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Graduate Symposium

Luana Micallef
(editor)

DIAGRAMS
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Graduate Symposium

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Preface

The Diagrams Graduate Symposium (GS) provides Master and Doctoral students with an opportunity to present their work and get feedback from established researchers in the field. It is also a supportive environment for students to network and make contact with potential future colleagues or employers. The GS was an integral part of the Diagrams 2016 programme. As in previous years, lively discussions led to suggestions about the students' on-going research, and allowed experienced participants to hear fresh ideas and view some of the new trends in the field.

Students participating in the GS submitted a short paper describing their research. Each paper was reviewed by two distinguished scholars, and based on the reviews, six students were selected. Each of these students gave a presentation at the GS and also showcased a poster at the Diagrams poster session. One student with a poster paper in the main conference programme also gave a presentation at the GS, while five other students who had a Diagrams short or long paper (and who got financial support from the conference) also attended the GS. At the GS, a panel of experts gave feedback to the students about their presentations in an informal and constructive environment. The background of the GS students was widely diverse consisting of 30% females, 20% self-funded, 20% part-time students, from nine different universities in six different countries (USA, Canada, UK, The Netherlands, India, Australia). Their research topics were also different, including: diagram drawing algorithms, evaluation of visualization designs and methods, diagrams in education and everyday life, and diagrams in connection to art, problem solving and reasoning.

The success of this year's GS is owed to, first and foremost, the National Science Foundation (NSF) who generously granted us a bursary of $20,000 USD to organize the GS and financially support all the students who sought funding to attend the conference and present their work. We are also grateful to the distinguished scholars for their insightful reviews of all the GS submissions, and the panel of experts who provided invaluable feedback to the students about their GS presentations. As part of the Organizing Committee of Diagrams 2016, we are indebted to the General Chair, Stephanie Schwartz, the Local Chair, Richard Burns, and the Program Chairs, Mateja Jamnik and Yuri Uesaka, for making the process of organizing the GS as smooth as possible. Finally, we would like to thank all those students who submitted their work to the GS.

The GS is an excellent opportunity for graduate students to improve their research, and an insightful experience for scholars to learn about the future of our field.

August 2016 Luana Micallef

Organization

Symposium Chair

Luana Micallef	Helsinki Institute for Information Technology, Aalto University, Finland

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Dave Barker-Plummer	Stanford University, USA
Peter Cheng	University of Sussex, UK
James Corter	Columbia University, USA
Simone Kriglstein	Vienna University of Technology, Austria
Emmanuel Manalo	Kyoto University, Japan
Margit Pohl	Vienna University of Technology, Austria
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Richard Burns	West Chester University, USA
Aidan Delaney	University of Brighton, UK

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Preparing for Academia: How to have a Successful Career

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The Diagrams Graduate Symposium has a key goal: to support early-stage researchers with shaping their research direction, helping them prepare for life as an academic. I have been invited to speak on how to have a successful academic career. In my opinion, planning research and related activities is paramount from early on, in order to realise career goals. To do this successfully, understanding what future employers will be looking for in terms of skills, achievements, and track record is essential. In this talk, I will focus on what I believe to be the most important elements of a track record when pursing an academic career, aside from research topic, and what you can proactively do to achieve them. These elements include publication record, networking activities, and community service, alongside having a clear career plan. By drawing on my own experience, I will aim to provide some hints and tips on how to make informed choices when devising a publication strategy, how to confidently network and how to begin contributing to conference organisation, peer reviewing and collaborative research as your career unfolds.

Overview of Graph Drawing Using Patterns

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Abstract. This paper introduces a novel method for drawing graphs. I identify certain predefined patterns in a graph and draw these in a consistent manner. The advantage of this method is that common graph structures are drawn in a the same way, so aiding user comprehension of the diagram. The paper details the patterns identified and the various combinations of connections between patterns. The algorithms for drawing each connection are then given.

Keywords: graph drawing, subgraph isomorphism, information visualization

1 Introduction

There are a number of existing drawing techniques for node-linked graphs, such as force-directed methods [2, 3] and simulated annealing [1]. I, however, propose a new technique that utilizes subgraph isomorphism. The proposed solution is that certain subgraphs (or patterns) are identified within a graph and these patterns are drawn in a consistent manner. There are challenges regarding the drawing order of the patterns and integrating the concept of an "ideal layout" with the previously drawn set of patterns. The basic process is as follows: Patterns are identified, connections between each pattern are determined, a subset of patterns is chosen to be drawn, these patterns are placed in an order for drawing, and finally each pattern is drawn.

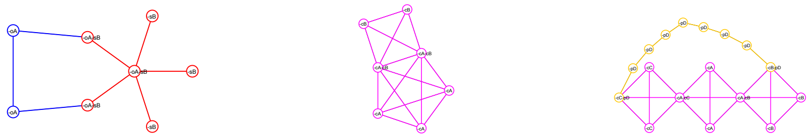
Drawing items with consistent layouts can help improve the identification, perception and understanding of the graph [5–7]. By drawing patterns consistently, it is hoped that the result will be clearer, more compact and easier to understand.

