Among other purposes, we use the gathered data for analyzing how children construct evaluation schemas of learning processes. One important kind of learning is learning which learning methods are useful and which harmful in different situations. We have examined how learning methods, which are different from skills, develop from simple to complex physical and social manipulation. Our research shows hints on how negative knowledge on unsuccessful learning methods is used to encourage cognitive constructs more advanced than binary repetition, resulting in developing complex methods such as learning to reason by analogies and use them to construct new complex hypotheses about the world, and using adults and other children as sources of knowledge. We are also researching how right kind of support and example from adults close to children are essential in endowing and encouraging children with using these abilities.

Categories and Subject Descriptors

H.1.2 [Information Systems]: User/Machine Systems – *Human factors, human information processing.*

General Terms

Measurement, Design, Experimentation, Human Factors, Theory

Keywords

Infant learning, cognitive models, multimodal behavioral corpus, behavior annotation

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1. INTRODUCTION

Whereas children's development-correlated skills, such as ability to walk, and "meta-abilities", such as ability to group objects by some property, have been a focus of much research (e.g. [6][7]), no extensive survey has been conducted on how prohibition and encouragement affect children's acquisition and evaluation of new ways to learn. Minsky has suggested that adult support and interception considerably influences how children evaluate their ways to retrieve information from the world in his Imprimer theory [4][5]. Where behavioral studies (e.g. [1]) give clues to general tendencies in how children interact in new situations, our long-term study aims to further examine how past evaluation and comments by close adults reflect in infant behavior in new situations, while describing the changes in a computable form.

We have built an infant-parent learning environment [2][8] for 1-6 year old children, where child-parent pairs attend classes centered on various tasks. The infants also have a chance for free play with or without adult presence. The project also includes an infant learning and upbringing counseling element, given by experts and carried out over the Internet. Everything is recorded using multiple cameras and microphones. The data thus gathered is annotated by a team of researchers and critical comments are given by non-researchers.

In this paper, we introduce our learning environment and corpus in general, and specifically discuss our findings on positive and negative assessment of learning methods; this is an important topic for parents who are willing to give constructive criticism without stifling the desire to learn in children.

2. INFANT BEHAVIORAL CORPUS

2.1 Data Source: Parent-Child Learning Environment

Our infant learning project is centered around regular weekly classes held in age groups, with up to 3 child-parent pairs in each group and the classes lasting roughly an hour each. Each class begins with a 30 minute teacher-guided session where the children and their parents engage in various learning activities, such as building block towers, drawing animals, or using specially developed touch-screen computer software to learn English. Then another half-hour session follows where parents discuss child development and learning with an expert over the Internet. During this time, the children are left to play freely. Each session is

recorded using multiple nonintrusive rotating cameras and both static and wearable microphones. Over 3 years, we have accumulated a total of 134 recorded sessions, with the child ages ranging from 1 to 6 years and project participation span between 1 and 3 years. Figure 1 is a snapshot of the classroom environment.



Figure 1. Real-time video call in learning environment.

2.2 Annotation and Behavioral Analysis

A distinctive feature of our approach is that recorded classroom and discussion data is annotated by a group of researchers using multi-camera streaming video technology. This is in contrast to semi-automatic approaches such as Roy et al. [4] as we aim at a highly knowledge-based corpus, for which (semi)automatic approaches are not yet technologically feasible.

The textual annotation data consists of objects in the scene, physical actions, and emotive and intentional analysis. We are using an annotation tool specially developed for the project. The annotation formats are both schema-organized and free form natural language data. As information on internal processes, such as motives, is inherently ambiguous and subjective, we provide multiple viewpoints by different people.

Further discussion of annotation principles and hardships we encountered is presented in [2]. Annotation schemata specific for learning methods analysis is presented in the next chapter, Chapter 4 illustrates an example scene, and Chapter 5 contains validity discussion and conclusions.

3. LEARNING METHOD SCHEMATA

3.1 Annotation & Analysis Topics

We target the following processes as elements of learning: problem recognition, problem representation, reaction, planning, information acquisition, object manipulation, communication, reflecting and remembering. Selection of learning methods takes place a priori and a posteriori: as how to acquire more information in an unfamiliar situation or a situation with an uncertain element, and as how to react during and after an expectation failure has occurred in a familiar situation.

