Innovator or collaborator? A cognitive network perspective to vision formation

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Abstract

Purpose – Having a shared vision is crucial for innovation. The purpose of this paper is to investigate the effect of individual propensity to collaborate and innovate on the development of a shared vision.

Design/methodology/approach – The authors build a network in which each node represents the vision of one individual and link the network structure to individual propensity of collaboration and innovativeness. During organizational workshops in four multinational organizations, the authors collected individual visions in the form of images as well as text describing the approach to innovation from 85 employees.

Findings – The study maps individual visions for innovation as a cognitive network. The authors find that individual propensity to innovate or collaborate is related to different network centrality. Innovators, individuals who see innovation as an opportunity to change and grow, are located at the center of the cognitive network. Collaborators, who see innovation as an opportunity to collaborate, have a higher closeness centrality inside a cluster.

Research limitations/implications – This paper analyses visions as a network linking recent research in psychology with the managerial longing for a more thorough investigation of group cognition. The study contributes to literature on shared vision creation, suggesting the role which innovators and collaborators can occupy in the process.

Originality/value – This paper proposes how an approach based on a cognitive network can inform innovation management. The findings suggest that visions of innovators summarize the visions of a group, helping the development of an overall shared vision. Collaborators on the other hand are representative of specific clusters and can help developing radical visions.

Keywords Network analysis, Innovation, Shared vision, Cognitive diversity

Paper type Research paper

Introduction

To face uncertain market conditions, firms develop innovation led by a clear vision (Koryak *et al.*, 2018). Developing a Shared Vision is crucial for successful innovation (Senge, 1990). Yet, innovation is carried out by employees, who each have an own vision (O'Connell *et al.*, 2011).

Developing a Shared Vision is complicated insofar as individuals are diverse in how they make sense of their environment (Wang and Rafiq, 2009). This is known as cognitive

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diversity: deep-level differences and beliefs, which influence how reality is perceived and interpreted (Chen *et al.*, 2019; Aggarwal and Woolley, 2019). Cognitive diversity within a group enriches the innovation process through the presence of multiple perspectives (Zouaghi *et al.*, 2020; Shin *et al.*, 2012; Aggarwal and Woolley, 2019; Mitchell and Boyle, 2021). Yet, diversity also generates conflict among contrasting perspectives, making groups unproductive and hampering implementation (Andriopoulos *et al.*, 2018; Chen *et al.*, 2019).

Perry-Smith and Mannucci (2017) suggest that idea generation benefits from diversity and innovativeness at first; but hereafter a shared vision needs to be developed to align stakeholders around an innovation project. Innovation hence requires innovators and collaborators: individuals who are innovative (Chen *et al.*, 2019), to make sure the vision pursued is indeed innovative and aspirational; and collaboration among team members towards a shared vision (Barczak *et al.*, 2010).

Cognition and vision formation are central to innovation (Pearce and Ensley, 2004). The vision orients the implementation process, simplifying sensemaking within innovation teams (Andriopoulos *et al.*, 2018). Despite this, there is a surprising lack of studies investigating how individual visions are related. While most innovation studies focus on action and outcome, a need for studies investigating individual cognition in groupwork is emerging (Perry-Smith and Mannucci, 2017; Aggarwal and Woolley, 2019). Cognitive Network Science may provide answers (Siew *et al.*, 2019). Cognitive Network Science leverages the mathematical methods of network analysis to analyze cognition (Kilduff and Lee, 2020). We present a cognitive network in which each node represents the vision of one individual and links among nodes represent the similarity of the visions. The structure of the network highlights the structural relations among individual visions. In this study, we suggest a cognitive perspective to innovation, to understand how the network structure and centrality of individual visions relate to a shared vision (Aggarwal and Woolley, 2013; Shin *et al.*, 2012; Hensel and Visser, 2019). While past studies have shown that a shared vision has a positive impact on organizational performance (see O'Connell *et al.*, 2011 for an extensive review), the role of individual visioning remains largely underexplored (Kim and Zhong, 2017; Sjödin *et al.*, 2019). We aim to answer the following research questions:

RQ1. What is the structural relation among visions of innovators and collaborators in a cognitive network?

This study contributes to organizational literature in multiple ways. First, we enrich knowledge on group cognition, investigating the relation among individual visions. Through cognitive network science, we link individual visions to individual inclinations to collaboration and innovativeness. Second, our paper also holds a methodological contribution: through an analysis of images as vision representation, we apply cognitive network science to group theories (Siew *et al.*, 2019). Our findings extend previous literature which focused mainly on text-based metrics, suggesting that images provide additional insights into group cognition. In the following sections, we will first discuss the role of the individual and team collaboration for innovation and present our cognitive network approach.

Theoretical background

Cognitive aspects of innovation

For innovative organizations it is crucial to develop radically new visions of the future (Verganti, 2017; Dell'Era *et al.*, 2018). This vision may either be developed at the top management level and cascaded into the organization; or emerge from the voices of employees (O'Connell *et al.*, 2011). In either case, every individual develops a vision – and as individuals are diverse, the resulting visions are different. A key management challenge consists in understanding how a new vision can be developed and shared in an organization (Senge, 1990; Verganti and Shani, 2016).

