Balee Carpet Karuta: Interactive Generation of Data Analytical Requirements and Hypothetical Questions

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Abstract

The effective selection of data for artificial intelligence (AI) is crucial for enhancing well-being, yet translating requirements for data utilization into concrete implementations remains challenging. This paper presents Balee Carpet Karuta (BCK), a novel workshop framework that transforms the traditional Japanese card game "Karuta" into a logic-generation game enhanced by network-based card visualization. By uniquely integrating competitive game with co-creative data utilization workshops, BCK bridges the gap between abstract requirements and concrete, actionable data solutions. Through a case study with the Data Society Alliance, BCK demonstrated how participant interactions led to the evolution of both requirements and solutions, with initial requirements becoming more descriptive while solutions emerged as novel analytical questions worthy of investigation.

Introduction

There is an increasing demand for artificial intelligence (AI) systems to enhance well-being (Kido and Takadama 2023). The realization of well-being encompasses various aspects including career, social, financial, physical, and community elements (Rath and Harter 2010), making it a complex multidimensional goal. This complexity presents unique challenges for AI systems. Particularly, the selection and utilization of data for AI training and analysis is crucial, where requirements (what we need to achieve) and solutions (how we use data to meet these needs) must be carefully paired to ensure effective outcomes (Sekiguchi and Ohsawa 2024).

A promising approach to address these challenges is through co-creation. While collaborative workshops involving diverse stakeholders are commonly employed to facilitate requirement-solution matching (Ohsawa et al. 2013), successfully bridging the gap between initial requirement-solution matching and practical implementation of data analysis remains a significant challenge. Therefore, developing frrameworks that can translate requirements into actionable implementation plans is essential.

Therefore, this paper aims to implement a mechanism that promotes the generation of practical initiatives by applying an extended Karuta card game framework (Balee Carpet Karuta, BCK) to data utilization.

Related Work

BCK implements a co-creative, card-based gamified framework to enhance data utilization effectiveness. In the context of co-creation, traditional brainstorming approaches encourage participants not to be judgmental or obstructive, allowing for productive generation of ideas (Brown and Wyatt 2010). Furthermore, brainstorming emphasizes the use of emotional and intuitive thinking rather than rational thinking (Tschimmel 2012). Brainstorming has demonstrated that implementing these appropriate rules facilitates its desirable outcomes, i.e., making as many ideas as possible.

One promising approach to enhance such rules is through gamification. In the work domain, gamification has shown positive psychological impacts, including improved motivation, outcomes, and well-being, as well as organizational benefits such as enhanced team performance and productivity (Ferreira-Oliveira et al. 2017). Furthermore, the effect of *competitive* elements has been studied. Research by (Cagiltay, Ozcelik, and Ozcelik 2015) indicates that competition improves motivation and outcomes in serious games (games designed for purposes beyond entertainment) such as learning games.

The use of cards in creative activities has also been investigated. A review by (Wölfel and Merritt 2013) highlighted that cards offer benefits including simplicity, tangibility, and ease of manipulation. The review also suggested that cards can serve as communication tools that encourage criticism, debate, and collaboration. Additionally, cards enable simultaneous viewing, structuring, and grouping of information.

In data utilization, a co-creative gamified method called Innovators Marketplace on Data Jackets (IMDJ) has been proposed (Ohsawa et al. 2013). IMDJ matches novel form of metadata (Data Jacket) with solutions in a market-simulated game where multiple requirements and solutions coexist. While participants compete to earn the most simulated money, competition for individual requirements remains moderate. For example, IMDJ allows strategies targeting less competitive niches.

Recent data-driven decision methods utilize large language models (LLMs), which can be understood as co-creative activities between humans and LLMs. A review by (Glickman and Zhang 2024) dealt with AI and generative AI applications in research discovery and summarization. Their review indicates that LLMs utilize abduction, which

is partially based on intuitive thinking, as well as deduction and induction. Their applications range from the discovery of methods, literature, and topics to summarizing and visualizing them and conducting comparative analysis. While LLMs are highly applicable to various tasks, they require specialized instructions and mechanisms to achieve high effectiveness for specific purposes, such as matching requirements with solutions and leveraging competitive elements. As such a specialized application, an LLM-based gamified tool for realizing explainable AI has been proposed, which allows non-technical users to learn about machine learning models through interactive dialogue with LLM-powered characters representing visualized model states (You and Zhao 2024).

