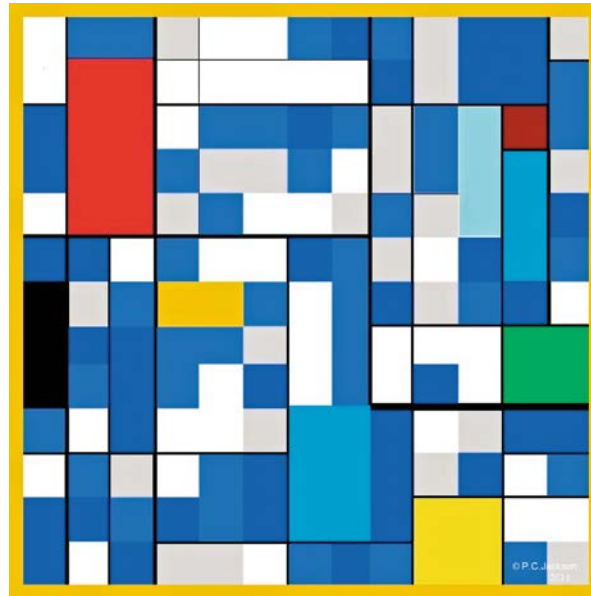# Thoughts on Bands of Action

Philip C. Jackson, Jr.
TalaMind LLC
www.talamind.com

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Topics

- Newell's Bands of Action
- Cognitive and Rational Bands
- Existence, Nature & Importance of the Social Band
- Timescale of Social Actions
- Mental Processes in the Social band
- Modern Technology and the Social Band
- Implications for the CMC

I will go quickly through these topics and have about 5 minutes for questions after the slides. Will be glad to discuss with people afterwards.

Newell's Bands of Action

- In considering human cognition, Allen Newell* discussed different time scales at which actions can occur that correspond to physical events and processes in human brains:

    Biological band
    - Organelle (10^{-4} secs)
    - Neuron (10^{-3} secs)
    - Neural circuit (10^{-2} secs)

    Cognitive band
    - Deliberate act (10^{-1} secs)
    - Cognitive operations (1 sec)
    - Unit task (10 sec)

    Rational band
    - Tasks ranging from minutes to hours

    Social band
    - Actions ranging from days to months

- These bands of action support Newell's proposal for 'unified theories of cognition', advocating eventual support for imagination, self-awareness, natural language, emotions, … – "the full range of human cognition".

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* Newell, A. (1990) *Unified Theories of Cognition*. Newell also mentioned historical and evolutionary bands of action.

Cognitive and Rational Bands

- Newell (1990, p.129) observed there is little time available in the biological band to achieve cognitive behavior. Search and problem-solving require timescales for the cognitive band.

  – As an example of the cognitive band, he discussed what happens when one person asks "Please pass the salt" and another person responds. (~ 2 seconds)

- He said as more time is available for solving problems, the system will find solutions using knowledge it already has. A 'knowledge-level system' operates in the rational band by using knowledge to achieve goals.

- In another paper*, I give reasons why Newell's definition of the knowledge level is problematical.

  – There are reasons to recognize an 'intelligence level' corresponding to human-level intelligence and potentially human-level AI, above the level of physical symbol systems, and very different from Newell's 'knowledge level'.

- The cognitive and rational bands should include all the abilities of human intelligence.

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* Jackson, P. C. (2018) *The intelligence level and TalaMind*. 2018 Conference on Advances in Cognitive Systems, poster paper.

Cognitive and Rational Bands, II

- Besides search & problem-solving, other thought processes happen in cognitive timescales (0.1sec – 10sec):

  - Using and understanding natural language.

  - Creating explanations and predictions, using causal and purposive reasoning.

  - Developing analogies and metaphors with previously known domains.

  - Imagining hypothetical situations. Spatial-temporal reasoning and visualization.

  - Metacognition, causal and purposive reasoning. Thinking about the past, the present and potential futures.