Groups should be diverse because interactions among diverse individuals lead to creativity (Shin *et al.*, 2012). Cognitive diversity refers to the differences in knowledge, skills, and thinking styles among members of a group (Shin *et al.*, 2012). Also defined as deep-level diversity, it goes beyond the surface distinctions among people, related to their gender, nationalities or functional role in the organization (Torchia *et al.*, 2015; Garcia Martinez *et al.*, 2017) and describes the different thinking styles of individuals (Schilpzand and Martins, 2010; Aggarwal and Woolley, 2013). Cognitive diversity connects to individual attitudes for innovation (Phillips and Loyd, 2006): when thinking about innovation, every person makes sense of innovation in her own way. This has two consequences: first, every individual has a different way to understand the task at hand (Chen *et al.*, 2019). For example, while one person may see innovation as an opportunity of individual growth, another may see in it the opportunity to collaborate with a team. Second, every individual develops a different vision for innovation (Hensel and Visser, 2019).

A Shared Vision can bridge diversity among diverse individuals. A Shared Vision is defined as “a common mental model of the future state” (Pearce and Ensley, 2004, p. 260), an image of the future a group hopes to achieve. It is a portrait of the future expressed in verbal or visual manner, which emerges as the integration of the individual visions for innovation (Carton *et al.*, 2014; Hensel and Visser, 2019). The Shared Vision represents a prescriptive mental model (how a system could become), determining the actions of individual team members (Strange and Mumford, 2002). New product development teams often struggle with front-end tensions related to internal and external diversity and a shared vision helps overcoming these problems (Shum and Lin, 2007; Andriopoulos *et al.*, 2018).

Perry-Smith and Mannucci (2017) suggest that a Shared Vision and Diversity are both relevant. The front-end of innovation in particular benefits from integrating diverse perspectives to find more meaningful ideas. Indeed, in an initial creativity phase cognitive diversity is essential to develop innovative and useful ideas (Shin *et al.*, 2012). Yet, it is also necessary to collaborate with individuals who think differently. Both individual innovativeness and collaboration are central in innovation.

Innovativeness and collaboration for innovation processes

Throughout innovation and creativity literature, the individual is increasingly moving at the center of scholarly attention (Perry-Smith and Mannucci, 2017; Lomberg *et al.*, 2017; Grass *et al.*, 2020). For example, Cooper’s (1990) Stage-Gate approach to product development defined a set of closed stages and validation gates. Yet recent approaches integrate this fixed and plan-based approach with interactions and collaboration (Cooper and Sommer, 2016). Indeed, more recent studies focus on the people-side, rather than the process itself (Grass *et al.*, 2020). Similarly, also creativity literature emphasizes how Creativity may be viewed as a process (e.g. Hargadon and Bechky, 2006) while recent studies, particularly in Design, focus rather on an individual dimension of creativity (Crilly and Cardoso, 2017; Dell’Era *et al.*, 2020).

The growing body of knowledge on groups diversity suggests that researchers should focus on understanding how diverse individuals can be helped to collaborate (Weiss *et al.*, 2018; Aggarwal and Woolley, 2019) as creativity and innovation are a collective act (Hennessey and Amabile, 2010). Individuals can contribute through innovative work behavior, but still need to function as a team to integrate their different knowledge (Scott and Bruce, 1994; Widmann and Mulder, 2018).

According to a first perspective, individual team members can engage in individual innovative work behavior to drive team and organizational success (De Jong and Den Hartog, 2010; Hughes *et al.*, 2018). Everyone provides value through individual Innovative Work Behavior (Hughes *et al.*, 2018; Bednall *et al.*, 2018; Chen *et al.*, 2019), creative idea generation

(Perry-Smith and Shalley, 2003; Shin *et al.*, 2012; Li *et al.*, 2018) or bringing differences in perspectives into the innovation process (Perry-Smith and Mannucci, 2017; Weiss *et al.*, 2018). Hence, scholars have investigated what drives individuals to innovate, such as motivation (Li *et al.*, 2018), perceived support (Chen *et al.*, 2019), resistance to change (Röth and Spieth, 2019), mindfulness (Byrne and Thatchenkery, 2019), the adoption of paradoxical frames (Miron-Spektor *et al.*, 2011) and cognitive flexibility (Miron-Spektor and Beenen, 2015; Li *et al.*, 2018). Yet, findings suggest that it is not merely individual characteristics, but collaboration among innovators which drives innovation (Perry-Smith and Mannucci, 2017).

According to this second perspective, individuals join their ideas and reflections to develop innovation; the outcome is a team effort rather than the sum of individual contributions (Hargadon and Bechky, 2006; Amabile and Pratt, 2016). The levels of trust and collaborative culture in a team positively influence creativity (Barczak *et al.*, 2010). Multiple studies also underline that knowledge sharing benefits team innovation performance (Zakaria *et al.*, 2004; Widmann and Mulder, 2018).

In conclusion, it is possible to see two areas through which individuals can contribute to innovation: First, individuals may contribute to the innovation bringing their diverse perspectives (Shin *et al.*, 2012) and adopting innovative behavior (De Jong and Den Hartog, 2010). Throughout this article, we refer to this first set of individuals as Innovators (Brenton and Levin, 2012; Perry-Smith and Mannucci, 2017). Second, individuals can contribute through collaborative behavior and teaming efforts (Barczak *et al.*, 2010). We will refer to individuals who are predominantly adopting this second approach as Collaborators (Wang, 2016).

Innovators and collaborators both contribute to innovation because they influence the network of people surrounding them (Tortoriello *et al.*, 2015). Yet, while the social implications of their behaviors have been extensively explored, how innovators and collaborators contribute to vision formation remains under researched.

