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Analysing the past to prepare for the future: Writing a literature review a roadmap for release 2.0

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ABSTRACT
This roadmap identifies two developments for improving the process of literature reviewing. First, a method for systematically digitally encoding papers' core knowledge contributions in the form of a graph is proposed. Second, the creativity literature is reviewed as a source of inspiration for crafting theoretical contributions.

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A future path

Since we first wrote our roadmap for literature reviews almost twenty years ago (Webster & Watson, 2002), others have followed with important papers outlining different types of literature reviews (e.g. Leidner, 2018; Paré et al., 2015; Schryen et al., forthcoming)or how to make searches more comprehensive and efficient (e.g. Bandara et al., 2015; Koukal et al., 2014; Larsen et al., 2019; Vom Brocke et al., 2009). Despite such activity, two major shortcomings remain.

First, there have been no significant developments to radically improve literature searching, although systematic and uniformly adopted methods for digitally encoding papers' core knowledge contributions are now possible. Instead, most scholars rely on the pre-digital era practice of reading papers for surfacing their conceptual and theoretical contributions. Thus, to enhance scholarly productivity and knowledge accumulation, we suggest that the field structure the core knowledge captured in articles. Specifically, we demonstrate the applicability of graph theory for knowledge coding of articles that represent key theoretical perspectives in graphical or graph-convertible propositional forms.

Second, little has been written on the most difficult part of conducting literature reviews: extending beyond the literature search and summary of past research to the development of theoretical directions for the future. For instance, a recent article with suggestions for conducting literature reviews (Templier & Paré, 2015) does not develop this notion further but cites our earlier paper for directions in this regard. Consequently, this paper suggests ways of crafting theoretical contributions by making brief forays into the creativity literature. Doing so should help scholars gain insights into how some people see connections that others might overlook.

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This commentary begins to address these issues by focusing on concept-centric writing and the representation of the core of a review as one or more graphs that can be coded and combined with similar representations to create a meta-synthesis[1] of knowledge that can be efficiently searched and explored. We advocate that scholars adopt a concept-centric discourse and representation to, respectively, advance preparing for the future in personal research and collectively for the field. Thus, this article provides some initial thoughts on how to synthesise research findings at a higher discourse level. To do so, we draw on our experiences in synthesising concepts across multiple domains (Ortiz de Guinea & Webster, 2017; Ortiz de Guinea et al., 2012; Watson, 2014, 2019).

The concept perspective

Concepts are the foundations of theory building and testing. Thus, many recognise that concept-centric writing raises the quality of a literature review by nudging it towards a synthesis of what is known about the concepts of interest rather than a summary of what various authors have reported (Webster & Watson, 2002). Once the notion of concept centric writing has been presented, most scholars find it a relatively uncomplicated to adopt through developing a concept matrix and flipping their writing style from author- to concept-centric (e.g. Burton-Jones et al., 2017). That is, micro-level synthesis is relatively straightforward.

We contend that a literature review also requires a higher-level synthesis. It typically needs to integrate concepts across domains into a holistic treatment of a subject. The author has to identify what ideas matter and then find a way to coherently link them into a stream that has a clear and relevant expository flow for the intended reader. Because of advances in graphical models, the associations represented by conceptual relationships can be transformed into a mathematical model with well-defined semantics and logic expressed as graphs (Pearl, 2009). In this article, we begin to develop a roadmap for learning how to manage the macro level of discourse synthesis through the application of graph theory,[2] which is concerned with the mathematical study of structures modelling dyadic relationships between objects. Graph theory has been applied in many fields, such as computer science networks and social network analysis (Burt, 1982), and is particularly appropriate for modelling conceptual relationships.

Element mapping

In our first article, we focused on the synthesis of a theme or topic: the many cites to this article suggest that urging scholars to be synthesis- rather than summary-oriented was beneficial. Now, we advocate that IS should aim to support a meta-synthesis of the field through formally mapping, as appropriate, the relationships among the core elements (e.g. concepts and processes) of a synthesis. We opt for the term *element* to accommodate particular implementations of a set of relationships, such as a process diagram, because of our field-level ambition of codifying core IS knowledge. We suggest that this could be based on the creation of element graphs (such as a nomological or process relationships) and their corresponding descriptions in a graph notation language. Once so coded and verified by scholarly review, the data could be loaded into a graph database, and if this process were widely adopted, we would gradually build a meta-synthesis of Information

Systems research. That is, the coding of each publication could be used to update a graph database so that a meta-synthesis of the literature would emerge over time. Thus, we would end up with a single database with hundreds of connected concepts, processes, theories, frameworks, etc., that people could query, such as identifying all papers that link two specific concepts. We describe how this might occur by first mapping at the publication level and then systematically aggregating across many maps.

A labelled graph properties database

A graph is composed of **nodes** and edges. In the domain of literature reviewing, an element of interest (e.g. a concept or process) is a node and a **relationship** between a pair of elements is an edge. A labelled graph properties database allows nodes and relationships to have properties (Negro, 2018; Robinson et al., 2013). A **property** of an element might be a concept's name (e.g. information asymmetry) and its type (e.g. a concept). The property of an edge relationship could be a descriptor of the relationship, such as 'precedes' in the case of a process diagram or 'causes' for a causal model. Another property could indicate the nature of a relationship, such as causal or temporal. Nodes can also have one or more **labels**, which are used to group nodes together and indicate one or more roles. Thus, all elements of the same type (e.g. processes) could be so labelled to group them. We suggest that a graph description language (GDL) could help in this regard in defining elements and nomological relationship maps. A graph query language (GQL) is used to query a graph database and provides features similar to SQL for the relational model. ISO is working on specifying a standard GQL based on openCypher and similar languages.[3] In this article, we use openCypher (or simply Cypher), which is currently the most widely adopted open query language for graph databases.[4] Cypher can be used to define and manipulate property graphs (Appendix A). We now consider relationship maps and their descriptions.