- Rational band processes (mins. – hrs.):

  - Iterations & combinations of cognitive band thought processes can happen over longer timescales corresponding to the rational band.

- While these activities may achieve goals, and use knowledge to attain goals, knowledge and goals do not indicate the qualitative nature of thought processes involved.

Existence of the Social Band

- On pages 152-153, Newell* expresses doubts whether events that happen in social realm constitute a higher band of action.

- Yet on pages 154-155 , he suggests the social band can be considered distinct from the rational band and says social groups do not have the same degree of rationality as individual people.

- He says individuals have more knowledge than they can rapidly communicate, and a social group cannot act like a person with "a single body of knowledge" and a single common goal structure.

- I disagree :

  - The world scientific community is 'superintelligent' relative to any person.

  - This group has developed and embodies more knowledge than any individual.

  - This group shares a common goal, expansion of scientific knowledge.

  - The time for natural language communication does not prevent rational action by this group.

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* Newell, A. (1990) *Unified Theories of Cognition*.

Nature & Importance of the Social Band

- Social groups differ from individual people in important ways Newell did not state, which distinguish the social band from the rational band of action:

    - Social groups can jointly know more than any individual.

    - Social groups can act over much longer timespans than individual lifespans.

    - Social groups can develop products and technologies which increase the range of physical actions and perceptions possible by individuals and by groups.

    - Social groups can have goals that transcend an individual's goals.

    - Social groups can create "intersubjective" entities (such as money, corporations, laws, nations, etc.) that exist mainly via shared beliefs between people in social groups.*

- <u>The social band in many ways has greater importance than the cognitive and rational bands</u>.

    - Humans are social animals, human intelligence is amplified by social interaction, and civilization is enabled by the social band.

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* Harari, Y. N. (2015) *Sapiens: A Brief History of Humankind*. Harari hyphenates the term: "inter-subjective".

Timescale of Social Actions

- Newell (p.490-498)* explained his timescale of days to months for actions in the social band by discussing "significant social interactions" among multiple humans.

  - Yet he noted some significant interactions can last about an hour, such as conferences, games, meals, and lectures.

  - He suggested ten minutes might be a lower bound for the timescale of social actions, by considering activities of middle-level managers.

  - It does not appear he defined the term 'significant'.

- Nowadays, someone can send a tweet which thousands or even millions of people read. It may take ten seconds to write the tweet, and one or two seconds to read it. Many people may consider the tweet significant.

- The significance of a social interaction is largely in the minds of those who participate in it: Two people reaching a decision to do something together may be significant and can take only a few seconds.

- Human communication itself is a form of social action, and an event, even if no other physical action occurs directly as a result.

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* Newell, A.(1990) *Unified Theories of Cognition*.

Timescale of Social Actions, II

- One person asking another to pass the salt, and the other passing the salt – perhaps 2 seconds.

- Two people exchanging text messages – perhaps 1 to 2 minutes.

- Two people chatting in a telephone call – typically 5 to 15 minutes, possibly an hour…

- Two or more people walking around a mall together, talking – typically 10 to 20 minutes.

- A group of people having dinner together – typically 1 to 2 hours.

- People attending a concert – typically 2 hours, possibly longer.

- A social fad spreading – weeks to months.

- An election campaign – months to a year or two.

- A major change in social attitudes developing and becoming accepted – years to decades.

Mental Processes in the Social Band

- What happens in the social band involves individual rational and cognitive processing, and also involves emotions and physical actions.

- Natural language is of major importance for many human social interactions: <u>Language is a bridge between minds in social groups.</u>

- <u>The social band is needed for individuals to learn a natural language</u>. Children do not learn natural language in a vacuum, they require interaction with adults and other children.[1]

- <u>Via shared natural language, the social band augments the individual's cognitive abilities:</u> the individual gains a resource for acquiring knowledge from others, and a resource for thinking in the cognitive and rational bands. A resource for "inner speech" and metacognition.