However, the application of card games incorporating competitive elements specifically for data utilization workshops remains understudied. This approach is effective because card games, particularly those involving competitive pair-matching, drive participants toward more effective matching of requirements with solutions. Therefore, developing a novel framework for competitive card-based data utilization workshops represents a significant contribution to these fields. Table 1 illustrates the positioning of BCK, which demonstrates the highest effectiveness rate.

Balee Carpet Karuta for Data Utilization

Basic Concepts

This research introduces Balee Carpet Karuta (BCK), a novel framework that utilizes a visual mapping system to display spatial relationships between cards (Karuta), enabling participants to observe interconnections during interactive sessions. In this framework, participants engage in competitive discourse while proposing viable solutions to given requirements, articulating their underlying reasoning processes. A distinctive feature of this approach is that these solution explanations inherently function as catalysts for generating new questions (hypotheses), thereby fostering motivation to actively address the problems identified.

Why Karuta?

When referring to Karuta in this research, we primarily focus on "Kyodo Karuta" (Local Karuta), which has many variations created throughout Japan. According to (Haraguchi and Yamaguchi 1995), Kyodo Karuta typically represents a prefecture or municipality, featuring local content such as nature, history, industry, culture, and place names in the form of Japanese syllabary cards (Iroha Karuta). "Carta," originally introduced to Japan from Portugal, had gambling characteristics. However, Kyodo Karuta evolved by combining Carta with traditional Japanese play activities. This evolved form has educational value, as players naturally acquire both knowledge and emotional connections to their local region through play.

Figure 1 shows an image of the first Balee Carpet Karuta (BCK) held at Hitoyoshi-shi, Kumamoto prefecture, Japan, using Hitoyoshi Kuma Kyodo Karuta (Sakura-kai 2024; Hitoyoshi Press 2024). As with traditional Karuta, BCK recommends playing while sitting directly on tatami mats (or straw mats, carpets, etc.).

Figure 1: An image of the first Balee Carpet Karuta held at Hitoyoshi-shi, Kumamoto prefecture, Japan.

While traditional Kyodo Karuta, as an Iroha Karuta, was a "sound matching" game where players match cards based on the initial sounds of the reading cards, BCK represents a significant modification by transforming it into a "logic generation" game that matches requirements with solutions based on content. This modification enables the generation of hypothetical questions for various activities, e.g., regional revitalization and data utilization.

Visualization of Karuta Cards

One of the distinctive features of general card games is their ability to provide an overview of multiple cards at a glance. BCK enhances this feature by visualizing the relationships between cards on a network through keyword analysis. Specifically, cards with similar keywords (perspectives) are clustered together in the visualization, supporting the generation of ideas.

For visualizing card relationships, we utilized the BaleeGraph (Sekiguchi et al. 2023) tool. Figure 2 illustrates the result of this visualization for DSA workshop. A network overview appears in the upper left to show the overall structure (detailed examination is not necessary). As shown in the lower part, central black nodes correspond to card names (i.e., torihuda), and keywords extracted from card contents (i.e., yomihuda) are radially arranged with blue edges. Then, initially blue keyword nodes turn red and form new red edges when sufficient similarity with keywords from other cards is calculated, with the overall layout following a mechanism where strongly connected nodes cluster together. The upper right spout shows the contents of the enlarged part. In Figure 2 (and Figure 4), dashed lines and italic fonts indicate supplemental information. This map is also available in https://baleegraph.com/gallery_view?graph_id=1408.

For data utilization, it is crucial to understand the relationship between requirements and solutions from the perspective of scenarios consisting of phenomena such as events, situations, and actions. Therefore, key technologies employed in BCK for data utilization include Feature Concept and

Features Significant for This Study	Traditional Brainstorming	Innovators Marketplace on Data Jackets (IMDJ)	Large Language Models (LLMs) for Research	LLM-Powered Narrative Gamifications Tool	Balee Carpet Karuta (BCK)
Based on co-creation	++	++	++	++	++
Utilizes emotional and intuitive thinking	++	++	++	++	++
Utilizes rational thinking (e.g., criticism and judgment)	-	++	++	++	++
Applicable to data requirements and solutions matching	++	++	+	-	++
Generates deeply refined ideas through competition	-	+	+	+	++

Table 1: An overview of the comparative features of Balee Carpet Karuta (++: Highly Effective, +: Effective, -: Not Effective). See also (Brown and Wyatt 2010; Tschimmel 2012; Ohsawa et al. 2013; Glickman and Zhang 2024; You and Zhao 2024).

