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Extended Logical Reasoning (ELR) integration with PROLOG for Natural Language Stories and Logic-Construction-Set (LCS) Application

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Abstract This works implements a children philosophy application of Extended Logical Reasoning (ELR), as backup of the mental logic solution, with a PROLOG implementation and hence an algorithmic solution of queries to the story. Examples are given for the PIXIE's children philosophy tutorial and concurrent to its ELR-SWI-PROLOG implementation. The example sentences are analyzed and translated into machine readable predicates. In PROLOG they are then (1) the database of knowledge or facts. As a second step (2) the logical relations are written as rule set, as well as the auxiliary conditions and constraints. This gives ”predicates” and ”logical operators” as language building blocks. The philosophical story here contains all the necessary logical content. (3) Finally the query - as a question to the story - as a searching-predicate is formulated. The question itself has a logical structure. The ELR answers can then be compared with the answers that are given by natural language reasoning, based on the same story or sentences. For (1), (2) and (3) there takes place a logical analysis of sentences. This is supported by a Logic-Construction-Set (LCS) material, that ”transforms” (i) the predicates and their arity, (ii) logical operators and (iii) words. Pupils can then discover logic reasoning, supported by a structural guiding Generalized Montessori Principle (GMP), as well as by means of an AI tool for ELR, both in a self-correcting and a context of discovering manner. As a highlight of the work there is given, in dependence on Wittgenstein's language as a city, a sketch how to construct a Logic City, which is the materialization of connexes and disnexes as the logical nexus of language.

Keywords Children Philosophy · PROLOG · Artificial Intelligence · AI · Natural Language Processing · Generalized Montessori Principle (GMP) · Connexus · Disnexus · Nexus

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Introduction

Nowadays the Artificial Intelligence (AI) paradigm is increasingly pervading our lives and our working environments. The effects of AI on our world as an increasing Popper's world III application (Popper and Eccles 1997) and implementation, by this, are emanating and increasing the interconnection of world I and II by means of a changing physical environment through AI-devices and a change in consciousness. This, as a consequence, leads to different teaching methods and concerns philosophy deeply. The core of this development can be seen two-folded: Firstly by the mechanization of work as a result of the first industrial revolution and secondly by the mechanization of thought by means of machines. Up to the 1970's the procedural paradigm in programming prevailed. Since then the logic oriented programming was implemented, with PROLOG as an important logical-programming computer language (q.v. Sokol and Flach 2018), which realized Wittgenstein's foundation of language as a collection of thoughts in a language (Wittgenstein 2019), and the assumption that the natural language is based on logic, equivalent to other formal logic language implementations. By this the logic base, according to the correspondence theory (Wikipedia 2019), ”Wahr ist was den Tatsachen entspricht”, which goes back to the Aristotelean discovery of logic, is formulated algorithmically as a computer language. In the Wittgensteinean sense this is equivalent according to Wittgenstein 2003, §1.1 ”Die Welt ist die Gesamtheit der Tatsachen.” and Wittgenstein 2003, §1.13 ”Die Tatsachen im logischen Raum sind die Welt.”, by introducing logic as a synonym for reasonable language. In our application case, we use PROLOG, that has mainly declarative use or can by regarded approximately equivalent to the formal logic of predicate logic, which is then called clausal logic. With these properties of PROLOG, it is in principle possible to ”speak” (nearly) with the computer application in natural language. The idea of the work presented here is to implement a children philosophy application of logical reasoning, as a backup of the naturally achieved mental logic solution, with a PROLOG implementation and hence an algorithmic solution of queries to the story. For this, some examples are given for a part of PIXIE's children's philosophy tutorial (Lipman and Sharp 1984, based on Lipman 1981, Sharp and Lipman 2006) and its parallel SWI-PROLOG implementation. The example sentences are analyzed and (1) formulated and implemented in PROLOG as the database of knowledge or facts. (2) The logical relations are then implemented in a second step as a rule set, as well as auxiliary conditions and constraints. With this the children philosophical story is set as a data set, containing all the necessary logical content which is stored in a file. (3) Finally, the query is formulated, out of a query as a question in the context of the database of facts as well as predicates and rules are defined. The question itself has a logical structure. The answers can then be compared with the answers that are given by natural language reasoning, based on the same story or sentences. The logical sentence analysis is supported by a material which is designed according to the Generalized Montessori Principle (GMP) in Heiden 2018. For (1), (2) and (3) there takes place a logical analysis of sentences. This is supported by a material, a LCS. One LCS is e.g. containing plates, which stand for the (i) predicates and their arity (1,2,3..), logical (ii) operators (<and>=<,>, <or>=<;>, <if then>=<:->, <sentence closing or neutral sign>=<.>, ...) and (iii) words, representing facts, as grounding terms. By this, the means of a tool according to the GMP is applied to the LCS. Hence the logical analysis leads to a transformation into the ”PROLOG language”, which then is implemented and tested. Pupils can then discover the world of logic by means of reasoning, asking the machine, but also by implementing their increasing, knowledge basis, and by this, experimenting with logical sentences and structures of the natural language.

