Big Data Analytics: A Threat or an Opportunity for Knowledge Management?

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Author	Family Name	Crane
	Particle	
	Given Name	Lesley
	Prefix	
	Suffix	
	Division	School of Computing and Maths
	Organization	University of Derby
	Address	Derby, UK
	Email	lesley@vantaggio-learn.com
Corresponding Author	Family Name	Self
	Particle	
	Given Name	Richard J.
	Prefix	
	Suffix	
	Division	School of Computing and Maths
	Organization	University of Derby
	Address	Derby, UK
	Email	r.j.self@derby.ac.uk

Abstract	Big Data Analytics is a rapidly developing field which already shows early promising successes. There are considerable synergies between this and Knowledge Management: both have the goal of improving decision-making, fostering innovation, fuelling competitive edge and economic success through the acquisition and application of knowledge. Both operate in a world of increasing deluges of information, with no end in sight. Big Data Analytics can be seen as a threat to the practice of knowledge management: it could relegate the latter to the mists of organizational history in the rush to adopt the latest techniques and technologies. Alternatively, it can be approached as an opportunity for knowledge management in that it wrestles with many of the same issues and dilemmas as knowledge management, The key, it is argued, lies in the application of the latter's more social and discursive construction of knowledge, a growing trend in knowledge management. This conceptual paper explores the synergies, opportunities and contingencies available to both fields. It identifies challenges and opportunities for future research into the application of Big Data to Knowledge Management.
Keywords (separated by '-')	Big Data Analytics - Knowledge management - Information overload - Discourse - Actionable knowledge - Opportunity and threat

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Lesley Crane and Richard J. Self[✉]

School of Computing and Maths, University of Derby, Derby, UK
lesley@vantaggio-learn.com, r.j.self@derby.ac.uk

Abstract. Big Data Analytics is a rapidly developing field which already shows early promising successes. There are considerable synergies between this and Knowledge Management: both have the goal of improving decision-making, fostering innovation, fuelling competitive edge and economic success through the acquisition and application of knowledge. Both operate in a world of increasing deluges of information, with no end in sight. Big Data Analytics can be seen as a threat to the practice of knowledge management: it could relegate the latter to the mists of organizational history in the rush to adopt the latest techniques and technologies. Alternatively, it can be approached as an opportunity for knowledge management in that it wrestles with many of the same issues and dilemmas as knowledge management, The key, it is argued, lies in the application of the latter's more social and discursive construction of knowledge, a growing trend in knowledge management. This conceptual paper explores the synergies, opportunities and contingencies available to both fields. It identifies challenges and opportunities for future research into the application of Big Data to Knowledge Management.

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1 Introduction

1.1 Purpose

This conceptual paper has the objective of identifying some of the synergies and similarities between the rapidly developing field of Big Data Analytics (BDA) and the well-established field of Knowledge Management (KM). The paper incorporates concepts from the developing field of Big Data Analytics Governance to identify some of the weaknesses and challenges of BDA and, by analogy, KM and their overall synthesis.

1.2 Context

This last year, firms sent and received over 100 billion emails each day. Add to this the burgeoning volumes created each day on Twitter, Facebook, LinkedIn, Research Gate and an unknown number of other social networking sites, and the information deluge starts to look like an inundation of tsunami-like proportions. According to Forbes,

scientists have worked out that the amount of data sent to the average person in one year is equivalent to every member of the human race reading 174 newspapers every day. Put another way, IBM reports that 90 % of the world's data was created in the last two years, and most of that is 'unstructured' [34], and more recently predict that by 2015, around 80 % of corporate data will be untrustworthy [16]. The knowledge economy is quite good at generating data but less able to analyse it. Predictions for the UK suggest about 40,000 new specialist big data staff will be required by 2017 [14], which equates to 100 graduates per UK university each year from 2014 onwards.

One way of attempting to mediate this ever increasing burden of information is to apply knowledge management (KM) practices. Conventional approaches to the management of knowledge turn on 'knowledge creating' [e.g., 31], 'innovation' [e.g., 2], 'knowledge sharing and transfer' [e.g., 15], 'knowledge re-use' [e.g., 30] and, to a lesser extent, 'knowledge application' [e.g., 3]. The baseline imperative to all of these approaches is 'knowledge acquisition' with the aim of codifying it, storing it, making it available when it is needed, and using it as a kind of lever to prise the emergence of new ideas, solutions, products and so on. As Deeds [10] argues, "(F)first that are effective in acquiring knowledge will be able to create and sustain a competitive advantage in the knowledge-based economy. Those that are not will have difficulty maintaining their competitive position," (p. 38). According to Bontis [5], the competitive pressures in the knowledge economy are getting harder, driven in part by a swell of turbulent times and rapidly changing technology and society.

