

Monadic Exploration: Seeing the Whole Through Its Parts

Marian Dörk

Potsdam University of
Applied Sciences, Germany
doerk@fh-potsdam.de

Rob Comber

Culture Lab, School of
Computing Science,
Newcastle University, UK
robert.comber@ncl.ac.uk

Martyn Dade-Robertson

School of Architecture
Planning & Landscape,
Newcastle University, UK
martyn.dade-
robertson@ncl.ac.uk

ABSTRACT

Monadic exploration is a new approach to interacting with relational information spaces that challenges the distinction between the whole and its parts. Building on the work of sociologists Gabriel Tarde and Bruno Latour we turn to the concept of the monad as a useful lens on online communities and collections that expands the possibility for creating meaning in their navigation. While existing interfaces tend to emphasize either the structure of the whole or details of a part, monadic exploration brings these opposing perspectives closer together in continuous movements between partially overlapping points of view. We present a visualization that reflects a given node's relative position within a network using radial displacements and visual folding. To investigate the potential of monadic exploration we report on an iterative design process of a web-based visualization of a highly cross-referenced book and its six-month deployment.

Author Keywords

Information seeking; exploratory search; philosophy; theory; information visualization; network visualization.

ACM Classification Keywords

H.5 Information Interfaces & Presentation

INTRODUCTION

“A monad is not a part of a whole, but a point of view on all the entities taken severally and not as a totality.”
– Bruno Latour et al. [14]

There is increasing prevalence of large, relational data sets in the everyday practices of individuals. Most prominently, people are interacting with large-scale social data in the form of social network sites, and vast media collections such as photo archives, library catalogs, and blogs. With such data sets people are often interested in the content of particular elements as well as the entirety of elements as a whole. For instance, one might want to look at both a specific friend's profile page, while also gaining some idea of who their friends are. Or one might read an individual post and then wish to see how it relates and resonates within a community.

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As digitisation proceeds further we witness the popularisation of interconnected data sets and the desire to afford new modes of navigation to make sense of them. In this paper we explore a type of interaction with relational information spaces, which incorporates both the individual and the whole. We aim to harness the rich connections embedded in collections to devise new methods for moving along linked elements.

Some recent efforts in graph visualization defy the long-standing overview-first dogma in favor of filtered and local perspectives [10, 20]. These developments correspond to recent sociology theory promoting the part over the whole, as a richer and more nuanced view on social networks [14]. Our work here follows these lines of research in visualization and sociology and explores how information spaces can be navigated along individual entities in the context of their collection. We are inspired by the concept of the *monad*, which offers a relational perspective on the world by shifting emphasis from aggregation of the whole to movement among particular points of view [14, 17]. In fact, Bruno Latour explicitly challenged the CHI community to develop interfaces that support the visualization and navigation of monads [13].

This paper introduces *monadic exploration* as a new way of navigating relational information spaces. We propose three basic principles of the monadic perspective—having, difference, and movement—to inspire a new class of visual interfaces for exploring collections. The monadic perspective brings the contradictory representations of individual elements and entire collections closer together and suggests continuous movements between partially overlapping vantage points. Based on these ideas, we present a visualization that uses search queries or element selections to provide unique perspectives on the network through radial displacements and visual folding. We applied this visualization technique to a highly cross-referenced book and deployed it for a six-months period on the Web. We report on the largely positive feedback and discuss future directions for research and design.

VISUALIZING NETWORKS AND COLLECTIONS

Visualizations have played a significant role in the analysis of social networks. Starting from manual drawings of ‘sociograms’, there has been a gradual movement towards computer-supported methods for graph layouts [7]. The main aim of such visualizations has been to analyse the structure of networks, and secondarily to communicate derived understandings. Some efforts focused on graph visualization for more casual audiences, for example, by encouraging the playful exploration of one's own friend networks [10].

A range of alternative visualizations have been developed that provide different perspectives on networks and support various types of analyses. For example, node properties can be aggregated into higher-level representations thus allowing for a meta analysis of connection patterns [22]. Graphs can also be summarized by histograms representing facet distributions across neighborhoods and graph-theoretical qualities such as node and edge specific metrics to characterize and compare large networks [12]. A hybrid representation between node-link diagrams and matrices has been shown to support the analysis of local communities as well as global structure [11]. However, most network visualizations tend to provide a global perspective on a graph by attempting to represent it in its entirety or aggregating its nodes and edges based on their properties. Such global approaches can make it difficult to discern relations among particular nodes and neighborhoods.

In contrast to the emphasis on high-level views on networks, there has been some work favoring more local perspectives. Without requiring a global view, egocentric networks around particular nodes can support the analysis of, for example, group communication patterns and people's social roles [6]. In the context of online communities, it has been shown that 'starting with what you know' can serve as a more useful approach [10] than the established principle of 'overview first' [16]. When dealing with particularly large networks, search relevance can be used to initially establish a partial context and then expand the visualization from there [20]. While emphasizing individual nodes and their neighbors, local views lack the wider context of the network and thus can make it difficult to connect the part back to the whole.

The tension between global and local views relates to a long-standing research effort on focus+context visualization [2]. For example, radial graph layouts arrange a focus node at the center and connected nodes as context into concentric circles, e.g. [26]. The visualization we will introduce also features a circular layout, but integrates keyword search with the exploration of collection elements. Our work extends prior work on focus+context techniques to exploratory information seeking involving both search and navigation in rich collections.

