Leveraging creativity techniques in requirements elicitation : a literature review

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Leveraging Creativity Techniques in Requirements Elicitation

A Literature Review

In recent years, Creativity-based Approaches for Requirements Elicitation (CAREs) have appeared as one promising trend to tackle the requirements elicitation problem. Creativity-based approaches have been the subject of important proposals of practitioners and researchers. CAREs foster the collaboration of stakeholders and requirements engineers in order to create innovative ideas for new systems.

Known requirement elicitation techniques, like brainstorming, workshops, and scenarios, have been traditionally used in these approaches; nonetheless, a large set of new techniques have emerged recently, e.g., viewpoints combination, analogical reasoning, and walkthroughs among others. The goal of this paper is to review creativity techniques for requirements elicitation, synthesize available knowledge and discuss their pros and cons.

1. Introduction

Requirements Engineering (RE) is recognized as a complex cognitive problem solving process which takes place in an unstructured and poorly-understood problem context [1]. Requirements elicitation is the activity generally regarded as the most crucial step in the RE process. The term “elicitation” is preferred to “capture”, to avoid the suggestion that requirements are out there to be collected simply by asking the right questions. Information gathered during requirements elicitation often has to be interpreted, analyzed, modeled and validated before the requirements engineer can feel confident that a complete set of requirements of a system have been obtained [2], [4]. Requirements elicitation comprises the set of activities that enable discovering, understanding and documenting of the goals and motives for building a proposed software system. It also involves identifying the requirements that the resulting system must satisfy in order to achieve these goals. The requirements to be elicited may range from modifications to well-understood problems and systems (i.e. software upgrades), to hazy understandings of new problems being automated, to relatively unconstrained requirements that are open to innovation (e.g. mass-market software) [3].

Elicitation still remains problematic; missing or mistaken requirements still delay projects and cause cost overruns. No firm definition has matured for requirements elicitation in comparison to other areas of RE [5]. A recent understanding describes the RE process as inherently creative, involving cycles of incremental building followed by insight-driven re-conceptualization of the problem space [1]. Moreover, in the last decade, a line of

academic works have recognized the importance of creativity in the requirements definition process. These approaches develop a vision in which requirements should be imagined and invented by stakeholders, instead of being simply “gathered” from them [2], [4]. The relevance of these works, in a context where innovative solutions represent a competitive advantage for companies, is noteworthy.

This article explores recent advances in Creativity-based Approaches for Requirements Elicitation (CAREs), examining their contributions to the requirements elicitation problem and the challenges to be faced in the future. In a previous work, aimed at understanding the progress that has been achieved in the requirements elicitation domain, a Systematic Literature Review (SLR) of proposals resulted in 505 publications [6]. As an important result we identified a promising set of proposals in the field of CAREs. Other studies related to creativity in the RE domain have been carried out i.e. [7], [8]; our research is complementary to them and its main difference consists in the focus on the requirements elicitation domain and creativity techniques. The main contribution of this work is the identification and characterization of an important set of creativity techniques in order to support the work of practitioners and stimulate their adoption.

This paper is organized as follows: section II introduces creativity in requirements elicitation, section III presents the method we have used in this paper, section IV introduces the results, section V discusses the obtained results and section VI considers conclusions and future works.

2. Creativity and Requirements Elicitation

From a cognitive psychology perspective, creativity is “the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task and constraints)” [10]. An idea is creative when it brings a new insight to a given situation [20]. The process of creativity includes the ability to change one's approach to a problem, to produce ideas that are both relevant and unusual, to see beyond the immediate situation, and to redefine the problem or some aspect of it. Creativity as a multidisciplinary research field has been investigated from the perspective of design, arts, psychology, literature, among other areas. In the field of requirements engineering, several authors have emphasized the importance of treating requirements elicitation as a creative problem solving process [11]. Indeed, while requirements were traditionally considered to exist in an implicit manner in the mind of stakeholders and the analyst´s job is to capture them, this view is now considered to drastically reduce the scope of the requirements engineering phase. Instead, invention is claimed to be an essential part of the requirements engineering activity, and “requirements analysts are ideally placed to innovate” [21].