In the following first section <Exercise Family Resemblances> there will be given the part of the PIXIE novel accompanying handbook, that is prepared for PROLOG in this work.

In the second section <Logic Construction Set (LCS)> there will be given ideas how to implement such a construction set practically.

In the section <PROLOG Implementation> we describe how to implement the story's logical sentence structure and the ELR by means of a query to PROLOG.

Finally in the section <Conclusion and Outlook> there will be given some conclusions to this work together with a short outlook to this work and its importance to the future of humanity.

1 Exercise Family Resemblances

In the following there will be given an application example, according to its following implementation in PROLOG: (1) The knowledge base, (2) the rules and (3) the questions or queries to the database.

The knowledge base According to the Exercise <Family resemblances> concerning the Pixie novel (Lipman 1981) in the handbook from Lipman and Sharp 1984, p. 39-40:

> ”(1) Mr. John Jones is the son of Lucy and Walter Jones. (2) Mary Jones, the wife of John Jones, (3) is the daughter of Wendy and Henry Smith. (4) John and Mary Jones have three children: Edward, Suzy and Betsy.”

In our context this is the base story, containing the knowledge. The numbers in round brackets indicate the logical sentence structures used for the translation into PROLOG used in Fig. 1,2 and 5 and which correspond to the *manifest* predicates P1-P4.

The rules That what is used as the rules in PROLOG are in the Pixie accompanying handbook from Lipman and Sharp 1984, p. 40 the resemblances:

> ”Now here are the resemblances:
> 1. (5a) John Jones has his mother's mouth, (5b) his father's nose, and (5c) his mother's eyes.
> 2. (6a) Mary Jones has her mother's chin, her (6b) mother's ears, and (6c) her father's mouth.
> 3. (7a) Edward Jones has Lucy Jones's nose, (7b) Henry Smith's mouth, and (7c) John Jones's ears.

4. (8a) Suzy Jones has[1] Wendy Smith's eyes, (8b) Walter Jones's ears, and (8c) Mary Jones's hair.
5. (9a) Betsy Jones has her father's nose, (9b) her mother's mouth, and (9c) her mother's eyes."

The queries The queries, i.e. the questions to the database are the questions we ask about the story. In the example part this is according to Lipman and Sharp 1984, p. 40:

"Questions:
1. Which member of the family looks most like Henry Smith (other than Henry himself)?
2. Which member of the family looks most like Wendy Smith?
3. Which member of the family looks most like Lucy Jones?
4. Which member of the family looks most like Walter Jones?
5. Which member of the family looks most like John Jones?
6. Which member of the family looks most like Mary Jones?"