Information visualizations are increasingly used to support the visual exploration of rich collections. This development coincides with a growing interest in more exploratory forms of information seeking without specific information needs, but rather a more open-ended desire to learn, play, and discover [15, 25]. Such positive and exploratory information practices have been conceptualized using the analogy of the flaneur curiously strolling through streets and experientially making sense of a city [4]. To foster such forms of serendipitous information seeking and spawn interest in collections, visualizations can offer unconventional and inviting views [18]. Presenting faceted relations as visual paths and connecting interface states through transitions can support lateral movements through interconnected collections [5]. Continuing these efforts in visualization and building on the concept of the monad, we will develop an approach to information exploration that takes search queries and particular elements as vantage points onto a collection.

TARDE'S MONADOLEGY

*"Each monad draws the world to itself,
and thus has a better grasp of itself."*

– Gabriel Tarde [17]

The people and artifacts in our lives define us, just as our relationships to them alter the meanings we ascribe to them. Friendships, interests, and professions are rich sources for understanding ourselves as well as our social and material environment. Such a relational perspective on the world coincides with a growing prevalence of richly interconnected information spaces on the Web such as social networks and media-sharing communities. However, this growing relational embeddedness of digital resources is still neglected by the interfaces used to navigate such collections. While each entity in these informations spaces, e.g., a person or a photo, is connected with many other entities, the existing interfaces downplay the rich interconnectedness that is becoming increasingly prevalent. To conceptualize the relational aspects of data sets and conceive new methods for interacting with them we draw from work in sociology.

Resembling the tension between global and local views on networks, there has been a struggle between the macro and micro scale in social science since its earliest days [14]. The social network model has grown as an analytic lens among social scientists as a means to study the structure of society [21], due in part to the widespread public use of social network sites. While social network sites are used in diverse ways, the underlying social network model and its representation as web-based interface provide only limited mechanisms for individual meaning making in navigation. The social network model tends to flatten relations, assuming them to be univariate and mutual [3]. Although social networks describe complex relations among individuals, they do not represent the richness of those ties. Moreover, as these social ties are decontextualized from the relational world in which they exist, they potentially further reduce the meaningful history of a relationship. Such reductions result in a top-down model of society, in the form of a highly abstract network—resembling the reductions that most visualization techniques rely on to provide overviews of large data sets.

While ostensibly operating at the global level, in-grained in this perspective is an assumption that the individual, as a fundamental social unit, has also changed [23]. Such 'networked individualism' asks the individual to become devolved from their context to preserve the value of a dispersed network (for instance in the actualization of social capital). It is thus argued that the social network profile, together with its many counterpart fragments across various social media channels, gives rise to the isolation of the individual from its context. In the case of the individual human actor, it is argued that online social networks change who we are as individuals because they allow us to deliberately write ourselves into being across distributed spaces [19], configuring local networks in global contexts. In contrast, we do not argue that individuals are isolated from each other, in fact, the opposite effect is often possible, but rather that the network model reinforces a dichotomy of the local and global, the part and the whole.

Among those scholars who resist this dichotomization, such as Tarde, Bakhtin, Simmel, Elias, and Latour, a relational worldview is espoused. In this text, we follow this argument as forwarded by Tarde [17] and, later, Latour et al. [14], to rethink the exploration of information spaces. We agree that the dichotomy of element and aggregate is unnecessary and unfounded, and that alternative theoretical accounts of the social world might be better founded on the relationships between those elements. This is the perspective put forward by Gabriel Tarde in his text ‘Monadology and Sociology’ [17]. Drawing on Lorenc’s reading of Tarde [17], we identify three principles of monadology, which can positively contribute to the study and design of novel exploration interfaces.

On Having, Not Being

Tarde sees a monad as an element’s own relational perspective onto the world—whether social or physical. The notion of the element and the characterization of the world as fundamentally relational can be seen in Tarde’s appeal to the Newtonian principle of reciprocal action: as each monad exerts its influence upon another, it is equally influenced by that other. Thus any attribute (reiterating the Newtonian link, we could consider weight) is defined by the relation (i.e., gravity) between elements, and not by the a priori being of the entity. He posits that the essential qualities of an entity is not that of ‘being’, but of ‘having’. Specific attributes then are those belonging to an entity, but to which, conversely, the entity also belongs. For instance, the monad of ‘me’ has the attribute ‘academic’, while the monad ‘academic’ has ‘me’.

Having suggests the primacy of relational aspects embedded in collections. Therefore each element should be understood as an entity mainly in so much as it has relations to other entities. For example, a photo meaningfully exists insofar as it relates to people, places, and events. Furthermore, we might also suggest that all elements have relations to all other elements, even when a relation is of total difference. In this way, a monadic interface represents the social world of an information space by visualizing the varying relations among the elements of a collection. While, this principle prioritizes the relations among elements, it does not preclude the use of individual properties of elements such as color or size.

The Essential Difference

Central to Tarde’s monadology is the argument that the element takes precedence over the aggregate. There is a critical point in this assertion, namely that difference is pivotal in the construction of monads. The monad is defined by its particular perspective on its world, which is defined by the unique relations to others. The monadic perspective then is dependent on the extent to which each monad is expended in the constituting monads of the others. Thus each monad is defined by the overlapping spheres of monadic influence of others. Given that monads are not mutually exclusive (elements can contain shared characteristics), we can assume that two monads that occupy fully identical spaces are, in fact, the same monad. By extension, the way in which we understand a monad is not in its similarity, but difference to others. Therefore, while a monad may exert influence over other monads, it must do so without itself becoming extinguished in the other—it must retain difference.

