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### Making sense of the collective intelligence field: A review

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## Making sense of the collective intelligence field: A review

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*“The world is bitterly, savagely competitive and intensely, vigorously cooperative, by way of alliances and partnerships, thus rapidly changing individuals and social systems alike.”*

*“We are pulled toward a single social system on earth.”*

*Dedijer, 1999, p. 72*

**ABSTRACT** The problem we want to solve is to find out what is new in the collective intelligence literature and how it is to be understood alongside other social science disciplines. The reason it is important is that collective intelligence and problems of collaboration seem familiar in the social sciences but do not necessarily fit into any of the established disciplines. Also, collective intelligence is often associated with the notion of wisdom of crowds, which demands scrutiny. We found that the collective intelligence field is valuable, truly interdisciplinary, and part of a paradigm shift in the social sciences. However, the content is not new, as suggested by the comparison with social intelligence, which is often uncritical and lacking in the data it shows and that the notion of the wisdom of crowds is misleading (RQ1). The study of social systems is still highly relevant for social scientists and scholars of collective intelligence as an alternative methodology to more traditional social science paradigms as found, for example, in the study of business or management (RQ2).

**KEYWORDS** Collective intelligence, social intelligence, social systems, wisdom of crowds

### 1. INTRODUCTION

The popularity of the collective intelligence research area has increased significantly. The Web of Science lists 552 article with the term in the title, the first of which was written in 1989. The last 500 articles were written since 2005. Research groups at the most prestigious universities receive grants to establish separate research centers and the ideas have received significant interest from the general public as well as politicians. At the same time

the phenomenon seems old and familiar in the scientific literature. Moreover, the field seems to be highly interdisciplinary and does not seem to fit into any of the established business, management or social sciences disciplines. So, what is new and valuable in this field of how we learn and make decisions together? (RQ1). In addition, how are we to understand where collective intelligence fits in a larger social science context? (RQ2) The research gap suggests that there is no critical review article

that examines the phenomenon of collective intelligence from a historical context where the aim is to understand what this body of literature is about.

## 2. METHOD

This article attempts to answer the research question through the historical method, comparing what has been written in the past about learning together to the spread of collective intelligence during our own time. Moreover, the attempt is to compare the collective intelligence literature to that of social intelligence. Social intelligence was present in the 1970s, at the start of what became intelligence studies in business. The sources are scientific articles, books, internet articles and videos. I have attempted to follow a theme, inevitably missing much relevant information as the phenomenon is so wide and spread over synonyms containing the words intelligence, collaborative, collective, crowd, group, knowledge, open source, smart, social, and connectivity, just to mention some of the most relevant. The methodological problem here is first one of what articles to select and why. I have chosen to read the most cited articles first, the most popular non-scientific sources and what can be deemed significant scientific contributions over time, including books. This limited the sources down to less than fifty relevant publications, where about half are listed as references here. In terms of scientific articles, there were about thirty that had twenty or more citations in the Web of Science. All of them have been included here. I have not cited sources I have not read in their entirety. Only a few have been discarded, as they were too technical.

There are numerous limitations in this study. Leading articles and leading scholars are reduced to citations on Web of Science and Google Scholar, which does not give the full picture. Further, it would be interesting to go deeper into each of the disciplines mentioned in the articles, both when it comes to definitions, but more important to their actual meaning and content to detect similarities and differences, but also to investigate the theories and experience they build on. Part of this is due to the limited number of pages allowed in the article by the journal.

## 3. LITERATURE REVIEW

In 1886 Francis Galton, a cousin of Charles Darwin, wrote an article called "Regression

towards mediocrity in hereditary stature" which showed that there was a regression towards the mean with larger numbers. This was statistically proven by for example having a large number of people guess the weight of an ox at a fair. As the number of responses increased, the average guess ended up reflecting the actual weight, showing a simple linear regression of data points. The technique was useful for simple questions demanding numerical answers, but Galton thought, as the title suggests, that the logic would lead to "mediocracy" when applied to other problems. This critique was considered common sense at the time, supported by scientists, humanists and men of letter alike (from Henry David Thoreau to Friedrich Nietzsche).

However, despite the critique, the idea was useful in statistics and received renewed attention with the rise of computer science and in particular big data and now with artificial intelligence and digital marketing, for example when counting averages such as webpages visited or number of clicks on a webpage. This tells us about peoples' behavior online. Web 2.0 caught on during the first decade of the new millennium, the idea of creating content through interaction and collaboration using social media. In rapid succession, Facebook was founded in 2004, YouTube the year after and Twitter the year after that. When competitors arrived, they were simply bought up, guaranteeing near-monopolies for the new data giants. Due to the large amount of data collected, these companies are now able to predict our behavior more accurately as they collect more data on and from us.

