

General Collective Intelligence vs the Innate Collective Intelligence Factor

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Abstract

INTRODUCTION: Groups of individuals of species exhibiting collective behaviours have been suggested to have some innate general collective intelligence. General Collective Intelligence or GCI has been described as a platform that organizes individual humans into a single collective intelligence with the potential capacity for exponentially greater general problem-solving ability.

OBJECTIVES: To explore whether a functional modelling approach might have the capacity to represent any system of organization resulting in a general collective intelligence factor. And to explore what functionality might be required for a GCI to exponentially increase it.

METHODS: An analysis of the meaning of general problem-solving ability in the functional state space of a system of cognition or collective cognition is used to assess whether GCI has the potential to exponentially increase that ability.

RESULTS: GCI has the potential to exponentially increase increase impact on all general outcomes where limited by general problem-solving ability

CONCLUSION: While an innate general collective intelligence factor might exist, and while conventional CI solutions might have significant impact on specific collective outcomes, a GCI is required to exponentially general problem-solving ability, and therefore to exponentially increase collective outcomes. This capacity has the potential to be disruptive.

Keywords: General Collective Intelligence, Human-Centric Functional Modelling, Artificial General Intelligence

1. Introduction

Groups of individuals of species with collective behaviours have been suggested to have some innate general problem-solving ability (intelligence) over and above that of individuals in the group. This intelligence has been described by a general collective intelligence [5]. In addition to a general collective intelligence factor that is innate to groups, that factor might also potentially be created artificially. General Collective Intelligence or GCI has been described as a platform that organizes individual humans into a single collective intelligence with the potential capacity for exponentially greater general problem-solving ability than that of any individual in the group. Hence, GCI may have the potential to significantly increase any innate general collective intelligence factor. Analogous to the difference between Artificial Intelligence (“narrow” AI) and Artificial General Intelligence (AGI), where conventional Collective Intelligence (CI) solves a single problem or a narrow range of

problems, a GCI has more general problem-solving ability. Having general problem-solving ability, where a CI must have the capacity to find optimal solutions to specific problems or specific ranges of problems, a GCI must also have the capacity to choose the optimal problem to solve.

Human Centric Functional Modelling (HCFM) [1] aims to represent any dynamical system with repeatable states in terms of the minimal set of reversible functions required to enter those states. The states accessed through these functions form a “functional state space” through which the system moves. By modelling all of the system’s functions, this approach can potentially be used to represent all the behaviour of complex systems even where the mechanisms by which that functionality are implemented are unknown. This approach has been used to define a Functional Modelling Framework (FMF) [2] for modelling the human system, including human cognition.

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2. Related Work

In this Functional Modelling Framework, the human system is represented as an adaptive problem-solving system that solves problems in a number of domains, one of which is cognition. In the cognitive domain this framework has been used to define what is believed to be the first model of human cognition with the capacity to represent everything human cognition can do, and therefore the first model of human cognition with the capacity for human-like general problem-solving ability. Being a functional model independent of implementation, it has also been used to define a model of Artificial General Intelligence or AGI [3], as well as a model for collective cognition (the General Collective Intelligence or GCI described here).

Problem solving in the cognitive domain consists of forming a path between a point in conceptual space representing one concept, and another point in conceptual space representing another concept. Uncoordinated problem-solving by individuals involves problem-solving in each individual conceptual space. That is, entities employ their individual problem-solving abilities in groups (such as ants of different species that lack the organization of a colony). In this modelling approach a general collective intelligence or c factor involves motion of the collective cognition through a collective conceptual space. This motion is potentially chaotic and non-deterministic, but must also be globally stable with respect to some function that optimizes collective outcomes. For organisms with an innate c factor, individual behaviour is modified in certain group contexts by that collective optimization function. For example, ants are capable of individual behaviour, but in this model, of the many possible interactions between ants, the behaviour that evolves to be self-sustaining in an ant colony (and therefore globally stable) must be determined by some colony optimization function. The function formed by the collective behaviours of one species of ant might optimize different outcomes than those of another. Some behaviours that persevere within groups of humans might similarly be determined by some collective optimization function that creates an