Difference as the second defining feature of an element should be recognized within the information space. In contrast to a focus on similarity among elements (e.g., products in online shops), a monadic perspective emphasizes an element’s distinguishing qualities. In line with ‘having’, difference is not an a priori property of the element but its unique position in the world. We propose therefore that each element must stamp its particular identity on the relational world, which is its own monad. That is, the difference of the element must be conveyed by taking the monad’s perspective on the world.

Meaning in Movement

The principles of having and difference construe the monad as a unique perspective onto the world achieved through the relations with other entities. However, the monad’s perspective on the world is not simply inscribed by mechanistic laws. Tarde stresses that a monad is not a configuration of static relations, but rather a highly dynamic and contingent arrangement. This is a fundamental break away from the structuralist perspective of many of Tarde’s contemporaries (and those who followed them). For him, this is a significant consideration for sociology, as it is equally for us with regard to information exploration: in what way can we understand the whole through the dynamic relations among the parts? Tarde is joined in this concern by many others, most notably Simmel. As Frisby reiterates Simmel, the question of understanding the whole (famously ‘What is Society?’) is reliant on exploring “all those modes and forces of association which unites its elements” [8]. How can we make these forces of association in collections visible? This question corresponds to Latour et al.’s challenge “to account for longer lasting features of social order by learning to navigate through overlapping ‘monads’” [14]. This emphasis on navigation ascribes a unique role to movement as a way to experience the relations and differences among elements.

Movement suggests a way of making sense of an information space by navigating along elements as overlapping monads. While the principles of having and difference highlight the relational quality of an element’s unique position in an information space, the principle of movement relates to the dynamic quality of an element and the potential of exploration as a form of interpretative sense-making. The movement between monads should serve as a meaningful proxy for the viewer’s movement through an information space. The principle of movement is an invitation to explicitly consider the purpose of animation to support exploration.

Taking the principles of having, difference, and movement together, we propose *monadic exploration* as a way to make sense of the relationships among entities exerting their influences throughout an information space. Monadic exploration is, therefore, the meaning-making movement between overlapping vantage points in a relational world.

DESIGNING FOR MONADIC EXPLORATION

A monadic perspective suggests an approach to relational information spaces that promises new types of explorations. To substantiate this approach, we have undertaken an iterative design process that started with above elaborations about monads, continued with more practical considerations about

design goals for an interface, and finally led to a prototype. In parallel, we engaged with a community behind a particular information space that provided us with the opportunity to get feedback and a sense for the potential for monadic exploration. While we envision a wide range of interfaces to be based on the idea of monadic exploration, we present here one initial design that serves as a concrete example. This design is not the only or necessary one, but it is explicitly intended for monadic exploration of a densely interconnected information space. In this section we focus on the decisions behind the design of the visual interface. In the subsequent section, we describe the findings from the case study of a highly cross-referenced book and its six-month deployment.

From Profiles and Graphs to Monads

The dichotomy between micro and macro in the social sciences finds resemblance in the contrast between profile pages and graph visualizations of social networks. The typical structure of a profile page can be found on almost any web-based information space far beyond social network sites. While a few related entities are displayed on a given page, revealing the relationships among other entities and the rest of the information space requires conventional navigation from one page to the next. In contrast to profiles, a graph visualization represents the whole network typically using a globally optimized graph-drawing algorithm. To convey higher-level structures in a network, graph visualizations tend to diminish the individual differences between nodes and their particular relations among each other.

Considering the monadic principles developed in the previous section, it becomes apparent how neither profiles nor graphs facilitate the movement between elements to discern their differences and explore their influence on the collection. The profile focuses on the individual details of one node without much consideration of the larger context and a graph portrays the abstract structure of an entire network neglecting the richness of individual elements at the node level.

We seek to find a way to retain the individual and relational aspects of elements when representing an interconnected information space. To support monadic exploration, we aim to design a visualization of elements as both vantage and navigation points providing both nuanced perspectives on and inviting gateways through relational information spaces. Based on this general aim and the principles of having, difference, and movement, we posit these design goals:

Offer elastic layout. Visual arrangements of a collection should portray both subtle and marked differences in relations among elements. Based on the explorer's steps, the layout should fold and stretch as elements shrink, expand, and move.

Reveal differences. During the exploration of the collection the variation of attraction among elements should be represented as animated transition of positions, opacities, and labels. The resulting movements should convey difference.

Integrate navigation and search. The explorer should be able to shift between different forms of information seeking. Both open-ended navigation and more targeted keyword search should be supported within the same visual arrangement.

Representation: Taking a Monadic View

We first discuss the representational considerations for a monadic visualization of a relational information space. The premise is that elements have some relationships among each other, feature textual and/or visual attributes, and can have a type to distinguish, for example, between people and artifacts.

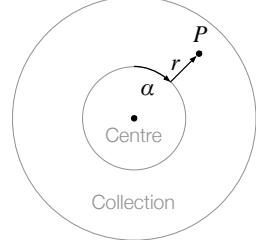


Figure 1. A monad has a search query or an element selection at its center and a circular arrangement of a collection's elements around it.

