From T-patterns to T-strings to T-societies

What makes humans unique?

Over half a century ago, Professor Magnus S Magnusson, now at the Human Behavior Laboratory of the University of Iceland, set out to define what separates humans from all other animal species. By detecting and analysing interaction patterns of behaviour from the nanoscale to human scales, he discovered T-societies in both proteins and humans. This breakthrough led to the realisation that only modern human mass societies are second-order T-societies and delivers a biomathematical definition of human uniqueness.

By the mid-1940s, two world wars in less than 40 years saw many millions killed by what were considered some of the world's most advanced societies. Researchers wanted to make sense of such a world. Some looked to biology and primatology in their pursuit to better understand human behaviour. In 1967, Desmond Morris published *The Naked Ape*, detailing his primatological perspective of the social behaviour of humans, and in 1965, Niko Tinbergen's book *Animal Behavior* became an influence for many researchers in the field. The 1973 Nobel Prize in Physiology or Medicine was shared by Tinbergen, Konrad Lorenz, and Karl von Frisch for their ethological discoveries regarding social behaviour patterns in animals.

Inspired by this research, Professor Magnus S Magnusson aimed to define what distinguishes humans from all other animal species. During his undergraduate studies and doctoral research from 1972 to 1983 at the University of Copenhagen, for which the university accorded him its Silver Medal in 1979, his research was strongly influenced by the work of B F Skinner, especially on verbal behaviour, N Chomsky's work on syntactic structure, and their famous debate. Important inspiration came also from S Duncans's research on human turn-taking and the French ethologist Hubert Montagner's work on interactions in social insects and children. Magnusson's attention was drawn to structured mass society and what appeared to be a commonality with external memory – meaning that information is stored in the environment, such as the use of tracks and scent marking in the structured mass society of insects and textual memory aids like notes and books in human society (Magnusson, 1975).

PATTERNS HIDDEN IN HUMAN INTERACTION

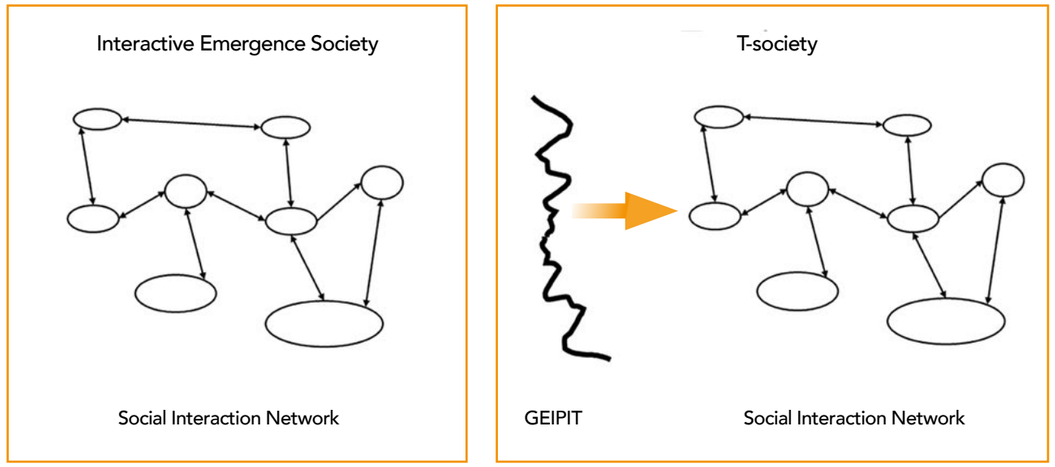
Magnusson's research involved defining, detecting, and analysing interaction patterns of behaviour in animals and humans. He developed the mathematical real-time pattern type, T-pattern, which he initially called 'temporal configuration' (Magnusson, 1983). T-pattern analysis reveals repeated timed sequences of behavioural events and can be used to examine the temporal behavioural characteristics of species ranging from rodents to humans.

To begin with, Magnusson concentrated on dyadic interactions between children. For instance, his analysis of the interaction of two children playing with a toy for 13.5 minutes revealed a considerable surprise: recurrent patterns that were far more regular and complex than expected (Magnusson, 1982, 1983). He then widened his focus to include adults as well as other species (Magnusson, 1988, 1996, 2000) and, ultimately, interactions in neuronal brain networks and polymer strings (Magnusson, 2016). He found a multitude of T-patterns at different time and spatial scales in all contexts, from proteins and neurons to primates, across many levels of organisation and orders of magnitude that ranged in scale from nano to human.