2 Outline of Algorithm

To draw patterns in a consistent layout, it is first essential to define what patterns are required. These are cliques, stars, circles, paths and triangles.

A **clique** must contain at least 4 nodes and all nodes must be connected to the others within the clique. A **star** must contain at least 5 nodes, must have one central node which connects to all other nodes in the star, and non-central nodes may not connect to any other node in the star. A **circle** must contain at least 4 nodes and the nodes in the circle must form a closed path. There is a maximum limit of 8 imposed on the size of a circle to increase the performance of the system: searching for large circles is computationally slow and large circles are uncommon in graphs. A **path** must contain at least 4 nodes, must form an open path, while only the end nodes can connect to nodes not in the path and any paths that are also circles are treated as circles. A **triangle** must contain exactly 3 nodes and all nodes in the triangle must be connected to each other. Triangle are technically both small cliques and circles. However, for the purposes of this work, they are treated as a separate pattern, because of their common occurrence in many examples.

These patterns are then identified before a drawing order is created. This order takes a number of considerations: the type of connection (node shared, edge shared, edge connected, no connection), the number of connections (1 node shared, 2 node shared, etc), the size of the pattern and the type of pattern (in the order: Clique, Star, Circle, Path, Triangle). Examples of these are shown in Fig. 1. As a result of this, patterns which do not match the connection types above (e.g. a pattern which shares 3 or more edges with the already drawn patterns) are discarded.


(a) Circle with 2 edges shared (b) Clique with 1 edge shared (c) Path with 2 nodes shared

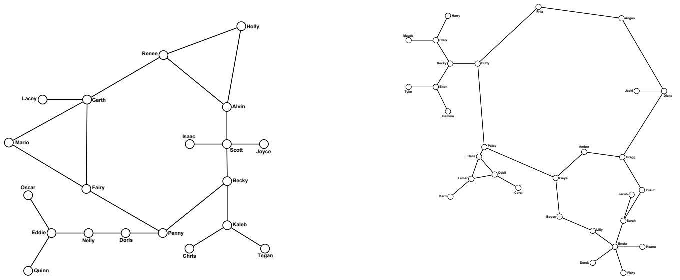

(d) Star with 1 node shared (e) Clique with edge connecting (f) Triangle with no direct connection

Fig. 1: Examples of connection types

Each connection type has a specific drawing method, although some patterns may share a method. For example, circles, cliques and triangles all share the same method when sharing one edge with the currently drawn set. There are a variety of drawing techniques, such as Share One Edge, which places the new pattern in the correct position and correctly scaled depending on the size of the shared edge. Others, such as stars sharing one node, may find the best area to draw the pattern in based on size and occlusion scores. Some methods, such as cliques sharing one node, or patterns connected by an edge, use a search based technique.

In this and other cases, each possible outside edge is used in order to maximise the number of potential drawing locations. Paths are initially drawn in a straight line, before being arced in both directions to determine if there is a better location. One all patterns have been drawn, any remaining nodes are also drawn.

A formal empirical study was also performed where participants were asked 4 types of question (3 of which were taken from [4]), on 6 examples of data (3 sizes and 2 drawing methods - this and a force directed layout). Examples of these are displayed in Fig. 2. The results of this were, unfortunately, inconclusive.



(a) 2009-11 F1 teammates (b) 1996-98 F1 teammates

Fig. 2: Examples of the drawing method

3 Conclusions and Further Work

It is expected that this work will show that it is inconclusive as to whether drawing a graph using patterns is more effective than existing methods. The study results show that in some cases it is comparable to existing measures, but further work is required. It would be of most benefit to hear advice on future directions of this work (for example, increased number of patterns) and any improvements to the empirical study that would perhaps lead to a conclusive result. It would be useful to have advice on whether patterns could be focussed on for a particular domain, or applying more general subgraph isomorphism techniques to the system.

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SAT Diagram: An Interactive Visual Representation for Learning Analytics

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Abstract. Analytics of teaching-learning scenarios often involves collecting multi-attribute student data and then exploring patterns and relations in the dataset to understand the learning experience and identifying possibilities of improving the experience. Analyzing such data either at a micro level using robust machine learning algorithms or at a macro level across multiple attributes remains difficult for stakeholders such as classroom instructors and educational researchers. As a part of this doctoral work, we propose the use of a visual artifact for analytics called the Stratified Attribute Tracking (SAT) Diagram. The SAT diagram is an interactive visualization of a multi-attribute dataset which groups data within each attribute based on user-specified criteria and visualizes proportions of each group. Further, it traces how these groups of data transition between one attribute and another related attribute, where the relation is interpreted based on the specific teaching-learning scenario. This paper presents an overview of the work, the research questions, methodology of study and possible contributions of the SAT diagram.