- Emotions are also a language for the social band: emotions are the first language infants use for communication with parents, and remain a language for communication throughout life.[2]

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[1] Pinker, S. (1994) *The Language Instinct – How the Mind Creates Language*.
[2] Ninivaggi, F. J. (2015) Emotions as a second language – Or should they be our first? *Psychology Today*, Sept. 7 2017, blog entry.

Modern Technology and the Social Band

- There have always been phenomena in the social band that happen in timescales of seconds (people have always asked "Please pass the salt" in some language).

- <u>With modern technology, the information bandwidth for the social band has increased exponentially.</u>

  - Before loudspeakers were commercially available about 100 years ago, the human voice might only carry to an audience of a few thousand people in an auditorium.[1]

  - With Twitter, thousands or millions of people can read a message from any person, at any time.

  - Email, web pages, Wikipedia, and YouTube also exponentially increase individual ability to share information publicly.

- This bandwidth may make the social band more comparable to the cognitive and rational bands.

  - The social band approximates a 'society of mind' in the generalized sense (using a language of thought) described by Doyle[2], rather than the sense described by Minsky.

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[1] For example, the Auditorium Theatre was designed to seat 4000 people in Chicago in 1889.
[2] Doyle (1983) used the term 'language of thought' in a general sense, not referring to Fodor's theory. (Nor do I.)

Implications for the CMC

- The social band is very important for human-level intelligence. This prompts <u>suggestions for future research on the Common Model of Cognition</u>:

    - Experiments with social groups of Common Model systems, interacting via natural language (and in theory, also using emotions as a language).

    - Experiments in which a Common Model system acts like an infant, learning a natural language by interacting with other Common Model systems that already know the natural language, representing parents or older children.

    - Experiments in which two Common Model systems learn to understand each other's different natural languages.

    - To model human-level cognition, it could be important to add a generalized society of mind (Doyle 1983) into the architecture of the Common Model, using a 'language of thought'.[1]

- These suggestions are consistent with a separate paper [2] recommending use of a 'natural language of thought' within a future version of the Common Model.

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[1] Schneider (2011) considered arguments for and against Fodor's theory and presented an alternative theory for a computational language of thought, developed to be compatible with cognitive science and neuroscience.

[2] Jackson, P. C. (2018) *Natural language in the Common Model of Cognition*. 2018 BICA Postproceedings.

Thank You

This concludes my talk. I'd be glad to try to answer questions.

Extra Slides

Newell's 'Knowledge Level'

- Newell's (1982) 'knowledge level' is: *Potentially Infinite, Unchangeable, Unreal, Unnecessary*.

- Regarding the knowledge level, he wrote:

  - An agent is composed of a set of actions, a set of goals and a body. The medium is knowledge.

  - There are no laws of composition for these components. There is a "complete absence of significant structure".

  - 'Knowledge' is not defined – it's whatever an agent uses to determine actions to attain goals.

  - An agent can have infinite knowledge: it knows all the consequences of everything it knows. Real systems can only "approximate" the knowledge level.

  - "Intelligent systems are not to be described exclusively in terms of the knowledge level." "Representations exist at the symbol level", not at the knowledge level. The knowledge level is "immediately above the symbol level."

  - "Perfect" intelligence is using all an agent's knowledge to achieve goals. Thermostats have perfect intelligence, humans have imperfect intelligence. (Newell, 1990)

  - Newell's (1990) discussion of "bands of action" was quite different from the theoretical idea of a potentially infinite knowledge level. The bands of action were based on real processing in finite human brains.

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* Newell, A. (1982) *The knowledge level.* Artificial Intelligence, 18, 87-127. Also discussed in Newell (1990).

The Intelligence Level [1]

- Newell (1982)[2] gave an insightful discussion of 'computer system levels':

  – Electronic device level, Circuit level, Logic level, Register-transfer level, Symbolic program level.

  – "Each computer system level is a *specialization* [subset] of the class of systems capable of being described at the next lower level."