A Monad As a Circular Layout

We define a *monad* as the visual arrangement of a collection around the explorer's interest that is manifested at the center of the monad and expressed either as a search query or an element selection. We adopt a polar coordinate system to negotiate the overall structure of a whole with the differences among the parts. As shown in Figure 1, an element is positioned at point P with angular coordinate α encoding any collection-wide ordering (e.g., by type or name) and radial coordinate r being inversely proportional to the search relevance or the attraction strength to the selected element.

By using a combination of node specific and collection wide encodings for position, the monad has both dynamic as well as stable qualities. In this sense, the monad offers an elastic lens, which dynamically draws the elements to the center or pushes them towards the periphery within a stable structure of a global ordering around the circle. The radial movements of elements only represent changes in attraction, making the movement a meaningful visual variable to discern difference.

Subtle AtTRACTIONS

The radial coordinate is intended to convey likely interestingness of a given element based on its relationship to an explorer's search query or element selection. The effect is that the more relevant an element is, the closer it gets positioned towards the center than those that are less relevant. Search relevance can be computed, for example, by counting the occurrences of the query across each element's text fields (e.g., title, teaser, and text). A more robust technique is tf-idf, a common measure used in information retrieval to determine how relevant a result is for a given set of search terms; if one of the terms is more common in the collection than the others it will contribute less in the overall ranking.

Besides a search query, an element itself can be the basis for determining the possible interestingness of each element in a collection. For this we assume that a direct connection between the selected element and another element in the collection is an indicator for attraction. However, a connection between nodes is binary and does not account for the dense pathways contained in interconnected information spaces.

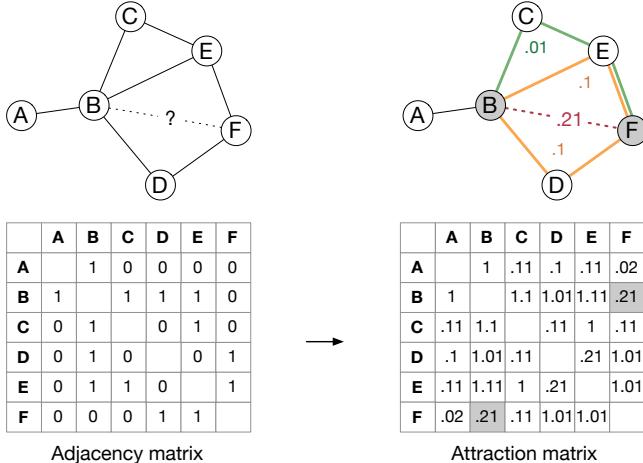


Figure 2. Both direct and indirect connections contribute to the relationship between nodes. Based on the information from the adjacency matrix, the attraction matrix captures more nuanced relationships.

To get a more nuanced sense of relationship between two nodes we can additionally consider the indirect connections between them. Consider the graph depicted in the top left of Figure 2. There may be no direct link between B and F, however, there are three paths via C, D and E that suggest an implicit attraction nevertheless (top right). To consider a more nuanced indication of attraction between elements, we include indirect paths between elements in addition to direct links. The attraction score $A_{I,J}$ between two nodes I and J then corresponds to the weighted sum of paths p_i :

$$A_{I,J} = p_1 + w_2 \cdot p_2 + w_3 \cdot p_3$$

with p_1 equal 1 if directly linked, otherwise 0, p_2 and p_3 as the number of two-hop and three-hop paths, and w_2 and w_3 as weights (through iterative refinement we settled with 0.1 and 0.01). Given a binary adjacency matrix we can calculate an attraction matrix containing the strength of attraction for each pair of nodes (see Figure 2, bottom). We assume that edge weights equal 1; this can be adapted to account for weighted edges by introducing additional weights for each summand.

When there is neither an active search query nor element selection, the displacement of elements is based on a node's degree, i.e., number of direct connections, as a straightforward measure of centrality. Node degree serves as a proxy for potential interest inviting the explorer to select an element without having to enter a search query to see some elements.

Dots and Labels

Labeling is a computationally complex challenge in visualization, especially when displaying many elements. We address this problem in two ways: 1) only elements with relatively high attraction scores are labeled, and 2) labels are displayed in radial arrangements around the circular layout around which each element has a dedicated segment. The only time label overlaps occur is when two similarly relevant elements are neighbors in the circular ordering. Using the mouse pointer one can clarify and read them individually.

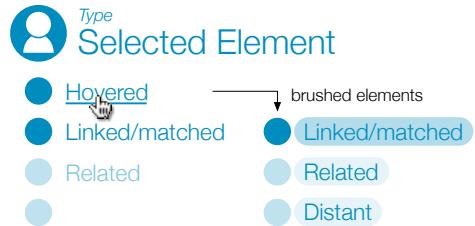


Figure 3. An illustration of the varying visual appearances of elements according to their attraction value as well as interaction state. If an element is directly connected with the hovered element, a brighter tone of the element's dot color is added as a background behind its label.

Elements are displayed as a dot and optional label. As illustrated in Figure 3, the visual appearance of dots and labels is varied to reflect different relationships and interaction states. There are two types of relationships to convey: adjacency as the binary relationship of having a direct connection, and attraction as the more nuanced relationship based on direct and indirect paths or search relevance. The attraction values are already encoded by an element's position using the circular layout discussed above. Position allows for the discernment of smaller differences that is adequate to represent more nuanced differences in attraction. The binary connectivity is conveyed by the opacity and therefore darkness of the dot and label: linked elements are displayed significantly darker. Similarly for search, if an element has at least one occurrence, the element is drawn darker. There are only two levels of opacity used for the dots, making the visual discrimination between these two effortless.