innate c factor. General Collective Intelligence or GCI can also be artificially created by a platform that explicitly defines a collective optimization function which organizes individuals into a single entity that might have exponentially greater general problem-solving ability (intelligence). Though others have described the concept of a general collective intelligence factor (c factor) [5], though at least one other has defined a model for a general collective intelligence factor [13], and though others have described the concept of a collective super intelligence [6], to the author's knowledge the author's own work is the only model that defines the specific mechanisms required for a GCI with the capacity to achieve super intelligence in that general collective intelligence factor. Because of this, and because this model is so new, all of the existing literature surrounding GCI refers to the author's own published work, or pre-prints of the author's unpublished work that are still under review.

3. Research Questions and Approach

The research questions addressed in this paper are approached with the method described below:

Section 3: Research Question Addressed

3.1 Can GCI achieve an exponential increase in general problem-solving ability?

Section 4: Model

4.1. Defining a universal representation for information and collective reasoning.

4.2. Defining the functionality required for collective reasoning and how a functional modelling approach might be used to represent any system of organization resulting in a general collective intelligence factor.

Section 5. Method

5.1. The meaning of an increase in general problem-solving ability in conceptual space was assessed.

5.2. The functionality that the GCI model provides to increase general problem-solving ability was assessed to determine if that increase might be exponential.

Section 6. Findings

Section 7. Research Limitations
 Section 8. Practical Implications
 Section 9. Conclusions

4. Model

A full discussion of the models of individual and collective cognition is too broad for a single paper. Aspects of the model of collective cognition that are relevant to the research questions are described below.

4.1. Defining a Universal Representation for Information and Collective Reasoning

Any collective reasoning process can be represented as a set of set of reasoning activities, where each reasoning activity is executed by some entity in the group having some particular role.

Collective Reasoning Processes

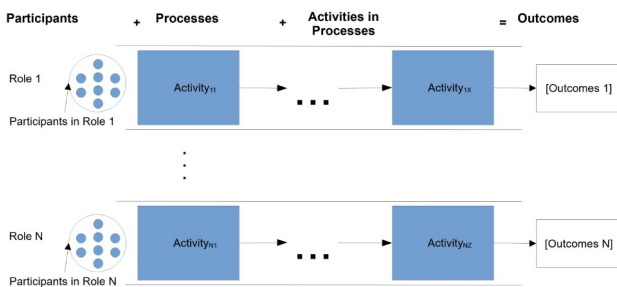


Figure 1. Decomposing reasoning processes into functional models using a common approach enables systems of individual or collective cognition to be modelled in a common way and applied to those problems.

Representing collective reasoning processes as having activities executed by individuals within roles enables the most important properties of execution to be decoupled from any particular instance of execution so that outcomes might be scaled. Aside from this very general representation, a more detailed representation of reasoning processes and of the information passing in and out of those processes is provided by the Functional Modelling Framework which defines the building blocks that all semantic models must be comprised of, from a functional modelling of view. But consideration of this level of detail is not necessary here and is outside of the scope of discussion.

4.2. The Functionality Required for Collective Reasoning

In the functional model of individual cognition, the cognition of one individual is distinguished from that of another second individual in that it is constrained by a separate optimization function. The cognitive awareness process of each individual must satisfy the boundary condition of keeping their own individual cognitive well-being within a stable range. In other words, the cognitive processes are fundamentally bound by that individual’s cognitive well-being function. In the same way, within this model, collective reasoning is distinguished from the reasoning of any individual in the group by being bound by a collective outcome optimization function (the collective well-being function [7]). Individuals can engage in any decision-making processes and contribute any reasoning to the group that they like, but reasoning is only collective if the reasoning that the collective reliably converges on is that which is bound by a cognitive outcome optimization function.

The functionality required by collective reasoning is the same functionality required to enable individual reasoning to be governed by an outcome optimization function, as listed in table 1 below.