Maiden and Robertson in [12] noted a lack of creativity theories and models in current requirements elicitation research and practice. In this paper, we adopted and were inspired by the framework developed by Nguyen and Shanks [9]. This framework provides a structured means for understanding the role and potential of creativity in requirements engineering. For the purpose of our study, we focus on the product and process perspectives. From a product perspective, three characteristics are essential: novelty (i.e. new, original), value (i.e. helpful, useful) and “surprisingness” (i.e. unusual, unexpected). From a process perspective, Nguyen and Shanks adopt the analysis of Boden in [14] and Shneiderman in [15]. They describe the creative process as an

internal process of exploration and transformation of conceptual spaces in the individual mind. They consider three views of a creative process, inspirationalist, structuralist, and situationist:

- Inspirationalist view tends to study how insight, the magical "Aha!" moment, occurs and emphasize an individual's creative cognitive processes. Wallas's model [16] is the dominant inspirationalist creative process model. Wallas describes his creative process model as consisting of four stages: preparation, incubation, illumination (insight), and the verification and expression of insight. Creativity involves conscious and unconscious mental processes and insight is seen as a breakthrough of unconscious ideas.

- Structuralist view is influenced by an alternative theory to problem solving which emphasizes a rational, systematic and structured search for information and the evaluation and selection of alternative solutions. The core of structuralist creative processes lies in the deliberate generation and evaluation of ideas. Therefore, a structured, guided process of divergent and convergent thinking exists in various structuralist process models.

- Situationalist view emphasizes the role of the human and social environment and professional domain in the creative collaborative process. Overall, the situationalist view incorporates the communication of creative ideas within teams and thus has the potential to be aligned within core requirements elicitation activities including requirements communication, negotiation and agreement [4].

3. Method

This paper focuses on techniques used in creativity-based approaches for requirements elicitation. The term technique is used here to denote any specific way of handling, conducting or managing the requirements elicitation task. In the first place, we have taken the set of CAREs identified in a previously published systematic review of the requirements elicitation literature [6]. Using the snowball technique to identify and select relevant studies in the literature, each of the articles was scanned aiming to find new CAREs in their references. Once a candidate paper was found we read the abstract to validate the criteria: (1) the paper must deal with a proposal for CAREs and (2) the paper must be published in a recognized scientific database i.e. IEEE, ACM, Springer among others. Moreover, we compared the list of papers we obtained with those included in a similar literature review publication [7]. At the end of this process we obtained the final set of papers dealing with CAREs (see Appendix 1). Analyzing carefully each paper, we extracted and identified the creativity technique that is proposed and used in the paper. The techniques are classified according to two dimensions, product (i.e. representation) vs. process. A technique is *representation-oriented* if it seeks to stimulate creativity by introducing a specific manner for describing the result of the requirements elicitation task. It is *process-oriented* if it defines a specific manner for handling the requirements elicitation task. Three subcategories are defined: *organizational* if the technique prescribes how the elicitation process is to be conducted and organized in order to be creative, *psychological* if the technique prescribes a way to psychologically stimulate the participant's ability to be creative; and *cognitive* if the technique prescribes a way to stimulate the participant's

cognitive capacities in being creative.

4. Results

We have selected 23 papers that present creativity approaches for requirements elicitation. They are presented in Appendix 1 and are numbered A1, A2, etc. From this set of papers, we have identified 30 different creativity techniques that are explicitly defined and used in these studies. The techniques are presented here according to the two perspectives: product and process. For each technique, we provide a brief definition, and when available, a short example that illustrates the applicability of the technique. This information is synthesized from the corresponding paper in Appendix 1.

4.1 Representation-oriented techniques

These techniques focus on the means by which requirements are represented. Creativity is expected to be stimulated because models help in capturing requirements in original and innovative ways.