An element's label is simply the title of the represented entity, e.g., the name of a person or the title of an article. Labels are placed facing towards the outside of the display, and rotated according to the angular coordinate used for element placement. Similar to how the dot's opacity varies, the label is shown only in full opacity for elements that have either a direct connection with the activated element or are matched against the search query. If the attraction value is weaker the label is shown either with reduced opacity or not at all—depending on the number of displayed elements.

The color used for the dot and label denotes the type of that element. While distinguishing elements by color is optional, it can help to discern the distribution of element types in a heterogenous information space. However, considering the perceptually limited discriminatory power of color, we suggest to use it when the number of types is lower than ten. The size of the dot represents the element's degree, that is the number of connections to other elements in the collection.

When an element is selected as the center of the monad, its dot and label move into the middle of the visualization and are increased in the respective sizes. Within the dot a symbol is embedded indicating the element's type. Below symbol and title, a brief description and an optional figure is displayed providing more detail for that element. Displaying elements as circles of varying sizes allows for non-disruptive transitions between these different states. Together with the selection of colors and fonts, the symbols can be used to reflect the aesthetic identity of a given collection.

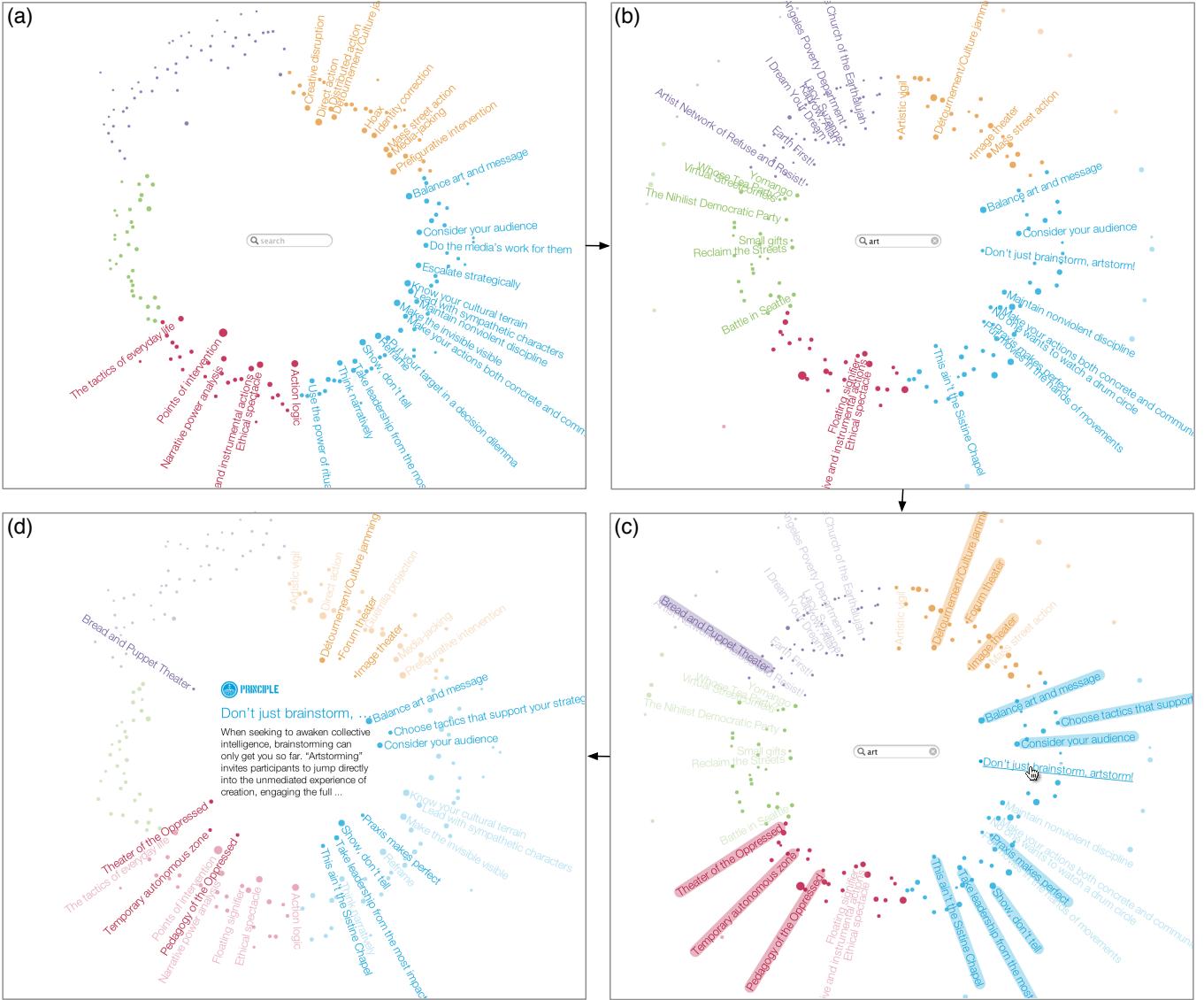


Figure 4. From views based on (a) node degree and (b) search relevance to (c) hover highlights and (d) selection of a specific node as the monad.

