

## Postscript for ‘Human-Level Models of Minds’

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### Abstract

This white paper further discusses some topics in (Jackson 2017): reasoning with natural language syntax; interlinguas and generalized societies of mind; self-talk; artificial consciousness and the Hard Problem of consciousness.

### Introduction

The ‘Talamind thesis’ ([Jackson 2014](#)) presents a research approach toward human-level artificial intelligence. This involves developing an AI system using a language of thought (called Tala) based on the unconstrained syntax of a natural language, and designing the system as a collection of ‘executable concepts’ that can create and modify concepts, expressed in the language of thought, to behave intelligently in an environment. A brief introduction to the TalaMind approach is given in ([Jackson 2017](#)).

Discussions during and after the 2017 AAAI Fall Symposium suggested it could be helpful to write this Postscript, further discussing some topics in (Jackson 2017).

Note: In the following paragraphs, the notation “§2.3.4” refers to thesis Chapter 2 section 3.4. Thesis chapter and section references can be directly accessed via hyperlinks from the Table of Contents for the thesis.

### Reasoning with Natural Language Syntax

The theoretical basis for Tala is discussed in Chapter 3 of the TalaMind thesis; §3.3 argues it is theoretically possible to use the syntax of a natural language to represent meaning in a conceptual language and to reason directly with natural language syntax.<sup>1</sup> This is illustrated in the prototype TalaMind demonstration system, which includes pattern-matching logic for Tala expressions (§5.5.3) to support inference with natural language syntax.

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<sup>1</sup> Although this was stated in (Jackson 2017), I think I forgot to mention it in a brief talk at the Symposium.

It is not necessary to translate natural language expressions to and from formal languages such as predicate calculus, conceptual graphs, etc., for machines to reason about meanings of natural language. Still, the TalaMind architecture is open<sup>2</sup> to use of formal languages and other symbolisms at the linguistic level in addition to Tala.

The Tala language responds to McCarthy’s 1955 proposal for a formal language that corresponds to English (viz. thesis §1.1) though not in the way McCarthy sought. Tala enables a TalaMind system to formulate statements about its progress in solving problems. Short English expressions have short correspondents in Tala, a property McCarthy sought for a formal language in 1955. Tala can represent unconstrained, complex English sentences, involving self-reference, conjecture, and higher-level concepts, with underspecification and semantic annotation. Thesis Chapter 4 discusses theoretical objections, including McCarthy’s arguments in 2008 that a language of thought should be based on mathematical logic instead of natural language (§4.2.5) and Searle’s Chinese Room argument (§4.2.4).

Chapter 3’s analysis shows the TalaMind approach can address theoretical questions not easily addressed by more conventional approaches. For instance, it supports reasoning in mathematical contexts, but also supports reasoning about people who have self-contradictory beliefs. Tala provides a language for reasoning with underspecification and for reasoning with sentences that have meaning yet which also have nonsensical interpretations. Tala sentences can declaratively describe recursive mutual knowledge. Tala facilitates representation and conceptual processing for higher-level mentalities, such as learning by analogical, causal and purposive reasoning, learning by self-programming, and imagination via conceptual blends.

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<sup>2</sup> The TalaMind architecture is actually a broad class of architectures, open to design choices at each level. (See §1.5 and §2.2.2.)

## Interlinguas & Generalized Societies of Mind

The TalaMind hypotheses do not require a society of mind architecture, but it is consistent with the hypotheses and natural to implement a society of mind at the linguistic level of a TalaMind architecture. In the TalaMind prototype, a Tala agent<sup>3</sup> has a society of mind in which sub-agents communicate by exchanging Tala concepts. Thus, Tala is used as an interlingua.

Note that the term ‘society of mind’ is used in a broader sense than the approach described by (Minsky 1986), to refer to a multiagent system open to methods for organizing agents and communication between agents other than the methods specified by Minsky, e.g. including languages of thought. This broader, generalized sense corresponds more to a paper by Doyle (1983). See §2.3.3.2.1 of (Jackson 2014) for further information.

Polyscheme (Cassimatis 2002) could also be considered as implementing a society of mind architecture in the generalized sense.<sup>4</sup> Polyscheme uses a propositional language for communication between agents called ‘specialists’. (Cassimatis 2002, p.54) Propositions are specified by elements which might have values like<sup>5</sup>

```
at( ball17, pBall, t1, R )
at( screen12, pScreen, t1, R )
behind( pBall, pScreen, t1, R )
```

In contrast, Tala is a language of thought based on the unconstrained syntax of a natural language, English. A sentence in Tala might be an expression like:

```
(ask
  (wusage verb)
  (subj Leo)
  (indirect-obj Ben)
  (obj
    (turn
      (wusage verb)
      (modal can)
      (sentence-class question)
      (subj you)
      (obj
        (grain
          (wusage noun)))
      (into
        (fare (wusage noun))
        (for
          (people (wusage noun))
```

<sup>3</sup> A ‘Tala agent’ is a system having a TalaMind architecture.

<sup>4</sup> Minsky was thesis advisor for Cassimatis’ work on Polyscheme. Polyscheme used ‘trans-frames’ from (Minsky 1986).

<sup>5</sup> See (Cassimatis 2002), p. 57. This collection of propositions is equivalent to “Ball 17 is behind screen12 during time t1.”

```
))))
(tense present)
(subj-person third-singular)]
```

Tala’s use of nested list structures to represent natural language syntactic structures facilitates pattern-matching of Tala sentences, which combined with a syntax for variables in Tala, and representation of inference rules as if-then sentences, enables symbolic processing for logical deduction. (§5.5.3)

## Self-Talk

Mental discourse (self-talk) is an important feature people often ascribe to their minds. It seems we each have the ability to mentally hear some of our thoughts expressed internally as natural language sentences. This psychological phenomenon has been remarked upon for centuries: The epigraph for thesis Chapter 5 gives a quote by William James from Thomas Hobbes’ *Leviathan* about “the discourse of the mind.” People commonly complain about too much noise by saying “I can’t hear myself thinking”. The topic of ‘inner speech’ is discussed in section §2.1 of (Baars and Gage 2007), who write:

“Verbal rehearsal is now thought to be another term for inner speech, the fact that human beings seem to spend most of their waking hours talking to themselves [...] Inner speech is not just for rehearsing and memorizing information; rather it keeps a running commentary on our ‘current concerns’ [...] Because it involves the sophisticated human language capacity, inner speech is closely tied to the linguistic and semantic component of the long-term stores...”

In the TalaMind prototype, a Tala agent has a society of mind with subagents communicating in the Tala natural language mentalese, each referring to the Tala agent by a common reserved variable ?self. Thus the TalaMind prototype simulates mental discourse within a Tala agent. (§3.6.7.13, §4.2.7, §5.4.16)

## The Hard Problem of Consciousness

The ‘Hard Problem’ of consciousness (Chalmers 1995) is the problem of explaining the first-person, subjective experience of consciousness. (§4.2.7) For the TalaMind thesis, there is the theoretical issue of whether a Tala agent having artificial consciousness can have this first-person, subjective experience. This is a difficult, perhaps metaphysically unsolvable problem because science relies on third-person explanations, based on observations. Since there is no philosophical or scientific consensus about the Hard Problem, the thesis may not give an answer that will satisfy everyone. Yet the TalaMind approach – implementing artificial

consciousness, ala (Aleksander and Morton, 2007) – is open to different answers for the problem, as discussed in §4.2.7.

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