Creativity technique: Topic maps	
Definition: a topic map consists of a set of nodes, linked by associations. A node may fill a specific role in an association. The representation mechanism also supports the subclass relation and the instance-of relation [A11], [22].	**Usage example:** in A11, the knowledge associated to a "selling goods" problem is represented as topic maps which are used to support the reasoning and generation of new ideas from a proposed set of heuristics. Other examples can be found in [22][22].
Creativity technique: Goal modeling	
Definition: consists in the use of goal models during RE activities as part of a creativity methodology guided by tool-support [A7]. Many goal-oriented notations for eliciting requirements have been proposed in the last decade, interested readers can see literature reviews on this subject (e.g. [17]).	**Usage example:** in A7, the authors present a running example of train transport from London airports, specifically, the purchase of tickets, which offers the possibility of many different train services at different prices and routes, and can be confusing to visitors. Using the goal-oriented notation i*, models of the problem are built and used as entry to creativity techniques which allow the reasoning on these models and the idea generation.
Creativity technique: Scenarios	
Definition: as the name suggests, scenarios are narrative and specific descriptions of current and future processes including actions and interactions between the users and the system [18], [23]. NB: we have classified the Scenarios also as a cognitive technique because writing a concrete scenario helps stakeholders in better grasping the functional and non-functional requirements for future systems.	**Usage example:** in A3, the authors foster creativity exploring the different uses of scenarios on requirements discovery using results from requirements processes in two projects. The first specified requirements on a new aircraft management system at a regional UK airport to reduce its environmental impact. The second specified new work-based learning tools to be adopted by a consortium of organizations. Other examples can be found in [23].
Creativity technique: Storyboard	
Storyboard is an extended version of the Scenarios technique. Beyond textual descriptions for a scenario, it	**Usage example:** in A4 storyboarding is used to generate requirements for a security access system scenario. Other

combines visual representations with graphics and text to describe system behaviors in a concrete form directly observable by stakeholders [A4], [24].	examples can be found in [24].

4.2 Process-oriented techniques

We present the process-oriented techniques according to three subcategories: organizational, cognitive and psychological.

4.2.1 Organizational perspective

Techniques in this category concern the way the requirements elicitation process is to be organized. We find here well-known techniques such as creativity workshops and brainstorming sessions; other more specific techniques seek to take stakeholders out of the usual brainstorming protocol and create new settings for collectively exploring the requirements elicitation problem. These techniques are generally combined with other techniques from the representation perspective (e.g. goal modeling) or the cognitive process perspective (e.g. analogies).

Creativity technique: Creativity Workshops	
Definition: a Workshop is a generic term given to a number of different types of group meetings where the emphasis is on collectively developing and discovering requirements for a software system [18].	**Usage example:** Within health care domain, a group of diabetes patients, doctors and nurses created visions about the technology and how they could be helped in their daily management of the disease. They collaboratively constructed a conceptual text-based scenario landscape relating to the participants' common situations and problems [A19].
Creativity technique: Brainstorming	
Definition: Brainstorming is a process where participants from different stakeholder groups engage in informal discussion to rapidly generate as many ideas as possible without focusing on any one in particular. It is important when conducting this type of group work to avoid exploring or critiquing ideas in great detail [18].	**Usage example:** In A7, using the London Airport Trains system, the authors illustrate the use of brainstorming in conjunction with goal models in order to help users to build and fill in the details of i* models.
Creativity technique: Roles playing	
Definition: Consists in the use of different roles (e.g. explorer, artist, judge, and warrior) to focus the participants on ideas generation from diverse and unexpected perspectives [A1].	**Usage example:** In a software project in the Air traffic management domain, workshop participants were encouraged to play each other's controller, pilot, and manager roles to generate ideas from unencumbered perspectives [A1].
Creativity technique: Walt Disney	
Definition: This technique decomposes the creative process into three different steps called Dreamer, Critique, and Realist, respectively. Each of these steps would usually lead to prolonged	