Key words: SAT Diagram, iSAT, Learning Analytics, Visual Cohort Analysis

Technology enabled teaching-learning practices are transforming both in-class and online learning experiences. Large volumes of data related to student attributes such as scores on tests, observed behaviors at various instances of a learning activity, quantified perception, etc. are stored in educational datasets. Thus learning and academic analytics is crucial to understand and optimize the learning process and learning environment [1]. Researchers, instructors, students, parents, educational organizations and policy makers are part of the wide spectrum of stakeholders interested in gaining insights from such analytics. But the skill set required often makes data analysis and meaning making a difficult task for these stakeholders. In this work, we investigate how to assist learning analytics and academic decision-making by enabling the visualization of transition patterns in educational datasets.

For example, given the records of 100 students' responses to three questions, individual histograms of response accuracy will not answer queries such as, 'how many students who were incorrect in the first question were also incorrect in the other two'. This information of the cohort helps the instructor to decide specific instruction and understand what proportion of the class shall benefit. Stratified Attribute Tracking (SAT) diagram (see e.g. in Fig.1) [2] is being developed as a possible visualization that helps in tracing such transitions. For the preceding example, the SAT diagram would consider each question as a Phase represented as columns (A in

Fig 1.) and possible accuracy states as Strata (B in Fig 1.) The main bars on the right of each Phase (D in Fig1.) denote the relative proportions of Strata in each Phase. Between two Phases, the bands denote Transitions across Strata (C in Fig1.). The sub bars (E in Fig1.) on the left of Phase indicate the proportion of cohort migrating from a particular Stratum in pre Phase. It has been shown that a 3-Phase SAT diagram can help in analyzing 7 possible transition patterns [3]. For instance, an instructor can explore the *Aligned* pattern to find the proportion of students who remain incorrect in all their responses. It is proposed that an interactive visual analysis based on the SAT diagram can help in tracing patterns of transitions in collected multi-attribute data and interpreting the patterns in educational endeavors.

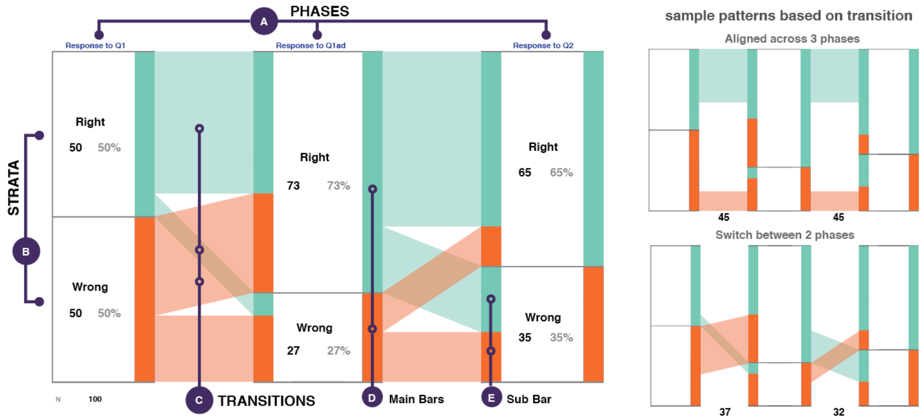

Fig. 1. Stratified Attribute Tracking (SAT) Diagram and sample patterns that emerge.

Research Questions – Methodology:

Following are the broad research questions (RQ):

RQ 1: How can transition patterns be visualized within a dataset in a manner such that various cohorts in the dataset emerge?

RQ 2: Considering an educational dataset, what are the various ways in which transition patterns and cohorts can be used to conduct academic analytics?

RQ 3: How usable is the tool that helps in developing an interactive visualization of transition patterns?

We are adopting the Design Science paradigm [3] to develop the visual artifact (SAT diagram) along with a tool (iSAT) to assist users generate the visualization and interact with their data. This research draws from research findings in information visualization, visual analytics and learning analytics to build the visual artifact, which is evaluated by mixed methods research.

Studies on SAT Diagram:

A need analysis was done by conducting meta-analysis of 52 sampled papers (19.5%) from the last 5 years' *Learning Analytics and Knowledge* conferences, which dealt with visual representations of data or analyzed trends of cohorts. The analysis highlighted the lack of existing tools to assist visual cohort analysis for educational researchers. Our work seeks to bridge that gap and help studies to visualize transitions in various datasets like, students' behavior during an active learning session, eye tracking data during computer based activities, response in perception surveys, performance scores based on rubric items, etc. Based on the transition patterns across the attributes, researchers could gain insights such as model engagement patterns in a large classroom during active learning session or compare eye-movement transitions of different learners, etc. Currently nine published research studies have used and reported data with SAT diagrams.