Relationship maps

An element relationship map could report the elements unearthed by a literature review and their relationships. For example, it could encapsulate the core of a theory as a series of relationships between concepts. These relationships can have descriptors (properties) or be merely presented as unidirectional or bidirectional linkages, with an implied verb between concepts. A generic element relationship map is displayed in Figure 1. In this diagram, the relationships between elements are generically described as 'relates to.' The type of relationship is a property of the graph, and thus variance, process, and hybrid models can be accommodated by the appropriate definition of a relationship's property.

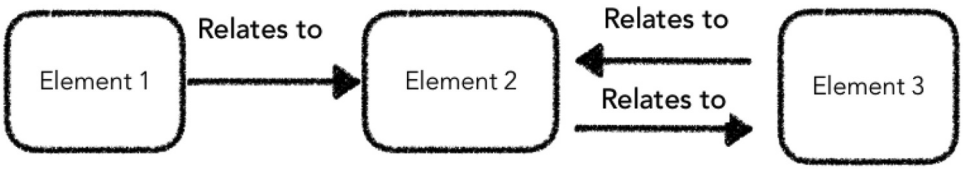

Figure 1. Element relationship map.

Furthermore, there is no requirement for a relationship to have a *type* definition, so diagrams need not have relationship descriptors for all or any relationships. In the example generic diagram, an element could be part of a process model, conceptual chain, or a mediating process (Appendix A gives examples of coding moderators and correlated concepts).

A publication map

To support a meta-synthesis, element maps need to be related to their source publications. Thus, a network graph needs to also contain nodes for a publication and its authors (see Figure 2). In fitting with existing identification standards, we propose that articles be identified by their Digital Identification Object (DOI).[5] For books, we recommend using the ISBN.[6] When a publication does not have a DOI or an ISBN, then a citation can be coded as a property of the node, and we suggest following the international standard ISO 690.[7] Furthermore, we propose requiring that authors also code an ORCID, a persistent digital identifier.[8] The adoption of such standards reduces coding without reducing information content, since the meta-synthesis database could be supported by an application that uses these identifiers to load the additional data associated with an identifier. For example, a DOI could be used to populate a node with a traditional citation.

Two illustrative examples

We first use a recently published paper (Watson et al., 2019) with two graphs to populate a graph database (Figure 3). The Cypher code is provided in Appendix B.

When populated with the paper's nodes (e.g. an author) and relationships (e.g. written by) the resulting automatically generated graph has 18 nodes and 38 relationships in (Figure 3). Because the paper's two models are represented in the one network, they are not readily discerned as separate diagrams. Furthermore, some element names and representation descriptions are truncated and some arrowheads missing. It is challenging

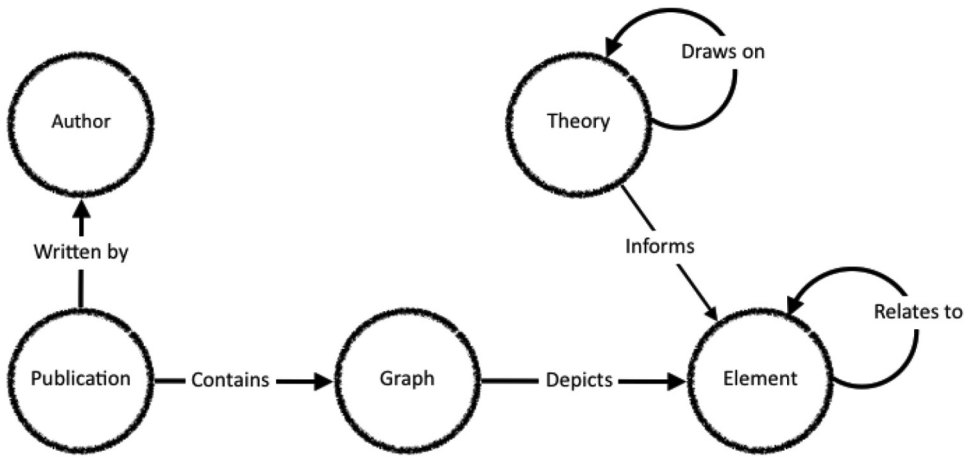

Figure 2. Publication graph data model.