Network research in innovation

Interactions among individuals are often analyzed through social networks (Tortoriello *et al.*, 2015). Network theories are based on the observation of individuals embedded within their social structures (Tasselli and Kilduff, 2021). Innovation emerges through interactions among the individuals in such a network, where support for innovation is provided (Perry-Smith and Mannucci, 2017). In social networks, nodes represent individuals and ties represent relationships (Perry-Smith and Shalley, 2003). Through social networks, it is possible to model flows of knowledge and support, describing the emergence of ideas and their subsequent implementation as a collective act (Hargadon and Bechky, 2006). Social network theories highlight the role an individual has inside an organization (Kilduff and Lee, 2020). Behavior, action and cognition are reciprocally related to an individual's position inside a network (Tasselli and Kilduff, 2021). Hence, the innovativeness of a group is related to the structural aspects of the social networks its' members are part of (Perry-Smith and Shalley, 2003). Wang (2016) reasons on the relevance of strong and weak ties (Granovetter, 1983) in a network of innovators: high tie strength enables communication and a shared vision among individuals, while weak ties enable cognitive diversity and a more heterogeneous situation for knowledge creation. Weak network ties represent structural bridges and allow communication between otherwise unrelated network areas (Newell *et al.*, 2004; Shin *et al.*, 2012; Montazemi *et al.*, 2012; Cantù *et al.*, 2015).

While managerial studies have predominantly focused on the role of social exchange, group studies are increasingly focusing on cognition (Chen *et al.*, 2019; Nowak, 2020). As we have highlighted, the success of innovation depends on group cognition in terms of diversity among individuals (Shin *et al.*, 2012; Chen *et al.*, 2019) and development of a shared vision (Pearce and Ensley, 2004). The role of cognition in networks remains though largely underexplored (Kilduff and Brass, 2010). While some authors reflected that an organization may be considered a network of cognitions (Bougon *et al.*, 1977), to our knowledge no managerial studies have attempted to measure organizational aspects from this perspective.

Cognitive networks are rooted in psychology and suggest that network analysis may be applied to the study of cognition inside groups (Kilduff and Lee, 2020). In an extensive review of cognition research, Siew *et al.* (2019) conclude that cognitive network science is emerging as an approach to study group cognition. While social networks focus on relationships among individuals, cognitive networks focus on concepts and their similarity. Social networks provide a schematic overview on a group, showing how relations of social relations and trust allow knowledge to flow through the network (Perry-Smith and Shalley, 2003). Cognitive networks are a representation of how concepts are related: when concepts are similar, they have a structural relationship in the network.

Cognitive networks have been used in the past at the individual level, to investigate associative patterns of individuals with different levels of creativity (Kenett *et al.*, 2014). Yet, while these studies may show the differences among group of individuals, the application of these networks was mostly at the individual level (Kenett and Faust, 2019). Recent studies suggest that cognitive network science may be insightful for studies of cognition at the group level as well (Kilduff and Lee, 2020). Scholars rely on social networks to highlight groups of individuals who are well-connected to each other and discuss the different positions in the network (Perry-Smith, 2006). Cognitive networks have the potential of highlighting which concepts are most relevant for the members of a group, visualizing the relatedness of these concepts. While vision development has been studied from a content perspective (e.g. Carton *et al.*, 2014; Carton and Lucas, 2018), these studies mostly take the point of view of a leader who wishes to inspire through the vision (Strange and Mumford, 2002). In a collaborative environment, where the vision emerges from the group, it is necessary to highlight the relations among the individual visions.

Research objective

Cognitive network science may bear significant insights for innovation as well, specifically for vision formation (O'Connell *et al.*, 2011). When individuals develop a vision for innovation, this takes the form of a mental portrait of what the future could one day look like, put into visual or textual form (Ware, 2004; Carton *et al.*, 2014).

Jaspersen and Stein (2019) argue that visual methods are powerful to bridge boundaries and allow reification of abstract concepts and strategy (Paroutis *et al.*, 2015). Early during innovation, individuals need to share the abstract vision which they have in their minds with their peers, and visual artifacts help to express their thoughts (Stigliani and Ravasi, 2012). Visual artifacts bridge the boundaries between the abstract and concrete (Ewenstein and Whyte, 2009) and allow actors to develop shared meaning (Jaspersen and Stein, 2019). Leveraging visual thinking capability of individuals (Ware, 2004) we explore the similarity of innovation visions in a cognitive network.

The aim of this research is two-fold: first, we aim to apply cognitive network science to the study of individual visions. The first goal of this study is therefore to explore how individual visions are structurally related within a Cognitive Network. Second, we aim to investigate the role of collaborators and innovators in the cognitive network.

Research methods

We performed an exploratory study to investigate the relation among a cognitive network and individual attitude to innovation. This study relies on data from four organizational visioning workshops held in four multinational enterprises in the context of the research platform IDeaLs [1]. IDeaLs is a research platform coordinated by Politecnico di Milano, connecting researchers and managers, studying new ways to engage people and make innovation happen (Press *et al.*, 2021). The objective of the workshops was to help employees translate the organizational vision into their routines, as making a vision become shared is one of the main challenges of organizational visioning (O'Connell *et al.*, 2011; Magnanini *et al.*, 2021). Table 1 summarizes the characteristics of our sample. More precisely, for each organization between 20 and 30 participants were selected from different organizational functions, as functional diversity is linked also to cognitive diversity (Mitchell and Nicholas, 2006; Torchia *et al.*, 2015). Participation to the workshops was voluntary, but strongly encouraged by top management. Finally, companies differed in size and industry (e.g. logistics, commodities and healthcare).

We chose the context of a specific innovation project for two main reasons: First, the analysis of the vision allows to analyze a dimension which is not related to individual cognitive styles, but to the specific innovation project. This limits the analysis to job-related factors, as it is performed on the representations of a project of which all members have the same knowledge. Second, analyzing concrete representations yields more objective results than the measure of perceptions.