Data Leaves (FC-DL) (Ohsawa et al. 2022). A feature concept (FC) is a representation of these phenomena as patterns that they aim to obtain; a Data Leaf (DL) represents the FC that is expected to be visible from a single dataset (Ohsawa et al. 2022). Therefore, we can realize requirement-solution matching by considering FC-DL relations.

Basic Rules

The basic rules of BCK are as follows:

1. One participant (requester) states personal and/or social requirements
2. Other participants (proposers) select one or more cards (Proposals of alternative data not present in the available cards are also permitted)
3. Proposers explain their card selection rationale
4. The requester selects his/her preferred proposal
5. The selected proposer acquires the card(s) and other proposers return their cards
6. Return to step 1 and continue in a clockwise order until everyone has served as a requester

Then, the rules were finely customized to accommodate participants' interests and circumstances. For example, when video/audio recording is not possible, write-in cards are used to document proposed ideas and selection results.

Workflow

The workflow of BCK is shown in Figure 3. The main actors involved are the requester and N proposers ($N \geq 2$) as well as the organizer. This workflow aligns with the operation of the previously mentioned basic rules. However, for simplicity, this workflow focuses on the thinking process, omitting operations such as holding or returning cards.

What distinguishes this approach from traditional brainstorming is the incorporation of an iterative cycle, i.e., a rectangle and a rhombus with horizontal hatching ($\times N$, theoretically) in Figure 3. For proposals to be accepted, proposers should refine their own ideas by evaluating ideas' interest and potential acceptability among other participants. Through this cycle, the game not only facilitates the generation of new ideas but also encourages deeper exploration of proposals. This process requires not only emotional and intuitive thinking as in brainstorming but also rational thinking as an essential part because it is necessary to explain the logic of why the proposed idea is effective for the request.

The second significant cycle in this process involves the iterative refinement of requirements through game communication (two rhombuses and two rectangles with vertical hatching in Figure 3). The key mechanism has been added where the requester can modify or update either the content of the requirements or the way they are explained, taking into account the solutions and questions presented by the proposers. The rational thinking of the requester, such as criticism and judgment of proposals, is also expected.

Moreover, the number of requesters directly correlates with the number of iteration cycles, enabling proposers to conduct more thorough explorations of promising solutions through competitive engagement while allowing requesters to refine their requirements.

Narrative Structure

To realize better relationship between humans and AI, narrative structures in data utilization is crucial to control the process. Therefore, to analyze this relationship, we adopt the hierarchical narrative representation (HieNaR) framework (Sekiguchi and Ohsawa 2024). Here, we chiefly deal with AI for analyzing data.

The HieNaR framework consists of three primary axes. The vertical axis represents hierarchical narrative levels such as Set of texts (Worldview), Text (Narrative), Subtext, Sentence, Subsentence, and Word. The horizontal axis depicts three states of expression: Raw State, Descriptive State, and Patterned State. Then, the horizontal and depth axes of each plane (depicted by solid or dotted lines) correspond to the visualizations being addressed. In this study, the depth dimension represents the relationship between objectives and means, with requirements positioned toward the back and concrete data toward the front.

In the discussion section, we will describe how this arrangement explain the requirement-solution matching in BCK workshops.