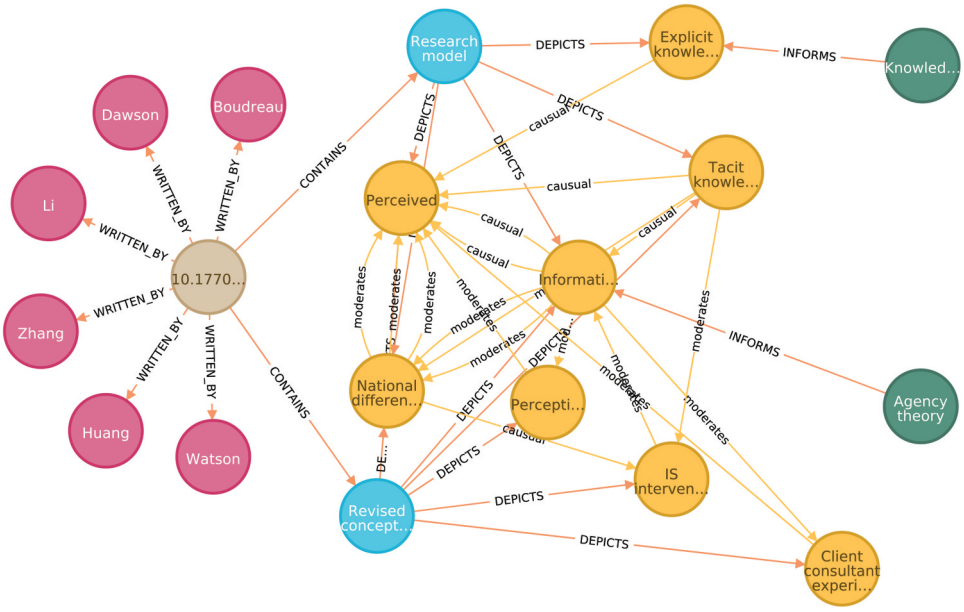

Figure 3. A graph database representation of a causal model and related data.

to create an algorithm that avoids such issues, and as the number of nodes and relationships increases the noisiness of a graph increases. Think of the figure as a starting point for further analysis. As with any database, a query language is required to isolate the aspects of interest or deepen the analysis. The following Cypher code illustrates how one of the two models in Figure 3 can be extracted to produce Figure 4:

```
MATCH (e1)-[r:RELATES_TO]->(e2)
WHERE toLower(r.model) = 'revised conceptual model'
RETURN DISTINCT e1, r, e2
```

Further examples of the use of the Cypher GQL are shown in Appendix C.

The second example reports only the process model (Figure 5) of a published article (Ortiz de Guinea & Webster, 2017). The coding, including authorship and publication details, is provided in Appendix D.

The vision

Our goal is to change the synthesis of literature in three ways. First, we want each synthesis to construct a graph database of the causal or process models appearing in the literature included in its review. We are developing tools to support the creation and analysis of these various graphs. The intention is to assist in identifying integrative causal or process models with a reproducible method. Second, we use uniqueness constraints on identifying properties (such as concept names and ORCIDs) to pool the various graph databases into a single public database available to all scholars. For example, if a coded model contains a node for concept X, the tool will create a relationship to the existing

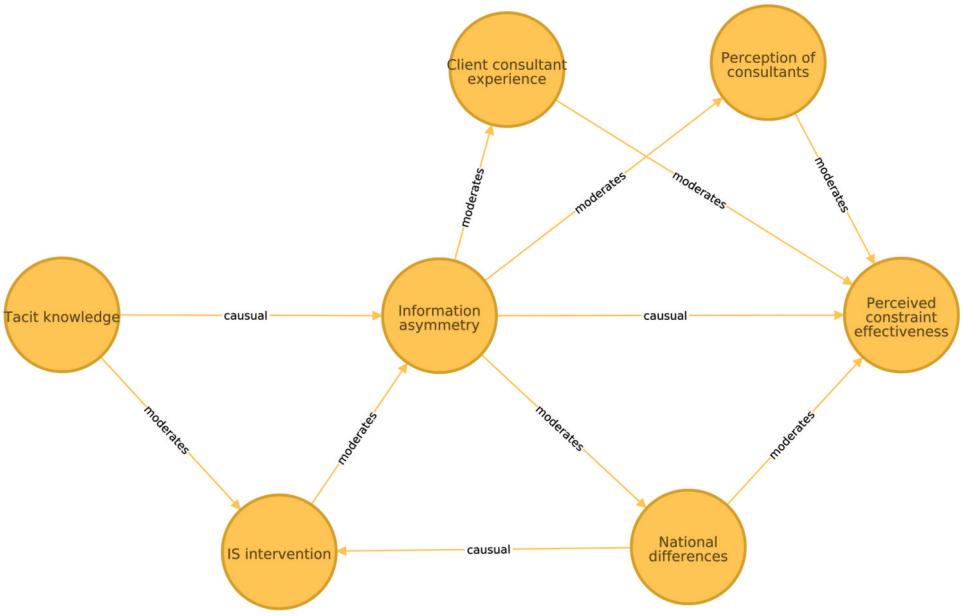

Figure 4. Extracted graph.

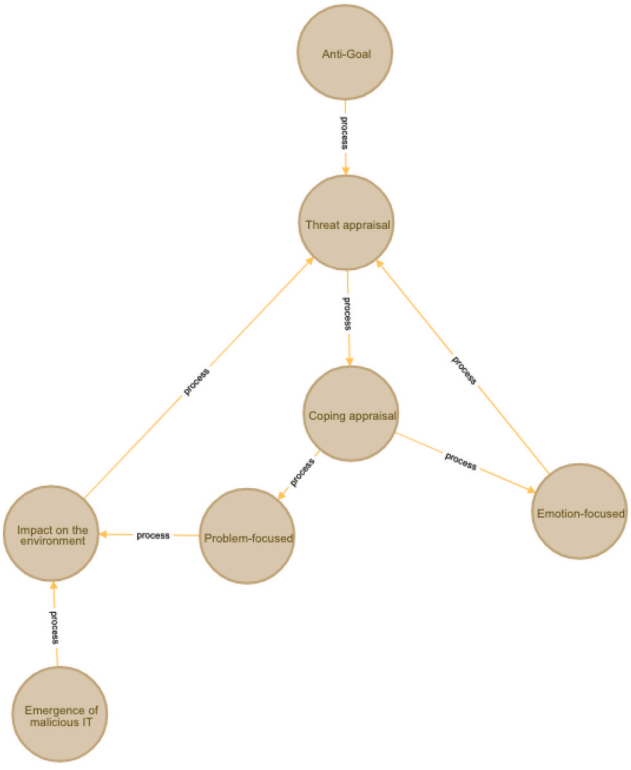

Figure 5. A graph database model of a process model.

node for X or create a new node for X. Authors will be given prompts to link a concept to an existing definition or create a new one when coding a model. In parallel and continuing, we want all journals to submit database updates as articles are published or accepted for publication. Third, we want to improve the efficiency (faster identification of relevant articles) and effectiveness (tools to improve synthesis) of literature reviewing based on the public database. This will also include encouraging research on the analysis of the graph database of causal and process models.