Knowledge acquisition is a complex area, attracting many competing, often disparate theories [e.g., 1, 4, 10, 18, 20]. Deeds [10], for instance, discusses different strategies for acquiring knowledge beyond the firm's boundaries, arguing that these rely heavily on social relationships. One complication in formulating an external knowledge acquisition strategy, he advises, rests on the difficulties firms face in predicting future needs of not only knowledge, but also skills. But acquisition is only half of the story. The knowledge imperative is also concerned with what use that knowledge is put to, and how. Knowledge capture and application are then seen as crucial to the firm's economic and competitive success. One emerging field may well hold profitable lessons for the KM project (and vice versa): Big Data Analytics (BDA). BDA can be seen as both a threat and an opportunity for knowledge management. While KM is concerned with identifying, capturing and managing knowledge, BDA is concerned with the acquisition of huge volumes of what we might term 'mundane knowledge' or raw, often unstructured data (e.g., from social websites and networks), and its analysis for predictive insights. Both fields share a foundational perspective of knowledge as the essential under-pinning factor in improved decision-making [e.g., 43], competitive edge [e.g., 25], innovation [e.g., 12] and economic success [e.g., 44]. As Ohlhorst [34] reports, the ability to transform data into knowledge and thence to action has transformational potential.

2 Spotting the Opportunity

A good example of the application of very advanced analytics technologies to the claimed development of deep knowledge is the Watson system [24], created by IBM's

DeepQA (for Deep Question Answering) project. Watson is designed to use natural language to analyse very large volumes of documentary data in order to assist human activities. It was first demonstrated in the USA on the Jeopardy TV programme, where it was able to beat its human competitors, who were all previously top-ranked winners [34]. Watson has been developed to assimilate a huge collection of medical articles and research papers on cancer diagnosis, in order to help doctors more effectively diagnose and treat cancer, bearing in mind medical information doubles every five years [34].

Another BDA project which was extremely successful, from a technical perspective, was the development, by the USA retail giant Target, of analytics capability that was able to identify pregnant women in their second trimester based on their purchasing patterns, thus allowing Target to send special offers [13]. In the end, this backfired with some reputational damage as a result of the feeling of being cyberstalked.

Both of the above examples illustrate an important clue to one of the problems that Big Data causes for KM, namely the use of the word "Data", which is defined in the Oxford English Dictionary (OED) as "facts and statistics collected together for reference or analysis". That is, it is the raw source, from which information, defined as "what is conveyed or represented by a particular arrangement or sequence of things", can be developed in an appropriate context with some form of analytics. However, this still does not deliver the holy grail of actionable knowledge, defined in the OED as "facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject". It is this disjunction between the raw sources of data (Big Data) and the difficulties of developing the valuable, actionable product that is required, 'Knowledge', which is the subject of this paper.

This position paper investigates the role that BDA can and should take on in the KM context, but also argues for a more semantically-driven approach to the analysis of data. The discussion proceeds with a discussion of what is regularly held up as one of the most contentious subjects in KM: the nature of knowledge. This is followed by a critical review of the field of BDA and its leading theories and methodologies, which leads into a discussion of some of the limitations in the field, and how perspectives from KM might offer insight. The case is made for a more discursive – semantic – approach to data analysis, and the connections to the aims of knowledge management. Finally, conclusions focus on the implications for knowledge management and BDA, with new avenues opened for future research.