  – Each level provides functionality not provided by all systems at the next lower level.

- By the Physical Symbol System Hypothesis[3], a subset of the systems at the Symbolic program level can perform *"general intelligent action"*, "the same scope of intelligence as we see in human action."

- This subset will be a specialization of the systems at the Symbolic program level, so it will be a computer system level above the Symbolic program level.

- It is appropriate to call this new computer system level the *Intelligence level*. The human brain is an existence proof that systems can exist at this level.[4] Human-level AI would exist at this level.

- Systems at the intelligence level will be real, finite, changeable, useful systems. They will support Newell's bands of action and unified theories of cognition.

- The intelligence level is very different from the 'knowledge level' described by Newell (1982).

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[1] Jackson, P. C. (2018) *The intelligence level and TalaMind.* 2018 Conference on Advances in Cognitive Systems, poster paper.
[2] Newell, A. (1982) *The knowledge level.* Artificial Intelligence, 18, 87-127.
[3] Newell, A. & Simon, H. A. (1976). *Computer science as empirical inquiry: Symbols and search*. CACM, 19, 3, 113-126.
[4] If the human brain can in theory be completely simulated by a large enough digital computer.

# Human-Level AI ≠ Human-Identical AI

Human-level AI can be 'human-like' without being human-identical.

AI can use thought processes similar to humans, and understandable by humans.
The TalaMind approach strives for this.

TalaMind defines human-level AI by a *design inspection approach* (Jackson 2014, §2.1.1) :

- Achieving *higher-level mentalities* which people agree indicate human-level intelligence.
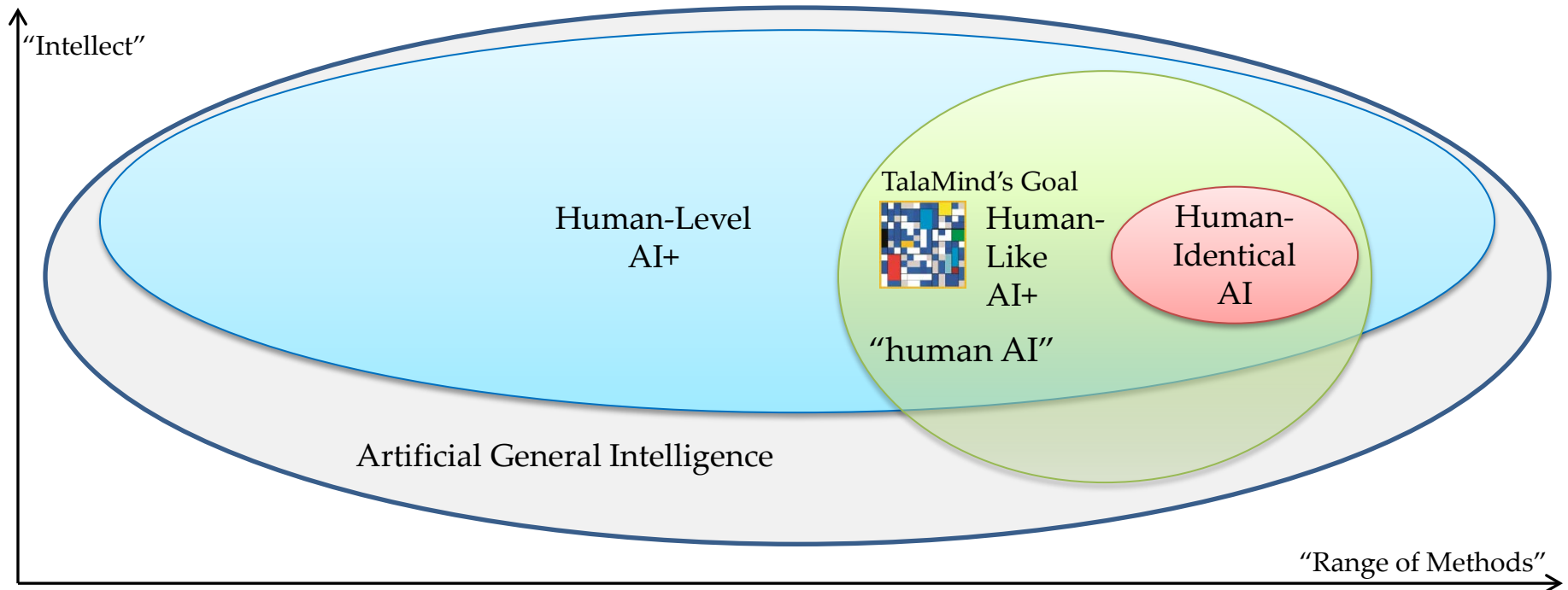
Ideas about a "Language of Thought"

