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How do people navigate their ideas during problem scoping of open-ended ill-defined problems? A knowledge graph-based approach

Keywords: knowledge exploration, problem scoping, ill-defined problems, open-ended problems, knowledge graphs

Extended Abstract

Many—if not most—important real world problems are complex, open-ended, and ill-defined. This implies that for such problems there is a potentially large set of relevant knowledge and perspectives and, consequently, also a large set of possible answers or solutions. We can find such open-ended and ill-defined problems emerging during crisis scenarios (e.g., COVID-19, climate change, etc.), and policy-making processes more generally, where it is not clear what the relevant knowledge domain is to successfully tackle the problem. Thus there is a serious risk of ignoring relevant perspectives. For example, developing effective and efficient climate change mitigation measures requires considering the perspectives of climate scientists, but also economists, behavioral scientists, health experts, communicators, educators, implementation scientists etc. Therefore, it seems prudent to have—prior to the actual problem-solving phase—an initial phase of *problem scoping* where the relevant knowledge domains, concepts, etc. are identified. This then should be useful in later phases of problem solving (e.g., in deciding which kinds of research fields, experts, practitioners, stakeholders etc. to involve).

Consider problem scoping as the process identifying the relevant subgraph of concepts from the full graph of general knowledge, as depicted by step *A* in the figure 1. This process can be understood as a heuristic process to prune a very large, broad knowledge space (e.g., everything that is in Wikipedia) to a much smaller subspace (e.g., a few dozen concepts or sites on Wikipedia). To our knowledge, there is no previous work on how to formally model people's navigation through such knowledge spaces and describing how people navigate such knowledge spaces during problem scoping.

In this proof-of-concept study, we pursue the development of a framework to describe the cognitive process behind problem scoping strategies, using methods of cognitive network science [9], natural language processing, and knowledge engineering [1]. We focus on how individuals, with no particularly strong expertise in the presented problems, approach the scoping of a series of open-ended ill-defined problems, presented as questions, when we ask them to respond providing a series of ideas they consider relevant to the problem as it were a *brainstormed fluency task*. We assume a problem knowledge space defined by its knowledge graph of related concepts (nodes) and relationships (edges), onto which the ideas provided can be mapped. Knowledge graphs have been widely used in cognitive tasks [9, 3], including knowledge spaces to navigate through [8, 4, 2]. As in [7], we use Wikipedia as good representation of all aggregated human knowledge, through one of its knowledge graphs: Wikidata[1]. For our purpose, we distinguish three necessary goals, as depicted in figure 1: (A) Identification of the **problem knowledge graph**: a subgraph from Wikidata containing all relevant aspects of such problem; (B) **mapping of ideas** onto the problem knowledge graph; and (C) **data**

[1] `https://www.wikidata.org/wiki/Wikidata`

analysis and description of the problem scoping process: (i) participants' ideas as free text snippets processed using natural language processing techniques [5] (e.g., entity extraction, word-embeddings) and translated into graph structures; and (ii) participants' demographic and cognitive characteristics (see figure 1). We are addressing the following research questions: (a) Which characteristics affect the way people explore the knowledge space? (b) Can we distinguish different types of *problem scopers*? – in analogy to [6] – And which associated strategies do they use? (c) Which properties (e.g., types of relationship between concepts) of the graphs are exploited?

These insights could provide us with a basis to further develop intervention strategies to reduce different exploration biases and ultimately provide more balanced exploration approaches that could enhance informed decision-making and reduce the risks of ignoring critical information. In addition, this could lead to the development of machine tools to support cognitive activities where biased information consumption behavioral patterns pose a risk for society, as shown in recent mis- and disinformation crises.