The reference sample in this study consists in the participants to the organizational workshops; out of 95 participants, our final sample included 85 useful observations for a response rate of close to 90%, divided as 13, 20, 30 and 22 from the four organizations. In a similar fashion to Gibbons (2004) we adopt a design of multiple networks with numerosity ranging between 10 and 30 individuals per network; while this is smaller than most network studies (Zagenczyk *et al.*, 2015), we discuss a phenomenon which emerges in multiple cases.

Data collection

Extensive research has linked cognition to language, because through words people express what they think (Maitlis and Christianson, 2014). Yet, the attention of management scholars is recently attracted to a different medium – that of visual content. Due to their richness in cognitive content, visual media are growing in adoption (Bell and Davison, 2013). In organizational research, this has led to a shift towards visual practices (Styhre, 2010): in organizations, a variety of visual artifacts such as pictures help to engage individuals (Ewenstein and Whyte, 2009). Visual artifacts can help to evoke meanings and spur conversation during innovation (Stigliani and Ravasi, 2012). In particular, images can communicate a vision of the future: Lösch (2006) studies visionary images in the field of nano-technologies and illustrates how future-oriented representations of a technology help to communicate intangible values of the same. In design sciences, visualizations are used because they support individuals to make sense of things (Ewenstein and Whyte, 2009; Dell'Era *et al.*, 2020).

For this reason, we asked participants to reflect on visual rather than textual content: strict guidelines concerning the definition of a single, visionary image led to comparable images (Bell and Davison, 2013). The usage of visual content provided a richer expression than the more common expression through written content (Lösch, 2006).

Upon briefing by managers, participants were asked to search for an image to represent their vision of the organizational innovation initiative at hand. Various authors have shown that user-generated visual content supports the expression of complex ideas (Wang and Burris, 1997; Guillemin and Drew, 2010). Participants could search for any image available online using image search engines.

Yet, visual content is most effective if it is also accompanied by text, because "*visual communication often works in parallel with linguistic messages*" (Bell and Davison, 2013, p. 175). Therefore, we also asked each participant to identify at least three keywords in English to describe the main characteristics of the upcoming innovation process.

Partner	Company size	Country of participants	Number of participants	Gender	Challenge description
One	100k – 500k	Worldwide	13 [20]	45% female	Company one wants to introduce a strategic change concerning the new product development process Individual visions and keywords describe behaviors for introducing the new Product Development process
Two	100–500	Italy	22 [23]	53% female	Company two wants to change its strategic direction, introducing new values and norms Individual visions and keywords describe behaviors for introducing the new strategic direction
Three	100–500	Switzerland, Italy	30 [32]	47% female	Company three wants to weave the opportunities provided by digital technologies into its values Individual visions and keywords describe behaviors for embracing the new digital values
Four	10k – 50k	Italy	20 [20]	45% female	Company four wants to introduce a new work model to improve its reactiveness to changes in the market Individual visions and keywords describe behaviors for introducing the new work model

Table 1. Descriptive statistics of the companies involved in the study and of their challenges

Keywords are often used together with images because they provide a more profound description of the image content (Yang *et al.*, 2011). We asked participants to provide keywords instead of extensive written text because these represent the key conceptual stimuli resulting from the participants' reflections (Junaidy *et al.*, 2015). Indeed, keywords help to synthesize information, and are used for indexing in various fields – from automated topic modelling (Hannigan *et al.*, 2019) to images (Yang *et al.*, 2011) and academic research. While the image represents the individual vision, the keywords would allow individuals to express their attitudes towards innovation.

Our data analysis consisted of two steps: first, we created the cognitive network based on the individual visions. Second, we analyzed and coded the keywords to assess whether individuals could be considered innovators or collaborators.

Vision analysis through images

Our visual processing system links two different modes of analysis, a cognitive and an emotional one (Styhre, 2010). The cognitive system analyzes the content of the visual input, while the emotional analysis is related to the feelings conveyed by the input. For our analysis we analyzed two dimensions for each image: the emotion expressed by the dominant colors of the images, and the content of the images (Wang and He, 2008). In the following sections we describe the analysis of both, highlighting how a cognitive network was built from the individual visions.

(1) *Measurement of emotion similarity* – To analyze the emotions, we applied the *Color Image Scale* (Kobayashi, 1992), an approach which associates to every dominant color

of an image a specific emotion. We analyzed the colors, because visual and color preferences in choice of imagery are linked to emotions (Valdez and Mehrabian, 1994). Kobayashi (1992) identifies color combinations which have a specific emotional value, and maps these on a Cartesian plain. We converted the dominant colors of each image to Kobayashi's emotions, and found the average location of each image in the plain. The emotional similarity of two images was the inverse distance among the position of these images in Kobayashi's plain.

(2) *Measurement of content similarity* – To analyze the content, we applied automatic classification and computed the distance of images in a semantic net. In recent years, machine learning has been applied to solve a wide variety of challenges (He *et al.*, 2021). The images provided by participants were first labelled using the computer-vision API ClarifAI, one of the leading providers of image analysis algorithms (Available at https://clarifai.com/). ClarifAI's general model of classification returns a set of keywords which describe what you see in a picture, highlighting both distinct objects and general interpretations of a scene.

Second, we measured the distance among the labels of different images through a semantic network approach (Miller, 1995). Semantic approaches to language analysis rely on a structural aggregation of knowledge, in which words are grouped in a hierarchical manner. Words are organized into sets of synonyms called synsets and linked to other synsets with semantic or relational edges (Miller, 1995; Li *et al.*, 2006). Several resources are available for the representation of the hierarchical knowledge structure of the English language, among which WordNet was chosen due to its diffusion and ease of use (Miller, 1995). The distance among the set of keywords in each image was based on path-length (Li *et al.*, 2006; Wu and Palmer, 1994).