Family Tree The family tree of the story context from Lipman and Sharp 1984, p. 40 is depicted in Fig. 1 with regard to the logical relation connections indicated as lines with arrows. In the round brackets the related sentences are depicted. (1) depicts the relation to senctene (1) according to the paragraph <The knowledge base>. The relations are also depicted by sentences, that consist of rules then, according to the paragraph <The rules>. E.g. the relation "John Jones has his mother's mouth" is indicated by (5a) and the relation-lines with arrows. In the diagram a relation to the property, which is in the previous example <mouth>, and the persons who own this property is depicted.

2 Logic Constructions Set (LCS)

In the following three LCS's are given. The *Logic Railway*, The *Logic Tree* and the *Logic City*. They all are GMP's, each to be constructed in some material-configuration, to support additionally the senses for learning logic sentence applications. All the LCS's contain some sort of order, that is connected to the logic sentence structure.

Logic Railway The Logic Railway is shown in Fig. 2 for predicates P1-4.

Here also the translation is given for the PROLOG writing. On each railway-track a predicate is given, and two readings: That of the natural language, and that of PROLOG, which can be written directly to SWI-PROLOG. This is shown in Fig. 2 for the railway-tracks and in Fig. 3 for the SWI-PROLOG Editor, both for the predicates P1-4.

[1] in original citation form "had"

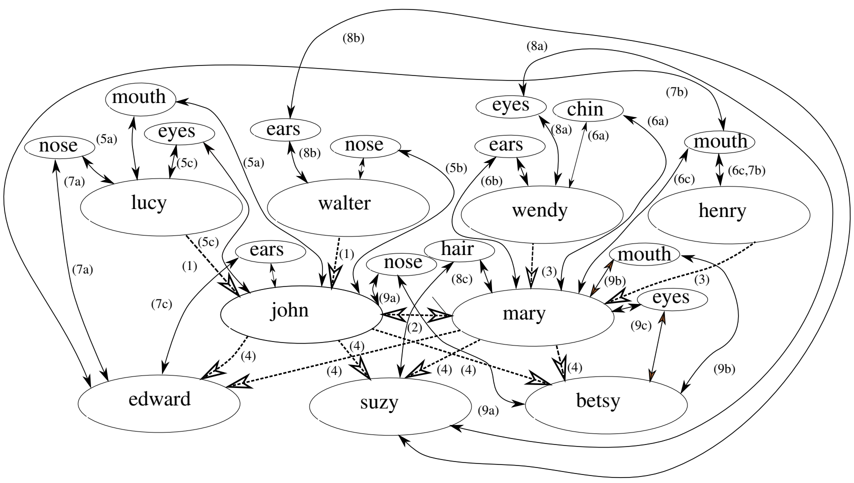

Fig. 1 Family tree for the family members and relation to the sentence manifest predicate relations in round brackets () for Story Sentences 1-9.