This analysis concentrates on information acquisition and physical object manipulation methods based on observation of 4-6 year old children [Figure 2]. Figure 2 also shows an observed proportional increase on social methods with age. The list is by no means complete, but we have selected these as a starting point for

analyzing development of complex conceptual and analogical learning in children. The items represent possible predicates for forming rules about the outside world and ones own mental processes in various realms, including direct perceptual, physical, social, mental and meta-learning realms. Level of abstraction is based on ease of observation from behavioral cues and symbolic computability.

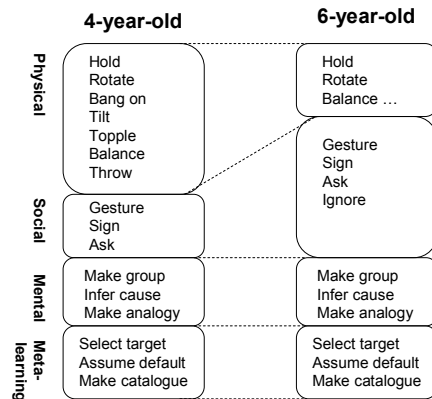


Figure 2. A basic scheme for annotating.

The following subchapters discuss finer details of annotation schemes, their relevance, and how they appear in the corpus.

3.2 Problem Recognition and Representation

Selection of learning methods is intrinsically related to recognition of problem types. Classification of problem types and utilization of effective representations for solving them - or deciding what to do about them - is a process which evidently improves with learning: a child won't be able to solve written mathematics problems without learning numbers and operators, at least not in the way adults expect.

The following are basic types of problems which trigger both a priori and a posteriori learning: *failure to infer a goal, lack of knowledge, lack of suitable representation, impasse in physical world.*

3.3 Observable and Non-observable Behavioral Cues

A major obstacle in making good theories on child learning is the difficulty of observing mental processes, and relation between these internal processes and external behavior is one of our key points of focus. Leaving aside exactly how these representations are formed, we are taking the stance that many commonly occurring phenomena, such as wanting to do something, ideas of ownership, or building things according to a pre-thought plan, can be retracted back to basic atomic mental units. Thus, we are annotating "wanting to do something" (possessing a goal with positive commitment) and "voicing wanting to do something" (communicating a goal with positive commitment as a part of a plan of fulfilling the goal) as a separate internal-external action pair. The external action implies the internal action, but the annotated script may include the internal action with no explicit

external action necessarily occurring. This is for increasing flexibility on the annotator's part, and is a feature for eventually evaluating the ambiguous internal analysis data and drawing correlation maps.

Some indicative internal-external process pairs are:

Intend – voice intent; pay attention to – catch attention; own – indicate ownership (speech, gesture); allow – give approval; fail – express disappointment; feel thirsty – drink.

3.4 Physical Information Accrual

If the problem a child encounters is a physical impasse, for example failure to balance objects, then he/she can try to find out more about it through physical experiments, such as:

Hold, squeeze, rotate, bang on, tilt, balance, topple, throw, twist, push, scrape, push against, pull on.

Especially much of younger children's visible behavior consists of these operations. These operations can lead to information on following relationships and properties:

Tactile, haptic, causal, temporal; weight, solidity, balance, trajectory, support, jointedness

3.5 Conceptual and Social Information Accrual

With enough experience, a child can make analogies between physical objects based on their observed properties: in a simple case, building blocks are assumed to operate the same way even if their color is different. A problem from the annotating stance arises from the fact that analogical reasoning is highly unobservable. Nevertheless, some classes are considered:

Infer property by analogy; infer goal by analogy; construct a script; deliberate a plan

If acquired concepts are similar enough to other children's or adults', communication opens a new channel for acquiring information, which makes some of analogical reasoning observable. At this stage, much physical information is one-way, such as in "Watch out, it's heavy/hot/sharp", whereas much of the information requested by children is pragmatic, such as "What is it used for?"

The following are annotation markers for conceptual and social information accrual:

Evaluate concept agreement¹; evaluate response; ask about a property; ask about a goal; explain a property/goal; suggest a plan; ask about causality; refer to a script

3.6 Outside Opinions

We also make records of how adults comment on child learning behavior. Children generally trust adults, and also other children.

There are levels which may result in differences of how seriously the other person's opinion is taken, though, which is reflected in the following division.

Adult: Imprimer, Close&Trusted, Trusted, Not trusted; Peer: Close&Trusted, Trusted, Not trusted.

Adult and peer opinions which, in our model, are specifically aimed at affecting evaluation of a priori and a posteriori learning are:

Suggest/show a different representation; Suggest/show a different action; Approve/disapprove of action; Ridicule; Pay attention/ignore

4. EXAMPLE

This chapter introduces an example where a child is presented with a new toy: a rubber-band propeller. It is made from a 12-cm long, 2-cm high U-shaped hard plastic with a rubber band (spring) attached to one end and a propeller attached to a rotating axle attached to the other end of the rubber band at the other (diagram at lower part of Figure 3).