(3) *Measure integration and Network Analysis* – Network analysis provides visual representation of interactions and exchanges among nodes. Each node represents a single entity, which has a one-to-one relationship with a limited number of other nodes. The edges connecting nodes display a weight, or tie strength, representing the strength of the relationship (Siew *et al.*, 2019). In the cognitive network each node represents the vision of one individual. The edges represent the similarity of two visions, meaning the highest value among emotion- and content-similarity. Only the k strongest links were considered for each network, where k is the square of the number of total participants (Lall and Sharma, 1996). In case of more than k edges with the same weight, all edges were considered pursuing a comprehensive approach.

The graph analysis tool Gephi was selected for visualization and analysis of the similarity network (Bastian *et al.*, 2009; Sapountzi and Psannis, 2018). We analyzed two structural dimensions of the network, namely the clustering of nodes and their centrality. First, we created clusters of nodes via the Louvian community detection algorithm (Blondel *et al.*, 2008). The Louvian algorithm maximizes in-cluster density, thus identifying groups of nodes (in this case, visions) which are more similar than visions in the other clusters. Two measures help describing the structure and strength of network clustering, namely the average clustering and modularity coefficients. The average clustering coefficient describes the cliquishness of a network, or the extent to which two nodes connected to a third node tend to be connected also to each other (Watts and Strogatz, 1998). The modularity coefficient, on the other hand, represents the strength of a networks' division into modules (Blondel *et al.*, 2008). If modularity and clustering coefficients are high, this means that visions inside a cluster are very similar to each other and different from those in other clusters.

Second, we measured centrality through closeness, a metric which measures the distance the other nodes (Bavelas, 1950). This allowed us to identify the visions which were most similar to all other visions in two ways: First, we measured centrality in the overall network: network centrality represents how close a vision is to all other visions in the network. Second, we also measured centrality in the clusters: cluster centrality represents how close a vision is to all other visions in that cluster.

Different approaches to innovation

In addition to the structural network metrics, we analyzed participants' inclination towards innovation through their keywords. All words were stemmed and counted, and only word stems occurring at least three times were considered in the following steps of the analysis.

The keywords of participants were then grouped into categories (Junaidy *et al.*, 2015). We decided to use an inductive approach to allow free expression of individual deep-level attitudes (Phillips and Loyd, 2006). Our coding process highlighted two categories which connect with theory and led us to identify two main clusters: an inclination towards collaboration (Hargadon and Bechky, 2006; Barczak *et al.*, 2010) and innovativeness (De Jong and Den Hartog, 2010; Hughes *et al.*, 2018). For example, words in the collaboration category express the tendency to share knowledge and perspectives ("shar-") (Men *et al.*, 2019), or the mention of team-relevant factors such as communication ("communic-") or trust ("trust-") (Barczak *et al.*, 2010; Hughes *et al.*, 2018). Words in the innovativeness category express the willingness to change ("chang-") or search for opportunities to adopt innovative behaviors ("innovate-") (Bednall *et al.*, 2018; Chen *et al.*, 2019). Not all words used by participants could be grouped into the innovator/collaborator categories; we identified a total of seven word-stems describing the inclination towards Collaboration, while six stems were identified to describe the inclination towards Innovation (Table 2).

Based on the words selected, we associated to each participant a score in terms of innovation and collaboration inclination, as the percentage of words of each category over the total number of words used by the person. *Collaborators* are those individuals who used at least one word related to the words related to *Collaboration* category; *Innovators* have at least one word related to the *Innovation* category. We considered one word sufficient as it was the result of a deep sensemaking process, summarized in few prioritized keywords. We identified 41 Collaborators (average *collaboration* score = 0.327) and 28 Innovators (average *innovation* score = 0.298). 16 individuals were both Innovators and Collaborators and were considered in both analyses.

Results

Our findings suggest that through a cognitive network it is possible to identify clusters of similar visions. Nodes grouped in a cluster represent visions with similar characteristics (Blondel *et al.*, 2008). All observed networks have a high average clustering coefficient – above 0.5 – and a low modularity coefficient – below 0.25. Further, people also have a unique attitude towards developing innovation (O'Connor and Veryzer, 2001). Our findings suggest that Innovators and Collaborators have different centrality in the cognitive network: while innovators are central in the overall network, collaborators are central in the cluster (Table 3). In the following paragraphs we outline the role of each of these categories in the Cognitive Network.

Innovators: envisioning innovation

Throughout the innovation process, Innovators drive the development of an idea: they generate creative ideas, and champion them throughout their journey (Perry-Smith and Mannucci, 2017). To highlight the role of innovators in vision formation, we analyze the keywords used to express

Table 2.
Coding of word-stems to the categories of collaboration and innovation

Category	Word-stem	Sample words	Occurrence
Collaboration	shar*	share, sharing	13
	collab*	Collaboration	11
	lead*	leadership, leader	4
	trust*	Trust	8
	team*	teamwork, team	6
	communic*	Communication	4
	togeth*	Together	3
Innovation	chang*	changing, change	10
	grow*	growth, growing	7
	transform*	Transformation	5
	inspir*	Inspirational, inspire	5
	innov*	innovation, innovative	5
	vision*	vision, visionary	3

Table 3.
Correlations among individual attitudes for innovation and centrality measures

		Closeness centrality	
		Network	Cluster
Individual attitude	Innovator	0.302**	0.138
	Collaborator	0.142	0.238*

Note(s): Table displays pairwise correlation coefficients where $^{**}p < 0.01$, $^{*}p < 0.05$

their inclination towards the innovation process. We identify 29 Innovators, who describe an innovation process with words related to growth and transformation. Figure 1 shows the cognitive networks of our sample, highlighting the location of Innovators in the network.

