Language Acquisition

How (We Think) Humans Learn Language. Can Artificial Beings Too?

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1 Aknowledgement

This work has originated as a report for the course of Cognitive Science by Mr. Martin Takáč, summer 2003.

I've used three main sources. Kalaš's report [Kalaš, 2002] from last year's seminar, [Rybár et al., 2002] and [Steels and Kaplan, 2002].

I would like to thank to `<Angel_32>`, `<shin->`, `<sharon‘‘>` and others for very valuable discussion about child's talk and for sharing their experience with own children at `#worldchat`, IRCNet.

2 Basics

According to Piaget's stage theory of development children progress through four stages (see for instance in [Rybár, 1997]).

During the first *sensorimotor period* (until one and a half, two years) child's cognitive system is limited to motor reflexes. They build on these reflexes to develop more complex procedures.

Throughout the second *preoperational thought* stage (until about six years) children acquire mental representational skills and also language. They are self-oriented, and have an egocentric view. They only view the world from their own perspective.

Children in the *concrete operation* stage (until about eleven, twelve) are able to take another's point of view and take into account more than one perspective simultaneously. Children who attain the last *formal operation* stage are capable of thinking logically and abstractly.

The process of language acquisition is just one of the great cognitive tasks every child is undergoing from early age.

Another one is to learn to distinguish among things in the environment. This is said to be the *acquisition of meaning* or the *conceptualisation*, as children acquire so called *concepts*—abstract categories of objects bound with similar characteristics. Without the conceptual representation, proper modeling of the world in one's mind and abstract reasoning would be impossible. Very interesting view on this subject is the Gärdenfors' theory of conceptual spaces [Gärdenfors, 2000].

Learning of language, *verbalisation* or *lexicalization* then can be viewed as associating the appropriate word for each concept.

3 The History of the Investigation of Language Formation

The question of how children acquire language has been here for ages. For example, already in fourth century Augustine in [Augustine,] writes:

> *"When they (my elders) named some object, and accordingly moved towards something, I saw this and I grasped that that the thing was called by the sound they uttered when they meant to point it out. Their intention was shown by their bodily movements, as it were the natural language of all peoples; the expression of the face, the play of the eyes, the movement of other parts of the body, and the tone of the voice which expresses our state of mind in seeking, having, rejecting, or avoiding something. Thus, as I heard words repeatedly used in their proper places in various sentences, I gradually learnt to understand what objects they signified; and after I had trained my mouth to form these signs, I used them to express my own desires."*

Philosophers of language, like Wittgenstein in [Wittgenstein, 1953] disagree with this Augustinian proposal. According to him one cannot learn meanings without learning the language. We use the language for thinking too, thus it is impossible to reason without language. Conceptualization and Language are closely interconnected.

Also the process of learning does not work like in Augustine's imagination. In our language there are many constructs such as wishes or promises, that cannot be just assembled from descriptive words. Instead of simple observational learning, Wittgenstein offers the notion of language games to fit the learning process better. The learner is repeatedly involved in the situation, in which the person, who knows the language already, exhibits various language constructs to him and expects some (appropriate) feedback. This way learner is trained to use the language correctly (i.e. as it is used).

3.1 Behaviorism

In the fifties psychology, behaviorists like Skinner emphasized the role of parents in the process of learning. Behaviorism was not interested in what is happening in one's mind. They were focused only on inputs and outputs. Language was supposed to be learned by imitation and selective adaptation of language habits.

3.2 Nativism

In the sixties nativism was born as an extrapolation of the principles of Darwin's theory (of the evolution of the species) to cultural sciences. Nativists based their theory on two basic points.

First. It is impossible to acquire (complex and composed) concepts by empirical generalization. This is called the *impossibility argument*.

Second. Child learning language gets quite poor input and soon it is able to produce very rich output. Behaviorists had serious problems to explain this emergence. This is called the *poverty of stimulus argument*.

In order to explain that children can acquire language without great efforts, although it is quite complex, Chomsky stated the *universal grammar hypothesis*. That is the existence of innate grammar that is easy parameterizable to fit every language. Language acquisition is then viewed as the process of adjusting this parameters. This direction is also known as *generativism*. See for instance [Chomsky, 1986].

In fact, Chomsky's formal theory of grammars developed for this purpose has far higher value in theoretical computer science.

Another approach, *modularism*, states that crucial in the human cognition is the presence of innate autonomous functional units, so called modules [Fodor, 1983]. Conceptualization and verbalization are viewed as operating in independent modules, which have no influence on each other.