If the formal reporting and coding of element graphs derived from a literature review and accepted articles were adopted, then a meta-synthesis of the IS field would be possible. It would likely require an organisation (such as *AIS* or one or more IS journals) to undertake the creation and maintenance of the necessary database. To further the development of this meta-synthesis, journal editors would need to encourage or require authors, where appropriate, to create and submit their Cypher code to the journal for review.

In sum, increasing the precision of searching would likely raise the profiles of authors and journals who encode their core knowledge contributions and make them publicly available in a collective graph database. Following these suggestions would afford faster and more complete literature reviewing. It would also offer a set of data for future empirical analyses.

Developing future research directions

The development of a meta-synthesis graph database potentially provides a new foundation for future research directions because it will provide a new perspective on existing knowledge and the opportunity to use graph analytics to detect gaps or unrecognised associations. It should provide additional methods to uncover what we know and stimulate our thinking and discovery of connections between knowledge elements.

Understanding the literature through these meta-syntheses as well as our earlier suggestion of concept-centric literature reviews (Webster & Watson, 2002) represent important first steps in identifying research opportunities. However, as we argued in 2002, 'extending or developing theories is a difficult task and is often the weakest part of a review. Nonetheless, it is the most important part of a review and generally needs the most elaboration' (p. xix). We went on to suggest several notable methods for helping to create new ideas, such as examining what others have done (e.g. Griffith, 1999) and considering suggestions for developing interesting research (Davis, 1971). Nevertheless, the theoretical development of a review paper continues to challenge authors (including ourselves!): we would like to propose some additional ideas for developing future research directions. In this paper, we suggest three creativity-enhancing methods, specifically changing one's environment/tasks, using software aids, and participating in mindfulness training.

One method that helps develop more creative work is to step outside one's typical environment of demanding tasks to take part in positive constructive daydreaming (PCD). PCD represents mind wandering 'characterised by playful, wishful imagery, and planful, creative thought' (McMillan et al., 2013, p. 1). In contrast to guilty-depressive daydreaming or poor attentional control, PCD results in higher divergent thinking, creativity, and problem-solving. In terms of encouraging daydreaming, it

> *emerges as a kind of default brain process when our attention to external stimulation is reduced. Most people report that they are especially likely to drift into daydreaming when they shut their eyes and relax their limbs as they prepare for sleep. It is also likely that many times when we are performing overlearned or very repetitive tasks we seem to go into an 'automatic pilot' state and may be able to sustain overt tasks like walking down the street or even shopping* (Singer, 2009, p. 192).

Daydreaming facilitates the formation of novel associations because one's imagination is relatively undisturbed by environmental stimulation (Zedelius & Schooler, 2016). Consequently, engaging in undemanding tasks can help facilitate the creative problem-solving process (Baird et al., 2012). Some experience their most creative ideas when disengaged from work, for example, while exercising (Mandolesi et al., 2018) or in nature (Edwards, 2019). Although there are individual differences in creativity, daydreaming can be encouraged when we are not trying to actively (mentally or physically) problem-solve, such as sitting in a reduced-stimulation room (Singer, 2009). And to encourage PCD, researchers can follow methods for discouraging counterproductive mind wandering (Dane, 2018). Thus, we suggest that researchers take themselves outside of their normal work tasks and sites to increase positive daydreaming.

A second method could be to try out software aids to help with brainstorming and conceptualising new theoretical directions. For example, the Post-it® App (post-it.com) allows individuals and teams to convert analog Post-it notes to digital ones, sharing and organising them across devices and collaborators. Another example could be mind-mapping software, like MindMeister (mindmeister.com), a free-form tool that allows individuals 'to imagine and explore associations between concepts', promoting brainstorming and creative thinking (Davies, 2011). These tools might help researchers with the development of theoretical models for explaining a phenomenon.

A final method that we will suggest here concerns participating in mindfulness training. Mindfulness, or the 'state of conscious awareness resulting from living in the moment,' is made up of distinct skills (Baas, Nevicka, & Femke, p. 1092). These skills, classified as observing internal and external phenomena, acting with awareness, describing non-evaluatively, and accepting without judgement, can be trained (Baas et al., 2014). However, not all mindfulness skills predict creativity: open-monitoring training promotes divergent thinking, while focused-attention training does not (Colzato et al., 2012). Similarly, over a series of four studies, Baas et al. (2014) demonstrate that observing (open-monitoring training) was the only mindfulness skill to increase creativity. Thus, we propose that researchers consider the use of appropriate mindfulness training to increase the creativity of their models to help drive future research directions.

Next steps

In this article, we began to develop a roadmap for managing the macro level of discourse synthesis. We have suggested how researchers could synthesise element models based on prior research through the development of graph networks, and we have proposed how they might better develop future research directions by drawing on creativity methods. That is, we have made suggestions for the two phases of a theoretical review, synthesising existing knowledge and proposing future research directions to create knowledge. The critical contributions of both can be represented as graphs.