First, we find that Innovators are distributed throughout the network in different clusters. Every cluster contains several individuals who can be identified as innovators, which means they describe innovation with words expressing desire to Transform and aspiration to change. Thus, the attitude towards innovation is independent from the content of ones' vision. Innovative attitude is not an indicator of the direction an individual aims to pursue; rather, it describes how she or he wants to get there.

Second, we observe that Innovators are largely located in a central network position: In Figure 1, the size of nodes represents the Closeness Centrality of a node in the network. We found a weak positive correlation among the closeness centrality of a node and its Innovation score ($r = 0.302, p = 0.005$). Hence, individuals defined as Innovators occupy a central position inside a cognitive network.

Creating a shared vision: collaborators

While innovative individuals can conceive and drive innovation, creativity and innovation are an act of collaboration (Amabile and Pratt, 2016). Collaborators are fundamental to turn an abstract idea into a concrete solution, interacting with individuals throughout the innovation process. From a social perspective, collaboration with distant ideas helps developing creative outcome (Perry-Smith and Shalley, 2003). When Collaborators create strong ties with their peers, they tend to develop a Shared Vision (Wang, 2016).

We identify 41 Collaborators, who opted for a description of the innovation process characterized by words such as Teamwork, Collaboration and Communication. These individuals embody the concept of innovation as a collective act (Santos *et al.*, 2015). The four cognitive networks of our study are represented in Figure 2, where Collaborators are highlighted in darker color.

In an analogue manner to Innovators, also Collaborators are not limited to certain clusters. Indeed, Collaborators are distributed among all clusters in all networks. Therefore, inclination towards collaboration or innovation is independent from the content of one's vision. Second, we analyze how positioning in the network and attitude are related. We observe that Collaborators tend to be located at the center of the cluster they are part of. The size of nodes represented in Figure 2 is proportional to the Closeness Centrality measure within the specific cluster. We found weak positive correlation among the closeness centrality of a node in a cluster and its' Collaboration score ($r = 0.238$, $p = 0.028$). Therefore, individuals who are incline to collaboration with colleagues are located close to those who have a similar vision within a cognitive network.

Discussion

Interest of scholars is shifting from the investigation of relational to cognitive exchanges for innovation purposes (Perry-Smith and Mannucci, 2017). Our study aims to respond to the need for a more thorough investigation of the cognitive side of innovation (Santos *et al.*, 2015).

In doing so, the first objective of this article was to identify how the analysis of a cognitive network could help unravelling the visioning process. Siew *et al.* (2019) postulate that network science could inform the study of groups at the cognitive level. Yet how a network can be formed based on cognition inside a group remains largely underexplored (Kilduff and Lee, 2020). On the other hand, O'Connell *et al.* (2011) suggest that vision formation is a central challenge for management. Our study contributes to literature on group cognition with the introduction of a novel representation method, which allows to identify similar and diverse innovative visions. While the relations among cognition and innovation have been extensively investigated (Joshi and Lahiri, 2015; Wang *et al.*, 2016; Nowak, 2020),

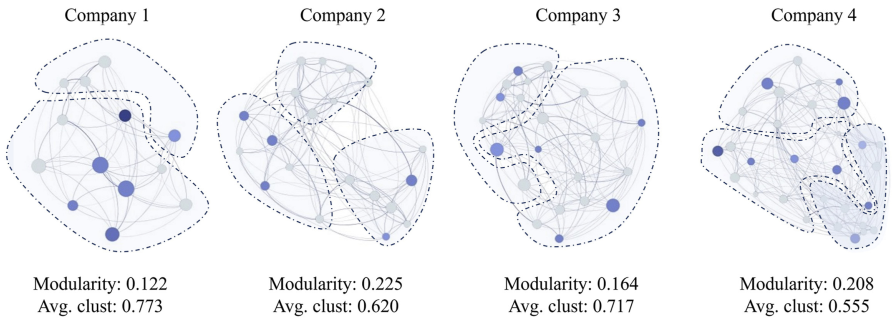

Figure 1. Cognitive Networks with Innovators. Groupings identify Clusters, Node size represents Overall Closeness Centrality; Darkness represents Innovation Score

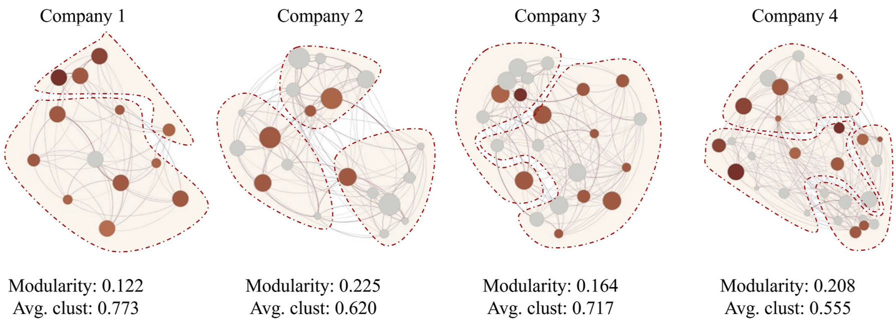

Figure 2. Cognitive Networks with Collaborators. Groupings identify Clusters, Node size represents Closeness Centrality within the Cluster; Darkness represents Collaboration Score

measurement relies mainly on the self-evaluation of the groups' cognitive structure (Wang *et al.*, 2016; Men *et al.*, 2019). Furthermore, we find that within the network Collaborators – who see innovation processes as an opportunity to share knowledge and co-develop innovation – occupy a central role in the network; Innovators see innovation as a possibility to change and grow and have a non-central position in the network.