3   The Thorny Issue of Definition

Scientists, philosophers, statesmen, politicians and business leaders have wrestled with the nature of knowledge for millennia. According to many [e.g., 9, 40], by far the most influential, and pervasive, formulation is that introduced by Ikujiro Nonaka in his ground-breaking theory of the knowledge-creating company, originally published in 1991 [33]. Since then, Nonaka's tacit-explicit duality of knowledge has become so widespread that it has almost reached what Despres and Chauvel [11] describe as a 'status of banality. However, as Despres and Chauvel point out, the source of the

tacit-explicit formulation is Michael Polanyi [e.g., 35]. Drawing on Polanyi's work, Nonaka placed this knowledge duality at the centre of his SECI model (Socialisation, Externalisation, Combination and Internalisation), with the emphasis on new knowledge resulting from an interaction of 'subjectivities' and 'objectivities' [32]. This model can be seen in, and as influencing, countless theories and practices across the KM landscape [e.g., 6, 26, 37, 41]. It is not, however, immune from criticism: Grant [22] is critical of the model's emphasis on organizational knowledge, Despres and his co-worker refer to the model as a 'shuffling of ideas back and forth', Virtanen [42] points to a misunderstanding of Polanyi's original work, and Gourlay [21] offers a forensic analysis of the model, arguing that the evidence simply does not support the model. Whichever side of the fence one chooses to adopt in this debate, the fact that Nonaka's model absolutely depends on a dualist perspective on knowledge – the tacit-explicit distinction – is arguably its principle weakness.

Amongst a myriad of alternative constructions of the nature of knowledge, there is an increasing trend towards the view of knowledge as a socially constructed process [e.g., 36; 23; 7; see also 40 for robust discussions], with many now influenced by the science of complex adaptive systems [38]. This perspective – often couched as 'knowing' rather than the implied reification by the term 'knowledge' – approaches the phenomenon as action-orientated, constructed in social interaction, and rooted to context. It is argued here that such a perspective offers a less limiting, more ecological and dynamic recipe for understanding organizational knowledge work, one which supports the view of organizations as complex adaptive systems.

4   Big Data Analytics: The Questions

The literature on Big Data Analytics, covering the collection, connection, storage, manipulation and presentation of these vast stores of data, is wide-ranging and extensive as befits one of the most recent fields of technology identified in the Gartner Hype Cycle [19]. Much of the literature on the analytics aspects derive from the statistics of correlation. This raises the limitations that correlation has in terms of gaining a deeper understanding linked to questions of causation, which has been the underpinning concept of Western science for several centuries. A relatively recent development of BDA has been the creation of Predictive Analytics to assist decision makers to make sense of the potential and probable futures that may unfold. The field of Text Analytics is another area of BDA advance which is used extensively in analysing the unstructured data from social media types of sources.

Big Data is typically defined by 3 words beginning with the letter V, referred to as the 3 Vs of Big Data [27]; these are Volume, Velocity and Variety. However, some authors have started to use more Vs to identify both definitional and consequential aspects of Big Data. It is possible to identify at least 10 Vs which have the capability to lead the critical analysis of Big Data Analytics to very important questions offering a wider understanding of the impact of Big Data Analytics in a range of contexts, including knowledge management. The Vs which will be used in this paper are shown in the list below.

- Volume (size)
- Velocity (speed)
- Variety (sources/format)
- Variability (temporal?)
- Value (to whom?)
- Veracity (truth)
- Validity (applicable)
- Volatility (temporal)
- Verbosity (text)
- Verification (trust?)

The consequences of these words will be critically evaluated in order to identify the impact on BDA and their implications for big-data-supported knowledge management.

The first three Vs are essentially definitional, and provide a means of identifying whether one is dealing with Big Data or more traditional forms of data. Applying them to the two examples above, Watson and Target tend to meet the Volume criterion.

Using the Velocity and Variety criteria, which relate to the speed with which the raw data is being generated and captured and the variety of sources and formats in which the data arrives or is sourced from, the Target situation is clearly big data, whilst IBM Watson is less certain, in that all the raw data is in documentary text form and, once loaded into the system is not, generally, added to at any significant rate.

Of these three criteria, the most interesting one from the perspective of KM is Variety, the range of sources and formats of the raw data. Technically, the wide variety of sources and formats presents challenges in ensuring that correct linkages are made between objects and entities in the different sources, such as between Twitter, Facebook and other social network accounts and the more structured data in the corporations' operational systems, to which the linkages may well be made. The consequence of Variety of sources is, therefore, both a technical challenge and a problem with the Veracity (or truthfulness) and Validity (also truthfulness) of the connected data, hence leading to questions as to whether knowledge can be reliably developed from such data. This is not to say that the correct linkages can never be made, but it does require very careful consideration and Verification and Validation of the techniques and algorithms used and the resulting connected data, before full trust can be placed in the analysed information and potential knowledge.