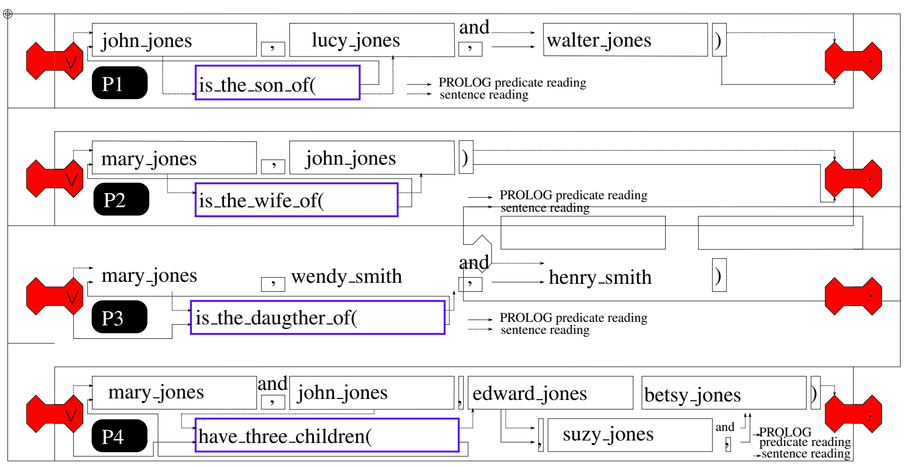

Fig. 2 Logic Train - Logic Construction Set (LCS) for the predicates P1-P4

Logic Tree The Logic Tree is depicted in Fig. 4. There is used the Stanford Parser for the *parsing* of the sentence (1) predicate - where the "direction" of the tree has been inverted. The parsing process, is the result of logically natural language parsing of language, combined with other AI techniques to divide a sentence in elements with regard to their grammatical and or semantic meaning. What we see in Fig. 4 is the "green" part (word area within the green outer line), showing the manifest sentence structure. The tree beyond this, due to parsing, is the underlying grammatical notation, as NP stands for noun phrases and VP for verb phrase for example (Stan-

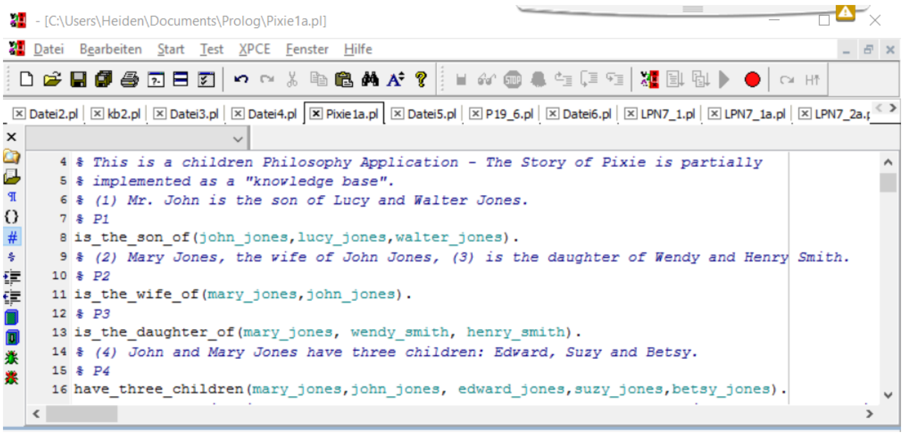

Fig. 3 SWI-PROLOG Editor (Röhner 2015) for predicates P1-4

ford 2019). Let us call this meta meaning-structure, behind the sentence, as latent structure, in analogy to Freud's interpretation of dreams as latent or manifest (Freud 1994).

Logic City The Logic City is depicted in Fig. 5. The picture shows the Logic City for the first four predicates (1)-(4) of the knowledge base (q.v. paragraph <The knowledge base>). The houses are the great squares with the initials of the names, e.g. John Jones is the square with JJ in it. The houses are in general that what is put into the predicates. This is indicated by the same color in the predicates, for what has to be inserted into them to build a "logical" sentence. In the Logic City the houses are connected by ways. The houses here are some, for the meaning essential, nouns, and the written part of the sentence symbolizes the predicates. Together they form a full sentence.

3 PROLOG Implementation

To implement the logic sentences in SWI-PROLOG, we use the SWI-PROLOG Editor, as shown in Fig. 3.

For PROLOG there exists first a file, this is the database.[2] In this file the facts are stored, or the sentences of the story in our case. The sentences can be divided for our purpose of translation from the story into the AI-frame with logic-programming, into three parts: (1) The manifest sentences, (2) the latent logical premises and (3) the rules.

The manifest sentences These are the predicates, here as an example P1-4:

[2] This is a Ascii-text-file with the extension ".pl".