Interaction: Moving Between Monads

The visualization supports three basic types of interaction: search, hover, and select. The intention behind offering these three interaction methods is to allow for targeted, provisional, and exploratory movements through a collection. The search allows the formulation of a query based on an existing interest, while the hover function lets one peek around without changing the layout; by selecting an element one can navigate through a collection along its elements. When a person opens the visualization with no active element, the elements are placed around the circular layout based on their node degrees (see Figure 4, top left). Highly connected elements are positioned closer to the center and are displayed with a label in contrast to less connected elements that are arranged towards the outside with no label shown. At this point the viewer can decide to either enter a search query or hover over any of the displayed nodes.

Search

When no element is selected, the search box is placed into the center. Once a few letters are entered, elements are moved according to their relevance scores (see Figure 4, top right). As the query changes, elements move in or outward and reveal or hide labels to reflect the changing relevance scores. The effect is that the person entering a query can get a general sense of the impact that query changes have by seeing the movements toward and away from the center in the immediate visual periphery of the search box. While many search interfaces already offer query suggestions or display results while a query is being entered, query changes lead to abrupt display changes. In contrast, changing the query in the monad does not disrupt the overall organization of the visualization. Instead, elements either get gradually expanded and pulled in when they become more relevant, or if not, they are gradually folded and pushed towards the outside.

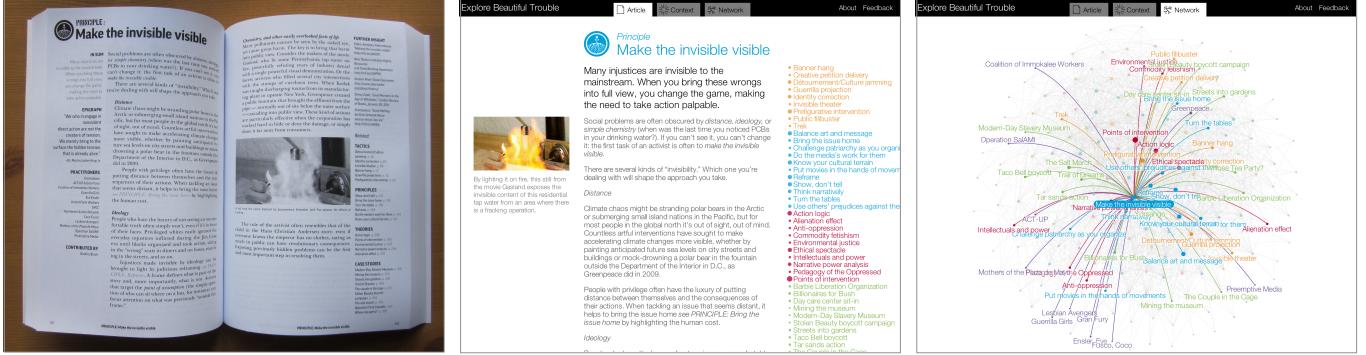


Figure 5. A book on creative activism (left) is used as a case study for monadic visualization. The interface represents the book’s contents using a monadic Context view (see Figures 4) and additionally as Article (middle) and Network (right) views.

Hover

Moving the mouse pointer over any element shows how it relates to other elements (see Figure 4, bottom right). Regardless whether a search query is active or an element has been selected, hovering over dot or label of an element highlights connected elements of that hovered element (foreshadowing which elements move closer when clicked). The hovering function allows the viewer to inspect whether two elements share an element as a neighbor. On the flip-side, it is possible to discern which elements are neighbors of the hovered element, but not of the centered element by looking for those highlighted elements with brighter dots. Furthermore, if an element’s label is not shown (due to a low attraction value), hovering over its dot reveals the label. Thus one can deviate from the emphasized elements in the center and investigate peripheral elements that differ from a search or selection.

Select

Clicking on any element turns it into the current selection of the monad (see Figure 4, bottom left). If there is an active search or a selected element, it is replaced by the element. The dot and label increase in size and move into the center. Below the label is a description of the active element. As a new active element changes the relative attraction values of the other elements they will gradually move and adjust their opacity. During this transition the hover highlights remain visible allowing the viewer to follow elements that are linked with the newly selected element. After the moving transition is over, the hover highlights eventually fade out.

CASE STUDY: BEAUTIFUL TROUBLE

To better understand the potential of monadic exploration we used the book ‘Beautiful Trouble: A Toolbox For Revolution’ [1] as a case study. Being highly cross-referenced, the book serves as an intriguing example of a relational information space. This book is also a particularly interesting dataset for our purpose here, because of the interest and passion that the editors and readers have for the subject matter. To contrast the use of the monadic perspective with established representations, we created an interface that also offered profile and graph views on the book’s contents. In collaboration with the team behind the book, we deployed the interface for six months on the book’s official website and invited readers to explore the book’s contents with it.

Setup and Interface Design

The book contains 194 modules about creative forms of protest and civic engagement. The modules are categorized into five types: tactics, principles, theories, case studies, and practitioners. In total, there are 1938 references linking related modules; in the book these references are shown on the margins of the pages (see Figure 5, left). The references turn the book into a densely interlinked information space. To integrate the visual design of the interface with the book, we adopted the same color scheme from the website and used the same symbols representing the module types.