It is well known that there are many social network accounts with incorrect or misleading credentials and that large numbers of internet users fail to present their true credentials in order to reduce the exposure of their personal details to the web. This leads to considerations of the Veracity of both the source data and the derived information. Typical changes made may affect the critical demographic details, such as name, age, gender and postal address, to identify but four items which are often critical to the analyses being made of big data, or are used in an attempt to ensure valid connection between disparate data sources to identify individual entities of interest.

Variability and Volatility relate to the changing values of the data captured from a source, perhaps reflecting the changing subjectivities and opinions of a single person over possibly quite short periods of time. The impact of this is to raise questions in

relation to Validity, Veracity and Value; how long does an opinion last before a person changes their mind? Can we derive Value from rapidly changing perspectives? What degree of trust can we place on the information? Does it really qualify as knowledge?

The final word is Verbosity which relates to the nature of text sources and the fact that humans are extremely good at understanding and using language, whereas computer systems are not good at understanding the semantics of natural language (other than a few environments like IBM Watson, after suitable training in a specific domain of information).

5 On Limitations and Insights

According to a recent and compelling piece of work by Madsbjerg and Rasmussen, although many companies are taking up market research, for instance, engineered by BDA, "…the pictures are far from complete and are often misleading," [29: p. 82]. The problem, they argue, is that people are not 'strings of ones and zeros', they are human, messy and irrational. To understand what drives human behaviour – in making a particular purchase, for example – one needs to study what people do, how they do it, and with what effect. From this common-sense perspective, 'data' is not knowledge, but with the right intervention, it can give rise to knowing, or actionable knowledge.

A further insight is offered by Bill Perlowitz, chief technologies officer at Wyle Laboratories: data analysis needs to be data-driven, [as cited in 34]. As Perlowitz explains, a traditional hypothesis-driven scientific approach, in terms of BDA, comes with limitations bounded by human imagination. The alternative is to collect data and analyse it for what it tells us. In other words, the value is already in the data, but in order for it to be transformed into actionable knowledge, new and better ways to leverage that knowledge need to be developed [34].

The value in the data is then correlated to the extent to which it complies with the 12 Vs discussed earlier, and an analysis that is not driven by the limits of preconceived ideas about what will be revealed in, for instance, relations or connections between data. Instead, an open mind and a readiness to let the data speak. Leading KM authority David Snowden [38] offers an insight that develops this perspective: central to transferring, and managing, knowledge are content and context. The latter, he argues, can be approached from two perspectives – abstraction and culture. The level of abstraction, and consequently its cost, depends on the existence or not of shared understanding (histories, language, culture) within a given group, whereas context refers to the availability of observable patterns in a given system (social norms). Can these perspectives, rising from the KM domain, inform BDA at a time when, as Ohlhorst reports, "…there is still a wide gap between its potential and its realization," [34: p. 111]. KM's struggle towards a more social and phenomenological understanding of knowledge may well serve as the bridge, and from this viewpoint, it is not Information Management that should be driving BDA, but Knowledge Management. One particular manifestation of the more social construction of knowledge is the discursive or semantic approach.

6   The Case for a Discursive Approach

People are innately disposed to share knowledge, and they do this through their actions and discourse [39]. The Psychologist Thomas Suddendorf makes a compelling argument for how this disposition to share knowledge is key to human evolution and the progress of cultural development, ear-marking this as a likely trait which differentiates humans from other species. Simply put, if people did not share knowledge with one another, humans would still be living in trees. Add to this perspective an approach which formulates discourse – talk and text – as action [17], and knowledge as a constructed psychological phenomenon sited in this action, then what emerges is a conceptualisation of talk and text as of paramount importance in the study and practice of knowledge work. This is not such a radical idea: many KM theorists emphasise the primacy of communication [e.g., 21, 23, 31]. Nor is it alien to Big Data Analytics, with its fundamental interest in what people say.