Social Implementation of Balee Carpet Karuta

We have already conducted six workshops across various settings as social implementations: (a) Workshop with lo-

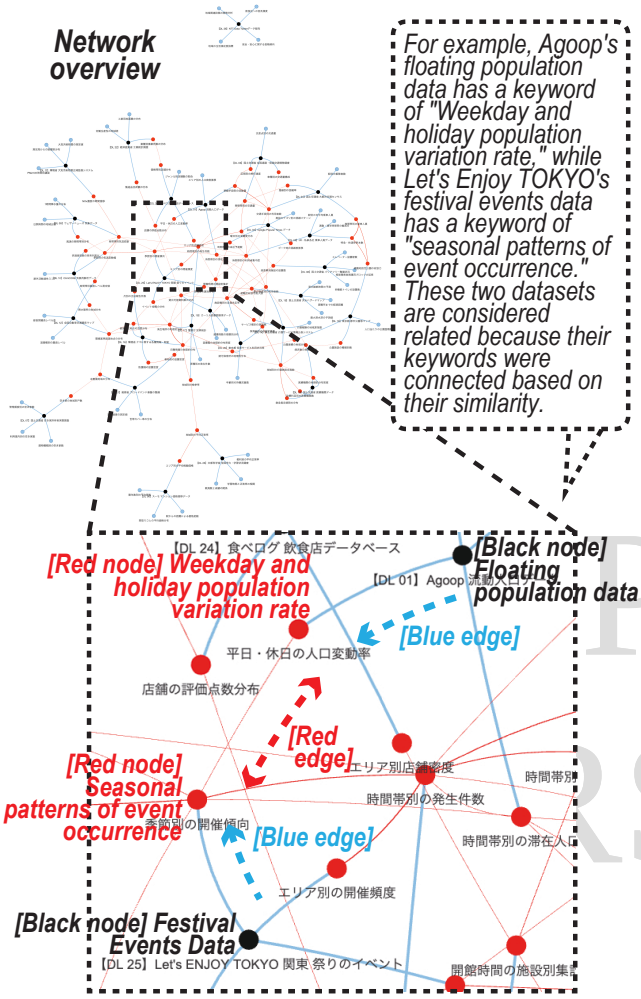

Figure 2: The map visualization used in the Data Society Alliance workshop using BaleeGraph. See also https://baleegraph.com/gallery_view?graph_id=1408

cal residents in Hitoyoshi-shi, Kumamoto prefecture, Japan; (b) Workshop at a joint study session with six research collaborative companies; (c) Workshop customized for specific themes with one research collaborative company; (d) Workshop for a Data Society Alliance (DSA) working group; (e) Ice break workshop at an academic seminar for young researchers; (f) Workshop at a School of Engineering lecture.

Through co-creation with society, BCK has been developed and implemented. In fact, through game (a), the rule of having solutions compete with each other emerged naturally and became established as a key feature of BCK.

Among these, four BCKs, excluding (a) and (e), incorporated data utilization support as a theme. In this paper, we report on a representative case (d) conducted at DSA.

Settings of Data Society Alliance Workshop

Outline of the Game

The DSA workshop was co-hosted by a DSA working group and the Data Federative Innovation Literacy initiative at The University of Tokyo and was held on November 7th, 2024. Ten participants, including two organizers, six professionals, and two undergraduate students (one participating partially), engaged in the BCK game session. The professional backgrounds of eight participants primarily related to data analytics and utilization, while the remaining two came from different sectors: one was a business person from a manufacturing company and the other was an administrator at a funding agency.

This DSA workshop explored “desirable cities to live in” as its theme. Participants individually presented their visions for ideal city characteristics as requirements, while others proposed data utilization scenarios to promote or verify these visions. Video recordings of the BCK activities were taken to enable subsequent analysis. The language used was Japanese.

Generating a Customized Karuta

For the DSA workshop, we designed a game matching requirements and solutions for data utilization, rather than using existing Kyodo Karuta contents. Therefore, to implement BCK, we needed to create original Karuta cards tailored to our specific objectives.

We created the Karuta through interactive sessions with a large language model (LLM: Claude 3.5 Sonnet). The primary interactions with the LLM were as follows: We (one author and the LLM) began our development process with the identification of distinctive cities among Tokyo’s wards and municipalities, analyzing their advantages and disadvantages from a residential perspective. We then compiled comprehensive open data sources for evaluating residential desirability, incorporating data from government agencies, private organizations, and research institutions.

While some identified data sources required paid access, we included them in our consideration to maintain comprehensiveness. To ensure reliability, we verified the existence of each dataset through its corresponding website URL, retaining only those with confirmed online presence. We also expanded the data list by incorporating known related data.

For each card, we used the “data name” as the taking card (torifuda). Instead of traditional reading cards (yomifuda), we focused on observable phenomena from each data we can expect (referred to as DL) and describe them as keywords. Through interaction with the LLM, we finally gathered four keywords for each dataset. These keywords were used for the map visualization by BaleeGraph.