Our meta-synthesis examples assume that papers include conceptual models or propositions as an abstraction of the literature. Some will argue that focusing on these will overly simplify the field, losing important richness from the text of source articles. Indeed, syntheses of any form diminish the nuance in the original documents. Some articles develop theoretical arguments without accompanying visual representations or formal propositions. We recognise that such perspectives and situations exist. Our stance is to encourage the development of models when a scholar can see a clear path of relationships or event sequencing in the literature. If such clarity is not evident, then the author should so state and avoid suggesting it can be readily synthesised graphically. If there is a small set of competing models, then the author might elect to present these alternative conceptualisations visually.

We hope that the IS field will come onboard and apply graph coding to new papers. In addition, we hope that the field will conduct coding of older papers, especially past seminal ones. If a published paper does not contain conceptual models or propositions, then a scholar could attempt to infer them from the text. In such cases, we encourage the original author or another scholar familiar with the domain to validate any inferred models. Further, we need to develop methods for ensuring the quality of coding and for managing the considerable effort required for this ambitious initiative. In the case of a new publication, the review process would ideally include checking the coding of a model. When existing publications are coded, the coder and reviewer could be publicly acknowledged. Any coding should be challengeable and modifiable as appropriate. We plan to partner with a journal to prototype graph coding and report back to the field on our experiences.

In the future, we also intend to follow this guide by identifying best practices, and ideally a methodology, for discourse synthesis. To do so, we plan to learn more about how those who excel in literature reviewing create theoretical models to drive future research. We plan to delve more deeply into what authors do by conducting interviews with those who have published conceptual models to discover habits and scholarly practices that support the fusion of multiple and diverse ideas into a coherent whole.

Scientific progress relies upon scholars synthesising existing work to lay a foundation for future research. Search engines have helped the discovery process, but they too often create a large basket of articles that must be read to detect those studies pertinent to the matter of interest. The fundamental problem is that knowledge is not encoded, and scholars must rely on the methods of their forebears (reading or scanning many papers) to take a step forward. With a continuing increase in scientific publications and articles, we suggest the efficiency gains of knowledge encoding to accelerate the pace of knowledge production. By recognising the graph nature of element and nomological maps, we have a method of encoding that will capture the essence of many papers and has the potential to give the IS field an efficiency gain. In addition, this method could potentially influence adoption by other domains, inspiring emulation by other fields. However, this proposed method for organising knowledge should not detract from the paramount goal of creative scholarship that opens up new vistas.

Notes

1. While not defined in the OED, there is usage of the term meta-synthesis to describe the synthesis of qualitative research in the health sciences area (Sandelowski & Barroso, 2006). We do not believe that this should preclude use of this compound word for higher order analysis in IS.

2. Some may suggest that statistical meta-analyses also help to synthesise past research: this is the case, but they are circumscribed in their focus on a smaller set of variables for which a considerable body of empirical research already exists (Lipsey & Wilson, 2001).
3. https://www.gqlstandards.org.
4. https://www.opencypher.org.
5. https://www.doi.org. See https://search.crossref.org/for finding an article's DOI, if it exists.
6. https://www.isbn-international.org. See https://isbnsearch.org/for finding an book's ISBN, if it exists.
7. https://www.iso.org/standard/43320.html.
8. https://orcid.org: the authors' ORCIDs are 0000–0003-0664-8337 and 0000–0002-0350-9115, respectively.
9. https://neo4 j.com.
10. https://www.opencypher.org.
11. https://github.com/opencypher/openCypher/blob/master/docs/style-guide.adoc.

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Webster, J., & Watson, R.T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, *26*(2), iii–xiii.

Zedelius, C.M., & Schooler, J.W. (2016). The richness of inner experience: Relating styles of day-dreaming to creative processes. *Frontiers in Psychology*, *6*, 2063.

Appendix A. Using Cypher as a Graph Description Language

Cypher is a graph description language (GDL) and graph query language (GQL) for labelled property graph databases. Originally designed for the Neo4 j graph database,[9] it is now, in the form of Cypher 9, governed by the openCypher Implementation Group.[10] Cypher is used in open source projects (e.g. Apache Spark) and commercial products (e.g. SAP HANA) (Francis et al., 2018). These actions indicate that Cypher will likely emerge as the industry-standard language for property graphs. Our interest is in the use of the GDL aspect of Cypher to define element and nomological relationship maps.

Here are the components the Cypher version of the element map diagrammed in Figure 1. First, we define the elements:

```
CREATE (:Element {elementName: 'Element 1'});
CREATE (:Element {elementName: 'Element 2'});
CREATE (:Element {elementName: 'Element 3'});
```

Each element is labelled by specifying:Element. In this example, an element has one property, a name in the form of a key-value pair (i.e. elementName: 'Element 1').

Second, we create the relationships:

```
MATCH (a:Element),(b:Element)
WHERE a.elementName = "Element 1" AND b.elementName = "Element 2"
CREATE (a)-[r:RELATES_TO {relationship: ['relationship 1']}]->(b)
RETURN r;
MATCH (a:Element),(b:Element)
WHERE a.elementName = "Element 2" AND b.elementName = "Element 3"
CREATE (a)-[r:RELATES_TO {relationship: ['relationship 2']}]->(b)
RETURN r;
MATCH (a:Element),(b:Element)
WHERE a.elementName = "Element 3" AND b.elementName = "Element 2"
CREATE (a)-[r:RELATES_TO {relationship: ['relationship 3']}]->(b)
RETURN r;
```

Following the Cypher style guide, relationships are upper case (e.g. RELATES_TO).[11] The first chunk of code represents the fact that Element 1 unidirectionally relates to Element 2 and this relationship can be described by a key-value pair (i.e. relationship: ['relationship 1']). The next two code junks describe the bidirectional relationship between Element 2 and Element 3. The DDL cypher code was implemented with Neo4 j (see Figure A1).