COMPUTATIONAL INTERACTION PATTERN

While computers made searching for hidden patterns possible, suitable detection algorithms were scarce. Working with computer statistics and SAS specialist Agnar Hoeskuldsson at IBM's Northern Europe University Computer Center, Magnusson considered using multivariate statistical methods. However, he realised that better pattern models and, with them, suitable detection algorithms and software were required. He thus developed the T-pattern model and implemented the corresponding detection algorithms as his dedicated THEME software package. This has enabled the detection and analysis of T-patterns in many areas of research.

Interactive Emergence Society (IES) vs T-society



Modified from Magnusson, M. (2023), doi.org/10.3389/fpsyg.2023.1157315

Figure 1. Magnusson distinguishes between two types of social organisation. First, Interactive Emergence Societies resulting from interactions between individuals as in the RNA world and in (nonhuman and illiterate) animal societies and, second, what he calls T-societies, only found in protein societies and literate human mass societies, where the behavioural potentials of the interacting individuals are defined by segments of external T-strings, genes of DNA, or curricula of text.

The data, called T-data, is made up of a set of discrete time-stamped event types collected during an observation period, with a series of occurrence times for each event type. T-data can be produced under either experimental or natural conditions and collected in a variety of ways. For example, it can be collected using multi-media coders or chips inserted in brain tissue, coded with a smartwatch app (eg, Theme Watch), or transformed from text or molecular data, including DNA or protein sequences.

FROM T-PATTERN TO T-STRING TO T-SOCIETY

A T-pattern is a repeated structure produced by a series of simultaneous or sequential events that occur in the same order and with similar time intervals more frequently than one would expect if each event type occurred independently and randomly over time. If we picture the T-data running horizontally with one row for the occurrences of each event type, then a T-pattern connects some (critically related) points of different rows, level-by-level, until it outlines the occurrences of each complete pattern (Magnusson, 1996, 2000, 2004, 2020, 2023, 2024).

T-patterns are binary trees where each node has a maximum of two child nodes at all levels with the same statistical relation between them, called a critical interval. They thus have a self-similar fractal-like structure. While in mathematics, self-similarity in fractal structures is infinite, in nature, biomathematical self-similarity holds across a range of scales. T-pattern detection and analysis (TPA) using the THEME software (PatternVision) has uncovered self-similarity between interaction patterns in animals and between neurons in their brains.

The T-strings in DNA, proteins, and written texts all display similarities in their patterning over different scales.

T-strings are physical strings, such as text, proteins, and DNA, that contain T-patterns. The T-strings in DNA, proteins, and texts thus all display similarities in their patterning over different scales and across varying levels of biological organisation.

Magnusson recognised a similarity between protein and literate human mass societies. They are both based on what he calls Giant Extra-Individual Purely Informational T-strings (GEIPIT) that establish the characteristics of the various types of individuals. Just as the genome is the complete set of DNA in a protein society, a textome is the complete set of text in a literate human society. Genomes and textomes are both GEIPITs, made up of complete sets of T-strings.

T-pattern analyses of text and DNA revealed a distinct self-similarity between the modern human literate mass societies and the protein societies in their body cells. Both have GEIPITs defining the possible behaviours of types of individuals. Magnusson calls these societies 'T-societies'. They don't occur in other animals or illiterate humans, only in most literate modern human mass societies and protein societies.

HUMAN UNIQUENESS

In a major evolutionary transition, humans are the only species to have developed the same type of social organisation that occurs in every biological cell. Text offers a precise, unlimited external T-string memory. The growth of knowledge and better access to it, particularly in the twentieth century,