Visualizing the Customized Karuta

We implemented BCK by visualizing this aforementioned custom Karuta using BaleeGraph (see Figure 2). BaleeGraph tool offers two visualization functionalities: one that is useful to visualize based on keyword lists for each Karuta card, and another that extracts and visualizes keywords from given reading cards by using OpenAI API. Since we had already prepared the keyword list for each dataset, we utilized the former functionality for visualization of BaleeGraph.

The visualized map and the list of source data used to create this map are available in the BaleeGraph tool (https://baleegraph.com/gallery_view?graph_id=1408).

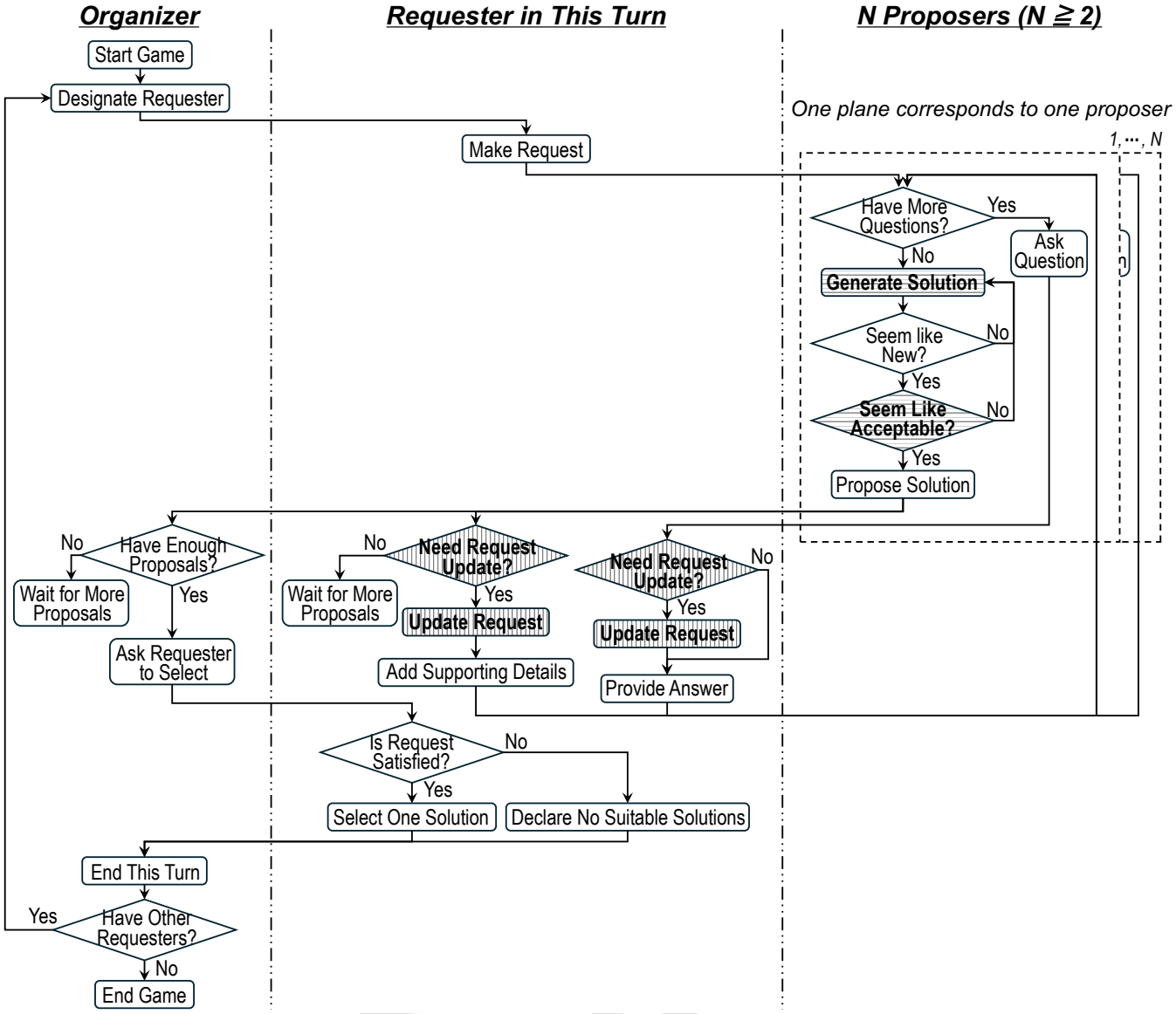

Figure 3: Workflow of the Balee Carpet Karuta.