Researchers saw this development coming, thus in 2002 Howard Rheingold argued that the most successful services in the future would not be hardware devices or software programs, but social practices online. In 2004 a young American journalist James Surowiecki wrote a book with the provocative title "The Wisdom of Crowds", based on Galton's idea. However, Surowiecki takes the idea further delving into economics, rejecting Adam Smith and other economists for their focus on specialization. Instead, he argues for decentralization:

"Decentralization's great strength is that it encourages independence and specialization on the one hand while still allowing people to coordinate their activities and solve difficult problems on the other". (P. 71).

In other words, valuable information may not come through when only a few are in the know. He gives the example of the CIA. The original idea of having a centralized intelligence agency as defined by Bill Donovan was later abandoned as the agency grew and more departments were established. These departments did not succeed in cooperating and sharing information, a consequence of which was the attacks on September 11<sup>th</sup>, 2001. The problem was timely and the book became a bestseller.

“The Congressional Joint Inquiry into the attacks found that the U.S. intelligence community had ‘failed to capitalize on both the individual and collective significance of available information that appears relevant to the events of September 11.’ Intelligence agencies ‘missed opportunities to disrupt the September 11th plot,’ and allowed information to pass by unnoticed that, if appreciated, would have ‘greatly enhanced its chances of uncovering and preventing’ the attacks. It was, in other words, Pearl Harbor all over again.” (Surowiecki, 2004; P. 68)

Surowiecki draws a parallel to Galton’s contributions, but a critic may argue that the information workers at the CIA are not your average visitor to the fair guessing the weight of an ox. The author is mixing experts and professionals with average people. Quiz games are a good counter example; you only stand a chance of winning if you can manage to gather knowledgeable people on your team. If you make up the team with those who just happen to walk into the pub that evening your team will have a small chance of winning. Lanier (2006) notes that the collective is more likely to be smart only when:

1. It is not defining its own questions,
2. The goodness of an answer can be evaluated by a simple result (such as a single numeric value), and
3. The information system, which informs the collective, is filtered by a quality control mechanism that relies on individuals to a high degree.

Lanier argues that only under those circumstances can a collective be smarter than one person. If any of these conditions are

broken, the collective becomes unreliable or worse.” (Wikipedia).

Another critical point is made by Tammet (2009), who argue that in systems of pooling knowledge, like Wikipedia, experts can be overruled by less knowledgeable persons. Thus it is important to build software that immediately alerts the experts when changes to the entry are made and allow discussion on the issues, saving these for other users to partake in to judge who is right. To build this system as a Galton-average-towards-the-mean would not work. In other words, Wikipedia works well because it pools smart people, despite the disturbance of less smart individuals because there are special mechanisms built into the system to deal with their erroneous entries.

Maybe the best counter argument was a game of chess held in 1999 called “Kasparov versus the world”, where the chess player played against over 50 000 people from more than 75 countries deciding moves by plurality vote. An expert system was put in place whereby four highly rated players (FIDE ranking) suggested moves first. These suggestions were mostly followed by ‘the world’. Kasparov won despite the experts, but he admitted it had been a tough match. If Kasparov had played against an average move we can assume that he would have won easily. Instead it must be suggested that the wisdom in the crowd is a romantic idea that fits well with the reigning democratic political ideology in the Western world and the equally dangerous belief that advancements in computer science will solve collective problems. It will certainly solve some, but new dangers will arise, as we saw with the invention of nuclear energy.

Surowiecki is right when he says that “The idea of collective intelligence helps explain why, when you go to the convenience store in search of milk at two in the morning, there is a carton of milk waiting there for you, and it even tells us something important about why people pay their taxes and help coach Little League.” (P. XIV), but not of the reasons he describes. There is milk in the store because the store managers knows how many customers buy milk on a specific weekday. The more of his business he can digitize the better information he will have on customer’s behavior. His other example is that many people pay their taxes because they know that it benefits all in society including themselves, especially as they get older. Of course, most pay taxes because they

have to and do what they can to avoid paying them. So, these are not good examples of what the author wants to convey.