In the context of instructional decision-making, we have studied possible application of SAT diagram during Peer Instruction activities (an in-class active learning strategy) [3]. Visualizing patterns of transitions of students' answer choices across the phases of Peer Instruction can help instructors to identify cohorts for specific instructions. Currently an investigation is being done on how the iSAT tool can help MOOC instructors to understand students' engagement and performance during an ongoing course and compare across multiple offerings to explore effective strategies that work.

Three introductory iSAT tool workshops have already been conducted. For evaluation of the tool, sampled stakeholders were interviewed and administered the System Usability Survey (SUS). Although the preliminary results indicate a positive response, further user data is needed to understand how iSAT assists researchers and instructors with insights into a cohort or to take instructional decisions based on the transition patterns in the SAT diagram. This input shall help to develop a framework that can be used by the stakeholders for visual cohort analysis of educational datasets.

Expected contributions of the Ph.D. work:

1. The SAT diagram: Its design rationale and systematic development;
2. An analysis framework: Useful to process data for visualizing as SAT diagram and study its transition patterns to identify cohorts in an educational dataset;
3. iSAT: A tool for generating the SAT diagram and interactively exploring the transition patterns;
4. Impact evaluation: An evaluation of the SAT diagram and the iSAT tool for stakeholders of Learning Analytics, specifically educational researchers and instructors.

Discussion agenda during symposium:

1. What are the appropriate methods to evaluate the effectiveness and utility of diagrams such as the SAT diagram that are meant for a specific target group?
2. What are the methods for identifying, evaluating and reporting biases associated with the generation and interpretation of SAT diagrams?

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kindly visit www.et.iitb.ac.in/~rwito/iSAT for other publications related to SAT Diagram.
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Perceptual Inventory: Contemporary Art as a Strategy for Studying Everyday Information Visualizations

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Abstract

How can contemporary art practices contribute to the study of information visualizations? The following paper outlines an exploratory visual-research project which brings together the overlapping infrastructures of contemporary art and social scientific reach methods to form new sites of inquiry into graphic representations. The project focuses its inquiry on the hand-drawn map, here defined as notations of directions often scribbled on paper (or the readily available napkin) for the purposes of helping people get from Point A to Point B. To date, we have performed the project in three cities- Toronto, ON, St. Louis, MO, and Brighton, UK- where we walked through the streets and collected directions from helpful passers-by. In total we collected a robust dataset of 180 hand-drawn spatial notations made with black pen on white pieces paper. As such, the project locates social scientific practices of graphic elicitation within in a genealogy of contemporary art, one that intervenes in public spaces, outside traditional gallery contexts in order to capture the interpretive and ambiguous perceptions of everyday spaces.

Keywords: visual methods; information visualizations; contemporary art; diagrams; drawing; spatial representation

1 Introduction

The research project explores the possibilities of using art as a strategy in the field of Information Studies to elicit new understandings of how information, specifically spatial information, is perceived and represented in graphical forms. Historically, information scholars have used philosophical-analytic techniques to develop disciplinary-bounded and word-based definitions of information [1, 2]. In contrast, the project addresses the visuality of information, an important site of inquiry given the unprecedented scale and proliferation of the image within our contemporary information landscape. The project focuses on the hand-drawn maps- directions made with black pen on blank pieces of paper for the purposes of helping people get from Point A to Point B (see Figure 1).

We start from the question: in a time when the ubiquitous Google Map dominates cartographical thinking, what is the nature of the spatial representations produced using intuitive diagramming methods? The project combines graphical elicitation with interventionist art practices to produce an exploratory research project based on the collection of hand-drawn directions from helpful passers-by. As a result, the process generates a robust data set of locative notations. The map is an important site to study information visualization, as both a mimetic and navigational medium that is at once familiar and historically imperialist [3]. As a result, the project is means to capture the interpretive and ambiguous perceptions of everyday spaces.

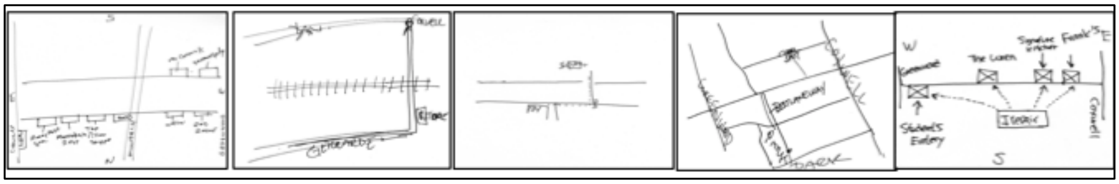

Fig. 1. A selection of 5 drawings from the Toronto dataset collected in April 2014.