Layout of the Field

The setup began with three data name cards placed on the visualization map in Figure 2, accompanied by supplementary cards containing data overviews for reference. In Figure 4, the upper left side shows the implementation scene of BCK for DSA where this carpet has been pulled to the center and participants are gathered around it playing BCK[1]. The lower right side shows an image of three stacked data name cards (left) and a dataset supplementary card (right) surrounded by blue or red nodes for keywords. The spatial orientation of diagrams in the venue is shown by the dashed arrows.

[1]Note that this image has been partially edited with Photoshop, Illustrator, etc. including the removal of visual obstructions to enhance image clarity.

Results of Data Society Alliance Workshop

Nine requirements were raised by the participants (while there were ten participants, one person left before his turn to state a request). Solution proposals totaled 47, with each requirement receiving between four to seven proposals, averaging approximately five per requirement. Five proposals involved combinations of two data, while four additional data suggestions were made and utilized in six solution proposals, despite some parts being unclear in the video recordings.

Table 2 shows an overview of representative cases of the DSA workshop. Due to space constraints, proposals corresponding to the second, third, sixth, eighth, and ninth requests were detailed.

Although participants presented their reasoning as proposals, these can essentially be understood as the form of hy-

Image of the scene of DSA workshop with participants gathered around the centrally-placed carpet

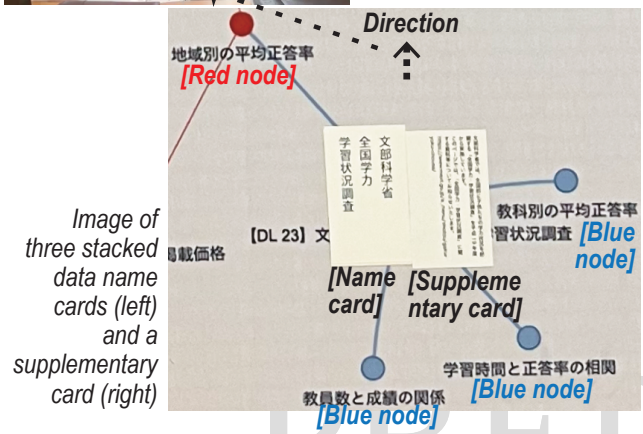

Image of three stacked data name cards (left) and a supplementary card (right)

Figure 4: An image of the Balee Carpet Karuta scene at the Data Society Alliance workshop.

pothetical questions asking "would this work?" in response to the requirements. Therefore, to clarify this point during the organization phase, they were standardized into question form by one of the authors. The results presented here were translated from Japanese to English by one of the authors, too.

Discussion

The DSA workshop revealed three key patterns in participant behavior and two philosophical implications.

Generation of Non-straightforward Solutions

Rather than proposing straightforward data solutions, participants frequently developed novel indirect approaches. For instance, consider the second requirement shown in Table 2: "A City with Mature Local Bars." The selected proposal suggested using festival-related data. While the list of candidate data included more direct restaurant data like "Tabelog data" (a restaurant review platform), no participant proposed using this to find mature local bars directly. Although there was one conversational proposal using this data, it took a rather roundabout approach, suggesting that "bars that aren't listed on Tabelog but are mentioned in tweets might be mature and local," but this was not selected.

Our findings suggest that when promoting data analysis implementation, unexpected yet plausible proposals tend to be more readily accepted. This effectiveness likely stems from their ability to spark curiosity and enhance motivation to proceed. This tendency is promoted by the competitive characteristic of BCK.

Interactive Refinement of Requirements

The BCK process helped requesters discover their "true" needs through communication, as evidenced by their evolving explanations based on questions, proposed solutions and subsequent discussions. This iterative refinement process enhanced both, the interpretation, the precision of expression and the ability to select from various concrete possibilities presented in the proposed solutions.