Looking at research during the past decade: Among the more cited research articles in the field are Woolley et al. (2010), presenting a short empirical experiment, where they found that social sensitivity and proportion of females explains why some groups work better together. In experiments like these, it's difficult to know what are the causes and effects, and it may be that IQ or other factors are better explanatory variables. Woolley et al. publish another article in 2015 with the same test, but it's difficult even to assess this one as it's short and does not describe the method, analyses or show data. Engel et al. (2014) argue that the same findings are just as true in online environments. The authors define collective intelligence as "the ability of a group to perform a wide variety of tasks" or "the general ability of a particular group to perform well across a wide range of different tasks". This is different from other definitions, for example as defined in Wikipedia: "the intelligence that emerges from collaboration, collective efforts and competition among individuals".

Furthermore, there is an understanding in these articles that collective intelligence implies that the sum of the efforts from all individuals in the group are greater than the sum of each individual's contribution, so that  $2+2=5$ , as it were. This is an attractive idea, but there are no good empirical experiments that confirm this assumption. It may be true in some cases, as when members of a quiz team only know parts of an answer each but become convinced when they pool their arguments together, making a strong case for a specific idea, but then again we are dealing with experts not with the average person.

There is one mathematical paper that addresses this problem. Nguyen (2008) shows how the intelligence of a collective can be larger than the intelligence of its members through mathematical modelling. "These examples show that the relationship between the intelligence of a collective and the intelligences of its members is not linear" (P. 543). "Thus, with some restrictions, one can claim that the hypothesis A collective is more intelligent than one single member is true." (P. 561). However, the paper builds on the implicit assumption that every member knows the same and for example is not wrong on a specific issue, which can cause confusion in a group. Knowing this the assumptions can hardly be said to be

realistic when dealing with crowds. It is the same *certeris parabus* we find behind most of what has been written about economics since the Second World War, we assume that all rational individuals can weigh alternatives and draw the right conclusions based on them. Individual and cultural differences (reality) tend to destroy most of these social science models. We can also say, it's the weakness of linear logic.

When looking at videos on collective intelligence, bees and ants are often used as analogies to show what can be achieved in the social sciences. There is both substantial and interesting research on the behavior of bees and ants performed by natural scientists. The first time the term 'collective intelligence' appears in research is in a study of ants (Franks, 1989). "The sharing and collective processing of information by certain insect societies is one of the reasons that they warrant the superlative epithet 'super-organisms' (Franks 1989, p. 138)." But the comparisons between species, even different kinds of bees, are more complicated, as Franks et al. remind us of in an article from 2002:

"Nevertheless, both species do make use of forms of opinion polling. For example, scout bees that have formerly danced for a certain site cease such advertising and monitor the dances of others at random. That is, they act without prejudice. They neither favour nor disdain dancers that advocate the site they had formerly advertised or the alternatives. Thus, in general the bees are less well informed than they would be if they systematically monitored dances for alternative sites rather than spending their time reprocessing information they already have." (P. 1583)

More to the point, people are not bees or ants and no one would like to be one, I believe, or to live according to their motives. This comparison is what is thought of as a mechanical worldview in the business literature. At the end it brings associations to fascism, hardly an attractive metaphor. Instead we as human beings enjoy our irrationalities, our cumbersome ways even our flaws. It is part of what makes us human. This is no denying that human are animals, but our behavior seem to be substantially different from those of ants and bees in general making the parallels of limited value.

The most cited article on collective intelligence and honeybees by Rajasekhar et al. (2017), argue that the algorithms developed over the past twenty years to understand their behavior are not well adapted to real life problems. The authors refer to an article by Sörensen (2015), who express his concern on the current trends in metaheuristic research (i.e. higher-level procedure or heuristic designed to find, generate, or select a method for solving problem) in the following way “... it seems that no idea is too far-fetched to serve as inspiration to launch yet another metaheuristic. ...we will argue that this line of research is threatening to lead the area of metaheuristics away from scientific rigor”. “The ideas should be presented in a metaphor-free language and more directly” (in Rajasekhar, 2017; P. 45).

In everyday business life a good collective intelligence system is developed as some sort of a business intelligence software. Thus valuable contributions to the field of collective intelligence will continue to come from software development. This is a continuation of web 2.0, a comparison which has its own problems:

“The most hyped examples of collective intelligence applications have been labeled as “Web 2.0” applications. Web 2.0 is an amorphous term used to define a computing paradigm that uses the Web as the application platform and facilitates collaboration and information sharing between users” (Gregg, 2010; P. 134). “The shift to a collective intelligence paradigm requires software developers to have different ways of thinking about how their how software might be used and what features would enable better visualization and use of information among groups of people. The new breed of collective intelligence applications needs to center around user defined data that can be reused to support decision making, team building, or to improve understanding of the world around us.” (P. 134).