2 Collecting Hand-Drawn Maps

We situated the project in three urban centres- Toronto, ON, St. Louis, MO, and Brighton, UK- where we walked through the streets and collected directions from helpful passers-by. In total we collected a robust dataset of 180 hand-drawn spatial notations made with black pen on white pieces paper. Having completed its pilot collection phase, we have yet to offer substantive conclusions to the motivating question outlined in the introduction, but we anticipate that this question will be addressed in the forthcoming phase of analysis. The action of asking for directions elicits multiple iterations of graphic notations that have aesthetic and conceptual value. Combined with carefully noted field notes, these direction become a site for studying how three-dimensional space is intuitively represented in two and one-dimensional notations (see Figure 2). We have completed the pilot stage, which provides the foundation for the main site of data collection. The resulting assemblage of 180 directions and corresponding field notes from each encounter are undergoing a process of inductive analysis to understand how graphic representation of spatial information comes to be intuited and communicated.

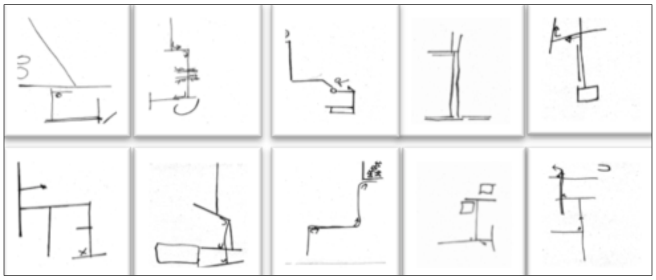

Fig. 2. A selection of 10 drawings from the St. Louis dataset, collected in February, 2015.

3 Disciplinary Considerations in Interdisciplinary Research

In order to successfully navigate these interdisciplinary practices, it is important to unpack what we mean by contemporary art. Art has long been a field that questions and responds to how images and representations are understood and translated [4]. In contemporary art, theories of aesthetics have broadened beyond material manifestations such as paintings and sculptures, to include process-focused performances and co-creative public events based in audience participation [5]. Therefore, the category of 'art' in this interdisciplinary project extends beyond the drawn object of the map to include the very site of data collection and the action of asking passers-by for directions. These encounters of asking for directions were deliberately subtle events that followed a trajectory of art, historically located in the performance and conceptual art traditions of the 1960s, specifically the works by French artist and theorist Guy Debord and Dutch conceptual artist Stanley Brouwn. Debord's *psychogeographic* explorations would lead people to wandering through a city as a means to create new self-reflexive relations to one's environment [6]. Similarly, Brouwn's conceptual work emphasized the provocative nature of minimal graphic and linguistic notations. Brouwn's piece *This Way Brouwn* (1961) is based on a similar form of asking for directions of how to get to the main square in Amsterdam and has been foundational to our artistic process [7]. Our project, in its current state uses these strategies of art and reinterprets them in the changed information landscape of our contemporary context. We see these socially-located artworks- social in that they happen or intervene in the public sphere, outside traditional gallery context- is in keeping with the emerging social scientific paradigms of critical visual methodologies that focus on participatory forms of data collection through such techniques as photography or drawing [4]. Indeed, visual research uses art as a catalyst for the exploration of questions and theories often citing the ability of an image to capture that which is difficult to articulate in words [8].

4 Discussion and Future Work

The project introduces novel research methodologies that work to reassert new projections of space within a context of diagram-based scholarship. The work enunciates space and provokes new forms of spatial thinking, interrupting the standardization of maps asserted by mobile device applications and satellite navigation systems. Both the processes and the images exist in abstraction, and yet both represent a specific set of purposes: to make visible that which is invisible, those subjective articulations of space that are expressed in an instant. The project provides examples of intuitive diagramming and provokes a discussion about the novel techniques of collecting and engaging with information visualizations.

We can locate this interdisciplinary method in taking up Information Studies scholar, Johanna Drucker's call for a new visual epistemology that re-conceptualizes the notion of data to be constitutive *capta*, defined by Drucker as the "humanistic lens" of data that capture the relationship between "observer and experience" [9, 10]. *Capta* acknowledges the interpretive context in which all information visualizations are constructed [9], which in this case of this project, is a chance encounter in which a lost stranger. The project produces multiple localized representations of space (see Fig. 3), and as such, a visual narrative that is at once subjective in representation and co-dependent in perception.

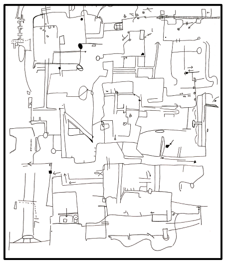

Fig. 3. A composite of the Brighton dataset, collected September, 2015, in which all 60 direction are connected.

As we move into the next stage of the research process, we will begin to apply rigorous analytical strategies in order to elicit robust and holistic substantive claims from the dataset, and future iterations of ethnomethodological investigations of intuitive diagramming. Overall, the incorporation of artful engagements with traditional ontological inquiries about information, advocates for the continued application of visual methodological outlooks that create new inter-determinate narratives and imaginative summaries of a discipline's big ideas. For now, the project's main contribution is based in how it brings together the overlapping infrastructures of contemporary art practices and social scientific research methods to create a new site of investigation to study how information visualizations are made and understood in everyday contexts.