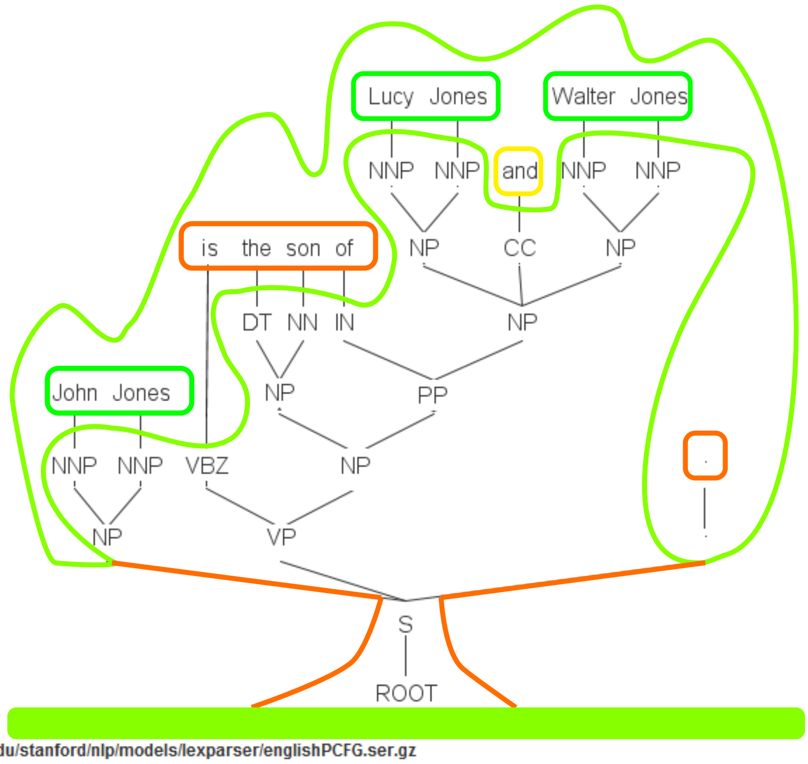

Fig. 4 The Logic Tree for the predicate P1. Latent and manifest sentence structure, on the base of the Stanford English Language Parser.

```
% P1
is_the_son_of(john_jones,lucy_jones,walter_jones).
% P2
is_the_wife_of(mary_jones,john_jones).
% P3
is_the_daughter_of(mary_jones, wendy_smith, henry_smith).
% P4
have_three_children(mary_jones,john_jones,edward_jones,
suzy_jones,betsy_jones).
```

Here it is of importance, that the PROLOG ”atoms” or ground-terms, like the name ”John Jones” are beginning with a lowercase letter. The logical variables, are beginning with an uppercase letter. The underscore _ denotes in a term for a variable, something like ”that it does not matter what to fill in”.

The latent sentences The latent sentences are the implicit premises, that have also to be formulated as sentences. These are as a part of all, for premises P5-30:

```
%P5,P6
```