Collective intelligence in this sense and for this group of researchers means developing new and better business intelligence software for collaboration.

Lykourantzou et al. (2010) sees collective intelligence as a continuation of a wiki. The authors present what they call a CorpWiki, “a self-regulating wiki system for effective

acquisition of high-quality knowledge content” (P. 18). “Inserted articles undergo a quality assessment control by a large number of corporate peer employees. “. This is close to the description of a software the author of this paper developed in 2004 called Subsoft, which never made it passed a beta version but was tested in local government organizations, not that it was unique.

The core research question of the Center for Collective Intelligence at MIT is “How can people and computers be connected so that – collectively – they act more intelligently than any individuals, groups, or computers have ever done before?” (Leimeister, 2010). This understanding is not that different from how software developers work. Software is not developed in a vacuum but with the users’ needs in mind, users who become ever more collaborative. The software simply reflects this reality with continual technological discoveries, giving rise to new product developments.

Just as with the effort to advocate for open source in software development, there are efforts to influence how collective intelligence systems are made, so as to make them more beneficial for all. We are now in the domain of political science and law. Schum et al. (2012) argue that the software should not be restricted to “government, scientific or corporate elites, but be opened up for societal engagement and critique” (P. 110). Basically, what is suggested is not that different from Wikipedia, but with some policy improvements on criteria: There should be:

“transparency of data sources, algorithms, and platform use – control of users over their personal data – privacy-respecting data mining – self-regulation, self-healing – reliability and resilience – promotion of constructive social norms and responsible use – crowd-based monitoring of platform use, involving non-profit organizations – tools to alert problems and conflicts, and to help solving them – incentives to share profits generated from data and algorithms provided by users – mechanisms for managing unethical use.” (P. 112-113).

Thus, we may already make our first conclusion: that the body of literature published under the collective intelligence umbrella is truly interdisciplinary (Conclusion # 1).

Wolf et al. (2015), tests the ideas of collective intelligence to increase decision accuracy on medical decision-making. The authors found that “all CI-rules systematically outperform even the best-performing individual radiologist in the respective group”, and that “the findings demonstrate that CI can be employed to improve mammography screening”. (P. 1). Again, in this case it’s experts - “multiple radiologists” - who give their input. These experiments do not confirm Galton’s regression towards the mean but the fact that many experts perform better than one, which is common sense, but also costly and thus less practical in real life. A more promising solution to this problem seems to be artificial intelligence, using computers instead of humans, but that is for another paper on a different topic.

A second conclusion is that we are confronted with the phenomenon we may call wisdom of the knowledgeable more than wisdom of the crowds (poking fun at Surowiecki, who in turn pokes fun of Charles Mackay’s article about the “Madness of the crowds”. See Mackay, 1841). The logic of crowds works for problems of how much an ox weighs or what the consumption of milk may be tomorrow, but not that well on problems of how to win a quiz tournament, or, closer to home, what goes on in a company or how to understand an industry. If we ask what the capital of Senegal is we may get the correct answer among thousands of answers, but how are we to know which one to choose if we are not allowed to check with someone who is smarter, more knowledgeable than the rest (Conclusion # 2).

Wisdom of the knowledgeable is common sense thus a less interesting conclusion. It is not the kind of title to sell books. What we can say is that the observation is reasonable and confirms what we have known for a very long time. There is another problematic aspect of the term ‘wisdom of the knowledgeable’ and that is the question of whether the knowledgeable are truly wise. The wise make decisions based on what is best from the wider perspective, in the long run. Being knowledgeable by no means guarantees that we are wise. Our modern society is becoming ever more short-term focused (financial markets, profits, product life cycles, etc.), increasing the gap between wisdom and knowledge. Another way of saying this is that neither the crowd nor the knowledgeable seem very wise. (Conclusion # 3).

The next question to consider is whether the literature reviewed on collective intelligence literature is new. The phenomenon studied is part of the topics studied under what we call the information age, preceding the industrial revolution. Alvin Toffler was one of the pioneers in the digital revolution of the 1970s and 1980s (Toffler, 1980).