Table 1. Components of cognitive process execution.

Component of Model	Description
Functional modelling (problems and solutions)	Components are modelled only by function to remove prejudice for or against any given implementation.
Functional decomposition	Functional components are decomposed into their most basic functional building blocks for reuse.
Functional domain bridging	Different domains in which different functions are more fit in achieving the same purpose are identified. These

	domains are bridged by using a set of weights which identify the best function in each domain.
Functional fitness	Every functional component is assigned some projected and actual fitness in achieving its function.
Functional stability	For functional components to persist they must display some degree of stability in fitness to function.
Functional adaptation	For functional components to persist in a changing environment they must have the ability to adapt their function.

This functionality combines individuals into a GCI, and in so doing potentially gives the collective access to all the information and reasoning processes of any individual in the group. In doing so, this removes the limit to the complexity of collective reasoning that can be executed.

In addition, a number of other adaptive domains defined by the FMF [7], [8] can be applied to that reasoning. One of these is the domain of cooperation. In an individual cognition this domain removes the limits to the number of functional components that can be engaged in the reasoning process. In collective reasoning this domain removes the limits to the number of participants that can be engaged. Where outcomes of reasoning can be scaled by executing more reasoning processes in parallel or in series, this potentially removes the limit to scaling impact on any outcomes that might be achieved through that reasoning.

Another example is reproduction. In a GCI based process of reproduction, solutions must be reproduced in a way that introduces enough difference to solve a problem, but not so much difference as to break compatibility with a potentially complex network of cooperation [14]. Outcomes must be optimized across all chains of cooperation using some methodical approach, such as a reproduction algorithm.

5. Method

The research question was addressed using the methods summarized in table 2.

Table 2. Components of cognitive process execution.

Research Question	Method
1. Can GCI achieve an exponential increase in general problem-solving ability?	1. An analysis of the meaning of general problem-solving ability in the functional state space of a system of cognition is used to assess the functionality required to increase general problem-solving ability. 2. An assess of the functionality of GCI is made to determine if GCI might exponentially increase that ability.

5.1. Defining an Increase in General Problem-Solving Ability

This model provides an objective definition of the functional state space of the collective cognitive system (the conceptual state space or “conceptual space”), which enables general problem-solving ability (intelligence) to be defined objectively as the volume of conceptual space that can be navigated per unit time. With this representation the problem of increasing intelligence can be generalized to the problem of increasing the complexity of paths that can be navigated through conceptual space, to the problem of increasing the number of paths that can be navigated through

conceptual space, and to the problem of increasing the ability to sustain that navigation.

5.2. Assessing the Capacity of GCI to Increase General Problem-Solving Ability

With this representation of general problem solving ability in conceptual space and with this generalization of the problem of increasing general problem-solving ability, the increase in general problem-solving ability achievable through AI or GCI can be quantified as exponential [11], [12]. In addition, wherever outcomes of group activities are limited by general problem-solving ability, as opposed to facing limits in available physical resources or other quantities with hard limits, this allows the problem of achieving an exponential increase in impact on outcomes to be generalized again to the problem of achieving an exponential increase in these three capacities for navigating complexity, for number of reasoning paths, and for sustaining reasoning.

As justification for this conclusion, assume that ability to scale complexity is represented by the length of reasoning processes that can be chained together through cooperation between individuals to contribute reasoning and information. Assume cooperation of any kind or complexity can be represented by Nth order barter transactions in which the first entity transfers some value to the second entity and so forth until the N-1th entity transfers some value to the Nth entity. By modelling the activities in these processes, and by modelling the processes themselves as chains of cooperation targeting specific outcomes, a system such as a GCI with all the functionality required to have general problem-solving ability (such as a universal way of determining the fitness of each chain of cooperation) can methodically then explore all possible chains of cooperation regardless of complexity, to find those that maximize outcomes. The ability of the group to generalize reasoning or information so that a self-contained understanding rather than descriptions requiring interpretation can be shared is required to remove the limit to the rate at which chains of cooperation can be found. This common representation of reasoning and information is

suggested to be provided by the conceptual space defined for the cognition by the Functional Modelling Framework, and by the functional models that might be defined in any hierarchy of domains using HCFM. With this limit removed, the ability of the group to navigate complexity can then potential scale with the exponentially with the size of the group [12].