For example, regarding the third requirement in Table 2, "A City Where We Encounter Flowers on Our Walks," the requester initially envisioned flowers grown in home gardens. However, when other participants questioned whether the requirement was about the flowers themselves or about people who would grow flowers at home, the requester clarified that the essential point was having residents who are motivated to plant flowers. This led to a more detailed clarification of the requirement.

The requester subsequently accepted a proposal to analyze childcare service data, recognizing that kindergartens commonly maintain flower beds visible to passersby. In this context, the requester acknowledged that homes with flower gardens and the presence of children (engaged in flower cultivation) in the community were inherently interconnected concepts, leading to the acceptance of this proposal. While this represented a shift in focus from private residential gardens to kindergarten flower beds, the fundamental desire of the requirements remained consistent.

Furthermore, since childcare service data was available in the existing dataset, this reinterpretation made the requirement practically analyzable.

Discovery of Additional Data

The DSA workshop proved effective in identifying needs for additional data that were not in the carpet, as demonstrated by the four additional data proposals. For example, regarding the sixth requirement in Table 2, "A City Free from Neighborhood Disputes," three additional data were considered, with two novel ones emerging from this case: examining residents' characteristics based on data about garbage disposal practices or data about public bathhouse (sento).

Furthermore, the eighth requirement, "A City Where Most Daily Needs Can Be Met on Foot," was proposed by one of the authors, and the hypothesis of examining town characteristics through the public bathhouse (sento) data was particularly intriguing, which led to its ultimate acceptance.

This aspect of adding data (cards) is a feature not found in traditional Karuta, but from a data utilization perspective, it is significant as it provides opportunities for data re-examination and, when necessary, serves as an entry point into new data creation.

Narrative Structure of Balee Carpet Karuta

The narrative structure of BCK can be clearly understood in HieNaR framework (Sekiguchi and Ohsawa 2024). For example, Figure 5 illustrates Case 9, which aims to realize "A City Where People Welcome Strangers with Kindness." Although well-being was not explicitly addressed during the workshop, the concept of "desirable cities to live in" inherently aligns with the worldview of well-being with AI. We organize this requirement within the patterned states shown in the right column.

No	Requirements	Proposed Data	Reasons	Reference URLs
2	A City with Mature Local Bars	Let's ENJOY TOKYO: Festival Events in the Kanto Region	A festival is a local event where friendly old men gather together. The bars in areas where such people gather are extremely local, and aren't there some truly local izakayas (Japanese pubs) in the area? This area (Sendagi) is exactly like that—this is precisely the kind of place I'm imagining.	https://www.enjoytokyo.jp/event/list/reg n01/cat0901/
3	A City Where We Encounter Flowers on Our Walks	Tokyo Metropolitan Area: Status of Utilization of Childcare Services, etc.	Since kindergartens grow flowers in their flower beds, wouldn't there be flowers to be found there?	https://www.fukushi.metro.tokyo.lg.jp/kodomo/hoiku/hoikuriyoujyoukyou.html
6	A City Free from Neighborhood Disputes	Let's ENJOY TOKYO: Festival Events in the Kanto Region	In areas where festivals are held, neighbors generally get along well, so wouldn't there be fewer neighborhood disputes?	https://www.enjoytokyo.jp/event/list/reg n01/cat0901/
8	A City Where Most Daily Needs Can Be Met on Foot	Additional Data: Distribution Data of Public Bathhouses (Sento)	Since I've rarely heard of people driving to public bathhouses, and generally the areas around bathhouses seem compact and livable for everyone, wouldn't walking be sufficient for getting around?	NA
9	A City Where People Welcome Strangers with Kindness	Ministry of Land, Infrastructure, Transport and Tourism: Flood Hazard Map	Rather, when dealing with hazards, all residents cooperate, so wouldn't people in such towns be kind to outsiders? Even in apartment buildings, everyone decides rules together, like who will set up flood barriers and such.	https://www.mlit.go.jp/river/bousai/main/saigai/tisiki/syozaiti/

Table 2: An overview of representative cases from the Data Society Alliance workshop's Balee Carpet Karuta activity (Japanese workshop; English translation by one of authors).