More Complex Conceptual Models

In addition to representing models such as the one diagrammed in Figure 1, Cypher can be used to represent more complex models, such as those encompassing moderators or correlated variables.

A moderator affects the strength of the relationship between two concepts, and a mediator intervenes to transform the relationship between two concepts. Traditionally, these have distinct common representations (e.g. Hall & Sammons, 2013), as shown in Figure A2. In words, the moderation diagram states that 'Concept 3 moderates the effect of Concept 1 on Concept2', and the mediation diagram states that 'Concept 3 mediates the effect of Concept 1 on Concept2'. In graph terms, both of these statements refer to the effect of one node on the relationship between two other nodes. Notice that the wording of the two descriptions differs only by the word moderates or mediates.

The common representation of moderation does not directly map to a graph because graph theory does not permit a node to have a relationship with another relationship. Thus, it also not in compliance with the graphical modelling of causality as advocated by Pearl (2009). This is a representation issue rather than a conceptual modelling shortcoming,

In a detailed and widely cited treatment of moderation and mediation (Kraemer et al., 2001) extending the seminal work on this topic (Baron & Kenny, 1986), an alternative representation is presented for moderation (Figure A3), which conforms with graph theory. However, it lacks precision in that it does not indicate that Concept 3 moderates the relationship between Concept 1 and Concept 2.

In conformance with graph theory and adding precision to Kraemer et al.'s (2001) alternative representation of a moderator effect, we represent the type of relationship by specifying the graph

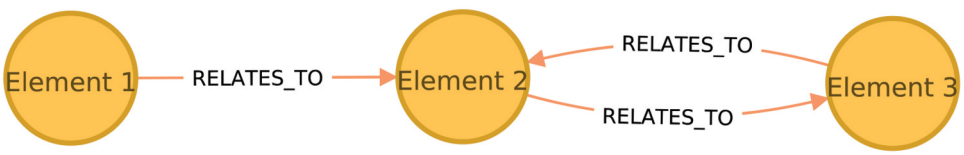

Figure A1. Neo4 j implementation of an element relationship map.

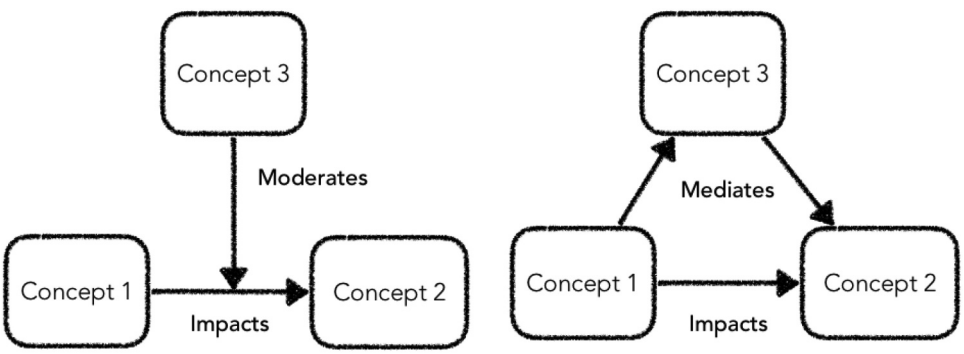

Figure A2. Moderation and mediation (e.g. Hall & Sammons, 2013).

for both moderation and mediation in the same form (Figure A3) and defining a role property for the Concept 3 node of 'moderator' or 'mediator', such as

```
CREATE (:Concept {conceptName: 'Concept 3', role: 'moderator'});
```

The additional precision for moderation is important for more complex models as scholars should not be left to infer the meaning from a concept map. Also, coding the type of relationship in conformance with graph theory, and thus the Cypher language, is necessary for enabling searching across a graph database of many conceptual models for a concept's role in a relationship. This does not mean that scholars need to adopt our graph-compliant representation within the body of their publication, but they must adopt the representation for Cypher coding to enable incorporation in a meta-synthesis database.

Conceptual models may also incorporate correlated concepts for which one does not cause the other (such as the relation between age and work experience). A correlation is a mutual bidirectional relationship between two concepts. Graph theory can represent such a bilateral relationship, though some implementations, but the Cypher GML only supports unidirectional relationships. The limitation can be surmounted by defining an edge labelled as a correlation so that the reader can infer the bidirectionality. An example of such a specification is:

```
MATCH (a:Concept),(b:Concept)
WHERE a.conceptName = "Concept 10" AND b.conceptName = "Concept 2"
CREATE (a)-[r:CORRELATES] - (b)
RETURN r;
```

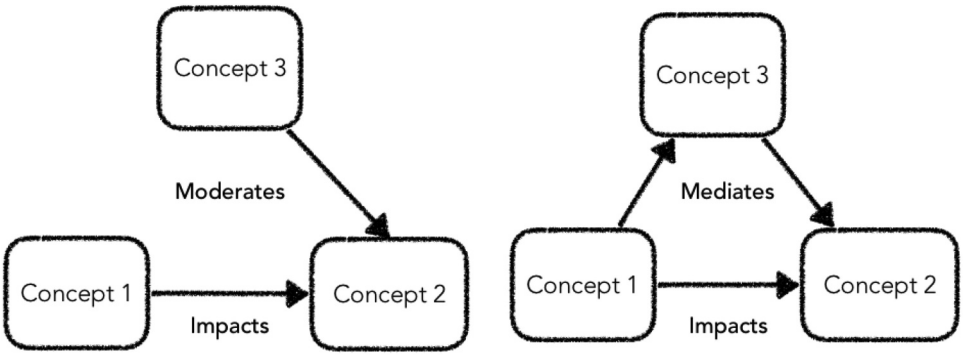

Figure A3. Moderation and mediation (Kraemer et al., 2001).