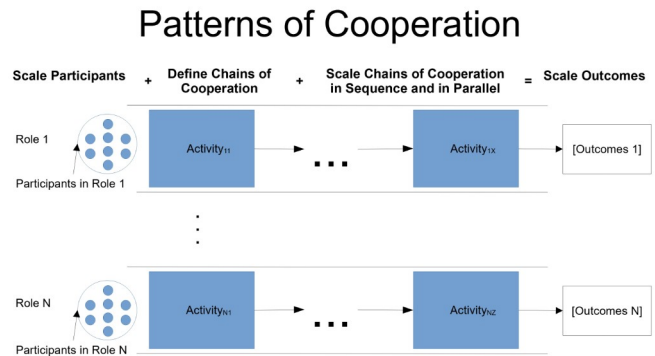


Figure 2. Functional modelling of reasoning processes enables GCI to scale those reasoning processes.

Furthermore, by decoupling execution of these reasoning activities from every attribute of their execution (physical location, identity of user, etc.) the processing involved in this problem-solving can then be handed off to other instances of execution (other physical locations, other users, etc.), and outcomes can be scaled through execution of as many instances of those processes in parallel or in series as required. Since processing can potentially be achieved through an unlimited number of intelligent agents interacting with the GCI on the individuals behalf, and doing so on any available hardware, the capacity for increasing the number of reasoning processes is also exponential.

To sustain that processing, the fitness of processes to achieve outcomes can be optimized over all processes. So that the synergies can create enough value to sustain the processing itself.

Scale Ability to Sustain Processing

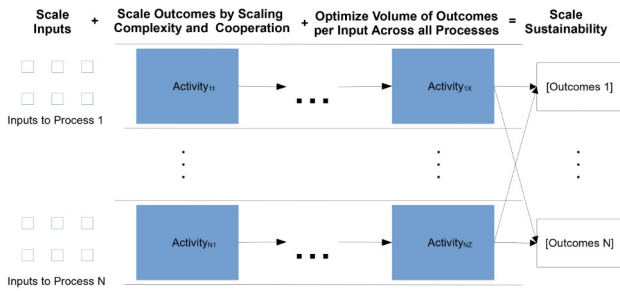


Figure 3. Functional modelling of reasoning processes enables GCI to scale the sustainability of those reasoning processes.

Since the number of processes that can be aligned in this way is unlimited, then wherever there is any positive value in such alignment that alignment can be increased to the point that the ability to sustain processing is exponentially increased.

6. Findings

The functional model described appears to have the capacity to represent all of the functionality required to display any group with an innate general collective intelligence factor, or any group organized by a GCI with a general collective intelligence factor. And the meaning of general problem-solving ability in this functional state space suggests GCI has the potential to exponentially increase collective general problem-solving ability.

Table 3. Research Findings.

Research Question	Findings
1. Can GCI achieve an exponential increase in general problem-solving ability?	1. An analysis of the meaning of general problem-solving ability in the functional state space of a system of collective cognition is suggests that GCI might exponentially increase that ability. This requires experimental

confirmation.

7. Research Limitations

Though models of a number of proposed GCI solutions have been defined in agriculture, health care, and other fields, and though conceptual case studies of these solutions have demonstrated the potential for the exponential increase in impact on outcomes as suggested might be achievable in this paper, GCI has not yet been implemented. As a consequence, many details inevitably remain to be clarified.