The BCK framework primarily operates at the subsentence level within the descriptive state, incorporating language-based requirements and keywords at the phrase level. The underlying raw data for each Karuta card is expressed at the word level in the raw data state, along with the utterance of the requirement (sound wave).

Requesters provide narrative themes as patterns, while proposers select specific cards to design solution scenarios. This interaction process can be visualized as a *spiral* development within the HieNaR structure (illustrated by the upper green spiral arrow in Figure 5). Data Leaves represent patterns derived from data, with actual (raw) data serving as their foundation (shown by the lower green dashed arrow). Furthermore, when participants discover alternative data, this approach ensures that they remain requirement-driven and necessary, maintaining alignment between high-level objectives and concrete data implementations.

Implications for Human-Compatible AI and AI-Powered Science

The DSA workshop revealed BCK's contributions to Human-Compatible AI (HCAI). BCK's competitive framework improves the explainability of data-driven decisions by requiring clear reasoning for data selection that can be inputs for AIs. Since BCK itself utilizes AI for the map visualization, BCK is also an example of HCAI when it succeeds in supporting human data utilization. Furthermore, BCK could facilitate human agency because it could help recognize and express the "true" requirements of human participants.

The viability of BCK in multicultural settings has been demonstrated by the first BCK implementation in the Hitoyoshi case, which included Taiwanese participants (Hitoyoshi Press 2024). This stems from its simple rules, much like how Karuta can be played by young children in Japan. However, implementation is considered to require at least one person who can explain the target content such as domain knowledge and data analysis experience.

For AI-Powered Science (APS), BCK facilitates scientific discovery by generating interesting and actionable hypotheses including sophisticating requirements, discovering alternative data utilization narratives, and identifying new data needs. The effectiveness of BCK for APS will be further enhanced through the integration of AI technologies beyond its current visualization module, BaleeGraph tool. One promising approach is leveraging Large Language Models (LLMs) to provide comprehensive information about candidate card contents during real-time communication. Moreover, implementing an LLM as a proposer will effectively stimulate competition and facilitate requirement refinement.

Conversely, this approach of providing others' interpretation in the form of proposals can also offer valuable applications in general chat systems by helping users refine their requirements through an iterative reflection process. This function is also considered effective in interdisciplinary scientific fields because it allow us to express and refine "true" requirements among stakeholders.

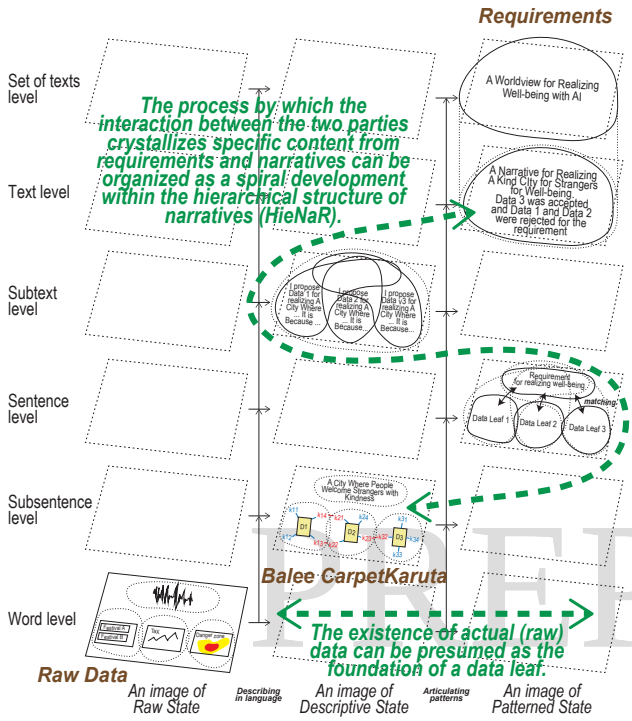

Figure 5: An image of the narrative structure of the Balee Carpet Karuta process.

Conclusion and Future Work

This study confirmed BCK's effectiveness in generating hypothetical questions about usable data while evolving requirements through interaction and competition.

Future work will advance social implementations and evaluate the BCK's impact through actual data analysis and project execution, thereby establishing a cyclical relationship between theory and practice in society. Additionally, enhancing AI integration represents a future direction that demonstrates how human-compatible AI can contribute to AI-powered science by promoting explainability and participants' agency.

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