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To Diagram or to Summarize When Studying Scientific Materials: Examining the Effect of Expertise

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Abstract. A 2 (learning strategies: diagram vs summary) x 2 (levels of expertise: low vs high) experiment was conducted to compare the effectiveness of using diagrams to writing summaries for students given biological information to learn and who possessed different levels of expertise in that topic area. A main effect of learning strategy used on number of idea units encoded (in diagrams or summaries) was found: drawing diagrams was superior to writing summaries. However, no interaction effect between learning strategies and expertise was found. An examination of students' subjective ratings of cognitive load revealed that those with low expertise reported higher levels of cognitive load when constructing diagrams. These findings suggest that using diagrams is effective for identifying and encoding important information when learning, but that it would be helpful to provide guidance about diagram use particularly to students who are novices in the topic area to reduce cognitive load.

Keywords: learning strategy use, diagramming, summarizing, cognitive load, expertise, science learning

1 Introduction

Diagram use in learning and problem solving is generally considered to be an effective strategy [1]. One research study that provides supporting evidence for this view is that of Leopold and Leutner [2], in which they reported that generation of diagrams in learning science texts was far more effective (in terms of both comprehension and subsequent transfer) compared to the text-focused learning strategies of summarizing and selecting main ideas. They explained their finding in terms of diagram construction providing students with a visual-spatial component to the information being learned, and thus facilitating use of both verbal and visual channels of their working memory. However, Leopold and Leutner did not examine the relative amounts of information they encoded/represented. If students encode more information when diagramming, this may at least provide an additional explanation for why diagram use results in more successful learning outcomes.

Two other factors that need to be examined in relation to diagram construction for learning are expertise and cognitive load [3, 4]. More specifically, it is important to find out whether students who possess more knowledge (and therefore “higher expertise”) about the topic they are learning are able to represent more information in diagrams they construct. Likewise, from an instructional perspective, it would be useful to find out whether students who possess less knowledge (and therefore “lower expertise”) might perceive higher amounts of cognitive load when constructing diagrams for learning. Perception of higher load or greater cognitive cost in using the strategy could prove to be a deterrent to students spontaneously using it [5, 6].

The present study investigated the above issues, testing the following hypotheses:

1. Diagram construction for learning would result in more units of ideas being encoded compared to summarizing.
2. Amount of information that students represent in diagrams and summaries would be related to their comprehension scores.
3. Students who possess more knowledge about the topic would represent fewer units of ideas when learning since they had previously learned the material already.
4. Students with less knowledge about the topic being learned would perceive higher levels of cognitive load when constructing diagrams.

2 Method

The participants were 34 8th-grade (approx. 14 years old; females = 19) and 39 7th-grade students (approx. 13 years old; females = 19) from a school in Beijing, China. The students in the 8th-grade had previously had lessons about the human blood circulation system, which was the topic of the passage that they had to read and learn for this study: hence, they were designated as having “high” expertise in the topic. In contrast, the 7th-grade students had not yet had those lessons, and were therefore considered as having “low” expertise.

The participants were given a 4-page booklet containing the tasks for the experiment. There were two versions of the booklet: one requiring construction of diagrams in learning the passage provided, and another requiring summarization instead. In each grade level, approximately half the students were randomly assigned to each of the diagram and summary conditions. The passage was identical in the two booklet versions, and comprised four paragraphs. After each paragraph, the students were required to either construct a diagram or write a summary of the key points. Then they had to provide a subjective rating of the cognitive load (i.e., amount of mental effort) they experienced in that diagramming or summarizing. On the last page of the booklet were four comprehension questions they were asked to answer.

The diagrams and summaries that the students created were scored for the number of idea units (previously determined) contained in the passage.

3 Results and Discussion

Analysis of variance revealed that the effect of learning strategy used was marginally significant, $F(1, 71) = 3.63$, $p = .061$, $\eta_p^2 = .050$. This indicates a tendency for more units of ideas to be represented when the students were generating diagrams to learn the contents of each paragraph. Correlational analysis also revealed that the amounts of idea units the students represented in diagrams and summaries were significantly correlated with their comprehension scores: for diagrams, $r = .479$, $p < .001$; for summaries, $r = .406$, $p = .014$. These results confirm the first two hypotheses, and suggest that the construction of diagrams in learning promotes the representation of more idea units from the material being learned. In turn, the more idea units students represent during the learning process, the better their comprehension of the material turns out to be.

The analysis results also supported the third hypothesis: participants of higher expertise represented fewer idea units in their diagrams and summaries, $F(1, 71) = 15.89$, $p < .001$, $\eta_p^2 = .187$. Interestingly, they also scored lower in the comprehension test, $F(1, 71) = 6.95$, $p = .010$, $\eta_p^2 = .091$. (The interaction between strategies and expertise was not significant.) These findings provide further support for the second hypothesis that the amount of information represented during learning would be related to comprehension scores. Because the students of higher expertise did not make the effort to represent as much information, they scored poorer in the test.