sessions, which could easily need several hours. While the basic goals of these steps are well defined, their detailed performance is hardly defined and no detailed guidance on their performance is given [A10].	
Creativity technique: Game mechanics	
Definition: This technique provides levels and goals, which can be in the form of awards, credits and acknowledgements, in order to motivate and engage participants in the creative problem solving process [A5].	**Usage example:** COLLAGE is an EU-funded Integrated Project, to inform and enable the design of effective Web 2.0 social creativity and learning technologies and services. Game mechanics are employed as a means to set intermediate goals in the overall search space that will both guide and engage problem solvers in further creative activities. Just as a game has levels that one tries to achieve, so should each creative search activity be informed by specific goals; game mechanics are used to provide these goals. Each subspace reveals a new goal that compels the problem solver to continue their creative search activity [A5].
Creativity technique: Positive space design	
Definition: Space design refers to the context in which creativity takes place, including its environment, place, situation and climate. It can also refer to the environment the person is in, the product that is produced or the process that takes place, and explains the interaction between the person and situation that can promote (positive) or inhibit creativity [A6].	**Usage example:** In A6, the authors illustrate the design of a positive space which included colorful, round-shaped furniture at different heights, a bed and vivid cushions that could support people standing, sitting in different positions and lying. The intention was to create a feeling of being at home. Other features of the positive space included hanging handmade lanterns to decrease the ceiling height, colorful pictures with positive themes such as food, nature, happiness, excitement, and people, pot plants, and windows to provide views of nature
Creativity technique: Hall of fame	
Definition: This creativity technique helps the participant to take a step away from the most obvious and reasonable perspectives by consulting the world great minds. The participants used these characters to force connections and generate new requirements for their projects by consulting the famous people [A23], [25].	**Usage example:** In A23, the authors illustrate and evaluate the Hall of fame and Idea box techniques. In total, 34 creativity workshops were conducted with 90 students from two universities, and 86 industrial practitioners from six companies. The results indicate that Hall of Fame was the technique that led to the greatest number of requirements that were included in future releases of the products. Other examples can be found in [25].
Creativity technique: Creative spaces for conversations	
Definition: Consists in the use of spaces that embrace creative conversations. The spaces bring together many project stakeholders and the creative team to address the social challenge in creative and innovative ways [A18], [26].	**Usage example:** The company Uscreates (UK) supports public-sector behavior change programs. During the design stage, Uscreates designs spaces that embrace creative conversations. The spaces bring together many project stakeholders including local authorities, community groups, and members of the target audience, and the creative team to address the social challenge in creative and innovative ways. Other examples can be found in [26].

4.2.2 Cognitive perspective

This category includes the largest number of techniques. This is easily explained by the fact that creativity is essentially a cognitive ability [13]. Some of these techniques are renown in other fields of research, e.g. constraint removal in innovation management; other techniques have been specifically designed for requirements elicitation.

Creativity technique: Constructivist learning	
Definition: Constructivist learning refers to two knowledge building mechanisms: assimilation and accommodation. Through assimilation, the learner interprets and incorporates new knowledge into an existing conceptual framework representing his or her knowledge of a topic area. Accommodation occurs when the learner could not fit the new learning into his or her existing framework, as a result he or she reframes (restructures) the existing conceptual framework [A13].	**Usage example:** Two experiential digital simulations (simulation of interviews system and simulation of requirements analysis system) are used as a proof of concept. Learning from these case studies suggests that both systems analyst and business users can be stimulated to be active learners in their discovery of problem, creative ideas and problem solutions in requirements elicitation and discovery.
Creativity technique: Analogies	
Definition: Analysts use previous experience in similar domains as a discussion template for facilitating group work and conducting interviews. Analogies and abstractions of existing problem domains can be used as baselines to acquire specific and detailed information, identify and describe possible solution systems [18].	**Usage example:** In the air traffic management (ATM) domain, in order to explore new ideas for conflict resolution, the authors invited a textile expert to discuss Indian textile design and a musician to discuss modern music composition. Participants were encouraged to find analogies between these domains and ATM, then to generate new ideas about conflict resolution using those analogical elements [A1].
Creativity technique: Presenting solution space knowledge	
Definition: In this technique people change the solution space in a way that things that were considered impossible are now possible [A1].	**Usage example:** The authors worked with Eurocontrol, the organization overseeing European air space. This organization has a complex sociotechnical system named CORA-2. Air traffic controllers will resolve aircraft conflicts using resolutions and advice from the CORA-2 software. The authors wanted CORA-2 requirements to specify how controllers should work and interact with the software system as well as how the software system should function—for example, how to increase automated support for controllers without deskilling them. In this context, the facilitators encouraged participants to change the CORA-2 solution space to make possible ideas that participants once considered impossible [A1].
Creativity technique: Constraints removal	
Definition: This technique identifies and challenges the current constraints of the system in order to eliminate them in a new solution [A1].	**Usage example:** In A6, the authors encouraged two design groups to identify multiple constraints on a supermarket car park service, select constraints to eliminate, diminish or reinterpret, and then generate new ideas in the less-constrained ideas spaces.