Stevan Dedijer, a contemporary of Toffler, wrote more specifically on intelligence and developed what we call social intelligence. His predecessor at the University of Lund, Wilhelm Agrell, explains in a foreword:

“Central to his work, his reading and vast correspondence was a concept of what he called social intelligence: the ability of individuals and organizations to orientate in an increasingly complex information environment... Stevan foresaw the coming of an age where individuals and organizations alike would become dependent on this ability to collect, process and use information curiosity and insights information and the immense challenge of a coming information explosion” (p. 7) (Dedijer, 1999)

Dedijer was well aware of the contributions that had preceded his own work. “If we look back before Web of Science and other databases collected that many articles the first insights of ‘organized intelligence,’ ‘social intelligence,’ and of a ‘planetary intelligence sphere’ emerged in the 1920s.” (Dedijer, 1999, p. 69). “Like Mendel’s article in 1903 on genetics, they were totally ignored for decades. Walter Lippman advocated in his ‘Public Opinion’ (1922) the use of ‘organized intelligence’ in all fields of government. The philosopher John Dewey in the 1930s saw ‘organized and social intelligence’ as the only tool humanity could use to avoid the Scylla of totalitarianism and the Charybdis of laissez-faire market capitalism.” (p. 69). Dedijer observed the changes that intelligence was bringing during his own time: “The basic intelligence goal for individual countries is changing from intelligence for national security to intelligence for national growth and development.” (p. 67). As such, he also foresaw the change from geopolitics to geoeconomics that Luttwak wrote about (Luttwak, 1990) and he foresaw that mass communication would lead to “individualization of intelligence”, with users becoming more isolated, self-centered, and egotistic. The crowd would get louder, more

daring in its attack. We see this on social media today with the phenomenon of trolls, spilling over to populism and the weakening (not strengthening) of the democratic process (as is implicit in the “wisdom of crowds”).

Dedijer, who fought in the US military as a paratrooper during the Second World War, worked on question of intelligence with the CIA and W. Colby, its director. The two friends shared information about how they saw the world changing and how the intelligence services should adapt. One of the developments Colby did not anticipate was the importance of collaboration:

“The second dimension I added to Colby’s intelligence ‘elephant’ was the emergence of development sciences related to the individual, various social systems, and humanity in general. All are engaged in ‘bridge building’ among biological, individual, social, technological, and global intelligence and social systems.” (P. 70). “‘Bridge building’ [ – what we call interdisciplinary today - ] is the name for current attempts at a holistic approach to all kinds of problems in every discipline or field. One of the best formulations of the bridge-building method is found in mathematics. S. Singh in *Fermat’s Enigma: The Epic Quest to Solve the World’s Greatest Mathematical Problem* (1998) tells how A. Wiles proved in 1995 a conjecture that confounded the greatest mathematicians for 358 years: ‘Mathematics consists of islands of knowledge...each one with its own unique language, incomprehensible to the inhabitants of other islands... Mathematicians love to build bridges. The value of mathematical bridges is enormous. They enable communities of mathematicians who have been living on separate islands to exchange ideas and explore each other’s creations.’ Such bridge-building techniques are used in physics, as shown by Nobel Laureate S. Weinberg in the development of individuals as well as social systems, including studies of the state of humanity.” (P. 70).

Interdisciplinarity of social systems was developed simultaneously, it seems, by a number of people, among whom the more influential included the German philosopher Niklas Luhmann (1968 and 1984), Kenneth Boulding (1956) and Ackoff (1971) in the US.

Dedijer believed that the intelligence discipline was going to be valuable for the social sciences, but he also saw the difficulties the discipline was facing due to its unfortunate parallel and association to spying.

“Because of isolation and confusion among intelligence disciplines and the myth that intelligence is above all espionage, billions of individuals, organizations, and governments today use information technology yet fail to perceive the innumerable signals which tell of a new intelligence revolution in the evolution of humanity.” (Dedijer, 1999, P. 71).

This is a problem that the collective intelligence literature is also confronted with, by default so to speak, as will any new discipline that uses the term intelligence more in the sense of ‘information’ than ‘brains’.

In conclusion, we have shown that collaboration and sharing of information was at the heart of Dedijer’s idea of social intelligence. We argue that both collective intelligence and social intelligence is part of the same paradigm shift, like two waves of the same current. Just like AI has come and gone with new enthusiasm and interest the past decades, so the ‘information turn’ is visited and revisited with certain intervals and different approaches. We shall understand all of these developments as part of an ongoing intelligence paradigm. This is our forth conclusion (Conclusion 4).

The term ‘intelligence paradigm’ can be related to systems thinking, as will be discussed further in the analysis below. The term is also used by Lahneman (2010) related to international politics and security, and by Zadeh, (2008), related to machine learning, but we shall keep these two tracks out.