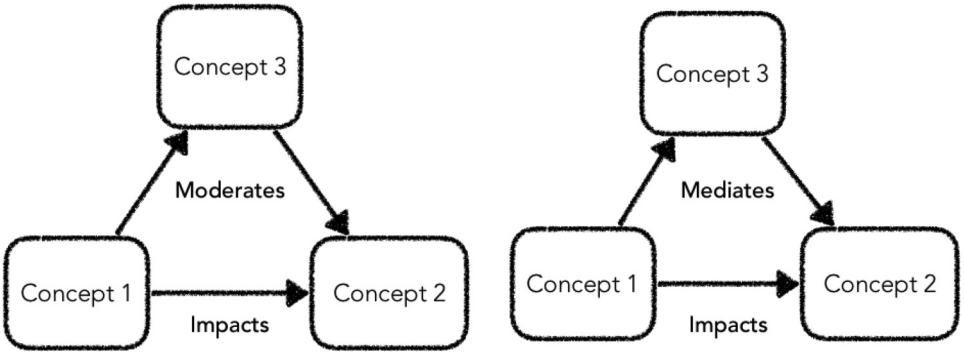

Figure A4.: Moderation and mediation representation to support meta-synthesis.

Appendix B: Sample Cypher Code for an Article

This code graphs models developed in Watson et al. (2019), as depicted in the preceding Figure 3.

```
// Sample Cypher code a publication
// Author: Richard T. Watson <rwatson@terry.uga.edu>
// December 2019

// Create each element with a property of elementName and elementType

CREATE (:Element {elementName: 'Tacit knowledge', elementType: 'Concept'});

CREATE (:Element {elementName: 'Information asymmetry', elementType: 'Concept'});
CREATE (:Element {elementName: 'Client consultant experience', elementType: 'Construct'})
CREATE (:Element {elementName: 'Perception of consultants', elementType: 'Construct'})
CREATE (:Element {elementName: 'Perceived constraint effectiveness', elementType: 'Construct'})
CREATE (:Element {elementName: 'IS intervention', elementType: 'Construct'})
CREATE (:Element {elementName: 'National differences', elementType: 'Construct'});
CREATE (:Element {elementName: 'Explicit knowledge', elementType: 'Concept'});
// Create an index to speed up searching on an element's name
CREATE INDEX ON :Element(elementName);

//Create a publication with properties for DOI (document object identi-
fier) and the citation.

// When implemented, the DOI API (https://support.datacite.org/docs/
api-get-doi) would be used populate properties discretely, such as
journal title
CREATE (:Publication {DOI: '10.17705/1jais.00560', pubCite: 'Watson,
R. T., Dawson, G. S., Boudreau, M.-C., Li, Y., Zhang, H., Huang, W. W., &
Al-Jabri, I. (2019). Constraining Opportunism in Information Systems
Consulting: A Three Nation Examination. Journal of the Association for
Information Systems, 20(7), 986-1022. doi:10.17705/1jais.00560'
});
CREATE INDEX ON :Publication(DOI);

// Create a graph for each model in the publication
CREATE (:Graph {graphTitle: 'Revised conceptual model'});
CREATE (:Graph {graphTitle: 'Research model'});
CREATE INDEX ON :Graph(graphTitle);

// Create a relationships between a publication and graphs it contains
MATCH (p:Publication {DOI: "10.17705/1jais.00560"}),(g:Graph)
WHERE g.graphTitle IN ["Revised conceptual model", "Research model"]
```

```
CREATE (p)-[r:CONTAINS]->(g)
RETURN r;

// Create a relationships between a graph and elements it contains
MATCH (g:Graph {graphTitle: "Revised conceptual model"}),(e:Element)
WHERE e.elementName IN ['Tacit knowledge','Information asymmetry',
'Client consultant experience',
'Perception of consultants','Perceived constraint effectiveness',
'IS intervention', 'National differences']
CREATE (g)-[r:DEPICTS]->(e)
RETURN r;

MATCH (g:Graph {graphTitle: "Research model"}),(e:Element)

WHERE e.elementName IN ['Tacit knowledge','Information asymmetry',
'Explicit knowledge',
'Perceived constraint effectiveness', 'National differences']
CREATE (g)-[r:DEPICTS]->(e)
RETURN r;

// Create the relationships between the elements for the 'Research
model'
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "Perceived constraint effectiveness"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "Explicit knowledge"}),(b:Element
{elementName: "Perceived constraint effectiveness"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "Tacit knowledge"}),(b:Element
{elementName: "Perceived constraint effectiveness"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "National differences"}),(c:Element {elementName:
"Perceived constraint effectiveness"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;
MATCH (a:Element {elementName: "Tacit knowledge"}),(b:Element
{elementName: "National differences"}),(c:Element {elementName:
"Perceived constraint effectiveness"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;

// Create the relationships between the elements for the 'Revised con-
ceptual model'
```

```
MATCH (a:Element {elementName: "Tacit knowledge"}),(b:Element
{elementName: "Information asymmetry"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "Perceived constraint effectiveness"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "National differences"}),(b:Element
{elementName: "IS intervention"})
CREATE (a)-[r:RELATES_TO {type: ['causual']}]->(b)
RETURN r;
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "Client consultant experience"}),(c:Element
{elementName: "Perceived constraint effectiveness"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "Perception of consultants"}),(c:Element {elementName:
"Perceived constraint effectiveness"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;
MATCH (a:Element {elementName: "Tacit knowledge"}),(b:Element
{elementName: "IS intervention"}),(c:Element {elementName:
"Information asymmetry"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;
MATCH (a:Element {elementName: "Information asymmetry"}),(b:Element
{elementName: "National differences"}),(c:Element {elementName:
"Perceived constraint effectiveness"})
CREATE (a)-[r1:RELATES_TO {type: ['moderates']}]->(b)-[r2:
RELATES_TO {type: ['moderates']}]->(c)
RETURN r1, r2;

// Create the authors
CREATE (:Author {ORCID: '0000-0003-0664-8337', authorFirst:
'Richard', authorMiddle: 'Thomas', authorLast: 'Watson'});
CREATE (:Author {ORCID: '2', authorFirst: 'Gregory', authorMiddle:
'S.', authorLast: 'Dawson'});
CREATE (:Author {ORCID: '3', authorFirst: 'Marie-Claude', authorLast:
'Boudreau'});
CREATE (:Author {ORCID: '4', authorFirst: 'Yan', authorLast: 'Li'});
CREATE (:Author {ORCID: '0000-0001-9542-7493', authorFirst:
'Hongyun', authorLast: 'Zhang'});
CREATE (:Author {ORCID: '6', authorFirst: 'Wei (Wayne)', authorLast:
'Huang'});
CREATE (:Author {ORCID: '0000-0002-2217-5675', authorFirst: 'Ibrahim
', authorLast: 'Al-Jabri'});
CREATE INDEX ON :Author(authorLast);
```

```
// Create the relationships between the authors and publication with
authorOrder as a property of the relationship
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '0000-0003-0664-8337'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 1}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '2'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 2}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '3'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 3}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '4'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 4}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '0000-0001-9542-7493'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 5}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '6'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 6}]->(a)
RETURN r;
MATCH (p:Publication {DOI: '10.17705/1jais.00560'}), (a:Author
{ORCID: '7'})
CREATE (p)-[r:WRITTEN_BY {authorOrder: 7}]->(a)
RETURN r;
// Create some theories referenced in the publication and related them
to elements.
CREATE (:Theory {theoryTitle: 'Agency theory'});
CREATE (:Theory {theoryTitle: 'Knowledge types'});
CREATE INDEX ON :Theory(theoryTitle);
MATCH (t:Theory {theoryTitle: 'Agency theory'}), (e:Element
{elementName: "Information asymmetry"})
CREATE (t)-[r:INFORMS]->(e)
RETURN r;
MATCH (t:Theory {theoryTitle: 'Knowledge types'}), (e:Element)
WHERE e.elementName IN ["Tacit knowledge", "Explicit knowledge"]
CREATE (t)-[r:INFORMS]->(e)
RETURN r;
```