For instance Pinker views language as innate instinct, independent of environment and culture, originated in the evolution perhaps by a catastrophic mutation.

Pinker's objector Fodor connects modularism with another paradigm of *computationalism* which views thinking as essentially a syntactic operation on local 'data'. He proposed that basic concepts are innate [Fodor, 1999], and language is acquired as spoken names for these concepts.

Some opponents of nativism claim that concepts are actually learned, for example by statistical learning methods. This is referred to as *empiricism* [Ellman, 1993].

Nativists often mention empirical investigations such as the historical linguist Bickerton did on Hawaii [Bickerton, 1990]. At the and of the 19th century, lot of people of various nationality came here to work on plantations. These people developed very simple language so they could communicate with each other. This language had very simple grammar. It used no articles, no prepositions, just present tense. Sentences only connected few words. Such as languages are often called *pidgin*. What is interesting, children of pidgin-speaking parents spoke far more complicated, so called *creole* language, containing articles, auxiliary verbs, multiple tense and so on. Ac-

tually, it was a full-value language. Many constructs in this language were different then in it's aborigine ancestor-languages. In other words language can be broken and then somehow reconstructed in just one generation. This is a strong argument for nativists that there are innate mechanisms responsible at least for learning language.

3.3 Semantic-Cognitive Approach

In the seventies, as Piaget proposed his development theory, corresponding branch started in language acquisition.

Bloom and Nelson [Nelson, 1973] emphasized the role of semantics, which overruns the role of grammar in the development of one's language skills. Syntactic rules and the structure of sentences arise from the needs of the communication, such as effectiveness and readability. People do not distinguish between grammatically correct and incorrect sentences, instead they try to extrapolate the meaning. Their aim is to understand what the speaker says, or even better what he bears in his mind. Syntactic conventions are only obeying linguistic rules if adopted early in the basic school. Otherwise they are hazy in the population—different in different communities and for different occasions.

They proposed in *strong cognitive hypothesis*, that cognition is the necessary and sufficient condition for development of language. However, this does not explain why some children with age-appropriate cognitive skills do lag in language development. The attenuated *weak cognitive hypothesis* only keeps cognition as the necessary condition of language development, what actually is quite plain proposition.

3.4 Pragmatism

Real breakthrough in understanding of children's language acquisition came in late seventies and early eighties. Bates and his colleagues attributed its essence to social factors of human communication, in the contact of children and their parents and in the development of sensorimotor behavior [Tomasello and Bates, 2001].

Moreover, there is a causal influence of culture in concept learning, and this role is particularly, even though not exclusively, played by language. This is known as the *Sapir-Whorf hypothesis*. It is based on evidence, that in different languages not only syntactic constructions differ, but underlying conceptualization is different as well. Language acquisition then goes hand in hand with conceptualization (once again).

This of course does not imply that there are no concepts prior to the beginning of language acquisition. In fact, there are probably millions of concepts used in sensorimotor control, social interaction, emotion and so on, which never get lexicalized [Steels and Kaplan, 2002].

3.5 The Russian School

As mentioned in [Kalaš, 2002], already in early thirties, Russian scientist Vygotskij stated basic theses of the cultural-historical development theory, which are of *social origin of psychic*, of the *symbol-mediated structure of higher psychical processes* and of the *function of psychical processes in the behavior control*.

His colleague Lurija understood psychical functions, including speech, as a complex dynamic functional system comprised of interacting and hierarchically organized psychical processes. He states, that complex psychical functions cannot be localized in brain nor in genome. Also that it is impossible to localize defects only by exterior observation, without knowing more about the inner mechanisms.

They also observed, that in the development of language first occurs pragmatics—expressing actual needs, before one year of age, followed by semantics—cognitive processing of objects in the environment, and only then syntax—expressing ideas obeying grammatical and morphological conventions.

4 Childrens' Language Acquisition Process

In [Kalaš, 2002] author presents an observation of children's language formation process.

4.1 Sensorimotor Period

There is no doubt that children possess some innate predispositions for social contact with people. These reflect in the very first behaviors, in sense for social signals. Infants are given the ability to reproduce and they do reproduce simple mimic expressions (sticking out one's tongue, eyes-shutting, ...). Children are soon very good in expressing their emotions (surprise, comfort, joy, dislike, ...) and also in reproducing such expressions.

On the other hand, regard how we—elders communicate with very young children. We do magnify our expressions, we use very narrow repertoire of words and expressions and we repeat them on and on. This treatment of

infants is conditioned in behavior of all adults and older children. Also, both—the child and the parent are pleased by successful communication, what stimulates them both to keep interacting.