Creativity technique: Combining ideas	
Definition: This technique creates new ideas from a combination and synthesis of existing ideas [A1].	**Usage example:** Combinatorial creative thinking is encouraged by means of different strategies e.g. randomly introducing unexpected items into the scenarios. The facilitators encouraged participants to investigate pairs of existing requirements and ideas to create new ones from unforeseen combinations [A1].
Creativity technique: Walkthroughs	
Definition: The requirements engineer leads stakeholders through a segment of documentation and the participants ask questions and make comments about possible errors, violations, omissions and other problems. The big idea behind walkthroughs is very simple: people are better at recognition than recall [A4].	**Usage example:** Each analyst walked through the scenario to discover and document requirements for the security access system. Next, the experimenter seeded the software tool combin-Formation with queries. The analyst continued the walkthrough with the tool to discover and document requirements [A4]. Other examples can be found in [27][27].
Creativity technique: Viewpoints	
Definition: This technique aims to model the domain from different perspectives in order to develop a complete and consistent description of the target system [18].	**Usage example:** Two experiments in A8 illustrate the proposal. The first one corresponds to the development of the Corsi Online system (a Web application to help manage on-line courses for a university) and the second one was conducted at the software company that had developed Civilia to support community services for citizens [A8].
Creativity technique: Deconstruction	
Definition: The basic idea of this technique is to start with the usual perception the developers had of their products and step-by-step remove certain constituents. Then the participants would need to replace them with something else [A10].	**Usage example:** In A10, the authors illustrate the use of the deconstruction, questions list and Walt Disney techniques with a case study corresponding to the development of an automatic web content creation system.
Creativity technique: Questions list	
Definition: Consists in the use of questions as a means to support divergent thinking [A10].	**See usage example for technique** “Deconstruction”.
Creativity technique: Heuristics	
Definition: A heuristic technique is a rule of thumb, strategy, trick, simplification, or any other kind of device which drastically limits search for solutions in large problem spaces. Heuristics do not guarantee optimal solutions; in fact, they do not guarantee any solution at all; all that can be said for a useful heuristic is that it offers solutions which are good enough most of the time [19].	**Usage example:** The use of heuristics is exemplified in A11 where the authors propose a set of heuristics which support the reasoning and generation of new ideas from a problem knowledge (“selling goods”) represented as topic maps. Other examples can be found in [22].
Creativity technique: Why why why?	

Definition: This technique urges the users to constantly question the motivation for each element of a system design. This, obviously, can help the user to move up the model, adding higher level intentions until the why question is no longer sensible [A7].	**Usage example:** The use of this technique is showed by means of the train transport from London airports [A7]. I* models of the problem are built and used in conjunction with why questions urging users to constantly question the motivation for each element of the goal models.
Creativity technique: Idea box	
Definition: The Idea Box technique starts by stating a challenge, followed by selecting the parameters of the stated challenge. Then, a list of options for each parameter is created, and finally, the participant should try different combinations to find new concepts and requirements [A23], [28].	**See usage example for technique** "Hall of Fame" in section 4.2.1. Other examples can be found in [28].
Creativity technique: Design rationale	
Design rationale, in simple words, is information which represents and explains the reasoning behind the requirements engineering process [A12]	
Creativity technique: Physualization	
Definition: Physualization is the physical manipulation of visualization entities – it is not just visualization for the sake of communicating or creating a record. Physualization actively promotes physical manipulation to help participants explore possibilities in the requirement and design spaces by engaging more of their sensory and cognitive processes – possibly leading to improvements in the requirements process and resulting artifacts [A15].	**Usage example:** The author presents examples taken from work performed in gathering requirements for video games. The focus in the work sessions was on capturing the intended user experience in general, and the intended emotional experience in particular [A15].
Creativity technique: Speed modeling	
Definition: It is a 3D form of brainstorming. Rather than exploring a subject area or question through a typical, written brainstorming, a facilitator poses a number of questions that participants have to answer by modeling with Plasticine within 30 seconds to three minutes. The time limit encourages quick thought and prevents participants from feeling conscious of the quality of their creativity and ability to express it [A18], [26].	**See usage example for technique** "Creative spaces for conversations" in section 4.2.1 Other examples can be found in [26].
Creativity technique: Picture stimulation	