Regarding students' subjective ratings of cognitive load when constructing diagrams, the effect of expertise was found to be significant, $F(1, 71) = 10.17$, $p = .002$, $\eta_p^2 = .128$. Participants with lower expertise reported higher levels of cognitive load compared to those with higher expertise. This finding supports the fourth hypothesis, and it suggests a need to provide instruction and guidance to students about how they might be able to effectively learn new materials with the use of diagrams, to alleviate the high cognitive load that such learning could entail. However, because of the previously reported low performance of the students with high expertise, these students' general lack of motivation/effort could have been a confounding factor. Thus, a re-examination of this issue in future research – perhaps in conjunction with examining the effect of instruction on experience of cognitive load – would be useful.

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Mind Control or Not?

Do Flow Charts Harmonize Information Processing?

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Abstract. Flow charts are used in health care, depicting protocols on medical interventions. These charts and the protocols they contain, are thought to harmonize information processing across medical professionals. We hypothesize that flow charts are not objectively processed, which undermines the expected harmonization. By means of experiments and eye tracking, we will study the effect of professional experience and personal traits on flow chart processing. Preliminary results indicate that flow charts do not harmonize information processing nor do they fully cancel out the influence of intuitive decisions made prior to processing the chart.

Keywords: Flow chart · medical protocol · dual process theories of reasoning · eye tracking

1 Introduction

The societal and political pressure on health care providers to minimize medical errors is high. This encourages them to implement guidelines. A guideline regularly comprises protocols that are depicted as flow charts. These charts and the protocol information they contain, are thought to harmonize information processing across medical professionals. We hypothesize that flow charts are not objectively processed, which undermines the expected harmonization. By information processing we mean combining the contents of a task with the contents of a flow chart, in order to take a decision.

We presume that three personal traits influence processing a flow chart. First, self-efficacy. Various authors state that having a low level of self-efficacy towards understanding diagrams can discourage people from using them effectively [1, 2]. Second and third, an individual's level of expertise, and inclination to reason intuitively vs. analytically. It is argued that simplified diagrams of a situation and the rich mental models of an experienced decision maker can come into conflict [3]. Mental models influence how a person comprehends a given situation, and shape an individual's response to the situation. These models and the response that they shape differ between individuals [4]. According to dual process theories of reasoning an individual's response to a situation can be a product of one of two reasoning systems: system 1 for intuitions and system 2 for deliberations [5]. System 1 relies on heuristics [6]. Actions

adfa, p. 1, 2011.

and conceptions flow from heuristics. When these are based on an expected familiarity with a given context that is not fully appropriate given the full array of available information, we speak of a bias. This bias may cause blind spots for details in information. System 2 can override or inhibit default responses flowing from system 1[8]. However, in the absence of a trigger that the response provided by system 1 is not sufficient for the task at hand, people tend to reason according to that response. Even diagrams may be perceived too simple to activate deliberate reasoning [7]. In research on text processing though, triggers are found that activate system 2 [9]. These, or similar triggers, may help prevent biases in flow chart reading as well, strengthening harmonized processing.

2 Method

We will test our hypotheses by the means of experiments and a questionnaire containing: (1) The Cognitive reflection test [10]; measuring an individual's inclination to go with a system 1 response. (2) The New general self-efficacy scale [11]; measuring an individual's perceived level of self-efficacy. (3) Questions on experienced complexity in working with flow charts. (4) Questions on the experimental task and on demographics. The experiments consist of simplified decision trees and paramedic flow charts combined with a task. We will use an eye tracking device for part of our studies. In this way we can accurately measure flow chart reading by identifying fixation points, scan-paths and the time needed to read a flow chart. The degree to which the information in a flow chart is harmoniously processed is estimated by measuring the occurrence of heuristic reasoning, comparing, across individuals, the level of detail of information taken in and the order in which flow charts are read.

3 Completed and Future Work

Study 1 (completed). Undergraduate students identified a subject by using a simplified decision tree. Results are preliminary, but indicate that flow charts do not harmonize information processing nor do they fully cancel out the influence of intuitive decisions made prior to processing the chart. We found a rich variation in flow chart scan-paths. A small number of participants even used the flow chart to suit their intuitive decision. This indicates that either a participant's processing of the flow chart information was influenced by the intuitive decision, or the intuitive decision annulled the flow chart outcome. Study 2. Replication of study 1 with trained flow chart users (paramedics). Study 3. Eye tracking. 60 experienced and 60 novice paramedics take part in experiments that consist of a case and its corresponding protocol (flow chart). Cases are either familiar or unfamiliar. The flow charts are familiar, new or new with a trigger. We will compare the results of the experienced to the novice paramedics.

Study 4. Survey. Paramedics respond to statements that constitute the New general self-efficacy scale and are questioned on experienced complexity in working with their protocols (flow charts).