#### **4. ANALYSIS OF THE INTELLIGENCE PARADIGM AS SYSTEMS THINKING**

Kuhn (1962) defined paradigm rather broadly as a development that “designates what the members of a certain scientific community have in common, that is to say, the whole of techniques, patents and values shared by the members of the community“. According to this broad definition there could be hundreds if not thousands of paradigms just in the study of economics and management alone.

Ackoff (1971) writes about the paradigm shift required for the study of management to redirect to systems thinking, referred to as complex systems and complexity theory. The basic idea is that organizations stop thinking of themselves divided into sections such as marketing, HRM, and strategy, but instead as elements that form relationships. It's the connectivity of the parts that is valuable, not the parts themselves. Ackoff's favorite example is the car. All the parts by themselves are useless, even added together as a sum they give nothing. It's the right connectivity of the parts that give an automobile that is actually useful and can take us from point a to b. The principles governing how we run business organizations should not primarily be existing departments but the exchange of information, or intelligence. In other words, the private organization is best run as an intelligence organization, much like state intelligence institutions. Many successful private organizations today do just that, like the largest wealth management fund in the world, Blackrock. Its offices and data facilities remind one more of the NSA than a classic bank. Most major companies today look much the same, including Google, Facebook and Amazon. The success they achieve is primarily determined by the value of the information they gather and analyze. Whether we as employees work in marketing or HR we are spending more and more time learning about new computer systems, electronic gadgets and related services. Without these skills we are worth little on the labor market.

One problem is that universities and learning institutions often assume that students already know this. The individual disciplines (economics, marketing, HR) are not taking into consideration how these new technologies are changing professions. One example is marketing. Students do not know digital marketing when they come to university. Actually, that is what they come to learn. If the teacher assumes that these are skills that the students already know and that it's enough to teach a broad set of general theories, then the education fails.

In reality, we have all become information workers during the past generation. The major difference today seem to be that some build the systems (engineers) and others use them (engineers and everyone else). Knowledge and skills have never been as important as now. Even to work in a factory you need more than a high school diploma. Never before in the

history of mankind have companies been better at locating knowledgeable people and bringing them together, no matter where they are on the planet. This development matches poorly with the notion of wisdom of the crowd. Companies are not hiring just anybody, but are getting better at finding those few who possess supervisor knowledge and experience. There is nothing appealing about the crowd except that all customers of the same product are worth just as much in terms of money (economic reasoning) and that one human life is not worth more than another (our shared human value).

Instead, the notion of wisdom of the crowd is appealing for political reasons, because it supports the notion that all citizens have a say and can control their own future through democratic elections, which is the basis of Western societies. Western governments support these ideas because it strengthens the status quo. In the same way, wisdom of the knowledgeable, besides being obvious as a term, thus dull, sounds elitist. The notion of wisdom of the knowledgeable brings up a painful contradiction in Western civilization. It indicates a difference between democratic and meritocratic values, which is as old as Western democracy and has been actively debated in Europe since the early 1960s (Young, 1959). To understand the popularity of collective intelligence it's impossible to ignore these political aspects. Politics may be the single most decisive factor for shift in scientific paradigms, not for having the ideas, but getting them implemented.

For this reason, it shall be suggested that the intelligence paradigm shift is probably not going to come from the Western world, but from Asia. The Asian way of conducting business and working is already in many ways similar to an intelligence approach. Chinese companies thrive by learning from the West, by travelling to foreign countries and copying our products. The whole Belt and Road Initiative (BRI) is a gigantic collective and collaborative effort in the spirit of the Competitive Advantage of Nations, an idea we used to master but have forgotten. As a result, it's not we who know more about Asia than they about us but the exact opposite: Our students know next to nothing about them, while their students know much about us, and are keen learners.

Asian companies are not limited by compartmentalized knowledge. Instead, they look for useful knowledge where they can find it (what works) and are in many ways better at solving problems. The popular notion is that

this is what we are good at, because we are more used to, or allowed to, question things. It was what the Western world did well after the enlightenment. Since then we have become less curious about the world, less eager to change it and instead more concerned with our own immediate private needs. A tragic example is that our social media applications have made us more isolated, not more collaborative. These services have made us less knowledgeable about the world, not more.

Dedijer understood this danger well as a leading nuclear physicist: “Information Technology is only a tool. Always ask how effective and efficient it is in terms of improving your capability to identify and solve problems by acquiring and using the information it can help to provide. The IT model of the future will more and more be “a thing that thinks”, as we call artificial intelligence. AI is further away from being a reality than what we are led to think, where the delay in self-driving vehicles is just a reminder.