Definition: In this technique a particular problem or idea can be reinvented using different angles motivated from pictures [A19]	**Usage example:** Picture stimulation and Cultural probing techniques were used in projects MAGNET (2004-2005) and MAGNET Beyond (2006-2008), part of the IST EU program, to express wishes and needs in the requirements identification [A19].
Creativity technique: Cultural probing	
Definition: Cultural probing is a technique which allows the user to carry around a probe designed to provoke inspirational responses in different circumstances [A19].	**See usage example for technique** "Picture stimulation"

4.2.3 Psychological perspective

The idea behind these techniques is to stimulate the individual's state of mind (e.g. humor, emotions, etc.) in order to enhance the cognitive abilities and encourage creativity. We identified only one technique in this category.

Creativity technique: Influence positive emotions	
Definition: Positive emotions technique seeks to adapt the way people think and act such that creativity during idea generation is augmented. Interactive systems can be designed to stimulate and influence participants' emotions and get more out of their own creative capabilities [A22].	**Usage example:** de Rooij et al. developed an interactive system in order to validate whether this system can be used to hack into the function of cognitive appraisal processes in emotion, positive emotions in particular, and that this can be used to augment creative ideation. Their findings show that effectively, an interactive system can be used to augment creative ideation [A22].

5. Discussion

The techniques we have presented browse a large spectrum of ideas for stimulating creativity and helping requirements engineering in finding ways to take stakeholders out of conventional settings. For maximum efficacy, these techniques need to be combined together. Indeed, most of the studies combine many techniques; only 5 papers rely on one single technique. On the other hand, a small subset of techniques (e.g. scenarios and brainstorming) is well-known in the requirements elicitation domain and these techniques are applied in many studies. However, a large set of techniques can be considered as "outsiders", i.e. they are at the stage of academic proposals, and have been applied in the context of only one single study (e.g. Topic maps, Cultural probing, etc.). Nevertheless, the profusion of creativity techniques illustrates their growing importance for the requirement engineering community.

5.1 Advantages and limitations of CAREs

With no doubt, the main advantage is the amount of requirements generated in a short time. Additional benefits include: the diversity of generated ideas from different stakeholders which typically differ from those generated with "standard" requirements elicitation techniques; shaking people out of tried and tested ways of thinking about requirements; Improvement of communication between stakeholders and Improvement of organizational

climate which facilitates the creativity processes, among others.

On the other hand, the main drawback of these techniques is the difficulty to implement in industrial settings due to the fact that a lot of resources and effort are required, which results expensive for companies. Indeed, participants of the experiments often reported having difficulty with using some these techniques. Furthermore, some authors argued that due to time-to-market constraints, there was insufficient time for creative thinking during requirements elicitation activities.

These advantages and limitations should be considered by researchers and practitioners when selecting CAREs. Likewise, techniques limitations introduce important challenges to be faced by researchers and practitioners in the future.

5.2 Some outstanding researchers and groups

Considering papers in appendix 1, it is necessary to highlight the work of Prof. N. Maiden and his research group who are by far the most prolific authors in this study with 7 articles (30.4 % of articles). Besides the number of publications, his influence in other authors´ approaches is remarkable as can be evidenced by the multiple references to his work. The proposals of Prof. Maiden range from 2004 to 2015; this gives us a measure of his permanent contributions to the field. Other outstanding authors of our study are: Berry et al., Schmid et al. and Nguyen et al. (8.7 % of articles each, 2 articles each).

6. Conclusions and future works

In order to explore recent advances in Creativity-based Approaches for Requirements Elicitation (CAREs), we have conducted a literature review and identified a set of 30 techniques to support creativity in requirements elicitation. Inspired by the framework of Nguyen and Shanks [9], these techniques were characterized according to two perspectives: product and process. The process perspective is specialized further to capture organizational, cognitive and psychological facts of the requirements elicitation process. Some of these techniques are well-known for requirements elicitation; however, most of them are new and illustrate the growing interest of the research community. Although some techniques have been applied on real world projects and in an industrial context, for most of these techniques, the available evidence is insufficient to demonstrate their feasibility and added value. More experimental and empirical research about creativity techniques for requirements elicitation is needed.

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Appendix 1. Analyzed CAREs aiming to answer the research questions.

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Appendix 2. Detailed analysis of the selected CAREs

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