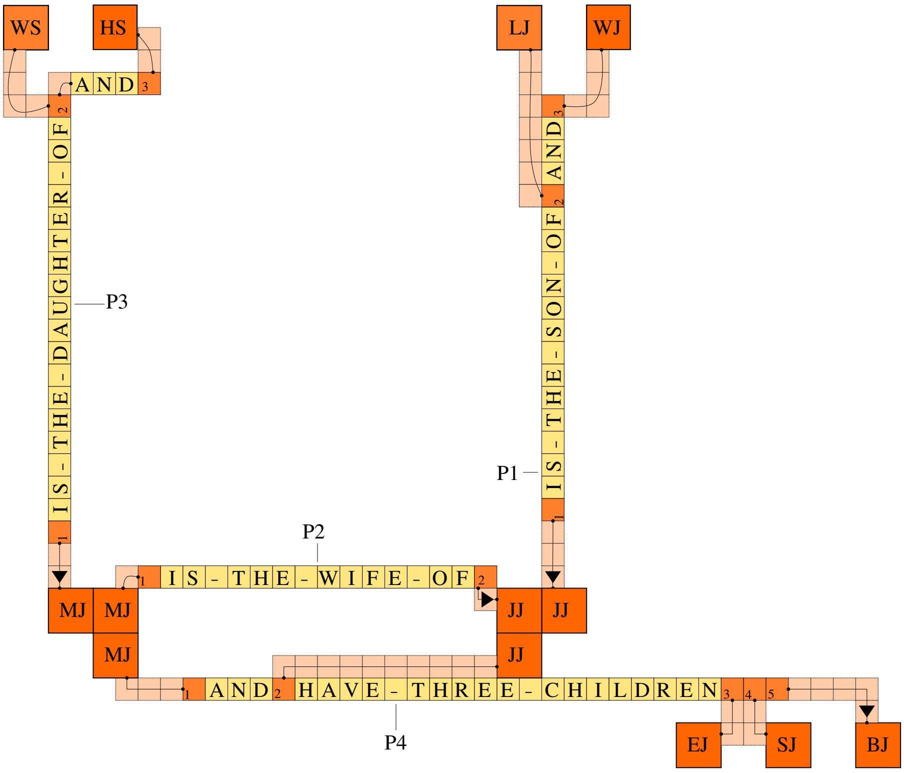

Fig. 5 Logic City for the predicates P1-P4

```
is_the_mother_of(A_mother,A_child):-
         is_the_son_of(A_child,A_mother,_).
%P7,P8
is_the_mother_of(A_mother,A_child):-
         is_the_daughter_of(A_child,A_mother,_).
%P9,P10
is_the_mother_of(A_mother,A_child):-
         have_three_children(A_mother,_,A_child,_,_).
%P11,P12
is_the_mother_of(A_mother,A_child):-
         have_three_children(A_mother,_,_,A_child,_).
%P13,P14
is_the_mother_of(A_mother,A_child):-
         have_three_children(A_mother,_,_,_,A_child).
%P15,P16
is_the_father_of(A_father,A_child):-
         is_the_son_of(A_child,_,A_father).
%P17,P18
```

```
is_the_father_of(A_father,A_child):-
         is_the_daughter_of(A_child,_,A_father).
%P19,P%20
is_the_father_of(A_father,A_child):-
         have_three_children(_,A_father,A_child,_,_).
%P21,P%22
is_the_father_of(A_father,A_child):-
         have_three_children(_,A_father,_,A_child,_).
%P23,P%24
is_the_father_of(A_father,A_child):-
         have_three_children(_,A_father,_,_,A_child).
```

The rules Finally the rules are defined. These correspond to the resemblances in the example given above. They are similar to the latent premises, and constitute in our case "if then" sentences, denoted by the PROLOG operator ":-". In the following the rules for the sentences (5a-c) are given, according to Fig. 1 and the paragraph <The rules>:

```
%P25,%P26 (5a)
has_the_same_mouth_as(john_jones,His_mother) :-
         is_the_mother_of(john_jones,His_mother).
%P27,%P28 (5b)
has_the_same_nose_as(john_jones,His_father):-
         is_the_father_of(john_jones,His_father).
%P29,%P30 (5c)
has_the_same_eyes_as(john_jones,His_mother):-
         is_the_mother_of(john_jones,His_mother).
```

The queries Finally the questions are asked according to the paragraph <The queries>. When we ask for example the question "Which member of the family looks most like Henry Smith (other than Henry himself)?" we first have to analyze the sentence and reformulate it as a predicate, that can be logically deduced by PROLOG. In this case, "member of family" and "looks most like" seem to be adequate predicates. As all the persons we defined are members of the family we leave out the first predicate. Then we look at the predicate "looks most like", this seems to be too difficult at first, as there is the question what means "most" logically. The word "most" seems to mean something with regard to the predicate itself. Therefore it is in nature something that is self-referential. So we divide the predicate by analysis into two predicates "most" and "looks like", and implement the last only. This is defined in PROLOG in the database e.g. for the property mouth with the rules:

```
%P62,P63
looks_like(A_person,Another_person,mouth):-
              has_the_same_mouth_as(A_person,Another_person).
%P64,P65
looks_like(A_person,Another_person,mouth):-
              has_the_same_mouth_as(Another_person,A_person).
```