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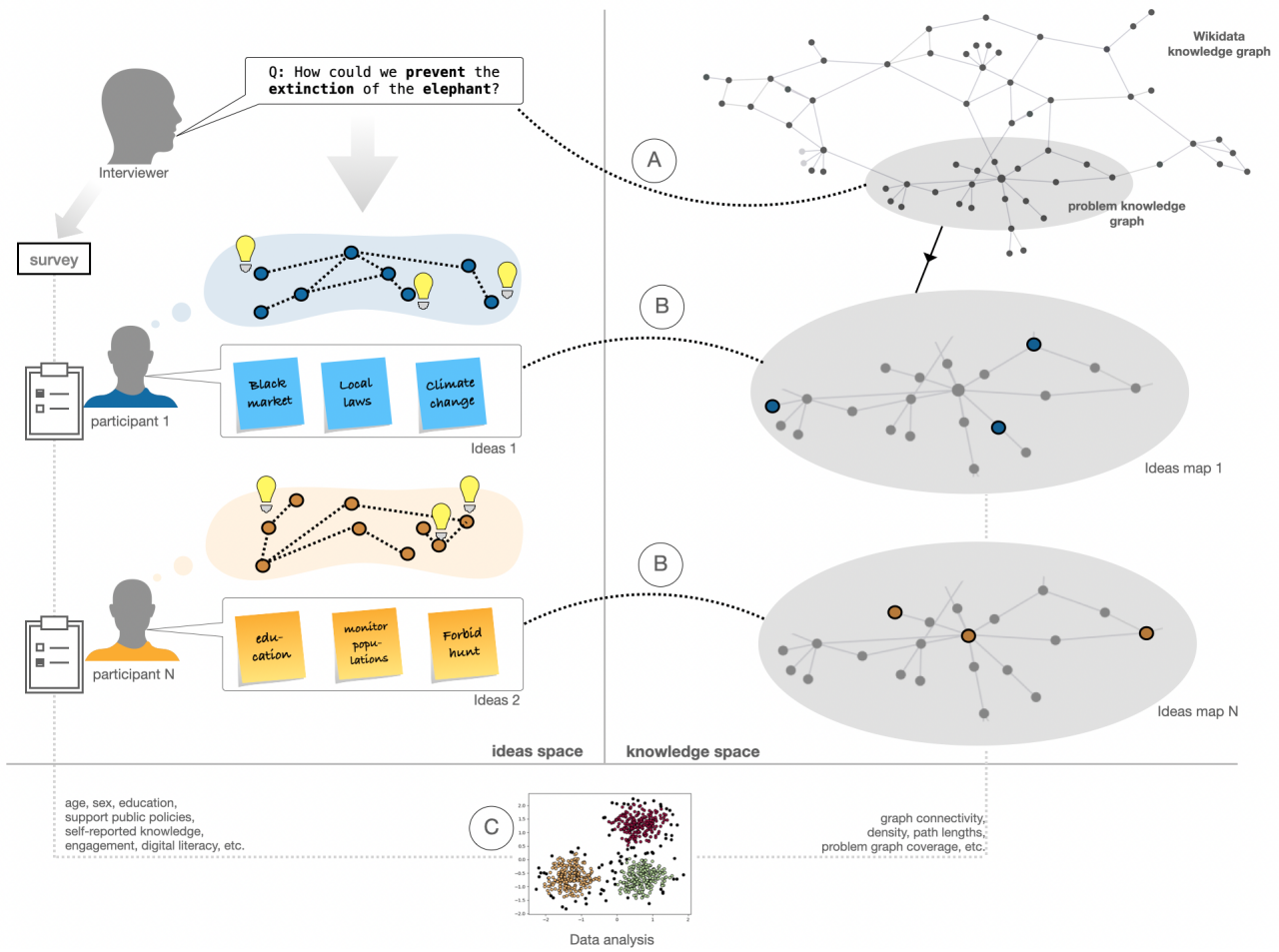

Figure 1: Participants are asked to brainstorm ideas they consider relevant to tackle the presented problems. Our goal is to show that: *(A)* we can represent the problem's knowledge domain as a subgraph of a general purpose knowledge graph (Wikidata[3]) using knowledge engineering and natural language processing techniques; *(B)* participants' ideas can be processed and mapped onto the problem knowledge graph; and *(C)* we can use the participants' demographic and cognitive characteristics (age, sex, level of education, support to public policies, political leaning, beliefs, self-assessed knowledge on the problems domain, self-reported concern and interest for the problems, digital literacy, curiosity, reasoning skills and divergent thinking) and properties of their ideas' maps (graph connectivity, density, path length, centrality, coverage, etc.) to describe and analyze the underlying problem scoping process.