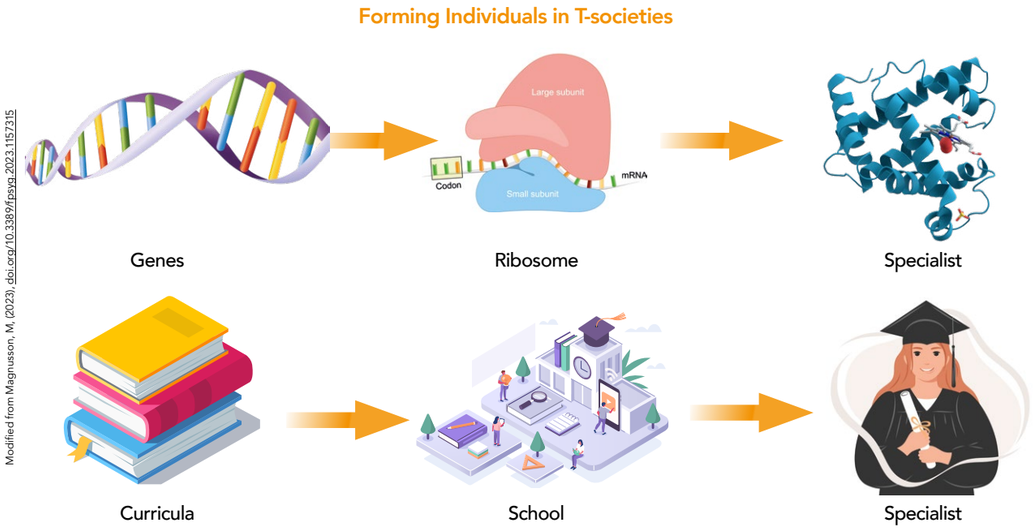


Figure 2. Texts and molecular strings do nothing by themselves, both need a particular environment to become active. Genes (DNA segments) need the ribosome to become a T-string of different elements and then, by folding into the three-dimensional structure of a protein, become a specialist in a protein T-society. Curricula, segments of the text of human society, similarly need 'schools' to create the corresponding brain patterns in the specialists of human T-societies. Thus, an analogy exists between a molecular T-string becoming a protein through *folding* and a textual T-string becoming a human brain pattern through *reading*.

has enabled the upsurge in the many kinds of specialisations of individuals supported by external memory T-strings, and likewise, the rapid growth of knowledge in areas such as science, law, and technology.

Writing, invented around 3500 BC, made human T-societies possible. The introduction of texts and progressively more effective ways to copy and distribute them in print and more recently electronically marked a departure from other primates and the start of human advancement towards T-societies. The arrival of mass education together with the standardised curricula used by school have been instrumental in the development of the numerous different brain patterns, and with them the behavioural capabilities of the many specialised humans. These unique modern human mass societies are a first for the extracellular world.

Humans are made up of cells that in themselves are protein T-societies. This means that human T-societies are in fact T-societies of T-societies. Magnusson calls this second-order T-societies. This T-society self-similarity does not happen in proteins and is unique to humans.

A BIOMATHEMATICAL DEFINITION OF UNIQUENESS

Over half a century ago, Magnusson set out to find something that clearly separates modern humans from all other animal species. Along the way, he discovered T-patterns and T-strings. These enabled his discovery of T-societies in both proteins and humans. This breakthrough led to the realisation that only modern human mass societies are second-order T-societies and that this unified view of culture and biology provides a biomathematical definition of the unique modern human mass-social organisation.

Magnusson explains that most people seem to agree that the invention of writing was essential for the development of human possibilities.

Humans are the only species to have developed the same type of social organisation that occurs in every biological cell.

However, proteins in their mass societies are specialised in numerous ways, each defined by DNA (T-string) segments external to the protein, called a *gene*. Similarly, in modern human mass societies the numerous specialisations of individuals are each defined by text segments called a *curriculum*. T-string segments external to the individuals determine their specialisation, a defining aspect of T-societies. This is common and exclusive to protein and human mass societies and happened very recently in humans, since around 1800 AD with the advent of mass-education (Magnusson, 2022, 2023, 2024).

Following the invention of text that provides unlimited external memory and a multitude of specialities and specialists, only humans have become aware of the Universe, from the elemental components of matter and the microscopic constituents of our bodies to phenomena of an astronomical scale, such as galaxy clusters. At last, it appears that the human species has earned its name: homo sapiens (wise humans).

Behind the Research

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Research Objectives

Professor Magnusson analysed interaction patterns of behaviour from the nanoscale to human scales, discovering what makes humans unique.

Detail

Bio

Magnus S Magnusson, PhD, is an Emeritus Research Professor in the Human Behavior Laboratory, University of Iceland. Between 1983 and 1988, he was Deputy Director at the Anthropology Laboratory in the National Museum of Natural History, Paris, and between 1989 and 1993, invited Professor at the University of Paris Sorbonne V, XIII, & VIII.

Funding

The Icelandic Center for Research, Reykjavik, Iceland

Collaborators

- Professor Starkey Duncan, University of Chicago, USA († 2007)
- Professor Hubert Montagner, INSERM, France
- Professor Jacques Cosnier and Dr Robert Plety († 2011), University of Lyon 2, France
- Professor Janine Beaudichon, University of Paris V, France
- Professors Irenäus Eibl-Eibesfeldt († 2018) and Karl Grammer, Max Planck, Germany
- Professor M Teresa Anguera, University of Barcelona, Spain
- Professor Silvia Sastre, University of Logroño, Spain
- Professors Claude Baudoin and Christoph Feron, Sorbonne Paris North University, France
- Research director Dr Joëlle Robert-Lamblin, CNRS, France
- Professor Judee Burgoon, University of Arizona, USA
- Professors Rodolphe Ghiglione († 1999) and Alain Blanchet, University of Paris VIII, France
- Professor Katharina Hirschenhauser, University of Education Upper Austria, Austria
- Professor Keith Kendrick and Dr Alister Nicol, University of Cambridge, UK
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- Professor Mariona Portell, Autonomous University of Barcelona, Spain
- Dir Dr Gudberg Jonsson, University of Iceland, Iceland

Personal Response

What inspired you to conduct this research?