The interface used for the deployment had three views: Context, Article, and Network. The *Context* view is the visualization discussed in the previous section. The *Article* view approximately resembles the display of many information spaces on the Web, such as posts on blogs or profile pages in online communities (see Figure 5, middle). The purpose of the Article view is to show great detail about an entity, allow for its close examination, and provide links to related pages. While there are many ways of visualizing networks, most network visualizations use force-directed algorithms and display all edges among nodes. The aim with the *Network* view was to provide one such perspective on the interconnections among modules (see Figure 5, right). The Network view uses the Fruchterman-Reingold layout [9] as is provided by the network visualization environment Gephi. Curved edges among nodes are shown in faint shades of grey, except for the selected element whose edges are displayed in dark tones of the element’s color. Node labels are only shown for the selected element and directly connected neighbors.

Each of these three views provides a different perspective on the book’s contents emphasizing different aspects and granularities. We integrated these three views into the same interface to allow for a close consideration of these distinct, yet related perspectives. The rationale behind this was not to illustrate the superiority of one of these views over another (admittedly we focused our design on the Context view), but rather to contrast typical ways of displaying relational information spaces with a view designed towards monadic exploration. By juxtaposing these views in one interface we can compare how they are used and received, and think how the experience differs between the three approaches.

The visual design and interactivity is integrated across the different views. The interface has a tab for each view on the top indicating which is active and allowing the viewer to switch modes, which results in an animated transition moving elements to their new positions in the respective layout. The intention behind this integration is to see the relationships between these views and notice how elements are arranged differently. For example, when switching from Context to Article view, the circular arrangement of elements gradually morphs into the linear list on the side of the Article view.

To integrate the interface with the book's website we worked closely with the technical lead of the team behind it. We had access to the book's modules via their content management system, and deployed the interface on a subdomain of the book's website.¹ Both website and visual interface were integrated with links between module pages and the respective states in the views. The team announced the visualization on their blog, mailing lists, and social media accounts as an experimental interface for exploring the book. Visitors were encouraged to give feedback in the interface. During the six months of the deployment, we received 124 feedback submissions and the visualization attracted 4890 visitors.

Editors: “Feels Like Home”

Following the initial deployment, we asked the editors to give their perspective on the final prototype. Having discussed the concept of the monad with them, we wanted to know how they felt the interface lived up to their expectations. Feedback was provided via e-mail responses. In what it contributes to their website, the editors felt that the visualizations “*highlight the web of relationships among the content elements*” [Andrew] and provide a “*variety of ways to interact with the content*” [Phillip]. Further comments from Andrew and Phillip reveal a difference in how they value the various views within the interface. For Andrew the Context view “feels like home”. He draws on this sense of familiarity, and compares those ways the overview of the book has been presented in print format with how the Context view extends upon them:

“It’s like a dynamic table of contents – a very organic and responsive and navigable ‘map’ of the book’s content and relationships – with an ability to glance at or skim the surface of the actual content.”

The Context view is, in this sense, an overview that captures the monadic perspective of the whole. Although this appears to stand aside from the content, Andrew insists that there is an organic connection between the Article and Context views:

“The Article View offers a focus or spotlight on a particular piece of content, one that you can organically ‘drop into’ from the Context View.”

For Phillip, it is the Article view that holds the most value as:

“The Article view is a nice compromise: showing both the module content and the relations in a way that makes it visually apparent that certain other modules are more or less related to the one in focus.”

¹<http://explore.beautifultrouble.org>

One possible solution is proposed as Andrew asks for a unified monadic interface, where the Article view is fully embodied in the Context view. Although we envisaged the three views as interwoven, this was not incorporated into the prototype interface. Both Andrew and Phillip provide negative feedback on the Network view, which they felt to stand apart from the symbiosis between the other views:

“The Network View feels disconnected from the other two views, more like a side-show novelty. It’s also a map, but not one that feels particularly welcoming or navigable or responsive or useful, compared to the Context View.”

Asked to speculate about future directions of using visualization to explore the content, Andrew is considering the “*possibility of making a combined Context-Article View THE interface for the site*”—not as an alternative, but a replacement of the existing website. Phillip mentioned that the interface does not support mobile devices, something which would need to be taken care of in the long term.

Participants: “Learning While Walking Around”

Feedback from visitors was collected through an online feedback tool built into the deployed interface. Visitors were asked to share “thoughts, impressions, and suggestions about the interface and the different views.” This feedback points, in the main, to positive and enjoyable experiences. More interesting for us are both the ways in which the constructed monadic perspective serves navigation and the limitations of the views achieving this. Much like the book editors, users also felt that the interface generally accomplished that which the monadic perspective requires. All feedback submissions that explicitly compared the different views favored the Context and Article views over the Network; for example:

“I liked the article and context pages and found it easy to use them—the visualization of relationships on the context page was exciting. Not so the Network page.”

Several comments suggest immersive qualities of the interface, such as: “*It feels like I could spend hours...*” and “*Makes you want to read another article.*” This suggests a complex relationship between aesthetics and substance, where the visuals seem to encourage a close engagement with the content, one where exploration supports meaning making. One user calls to mind the metaphor of the flaneur, reconstructing the flow of meaning making in transition: “*It’s nice and funny! :-)* learning while walking around.” Another user reiterates this sentiment, but draws attention to the potential for overload:

“When I first looked at it, I was a bit fazed by how it was organised... but it is remarkably intuitive and after the first few minutes, exploration became really enjoyable. There’s so much visually present that the occasional overlapping titles create a sense of information overload, but the system encourages its own familiarisation.”