This emerging picture, then, constructs discourse as action, and knowledge – or knowing – as fundamental, continuous, unavoidable and pervasive to that action. Drawing on Derek Edwards and Jonathan Potter's [17] 'Discursive Psychology', which introduced this approach with its focus on how people routinely go about the business of constructing identities, gender, group membership and so forth in discourse, Knowledge Discourse Psychology specifically focuses on 'knowing work' [e.g., 8]. In one way, Discursive Psychology and Knowledge Discourse Psychology could be seen as subsets of 'sense-making' and its practice of phenomenology, identified by Madsbjerg and Rasmussen [29] as attracting growing interest, with measurable positive outcomes, amongst firms and Organization Studies. While sense-making focuses on the human experience, basing its research paradigms on anthropology and ethnography – so, its business is the observation of human actions in every way imaginable – the discursive paradigms focus exclusively on talk and text as the location of human action. This feature is that which makes Knowledge Discourse Psychology directly relevant to BDA and knowledge management. Analysis of discourse, following this paradigm, looks beyond what people say to reveal what they do with their talk, what actions they accomplish, and with what effect. Another major difference between this and sense-making, as reported by Madsbjerg and Rasmussen, is that it pays as much attention to variation in discourse as it does to identifying patterns and trends, thus creating links to the Vs of Volatility and Variability. All of this makes the discursive approach entirely consistent with Snowden's [38] conceptualization of content and context.

What might a Knowledge Discourse Psychology analysis reveal in collections of so-called big data, particularly the unstructured variety? And what would be the implications for KM practice? First, it makes common-sense to see BDA, and big data, as a knowledge source – despite the use of the term 'data'. It could be a knowledge source internal to the organization, or gathered externally in, for instance, horizon scanning activities. Second, an investigation of patterning and variety in text collections would reveal sub-sets of data, described in their context of temporal location, physical location, and activity category. An analysis and comparison across data sets would reveal what people orient to as important and relevant – not what they

say, rather what they do, and what consequences this has. Such an analytic approach would reveal similar but arguably more entrenched actions and attitudes than sense-making, and in turn, sense-making reveals deeper actions and attitudes than conventional research approaches [29]. Most importantly, such a semantically focused analytic approach would reveal patterning and connections, and it is these that are essential to predictive forecasting. However, developing the technical groundwork for such approaches remains a considerable challenge.

7   Discussion and Conclusions

Big Data Analytics is in its infancy, but is developing fast as substantial investments are being made into the realisation of new techniques and technologies [34]. Reports in both academic journals and popular media point to BDA's take up by organizations around the world. For KM, Big Data Analytics represents both a threat and an opportunity. A threat in that it is foreseeable that BDA will sweep KM away, consigning it to a drawer of organizational history. Alternatively, BDA might propel knowledge management back into the dark ages characterised by a pure focus on technology and correlation, and the reported high incidence of failures [e.g., 42]. But on the other hand, BDA is wrestling with many of the same issues and dilemmas which KM has confronted for decades, in particular the foregrounding of technology over the phenomenological and human sociology perspective of knowledge. The problem for KM is that it has been and remains a highly dis-unified field. Could BDA offer the opportunity to bring some unity?

There are obviously synergies between the two disciplines, and mutual lessons to be learned. Such a proposition opens some fascinating avenues for future research. One example draws from a KM perspective which emphasises innovation and new knowledge rising from social interactions in groups with Leonard and Sensiper [28], for instance, emphasising the 'melting pot' of different backgrounds, experiences and social norms necessary to 'ignite' innovation (semantics being the core of this connection). Accordingly, knowledge work emerges in groups of workers – communities of practice. In BDA terms, those groups comprise millions of participants. A suggested line of research would approach Big Data not as a vast collection of data records, but rather as a giant conversation (a Discourse imbued with semantics and meaning) with its analytic lens focusing on connections, cause and effect. Does a promising future beckon or will it be a hellish dystopia.

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Change bold to non-bold type	(As above)	⊥⊦
Insert 'superior' character	/ through character or ⋏ where required	Ɣ or ⋋ under character e.g. Ɣ² or ⋋²
Insert 'inferior' character	(As above)	⋏ over character e.g. ⋏₂
Insert full stop	(As above)	⊙
Insert comma	(As above)	,
Insert single quotation marks	(As above)	Ɣ or ⋋ and/or Ɣ or ⋋
Insert double quotation marks	(As above)	Ɣ or ⋋ and/or Ɣ or ⋋
Insert hyphen	(As above)	⊢-⊣
Start new paragraph	⌐	⌐
No new paragraph	⌢	⌢
Transpose	⊔⊓	⊔⊓
Close up	linking ⌒ characters	⌒
Insert or substitute space between characters or words	/ through character or ⋏ where required	Ⴤ
Reduce space between characters or words	| between characters or words affected	⇧