4 Expected Results

We study the way flow charts are processed across individuals (students and paramedics) with (1) different levels of training in flow chart reading, (2) different levels of expertise with respect to content. Furthermore we will test the effect of triggers on the likelihood of noticing adjustments to the flow chart content, under the condition of high work experience. With the gathered knowledge, health care providers will know if and how flow charts can be effective in harmonizing medical practice and making it more evidence based. Moreover, we will contribute to the body of knowledge on dual process theories of reasoning and cognitive reflection. To our knowledge no study before related these theories to flow chart use.

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The Inferential Advantages of Diagrams in Reasoning Tasks

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Abstract. There has been a long-held belief that diagrams are more effective representations of information, as compared to symbolic representations when performing reasoning tasks. The aim of this project is to find out if that belief can be substantiated by providing empirical evidence that inferential advantages in diagrams aid reasoning tasks as compared to symbolic set theory.

Keywords: inferential advantages, Euler diagram, linear diagrams, spider diagrams, PaL diagrams, symbolic representations of sets.

1 Overview

The inferential advantages, a key generated by Stapleton et al. [1], are thought to allow users to glean and understand more information than notions without them. Inferential advantages occur when the user can read more information from one notation than they can read directly from the others notations, despite the fact that they represent the same information.

The same information, B is a subset of A and A and C are disjoint, can be represented in the three notations, in particular, in set theory $B \subseteq A, A \cap C = \emptyset$, by an Euler diagram (figure 1) and a linear diagram (figure 2).

Fig. 1: Euler diagram

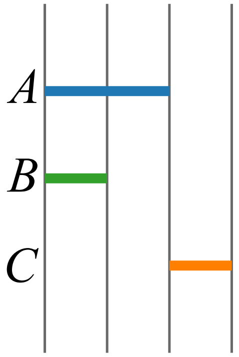

Fig. 2: Linear diagram

From figure 1, we can observe directly that B is disjoint from C; this information was not given explicitly by the symbolic set theory. A similar observation can be made from the linear diagram in figure 2. Such observations are called inferential advantages. Inferential advantages occur when the user can read more information from the diagrams than they can read directly from the symbolic set theory, despite the fact that they represent the same information. Little research has been done to establish whether inferential advantages bring significant benefit when people perform reasoning tasks [1]. We are going to do an emprical study between the three notiations, Euler, linear diagrams versus symbloic set theory to establish whether the diagrams have the inferential advtages when peroforming reasoning tasks. We will use an extension of Euler diagrams, called spider diagrams, and an extension of linear diagrams, called Pal diagrams, to extend the theory of inferential advantages to them. Spider and Pal diagrams allow us to show cardinality information. Once we extend the theory, we will design an empirical study between the three notations: spider diagrams, PaL diagrams and symbolic set theory.

2 Project's Questions

1. To establish whether reasoning tasks are performed more accurately or faster when using Euler diagrams and linear diagrams as compared to symbolic representations of sets.
2. To extend the theory of inferential advantages to spider diagrams and PaL diagrams to express non-emptiness of sets.
3. To establish whether reasoning tasks are performed significantly more accurately or significantly faster when using spider diagrams and PaL diagrams as compared to symbolic representations of sets.

3 Inferential advantages

Looking at the example in the overview section, we can see that the notions with inferential advantages might help users deduce more information more than the notions without them, despite the fact that they represent the same information. The definition of an inferential advantage requires three key notions to be defined: semantic entailment, semantic equivalence, and what it means for a statement to be observable from a set of statements [1]. It is a long held belief in the Diagrams community that free-rides, which are specified centered of inferential advantages, help users glean more information for the kind of diagrams we will consider [2] but there is no empirical evidence to support this belief. The aim is to fill this niche by providing the support for that belief in this project. However, if we demonstrate that inferential advantages do not aid users' performance, then, we will dispel this belief. This could urge the Diagrams community to rethink when and why diagrams sometimes aid users as compared to symbolic nations.

4 Methodology

The major component of this project is a series of empirical studies. These studies will consider the representation of information between Euler diagrams, linear diagrams, and symbolic set theory in reasoning tasks. In this stage, we are going to have a between-groups design for our empirical studies. Each group will take the study in one of our notations, Euler diagram, linear diagram, or symbolic set theory. Each notation in our study will have the exact information the others notations have. We are trying to compare the participants' performance with each notation to come up with the results that demonstrates which of the notations (Euler diagrams, linear diagrams, and symbolic set theory) help people to perform reasoning tasks in the most effective manner. These experiments are more likely to comprise multiple-choice questions. All participants will take the experiments in the same laboratory with the same computer. Having read papers [3, 4] of previously carried out empirical works, we have observed that they measured the time taken to answer the questions in addition to accuracy. Consistent with previous research in the field [5], we will measure these two variables for our experiments. People will discern the best way to represent the reasoning tasks upon the completion of the experiments. At this stage, where I have just started my project, I am looking for advice on how to design the empirical studies.

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