Appendix C. Sample Cypher Commands

As with any database, a query language is required to isolate the aspects of interest. Below are some sample Cypher commands to show what it is possible. Note the use of the toLower function to avoid case sensitivity problems.

Find all graphs containing an element called information asymmetry:

```
MATCH (g)-[r:DEPICTS]->(e)
WHERE toLower(e.elementName) = 'information asymmetry'
RETURN g.graphTitle AS `Model title`;
```

The preceding code (g)-[r:DEPICTS]->(e) is a 'pattern' for specifying that a graph depicts an element. This pattern is also used to define a relationship between a graph and element.

Find papers containing a model that includes information asymmetry and is called 'Revised conceptual model':

```
MATCH (p)-[r1:CONTAINS]->(g)-[r2:DEPICTS]->(e)
WHERE toLower(e.elementName) = 'information asymmetry' AND toLower(g.
graphTitle) = 'revised conceptual model'
RETURN p.pubCite AS `Publication`;
```

The preceding code shows how patterns can be connected, as in this case to report a publication containing a graph depicting an element.

Find papers with a relationship between elements containing the words 'tacit' and 'constraint':

```
MATCH (p1)-[r1:CONTAINS]->(g1)-[r2:DEPICTS]->(e1)-[r2:
RELATES_TO*2]->(e2)
WHERE toLower(e1.elementName) CONTAINS 'tacit'
AND toLower(e2.elementName) CONTAINS 'constraint'
RETURN DISTINCT p1.pubCite AS `Publication`, g1.graphTitle AS `Model
title`;
```

The prior query illustrates string handling and a search for relationships between specified elements.

Report publications and models containing the element 'Intervention' and the elements to which 'Intervention' is related directly or in a chain:

```
MATCH m = (p1)-[r1:CONTAINS]->(g1)-[r2:DEPICTS]->(e1)-[*]->(e2)
WHERE toLower(e1.elementName) CONTAINS 'intervention'
RETURN DISTINCT p1.pubCite AS `Publication`, g1.graphTitle AS `Model
title`;
```

In the preceding query the code (e1)-[*]->(e2) handles reporting any elements that are connected to 'Intervention' by one or more links in a chain. If you wanted to restrict to one or three links, the code would be (e1)-[*1.3]->(e2).

The prior examples show a property graph database enables a researcher to identify which publications include a discussion of specific elements and their relationships.