The propeller toy has some remarkable properties: first, winding the spring requires conceptual and motoric skills, as a typical adult does it by holding the body in one hand and rotating the propeller with the other, using fingers instead of hand; second, it does not have a clearly defined purpose though it can both fly with a unordinary trajectory or be used as a fan; third, the strength required to wind the spring increases polynomially.

The four-and-six-year old children (two each) we gave the toy to play with had different first responses: the four-year-olds begun with physical manipulation (*holding, twisting and turning*) whereas the first thing the six-year-olds did was to ask "What is it?" and "What is it for?" (*Failure to infer a goal: ask about a goal*).

None could wind the propeller at first, even though they tried twisting them with the flats of their hands: normal technique of grasping and twisting only works up to 180 degrees (*infer by analogy*). After being shown how to rotate the propeller with the index finger, the six-year-olds grasped the method quickly (*Show a different action by Close&trusted adult, construct a script*).

Afterwards, one of the six-year-olds would concentrate on winding the propeller and throwing it in various ways (*tactile analysis, trajectory modeling*), while the other would use it as a fan and aim the wind at herself and other people (*haptic analysis, evaluate response, approval of action*). The adults present did not strongly approve or disapprove of the actions.

A possible semantic organization of the annotated corpus data on the scene and basis for searching analogous situations is presented in Figure 3.

¹ The word "agreement" is used instead a word like "definition", to make a note that since a child is usually exposed only to a limited number of adults, he/she could, instead of developing unified "commonsensical" concepts, develop specific "concept sets" for communicating with individual adults. We think this is a topic which warrants further inspection.

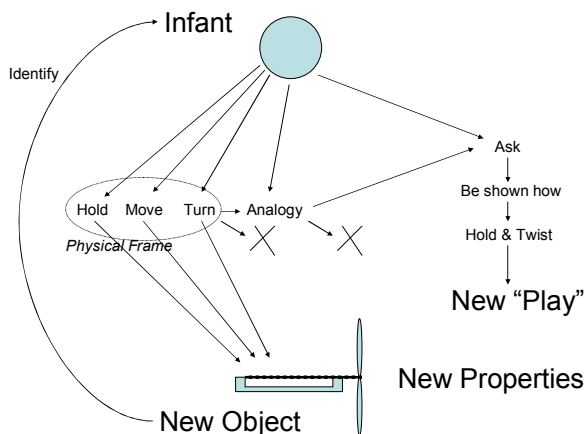


Figure 3. Semantic annotation of a “new toy” situation.

5. CONCLUSIONS AND FUTURE WORK

5.1 Conclusion and Validity Discussion

We have built a multimodal infant behavioral corpus which contains multi-angle video, multiple-stream audio, and formatted and free form annotated text with a special emphasis on physical and social learning and information acquisition methods.

An immediate question the annotation method arouses is how scientific validity of analysis on mental processes can be guaranteed. Regarding this issue, complete certainty will probably be unreachable for the near future. However, we have taken precautions to produce as *useful* data as possible.

Manipulation of physical objects, gesturing, and utterances are directly observable, and stochastic development of these behaviors can be observed objectively to a high degree. Regarding formation of analogies, social developments and mental processes, we use the tagged data as basis for categorizing the data in upbringing counseling and projecting behavior when actions are taken. Follow-up on consequent child development and evaluation of schemata by non-researcher experts have showed us the analysis improves our own learning environment. Applicability to other environments remains a hard-to-implement but important future topic.

5.2 Aims at developing corpus

One of the questions we hope our corpus will eventually help to answer is, “What kinds of things does a child learn with a single try, and what kinds of things require repeats?” Referring to the example in Chapter 4, the next time we gave the 6-year-olds the propeller toy, they instantly remembered how to operate it. However, the same children needed multiple attempts and had frequent mistakes writing things other than their names after they had learned to write. We hope to find many similar cases where apparently more semantically complex behavior takes less effort to learn than simpler behavior, as this suggest the existence of representations of various efficiencies.

Evaluating whether a child can draw a circle in response to the command “draw a circle” is simple to conduct in laboratory. Evaluating whether a child can make a sandwich is more difficult.

6. ACKNOWLEDGMENTS

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The annotation tool is specially developed by Naofumi Otani, who is also responsible for much of the project coordination.

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