Furthermore, as described elsewhere [11], [14] GCI is a complex system that must likely in effect be grown through initiating a self-assembling process that adapts in any way required to maximize collective outcomes rather than being developed in a top-down way that can become tightly coupled with centralized interests. Defining a simple functional model of GCI alone is not sufficient to implement GCI. An understanding of the self-reinforcing networks of cooperation and hierarchy of their deployment that is required [14], an understanding of the application of GCI to the customization of products and services deployed in those networks [15], an understanding of the platform required to execute processes with a GCI [16], as well as an understanding of the application of GCI to research, design and all the other processes in the business life-cycle might be required. In the same way that defining a simple functional model of the human system as containing a heart to pump blood, lungs to oxygenate blood and remove carbon dioxide, as well as containing other functional components is not sufficient to clone a human being. However, the process of understanding how to implement a GCI must begin with an understanding of the functional components required.

8. Practical Implications

GCI can potentially enable groups to reliably navigate reasoning collectively that is broad enough and complex enough to exceed the limits to individual human cognitive capacity. The definition of “broad” used here is that if the information that must be communicated in order

to convey a concept covers too great a range of conceptual space then its breadth exceeds the capacity of any individual mind. The definition of “complexity” used here is that if reasoning requires too many steps in conceptual space at too high a resolution in conceptual space, then its complexity exceeds the capacity of any individual mind (its magnitude of complexity is too great). In either case, problems that exceed the capacity of any individual mind cannot be reliably defined or solved.

Therefore any problem that has been defined or solved at any time in history is by definition within the capacity of individuals or groups to solve without GCI. And by the same token, any problem that has not yet been solved, whether global poverty or other sustainable development goals [8], [9] implementing an AGI [10], universal global access to health care, smart sustainable cities, or even achieving a higher level of convergence in science [1], perhaps as represented by the so-far unattainable goal of a unified field theory, may not be reliably solvable without GCI.

An exponential increase in ability to solve all problems might be more impactful than an exponential increase in ability to solve any specific problems that a programmer might conceive of. From a functional modelling perspective general problem-solving ability is the capacity to navigate a given volume of conceptual space per unit time. If the set of solutions achievable with a particular computing program represents a set of paths through conceptual space, then the volume in conceptual space corresponding to such narrow problem-solving ability might resemble a narrow rod. If a quantum computing version of the program is a billion times faster then the rod might be a billion times longer, and the narrow problem-solving ability corresponding to the narrow volume in conceptual space that can be navigated might be correspondingly greater. However, an exponential increase in general problem-solving ability creates an exponential increase in ability to replicate that rod of narrow problem-solving ability in all directions, including to the problem of designing a better quantum computer as well. If so, then GCI

through it’s capacity for an exponential increase in general problem solving ability is potentially a far more important innovation than even quantum computing. In fact, since according to this model an exponential increase in general problem-solving ability has never been possible before in the history of human civilization. GCI might be one of the most disruptive innovations mankind has yet seen.

An exponential increase in intelligence implies an exponential increase in ability to impact outcomes targeted by that problem-solving. The collective outcome function determining the problems solved by groups, or by civilizations as a whole, might be generalized in this model as maintaining stability in collective well-being. While maintaining stability in individual well-being requires the ability to maximize individual well-being and to maximize the sustainability of that individual well-being per unit of resources, maintaining stability in collective well-being involves the ability to maximize collective well-being per unit of resources. Use of resources, and conflict over resources might be one of the major forces shaping the evolution of human civilizations. For this reason, this exponential increase in intelligence is suggested to represent not just dramatically better problem-solving, but combination into a kind of collective organism. An important and fundamental shift in the way human civilizations organize

9. Conclusions

Individuals can reason as groups, but without GCI, according to this model, groups have little ability to engage in coherent collective reasoning. This distinction is very important, because it identifies specific bugs (or features) in group decision-making that in the absence of GCI prevent collective outcomes from being optimized [8], [9]. In so far as GCI might be the only model to objectively define them, and in so far as the model of GCI is not currently well known, these bugs or features might be hidden. But through creating the capacity for groups to reason coherently, GCI has the potential to significantly increase group problem-solving ability, and well as to address these bugs or features, and to remove

current limits to achieving collective well-being that they represent.

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