Now we are prepared to ask the question to PROLOG. This is done as follows: First the database is loaded. This is done directly in SWI-PROLOG (OpenSource-Software 1987) or the SWI-PROLOG Editor (Röhner 2015) by

```
['Pixie1a'].
```

followed by an <ENTER>, when the database filename is "Pixie1a.pl". Now the query can by written into the query window, which begins with the signs:

```
?-
```

The question is now formulated, after definition of a set of latent predicates as a query by the following sentence-predicate:

```
looks_like(henry_smith,X,Y).
```

The answer of PROLOG is first:

```
X=mary_jones,
Y=mouth
```

after pressing <SPACE>

```
;
X=edward_jones,
Y=mouth
```

and after another pressing of <SPACE>

```
;
false.
```

PROLOG returns to the starting sign

```
?-
```

. The answer can be interpreted as that Mary Jones and Edward Jones look like Henry Smith with regard to her mouth.

Still the answer is not containing the answer that Betsy Jones has the same mouth as Henry Smith, what can be followed from the relation that Betsy Jones has the same mouth as Mary Jones and that Mary Jones has the same mouth as Henry Smith.

This can be implemented as an extra rule, or by means of a recursive algorithm. This makes clear, that we need for each relation in this case a "rule", or a "general rule" like a recursion rule. An example is given below:

```
%--- First recursion P1, P2 ---
 looks_like(P1,P2,mouth):-
 has_the_same_mouth_as(P1,P2).
 looks_like(P1,P2,mouth):-
   has_the_same_mouth_as(P1,P3),
  looks_like(P3,P2,mouth).
%--- Second recursion P1, P2 switched to allow for different
%    input order of P1 or P2 ---
 looks_like(P2,P1,mouth):-
```

```
   has_the_same_mouth_as(P1,P2).
 looks_like(P2,P1,mouth):-
   has_the_same_mouth_as(P1,P3),
  looks_like(P3,P2,mouth).
```

When using the first recursion alone, the result is gained with the following query:

```
?- looks_like(X,henry_smith,mouth).
X = mary_jones ;
X = edward_jones ;
X = betsy_jones ;
false.
```

which is the answer we would expect. What is even missing here, in this case, is the self-reference, i.e. that also Henry Smith looks like Henry Smith.

When we implement this rule, the answer to the question ”most like”, can be inferred from the PROLOG answer, as Mary Jones, Edward Jones and Betsy Jones equally.

This reveals that, even with such ”simple” questions, with regard to an AI system, there have to be done additional assumptions in form of latent predicates and or rules. To formalize the answer to the question ”most like” would mean to implement expressions which logically calculate numbers and hence the logical ”meaning” of a number in general. Hence logic rules for numbers have to be implemented additionally. Alternatively the answers can by interpreted logically from a partly solution, as was shown in this example.

4 Conclusion and Outlook

In this work an approach how to implement an Enhanced Logical Reasoning (ELR) by means of the AI language PROLOG was presented. There was elaborated a children philosophy context by means of the Pixie novel, which is adapted for the use in children philosophy. To increase the nowadays pupils logical reasoning capabilities by means of AI this work has be done, to seamlessly integrate critical logical thinking apart from and concurrently together with that what matters, a story context. This can help to use AI tools, as well as the own mind, by this enhancing philosophical insight. The work about this method of reasoning, is itself challenging and has led us to the insights that were sketched in this work. A material according to the GMP that allows ”materially” for reasoning logically. This can be, a *Logic Railway LCS*, a *Logic Tree LCS* or a *Logic City LCS* implementation as well. All three LCSs, depict the nature of logic in a material, that can represent, lesser, or more dimensions of the originating logic-language as a material meta-interpretation. By this it is a means to logically reason with a material, leading to an intense ”understanding” of logic, as more senses are incorporated in the perception process of the addressed learning person. In this sense this is a ”natural” ELR. This natural ELR leads then by means of the translation procedure, provided with the material, seamlessly into an overall ELR process, in this case together with the computer tool PROLOG, that is completely based on intrinsic logical reasoning. By this process, the manifest and the latent structure of any logically structured language becomes apparent. This can be seen in logical programming, as well as reasoning, by the implementation of unspoken vs. spoken, unremembered vs. remembered and implicit vs. explicit relations. So it can be concluded, that the Logic City has a profound meaning in the discovery process of the world of philosophical inquiry, as here, the meanings become increasingly broader, when approaching ”deep philosophy”.