This is an intrinsic familiarization, where the interaction techniques produce an evolving knowledge. Users drew specific concerns with the Network view—as “messy,” “over-

whelming, and therefore, counterproductive." For some this is a fundamental difficulty with the system. In viewing the prototype system, users were concerned with the lack of directed navigation and information seeking:

"Not sure how useful this interface would be if I were looking for guidance in a particular area..."

Some users see the interface to be prohibitive for information seeking: "*The cross-indexing is very complex; I'm not sure it serves to quickly zero in on particular content...*" (The search function was not introduced until after the first four weeks of deployment.) However, the same visitor follows on to see this limitation as a potential:

"...it's a treasure hunt for discovering. Be prepared to wade in and be immersed in the collective [...] wisdom of the best social change agents active now."

DISCUSSION

The shared feedback largely resonates with Tarde's characterization of monads in constant movement with a drive to grasp the world and shape it to their desires [17], which raises some interesting questions about monadic exploration.

For the purpose of exploration, we defined the monad as a visual arrangement of elements communicating relationships and allowing for gradual movements through a collection. While these movements are triggered by human explorers, we have not considered their role in the visualization itself. As a person navigates using the monad, could the monad itself be seen as their avatar in an information space? With the desire of the monad to exert influence on the world we recognize the poetic, aesthetic, and imaginary interest of the information flaneur [4] as a central driver in making meaning of information spaces. However, can we position the flaneur as a monad into the world in which they navigate? We refer to Latour's expression that "another experience of 'being in a whole' should be explored that has little to do with 'being a part' of a 'structure' ..." [14]. The information flaneur relates to the collection, as the urban flaneur to the city, as not 'part' of the city, but nonetheless in it. In this sense, the flaneur reveals the space as a continuation of being therein, where "the added value is no longer the power of prediction, but the progressive shift from confusing overlaps to successive clarifications of provisional wholes" [14]. This is also crucial for the realization of the monadic perspective, as the interests of the flaneur might transcend the collection in question.

While the monadic view responds to the explorer's transient interest, their ongoing meaning making could form a more gradually evolving basis for attraction forces. Furthermore, the interaction histories of many explorers could inform collective attraction forces [24]. As Tarde explicitly rejects the monad as a machine with a static "distribution and direction of pre-existing forces" [17], people's changing inclinations and contingent movements through an information space can give rise to unexpected discoveries and changes to a collection. Considering attraction forces among elements and explorers to evolve over time, a monad becomes a temporally specific perspective on an information space. The visualization we introduced is atemporal, however, a simple addition

would be the introduction of temporal elements representing time spans meaningful for a given collection. However, besides treating time as metadata fields, the challenge is to meaningfully represent temporal dynamics in relational information spaces. Could time-sensitive monads help us recognize stories in evolving information spaces?

During the creation of a particular monadic interface, we found it useful to translate the conceptual principles of the monadic perspective (having, difference, and movement) into three concrete design goals (offer elastic layout, reveal differences, and integrate navigation and search). Due to the engagement with a community of book editors and their readers, we observed two additional design principles that appeared to be beneficial for monadic exploration: 1) provide stable, yet dynamic arrangements, and 2) consider the visual style of a given collection. First, by devising a layout that (paradoxically) integrated a reliable order with dynamic displacements, it was possible to negotiate the influence of the collection and the explorer; it seemed that this negotiation was crucial to provide a sense of orientation and facilitate meaning making. Second, the visualization design was meant to be sensitive to the aesthetics of the represented collection (especially via colors and symbols), which seemed to help the explorers to trust the interface to be truthful to the content.

CONCLUSION

We adopted the perspective of the monad, as advanced by Tarde and Latour, to problematize the dichotomy between aggregate and element. Based on the idea of a monad as an element's relational perspective onto the world, we introduced *monadic exploration* as a method to navigate relational information spaces along overlapping vantage points. We have presented one particular visualization that is based on this approach that merges the macro and the micro in a circular arrangement of elements. We applied this visualization to a cross-referenced book and deployed it as part of an experimental interface for six months. The feedback about the potential of monadic exploration was very promising; participants felt that the monadic view provided an inviting way to explore the book's contents and appreciated the visualization's immersive qualities.

In summary, we have made the following main contributions:

- A theoretical treatise about the concept of monads that identifies key principles to inform new types of interfaces.
- A visualization technique that represents a collection as a circular arrangement of elements designed to support both exploratory and targeted forms of information seeking.
- A case study of a highly cross-referenced book contrasting a monadic visualization with conventional representations.

During this work, interesting questions came up about the role of the explorer in a monadic interface and the treatment of temporal dynamics. How can a monad support explorers in following their changing interests? In what ways can the temporal dynamics be exposed that are latent in an information space? These are some of the questions we wish to pursue further in future work on monadic exploration.

The distinction between the whole and its parts has been a useful one for information visualization to cope with the scale differences at these two granularities, however, it also introduced an artificial boundary between high-level structure and low-level detail. While we do not claim that the presented interface resolves this dichotomy once and for all, we hope that the monadic perspective can bring fruitful considerations for interaction and visualization design to make the relational qualities of collections visible and navigable. To quote Bruno Latour from his CHI 2013 keynote: “the future belongs to those who are able to navigate through overlapping monads” [13]. In particular in the context of cultural archives, digital humanities, and the arts, we see great potential for monadic interfaces to support new types of engagements with relational information spaces.

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