- Fodor's (1975) statement of a 'language of thought hypothesis' led to philosophical arguments about whether an innate language must contain all possible concepts X, or limits the concepts that can be learned and expressed. X

- Schneider (2011) considered arguments for and against Fodor's theory and presented an alternative theory for a language of thought, which she developed to be consistent with cognitive and computational neuroscience. √

- Fodor reasoned the innate language of thought ('mentalese') must be as powerful as any language learnable by humans, though English would enable concise expression of concepts not primitive in the innate language. √

- Fodor also described the innate language of thought as a metalanguage, in which natural language extensions could be defined. √

- Fodor (2008) accepted the principle of semantic compositionality √, which was an issue in earlier debates.

- Sloman (1979 *et seq.*) contended that human-level intelligence requires some innate, internal language for representation of thoughts, prior to learning and using natural language. √

- Sloman argued that a system can learn new concepts (which may be represented by new words or symbols) that may not be definable in terms of previously known concepts, words or symbols. A system must be open to perceiving and learning new concepts from its environment. √

√ - indicates directions I tend to agree with. X – indicates directions I disagree with.

Timescale of Inspirations?

- Perhaps some important cognitive and rational events can take much longer than seconds to minutes to hours.

- For example, August Kekulé once said he created his theory about the ring shape of benzene molecules after a daydream of a snake biting its tail, and that the vision followed years investigating carbon-carbon bonds. At other times Kekulé gave different anecdotes about conceiving the ring shape of benzene.

- Yet the anecdotes suggest a question: Do inspirations that occur in a few seconds sometimes depend on subconscious processing over long periods of time?

- I don't know if there is any quantitative evidence regarding this. Perhaps it can't be studied in controlled psychological experiments, almost by definition.

TalaMind Architecture / Research Direction

At the linguistic level, TalaMind:

- has a <u>language of thought</u> (called '<u>Tala</u>') with the unconstrained syntax of English.

- supports reasoning directly with the syntax of English.

- is theoretically valid, and advantageous for human-level AI.

Tala (a 'natural language of thought'):

- <u>supports generality of human-level AI</u>

- <u>will be understandable to humans</u> and <u>open to human inspection</u>

<u>These features will be important for achieving beneficial human-level AI+.</u>

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TalaMind is open to use of additional languages, e.g. predicate calculus and conceptual graphs.

TalaMind is open to use of deep neural nets for each conceptual level.

Conceptual Levels

Linguistic Level: Linguistic Concept Structures
Higher-Level Mentalities
(Natural Language Understanding, Higher-Level Learning, Meta-Cognition, Imagination, Creativity & Originality, Curiosity, Consciousness, Sociality, ...)

Conceptual Processes
Tala Conceptual Language
Conceptual Framework

Percepts   Control Concepts   Effepts

Archetype Level: Cognitive Categories
Image Schemas, Radial Categories, Conceptual Spaces, Conceptual Domains, Semantic Frames, Perceptual Symbols...

Perceptions   Attention   Actions

Associative Level: Associations & Data Analysis
Connectionism, Statistical & Bayesian Processing, ...
Image, Sound, Haptic ...Processing

Sensors   Effectors

Environment