This may be the real difference from Dedijer’s social intelligence to Surowiecki’s collective intelligence, that now we are discovering machines that can “think” (artificial intelligence): more effective, more interactive, and faster IT systems that makes it easier to learn together. It is the study of how this is happening that lies at the core of collective intelligence. It is a world of new opportunities brought forward primarily by computer scientists and neuroscientists, but where social scientist will play an important part in evaluating applications and consequences. For this the literature will need be more critical. (Conclusion # 5). As the example of the Facebook–Cambridge Analytica data scandal has confirmed, social scientists should not be a gospel choir in the church of progress.

The age of information is changing everyone’s lives. Writing this research article is collective intelligence made possible by information technology, especially large databases (Web of Science) and fast internet connections (from home, or on the train on my way to work). Instead of meeting colleagues and exchanging information on a topic, we write articles and share them. I try to locate those who know more than me and learn from them. That is an active process of collective intelligence.

The idea of collective intelligence is as old as mankind, as man quickly discovered that he

had to cooperate and pool ideas if he wanted to trap and kill larger animals like the mammoth. The notion has been a frequent topic in literature throughout time to the point where it is difficult to say who has contributed the most to it.

The literature on collective intelligence is a good example of non-collaboration. Ever greater specialization in the social sciences draws groups of scientists and researchers further apart even when they study the same phenomenon. The reason this happens is because the databases we use do not contain older articles (basically just the last fifty years), there are almost no articles in other languages than English (even though much progress was communicated in German and French), and researchers come up with new buzz words to establish their own careers and distinguish themselves from others, for personal and economic reasons. If the social science project was truly critical, this reinvention of the wheel should not be possible. In the German scholarly tradition, one is always confronted with the question of meaning. “What does that mean?”, with the clear goal of understanding a phenomenon. Due to a systematic lack of such questions and aims, in the social sciences we now have dozens of groups, or tribes, studying the same phenomenon: artificial intelligence, collective intelligence, information sciences, and intelligence studies. The difference is the size of these groups, what networks they belong to and their financing. There are of course also differences in relevance and output of research.

The larger question is if questions of collaboration will continue to be studied by multiple disciplines with little contact between them, or if the modern social science project will merge into something else. Stevan Dedijer suggested social systems theory, going back to Bertalanffy (1968), and he explains:

“The world is bitterly, savagely competitive and intensely, vigorously cooperative, by way of alliances and partnerships, thus rapidly changing individuals and social systems alike... We are pulled toward a single social system on earth.” (Dedijer, 1999, P. 72).

Others, have elaborated the idea further. Mainzer concludes that [we must]

“learn to consider humans as complex nonlinear entities of mind and body... the

theory of complex systems explain what we can know and what we cannot know about nonlinear dynamics in nature and society... we need to ‘improve our knowledge of complexity and evolution’... mono-causality often leads to dogmatism, intolerance and fanaticism” (Mainzer, P. 294-5)

The same basic idea from the social systems literature in the social sciences is found in the complex systems literature in the natural sciences and in information sciences: behavior cannot easily be studied with small (for example, student group surveys), narrow (a few isolated variables) empirical projects with data of short duration (behavior changes in time and depending on circumstances). It requires the complexity of a multifaceted social structure. Any modelling that tries to reduce reality to a correlation analysis performed on a

few variables is of limited use. But, do leading scholars interested in collective intelligence interest themselves for systems thinking and complex systems today? Yes, they do.

#### 4.1 Analysis of Research Areas

To find out we analyzed the top-ranking scholars on collective intelligence according to Google Scholar, seeking out those with 1500 or more references. These are listed anonymously in the table according to their respective ranking. A total of five keywords or research topics are possible on Google Scholar, where it is common (but not certain) to list them according to the main interest of the researcher.

Five of the leading scholars are focusing on complex systems. That is more than for any other research area. Two of the four leading mention complex systems as a specialty.