Newborns are very sensible to what they hear and very soon they start to distinguish between their mother-tongue and other languages possibly present in their surroundings.

At about fourth months of child's life there appears a change in the synchronization of attention. Until now parent used to set his attention where the child's is oriented. Now child starts to figure out where parent is focused.

First tries to talk appear very early. At about six months of age child already prattles. At about nine months several monosyllables can be heard representing some broad concepts. For instance, "ma" not just for mammy but more for the anxious feelings and need of shelter.

After first year of life child reads simple sentences like "Where is daddy?". The vocabulary is broader, still comprised mostly of monosyllabic words. Concepts are still quite broad, e.g. "aam" for food, "ta" for more (of anything), "ba-by" for another child but also may be for a doll, "bu-bu" if something hurts or "ted-dy" for a toy.

Child already understands the principle of dialogue, that the discussing sides take turns. She often by itself repeats sentences and longer dialogues with correct cadence. Older children also reproduce dialogues and play 'language games' in pairs or groups.

4.2 Preoperational Thought

As children enter the preoperational stage, they handle polysyllabical vocabulary and connect several (typically about two) words into sentences obeying simple 'protosyntax'. For example "mammy aam" standing for "mammy, I want to eat" or "play ball" for "I want to play with the ball".

In this stage child usually is aware of the other's mind. She soon uses pronouns "we", "you" and "they" in plural. However, in singular she speaks in third person, for example—about herself, by name. Children start saying "me" and "you" in singular at about three years of age.

4.3 Concrete Operations Stage

With the beginning of the concrete operation stage, children use ordinary words and compose complex sentences. Some children may still prattle a bit, but this is eliminated soon, throughout first years at school.

4.4 Conclusion

It follows that crucial for the development of communication ability is the motivation. One of the greatest motives for the child undoubtedly is *emotion sharing*. Another important factor is the formation of the *awareness of other's mind*. This can be confirmed by the fact that autistic children that are less or more aware of another peoples' mind usually are able to learn to speak, while the autists that are not aware of others usually are not able to master language as well.

There is a digest of the growth of vocabulary with age in table 1. The very first concepts are quite broad. They are constantly updated by the classification or naming games parents and child play together. This way child's concepts are specialized until they approximately match concepts as present in the adult community. We see that concept and language formation are connected at least in a sense. Concepts are learned by means of language, and language reflects underlying concepts, which are different in various environment.

Also, pragmatic behavior occurs before early semantics can be observed in child's talk. And semantics occurs in the talk before the sense for grammatical structure.

Table 1: Development of the vocabulary size in time

months of age	count of vocabulary
12	6
18	20-30
24	200-300
36	aprox. 1000

5 Experiments with Artificial Beings

In [Steels and Kaplan, 2002] authors describe experiments with enhanced version of Sony's autonomous mobile toy-robot AIBO. Their robot was equipped with what they call 'state-of-art' AI algorithms for voice and image recognition and complex behavior-based motivation system.

Trying to answer two basic questions: "How does bootstrapping into communication take place?", and "How meaning is acquired?"—they had to consider proper learning methods.

There are basically two main learning models considerable. *Individualistic learning*, when child receives a large number of examples where speech is paired with situations. She either already masters all needed concepts or is able to induce them from presented situations.

We can easily improve this process by allowing little feedback given by speaker. Language learner is still rather passive, it is expected to associate labels with existing concepts. Therefore this model is also known as the *labeling theory*.

In the true *social learning* model, interaction between the learner and other human being is not limited. The teacher is rather called *mediator*, because is role exceeds just teaching in a sense. The goal is sort of something pragmatic in the world The mediator helps to achieve the goal and she often wants to see the goal achieved.

Steels and Kaplan performed series of various experiments in an environment with three objects—red ball, a toy called Smiley and a smaller imitation of AIBO called Poo-chi. Aim was always the correct classification of these objects, but the nature of experiments altered to test the potency of different methods.

The results confirmed crucial role of social interaction in the learning process, even if you deal with artificial learner. This objective is assigned to various aspects of the social learning model's nature.

The learner can initialize experiments to test uncertain knowledge. The mediator is available to give direct and concrete feedback to any experiment performed by the learner—unlike in passive learning, where learner simply has to wait until suitable situation arise. Mediator also sets constrains to the situation to make it more manageable and she adjusts the situation upon the consequences of learner's actions.

Authors also conclude that social learning enables to introduce the causal influence of language to the concept formation process which they propose to be required if the resulting concepts are to be similar with concepts already established in human culture. Individualistic learning often yields to slightly distinct conceptual structures.

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