The outlook for humanity is to reason increasingly reasonable. That means that the gap between thinking of children and grown-ups becomes smaller, as well as that of distinct professions. We live in a world, that is increasingly dominated by rational or, behind the scene, logical decisions, leading to an overall enhanced living. In this context an increased philosophical mindset, that can be ground-laid by means of children philosophy, may be generally advisable: The critical thinking about what is to be done in the world. Not only as it seems only now, important topics of mankind have to be solved. One reason that they have not been solved up to now, is that the logical reasons for reasonable action was not available to mankind up to now, and that might have been even the case since a long lasting time. For this it will be of utmost importance for our future to train the skills how to gain right and good decisions out of an awakened and enhanced logic mind.

References

Freud, Sigmund (1994). *Sigmund Freud Studienausgabe, Bd.1-11*. Ed. by Thure von Uexküll and Ilse Grubrich-Simitis. 12. Aufl. S. Fischer Verlag.

Heiden, Bernhard (2018). “Interdisciplinarity as an Approach of Unifying Science with Universal Methodologies – Practical Technical Education and Children Philosophy Implications”. In: *Internationaler Kongress für Kinderphilosophie Pluralismus und interdisziplinäre Perspektiven - Philosophische Untersuchungen in einer sich rasch verändernden Welt* (15.-18. November 2018, Meerscheinschlössl Graz, Österreich). Graz, pp. 1–12.

Lipman, Matthew (1981). *Pixie*. Upper Montclair, N.J. 07043: Institute for The Advancement of Philosophy for Children, Montclair State College. 94 pp. ISBN: 0-916834-17-4. URL: https://sites.google.com/site/iapcsummerworkshop2016/iapc-curriculum.

Lipman, Matthew and Ann Margaret Sharp (1984). *Looking for Meaning: Instructional Manual to Accompany Pixie*. University Press of America. 518 pp. ISBN: 978-0819138293. URL: https://sites.google.com/site/iapcsummerworkshop2016/iapc-curriculum---manuals.

OpenSourceSoftware (1987). *SWI-Prolog*. SWI-Prolog version (threaded, 32 bits, version 8.0.3). URL: https://www.swi-prolog.org/.

Popper, Karl R. and John C. Eccles (1997). *Das Ich und sein Gehirn*. Piper Verlag, München.

Röhner, Gerhard (2015). *SWI-Prolog Editor*. Version 4.26, 26.04.2015, SynEdit 2.05. URL: https://arbeitsplattform.bildung.hessen.de/fach/informatik/swiprolog/indexe.html (visited on 10/02/2019).

Sharp, Ann Margaret and Matthew Lipman (2006). *International Workshop - Philosophy with Children, ACPC*. 14.-17. Oct. 2006. Children Philosophy Institute, Graz.

Sokol, Kacper and Peter Flach (2018). *Simply Logical*. URL: https://book.simply-logical.space/.

Stanford (2019). *Stanford Parser*. Dictionary: englishPCFG.ser.gz; Stanford Lexicalized Parser v3.9.2 - 2018-10-16. The Stanford Natural Language Processing Group. URL: https://nlp.stanford.edu/software/lex-parser.shtml#Sample.

Wikipedia (2019). *Correspondence theory of truth*. accessed 30.9.2019. URL: https://en.wikipedia.org/wiki/Correspondence_theory_of_truth.

Wittgenstein, Ludwig (2003). *Tractatus logico-philosophicus - Logisch philosophische Abhandlung*. edition suhrkamp, Frankfurt am Main.

— (2019). *Philosophische Untersuchungen*. 9. Auflage. Suhrkamp Verlag AG. 300 pp. ISBN: 3518223720.