*Table 1 Keywords associated with the leading scholars on collective intelligence, according to Google Scholar. The columns show areas of study, ranked according to each person’s interest. The individual scholars are listed anonymously by ranking.*

Rank	Primary	Secondary	Tertiary	Quaternary	Quinary
1	Artificial Intelligence	Ontology	Collective Intelligence	Virtual Assistants	Intelligent Interfaces
2	Intelligence Augmentation	Collective Intelligence	Open Science	Quantum Information	Quantum Computing
3	Collective Behaviour	Collective Behavior	Swarm Intelligence	Collective Intelligence	Complex Systems
4	Machine Learning	Complex Systems	Data Mining	Information Retrieval	Collective Intelligence
5	Democracy Innovation	Innovation	Technology	Collective Intelligence	
6	Computational Creativity	Collective Intelligence			
7	Self-Organization	Collective Intelligence	Cybernetics	Complex Adaptive Systems	Distributed Cognition
8	Learning Analytics	Argument Mapping	Collective Intelligence	Human-Computer Interaction	
9	Knowledge Engineering	Collective Intelligence			
10	Collective Intelligence	Artificial Intelligence	Multi-Agent Systems	Sustainability	
11	Information Systems Design	Design	Visualization	Crowd Work	Collective Intelligence
12	Artificial Intelligence	Collective Intelligence	Cultural Algorithms	Evolutionary Computation	
13	Biological Physics	Statistical Physics	Slime Molds	Networks	Collective Intelligence
14	Social Decision Making	Collective Intelligence	Empathy	Justice	
15	Artificial Intelligence	Collective Intelligence	Human-Computer Interaction		
16	Collective Behaviors	Crowds	Computational Social Science	Complex Systems	Collective Intelligence
17	Swarm Intelligence	Collective Behavior	Collective Intelligence	Social Behavior	Slime Molds
18	Neuroscience	Psychology	Education	Collective Intelligence	Aging
19	Population Dynamics	Social Systems	Collective Intelligence		
20	Global Futures Research	Foresight	Futures Research Methodology	Global Challenges	Collective Intelligence
21	Business Analytics	Data Science	Crowdsourcing	Collective Intelligence	
22	Information Systems	Network Science	Computational Social Science	Crisis Informatics	Collective Intelligence
23	Network Science	Collective Intelligence	Crowdsourcing		
24	Systems Biology	Synthetic Biology	Statistical Inference	Self-Organization	Collective Intelligence
25	Democratic Theory	Constitutional Theory	Political Epistemology	Philosophy Of Science	Collective Intelligence
26	Computational Intelligence	Collective Intelligence	Natural Language Processing	Machine Learning	
27	Digital Innovation	Open Innovation	Collective Intelligence	Complexity	Computational Social Science

From the data we also learn that collective intelligence only appears once in the first position. On average, it is in the fourth place, which means that it is not a priority even for those who focus on this area. Artificial intelligence is the most reoccurring specialization, occurring three times in first place. Collective behavior is mentioned two times. The large majority of co-subjects are technical, related to information sciences at large, with few contributions from the social sciences. The variety of technical specialization is very large too. Topics related to crowds occur four times in total, innovation four times. We conclude that the direction of complex systems as a way to study the social sciences, and problems of collective intelligence in particular, is still a highly relevant research direction according to leading scholars. (Conclusion 6)

## 5. CONCLUSIONS

We have drawn a number of conclusions from the literature on collective intelligence. The collective intelligence literature is a continuation of contributions in what has been called the “Information Age,” a part of the “Digital Revolution.” This is a development brought forward by natural and computer scientists, but where social scientists have a role to play, first by studying the applications and consequences that technologies have on people and societies. The body of literature published under the collective intelligence umbrella is truly interdisciplinary (C1). The association to the notion of wisdom of the crowds is problematic for several reasons. The journalist Surowiecki’s idea is an erroneous interpretation of Galton’s contribution about the regression towards the mean in statistics. Experience and empirical findings suggest instead that the wisdom of the knowledgeable is a more accurate term (C2). However, as our societies are becoming ever more short-sighted (financial markets, profits, product life cycles, etc.) there is an increasing gap between knowledge and wisdom in society. As a consequence, we argue that neither the crowd nor the knowledgeable are very wise (C3) and “wisdom of the wise” is a tautology and a

meaningless expression. The content of the collective intelligence literature has been visited and revisited numerous times during the last half a century in the social sciences. As such, it can be seen as a part of a larger paradigm shift as noted in the first conclusion (C4). Just as with artificial intelligence, every revisit seems to bring something new and have great potential value. But, the collective intelligence literature strikes one not only by its lack of historical perspective, lack of good data in some of its leading publications, but by a general lack of critical sense as to the phenomenon studied (C5). Complex social systems seem still to be relevant for the study of intelligence related topics such as collective intelligence (C6). Stevan Dedijer made the same observations about the relation to social intelligence. The study of social systems based on evolutionary theory is a more fruitful scientific paradigm for the study of not only intelligence studies, but for the social sciences in general.

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