Our contribution is twofold: First, we answer to a need of network studies in team cognition (Siew *et al.*, 2019; Kilduff and Lee, 2020) introducing a network based on innovation visions. Second, our study also contributes to understanding how the organizational visioning process may be supported (O'Connell *et al.*, 2011). We highlight how Innovators and Collaborators have visions which are central in the overall network or in clusters of the network, respectively.

Innovators as network influencers

Innovators are individuals who see in innovation an opportunity to grow and change. Perry-Smith and Mannucci (2017) describe how an idea is brought from conception to implementation by innovators who have the capability to integrate diverse perspective into their idea. We find that Innovators have a central position in the overall cognitive network. This finding suggests that innovators have a vision which is influential in the network – in other words, their vision is similar to that of many others.

According to our findings, the innovator attitude leads an individual to develop a central position in the cognitive network. Every individual has her own vision – because individuals are cognitive diverse, and process information differently (Aggarwal and Woolley, 2019; Chen *et al.*, 2019). Innovation requires to interact with many diverse individuals, to understand their perspectives and see an opportunity from different angles (Janssen *et al.*,2004). Many authors suggest that cognitive diversity in a group is necessary to develop creative ideas (Shin *et al.*, 2012). As contrasting perspectives clash, uncommon associations are made possible (Kim and Zhong, 2017). Yet, over time, individuals who work together tend to develop shared mental models (Santos *et al.*, 2015). These lead to similar ways of processing reality, and thus the development of similar visions. Therefore, over time the innovator becomes influenced by external visions, and her vision becomes representative of the many diverse individuals who influenced her.

This finding may seem counterintuitive at first. One would expect individuals with a highly innovative attitude to have a disruptive vision (Verganti, 2017). Entrepreneurs for example, who go so far as to found an organization, are individuals driven by highly innovative visions (Hensel and Visser, 2019). Similarly, also large-scale organizations are increasingly fostering organizational entrepreneurship to cultivate innovative ideas (García-Morales *et al.*, 2006). Yet, team innovativeness does not require a lone innovator: To achieve innovative outcome, even creative star employees must collaborate with their teammates (Li *et al.*, 2020). Perry-Smith and Mannucci (2017) suggest that the development of innovative ideas requires the integration of many diverse perspectives; the authors stress that the final phases of innovation should be driven by a shared vision, which the innovator needs to establish with her or his stakeholders. Similarly, Verganti (2017) argues that innovative visions are not to be found in radical diversity; rather, they emerge when an innovator is able to synthesize weak signals emerging from diverse "interpreters" (Verganti, 2008). While an innovator displays an attitude towards innovation, transformation and change, our findings suggest that her vision may very well be close to that of her peers.

Collaborators as cluster influencers

We identify Collaborators as individuals who see innovation as an opportunity to collaborate with their peers. Pearce and Ensley (2004) suggest that when individuals collaborate in a team, they tend to develop a shared vision of the future state of the team.

According to our analyses, the clusters in the cognitive network only have a low value of modularity, which means a low significance of cluster differences. Yet, when we search for the role of Collaborators in the cognitive network, we find that their visions are central in these clusters. This finding is in line with previous literature: individuals who collaborate tend to develop a shared vision for innovation (Kakar, 2018; Heyden *et al.*, 2012). Collaborators are those individuals who most are focused on aspects of collaboration, and their vision becomes central in a group of similar visions. Interestingly though, our findings suggest that the visions of collaborators are not central in the overall network – thus, the collaborators do not have a global influence on the network.

Already Tortoriello *et al.* (2015) had reflected on two distinct roles in networks for innovation, innovators and catalysts. Innovators are individuals who carry out innovation and are most studied in network literature. Catalysts of innovation tap into diverse knowledge and perspectives but have a collaborative attitude, granting their peers access to this knowledge. Catalysts span across boundaries and turn diverse knowledge into practical support for their peers (Olabisi and Lewis, 2018). Our findings suggest that collaborators have an analogue role in the cognitive network: innovative visions provide a way to bridge diversity and tensions (Shin *et al.*, 2012; Wang and Rafiq, 2014). If teams want to be innovative, there should be trust and a collaborative culture among the members (Barczak *et al.*, 2010). Individuals who have a collaboration attitude are catalysts who absorb the perspectives of their peers, developing a vision which is representative of a group of similar visions.

Theoretical contributions

In addition to the structural benefits of analyzing cognition as a network, our study also brings specific contributions to the field of group management in innovation. In the cognitive network, every node represents the vision of one individual; hence, we link the position in the network to the individual approach to innovation to explore our second research question.

Tasselli and Kilduff (2021) introduce an agency perspective to network analysis, bringing the person back to the center in network analysis. According to the authors, studies throughout the past decades have devoted extensive attention to the analysis of network-level factors (see for example Wang, 2016; Schlaile *et al.*, 2018). Yet, recent studies focus on the individual rather than the structure of the network (Perry-Smith and Mannucci, 2017). The role of an individual becomes central in understanding how the network evolves around her.

Visioning in a cognitive network

The development of a cognitive network to analyze cognitive aspects of groups brings several benefits, as Siew *et al.* (2019) suggest. Though our study, we connect the emerging field of cognitive network science with vision formation in innovation.