" As a teenager in the 1960s, I remember that World War II and the Holocaust were still very present in people's memories, and it was hard to see how they could have happened among civilised nations. The same was true about slavery and colonialism, with human groups of all sizes tending to oppress and even enslave other groups. There was always news about famines. The contradictory but absolute truths claimed by world religions were baffling. When I was about 12 years old, I saw a TV documentary about social insects and thought animal behaviour might hold the key to understanding human uniqueness, but I found it instead on the nanoscale. "

What were the most challenging aspects you faced on your journey to discovering what separates modern humans from all other animal species?

" Searching for the most objective knowledge possible and the use of mathematical language, I decided on biologically oriented psychology, typically called the science of behaviour. Precursors to personal computers had arrived, and I presented my first paper on T-patterns in human behaviour (Magnusson, 1982) in an Artificial Intelligence workshop at the University of Uppsala, Sweden. Publishing in this new area was difficult, and the expected proceedings were not published. Still, a similar paper appeared in Statistics (Magnusson, 1983), and finally a university research network of forty universities formed around T-pattern detection and analysis (TPA) research. This network has produced many papers and three edited books (Anolli, Magnusson, et al, 2005; Magnusson, et al, 2016, 2023b). "

† Deceased

References

- Magnusson, MS, (1975) Communication and social organization in social insects and primates (humans included). [Unpublished BA thesis]. Copenhagen: Psychological Laboratory, University of Copenhagen.
- Magnusson, MS, (1982) Temporal configuration analysis: Detection of an underlying meaningful structure through artificial categorization of a real-time behavioral stream. Paper presented at Workshop on Artificial Intelligence, University of Uppsala, April 1982. Part of an Unpublished PhD thesis at the Psychological Laboratory, Copenhagen University, 1983.
- Magnusson, MS, (1983) Theme and syndrome: Two programs for behavior research. In: Edwards, D, Hoeskuldsson, A, (eds) Symposium in Applied Statistics, Copenhagen: NEUCC, RECKU and RECAU, 17–42.
- Magnusson, MS, (1988) Le temps et les patterns syntaxiques du comportement humain: modelé, méthode et le programme THEME. In: Revue des Conditions de Travail. Les actes du Premier Colloque National d'Ergonomie Scolaire, Université de Lille. Marseille: Octares.
- Magnusson, MS, (1989) Structure syntaxique et rythmes comportementaux: sur la détection de rythmes cachés. *Sci Tech Lab*, 14, 143–147.
- Magnusson, MS, (1996) Hidden real-time patterns in intra- and inter-individual behavior: description and detection. *European Journal of Psychological Assessment*, 12(2), 112. doi.org/10.1027/1015-5759.12.2.112
- Magnusson, MS, (2000) Discovering hidden time patterns in behavior: T-patterns and their detection. *Behavior Research Methods, Instruments, & Computers*, 32, 93–110. doi.org/10.3758/BF03200792
- Magnusson, MS, (2004) *Repeated patterns in behavior and other biological phenomena. Evolution of Communication Systems: A Comparative Approach.* Cambridge: The MIT Press, 111–28.
- Magnusson, MS, Burgoon, JK, Casarrubea, M, (2016) *Discovering hidden temporal patterns in behavior and interaction.* Neuromethods. New York, NY: Springer
- Magnusson, MS, (2020) T-patterns, external memory and mass-societies in proteins and humans: In an eye-blink, the naked ape became a string-controlled citizen. *Physiology & Behavior*, 227, 113146. doi.org/10.1016/j.physbeh.2020.113146
- Magnusson, MS, (2023) Sudden bio-mathematical self-similarity and the uniqueness of human mass societies: from T-patterns and T-strings to T-societies. *Frontiers in Psychology*, 14, 1157315. doi.org/10.3389/fpsyg.2023.1157315
- Magnusson MS, et al, (2023) Editorial: Behavior and self-similarity between nano and human scales: from T-pattern and T-string analysis (TPA) with THEME to T-societies. *Front Psychol*, 14, 1248233. doi.org/10.3389/fpsyg.2023.1248233
- Magnusson, MS, (2024) T-patterns and T-strings from the RNA world to the sudden and unique human T-societies and AI. PPT in *Journal of Nanosciences Research & Reports.* doi.org/10.47363/JNSRR/2024/PPT/1033