First, our study suggests that when individuals visualize their visions, some representations are similar to each other. Nonetheless, the clusters we identify have only a low modularity value. This suggests that, even though similar characteristics exist, these are insufficient to identify emerging visions. This finding confirms previous literature, according to which a shared vision within a group of individuals is not simply a sum of their individual visions; rather, the shared vision represents a shared mental image, which emerges through interaction (Pearce and Ensley, 2004). Only if the vision is shared, it can help members of a team to perform collaborative sensemaking processes (Andriopoulos *et al.*, 2018). Rather than the content of the vision itself, it is its sharedness which determines successful performance (Senge, 1990).

Second, our findings suggest that some of these vision representations are central in the network. In a cognitive network, a vision is central if it is similar to many ideas of a group. Identifying such central vision could be helpful in organizations which aim to pursue a bottom-up approach to vision formation (O'Connell *et al.*, 2011). One way to develop a vision shared throughout a group or organization consists in involving the whole group in designing the vision. While this shared vision formation in a group may work well in small team setting (Pearce and Ensley, 2004), it is more difficult to achieve in large organizations. When multiple perspectives collide, the diversity which should be leveraged to develop a more meaningful vision could lead to conflict, thus hampering innovation (Santos *et al.*, 2015; Garcia Martinez *et al.*, 2017; Chen *et al.*, 2019).

The possibility to identify the most central visions in a group could help in selecting which individuals should be involved in an organizational visioning process. Diverse individuals create a Shared Vision through an integration of individual perspectives (Hensel and Visser, 2019). Through the cognitive network, it is possible to identify visions which are most representative. These contribute to develop a vision which integrates the diverse perspectives present in a group.

Managerial implications

Our study also holds some implications for practice. First, the analysis of groups through a cognitive network (Siew *et al.*, 2019) yielded relevant results which could help in supporting the organizational visioning process. Our findings suggest that individuals are influential in the network at different levels: Innovators, who are oriented to growth and change, represent their vision in a way that is central to the network –a synthesis of the visions of the group. Managers who wish to build on employees' visions to develop a new organizational vision may work with innovators (O'Connell *et al.*, 2011). Innovators can be identified based on past behaviors and integrate ideas coming from the network. On the other hand, collaborators are people whose vision representations are similar to a small set of visions. Thus, if managers wish to cultivate diverging visions and foster the creation of radical circles (Dell'Era *et al.*, 2018), they could support collaborators to cultivate a shared vision with people close to them.

Our study also has practical implications for team design (Rajagopal and Rajagopal, 2008; Kozlowski and Chao, 2018). Aggarwal and Woolley (2013) define a management approach in diverse contexts but admit a difficulty in controlling the composition of a team. While much research has shown the benefits of Cognitive Diversity in innovation teams (Shin *et al.*, 2012; Chen *et al.*, 2019), understanding which individuals are cognitive diverse and should be put together is difficult. In innovation, individual vision diversity is necessary to develop new visions. The individual visions act as starting point for an integrative, shared vision (Hensel and Visser, 2019). Thus, we suggest that members from different clusters in the cognitive network should join to assure cognitive diversity (Garcia Martinez *et al.*, 2017). Interestingly, our findings suggest against creating a team consisting of only innovators as their visions are similar to the representations of many others. Rather, Innovators should be complemented with Collaborators, who have a vision which is representative of a cluster.

Limitations and future research

Our study also holds some limitations, which open avenues for future research. First and foremost, our study is limited to visual content analysis. Bell and Davison (2013) stress the difficulties of analyzing visual content, which is ambiguous and vague. We have tried to bridge these barriers building on (Styhre, 2010), suggesting to analyze the structural and emotional content of images leveraging comparison of words (Miller, 1995) and emotions (Kobayashi, 1992). Yet, the choices made throughout this paper are selective of certain aspects on cognition within a team. The non-fluency in the English or visual language may hamper representations, undermining the outcome of the cognitive representation strategy (Joshi and Lahiri, 2015). Even the preference of individuals for different type of imagery (e.g. metaphorical vs. concrete) may influence similarity. With the emergence of Machine Learning techniques, a non-dictionary-based measurement method should be evaluated to resemble the human thinking process more thoroughly (Kenter and De Rijke, 2015; Zhang and Zhong, 2016).

Second, various studies have demonstrated the relation among cognition and innovation behavior or decision making (Shin *et al.*, 2012; Armstrong *et al.*, 2012). Our findings suggest that not only how information are processed, but also the resulting vision is related to behavior. Future studies could search how individual cognitive styles determine vision creation, and how the content of visions is related to innovation outcome.

Third, our analyses are limited to the cognitive domain. Yet, Kilduff and Lee (2020) suggest that the integration of people and network analyzes may yield further insights into group processes. Previous studies have mainly looked at social networks, integrated with cognitive variables (Perry-Smith and Mannucci, 2017). Future researchers may want to further explore the connection among cognitive and social networks (Wang, 2016).

Further, the adoption of network science also entails some limitations: Tasselli and Kilduff (2021) argue there to be a reciprocal influence among the position of an agent in the network and the resulting behavior. Thus, it remains unclear whether a person acquires a central position through a behavior, or if the behavior is a result of the position in the network. Further studies are necessary to investigate whether innovation and collaboration lead to central visions, or if the centrality in the network fosters certain attitudes.

In conclusion, our study joins literature in innovation management and the visioning process, analyzing individual visions in a cognitive network. Our findings yield a relevant contribution to understanding vision diversity in innovation and how innovative and collaborative attitudes may be leveraged. While innovators are central in the cognitive network, collaborators are central in a cluster of similar visions. Thus, organizations that wish to have a global overview should engage with innovators, whereas collaborators are helpful to foster radical visions in a group.

Note

1. Information omitted for peer-review purposes, website available at https://www.ideals.polimi.it/.

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