

Accepted version—please cite the published version, which will appear in *Synthese*.

A Co-Citation Analysis of Cross-Disciplinarity in the Empirically-Informed Philosophy of Mind

Karen Yan (The first and corresponding author)
Institute of Philosophy of Mind and Cognition, National Yang Ming Chiao Tung University
No.155, Sec.2, Linong Street, Taipei 112, Taiwan

Chuan-Ya Liao
Institute of Philosophy of Mind and Cognition, National Yang Ming Chiao Tung University
No.155, Sec.2, Linong Street, Taipei 112, Taiwan

Abstract

Empirically-informed philosophy of mind (EIPM) has become a dominant research style in the 21st century. EIPM relies on empirical results in various ways. However, the extant literature lacks an empirical description of how EIPM philosophers rely on empirical results. Moreover, though EIPM is essentially a form of cross-disciplinary research, it has not been analyzed as cross-disciplinary research so far. We aim to fill the above two gaps in the literature by producing quantitative and qualitative descriptions of EIPM as a kind of cross-disciplinary research. Our descriptions aim to enable metaphilosophers to evaluate EIPM methodologically and epistemically. Our analyses use co-citation and categorization analyses informed by the literature on interdisciplinarity. We present five sets of descriptions and identify the three most common types of cross-disciplinary interactions in EIPM. The resulting descriptions enable us to locate two metaphilosophical challenges for EIPM philosophers. One concerns how they should incorporate empirical results in different disciplinary contexts, and the other concerns which theoretical virtue(s) they should aim for when tinkering with scientific theories.

Keywords: Empirically-informed philosophy of mind; Cross-Disciplinarity; Multidisciplinarity; Interdisciplinarity; Co-citation analysis; Theory-tinkering; Free-energy principle; Metaphilosophy

Introduction

Empirically-informed philosophy of mind (EIPM) describes a philosophy research style. It engages in philosophical reasoning by relying on empirical results from scientific measurements, observations, and experiments. This style of relying on empirical results contrasts with a priori conceptual analysis, which involves no empirical investigation (Ashton & Mizrahi, 2018). Knobe (2015) provides some quantitative evidence to show that EIPM is the dominant research style in philosophy of mind between 2009 and 2013.¹ His analysis is a landmark starting point for quantitative metaphilosophical analyses of EIPM.

However, Knobe's work does not tell us *how* empirically-informed philosophers rely on empirical research. He appeals to the criterion of "relying on empirical research" (2015, p. 37), but he does not explain this criterion in detail. The most natural answer seems to be that if a philosophical paper cites some empirical work, it counts as relying on empirical research. Nevertheless, philosophers cite empirical work for various reasons—some for introductory purposes, some for reviewing the literature, and some to support philosophical arguments. Different methodological or epistemological values may motivate different ways of relying on empirical research. If so, philosophers should evaluate them differently. However, we do not know the distinctive ways of citing empirical work in EIPM because we lack a systematic empirical description of the citing practices in EIPM.²

Moreover, to study how EIPM philosophers rely on empirical work is to study EIPM as a form of cross-disciplinary research. When philosophers use work from other empirical sciences, this amounts to crossing the boundary between philosophy and other empirical sciences. This angle is often neglected by both philosophers of mind and philosophers of interdisciplinarity. However, considering EIPM as a form of cross-disciplinarity opens up an opportunity to utilize conceptual resources regarding types of cross-disciplinarity from the extant literature in the philosophy of interdisciplinarity. In this paper, we will adopt Huutoniemi et al.'s (2010) categorization of cross-disciplinarity to help us characterize the distinct features of the EIPM's cross-disciplinary citing practice.

¹ Knobe's dataset includes the philosophy of mind articles published in the two periods: 1960-1990 and 2009-2013. He first identifies the twenty most highly cited philosophy journals based on Google Scholar Metrics. Within these journals, he analyzes the 397 most highly cited articles published between 1960 and 1999 and the 397 most highly cited articles published between 2009 and 2013. He then selects the ones concerning questions about the mind and codes these articles in terms of the following three categories: (1) a priori analysis, (2) relying on empirical research, and (3) original empirical research. According to his results, 'relying on empirical research' is the dominant research style (61.8%) in the philosophy of mind between 2009 and 2013.

² An example from the metaphilosophical literature on experimental philosophy also shows the importance of having a good empirical description of EIPM. Knobe (2019) points out that most metaphilosophers assume that different demographic groups have different philosophical intuitions about the same thought experiment. However, this assumption is typically grounded on several famous articles published in the early stage of experimental philosophy (i.e., the early 2000s). But this assumption needs to be backed up by a systematic description of all or majority of the articles in experimental philosophy. Knobe (2019) performs a systematic analysis of 30 articles from experimental philosophy. To most metaphilosophers' surprise, these articles show a degree of robustness of intuitions across different demographic groups. If Knobe is correct, then most metaphilosophers have made the wrong assumption about the metaphilosophy literature. This example shows how important it is for metaphilosophers to conduct their philosophical analyses based on robust empirical descriptions of the targeted philosophical literature.

This paper aims to fill two knowledge gaps. We will first generate a robust empirical description of how philosophers of EIPM cite empirical articles. Second, this description will provide an understanding of the form of cross-disciplinarity of EIPM and hence how philosophers of EIPM rely on empirical research. Our analysis uses quantitative measures to analyze the journal articles from the philosophy of mind systematically. We also use some philosophical and categorization analyses to characterize the quality of “being empirically informed.”³ Our goal is to produce quantitative and qualitative descriptions of EIPM. These descriptions are empirical because we use bibliographic and citation data between 1950 and 2019. Moreover, we show that our empirical descriptions are robust by satisfying the following three conditions:

1. Following a well-defined procedure for employing a quantitative tool
2. Following a well-defined coding procedure with more than one person performing the coding practice and checking the interrater reliability among their coding results
3. A convergence of different sources of data

The descriptions of EIPM we aim to produce can enable metaphilosophers to evaluate the cross-disciplinarity of EIPM methodologically and epistemologically. In this enabling sense, our empirical description also plays a normative role for metaphilosophers.

To achieve the above aim, we will proceed as follows. Section 2 will quantitatively analyze 2,761 philosophy of mind articles published between 1995 and 2019 and the 11,794 articles cited by these 2,761 articles from the Web of Science database (14,555 articles in total). Our analysis involves co-citation analysis (Chen et al., 2010). This analysis will help us identify some critical empirical articles from the 14,555 articles. In Section 3, we will introduce an empirically-tested framework for characterizing different kinds of cross-disciplinarity. Section 4 will analyze the citation practices of all the philosophy articles citing those articles identified as critical.⁴ Finally, Section 5 will explore how our robust empirical description of EIPM can inform metaphilosophy. We will point out two challenges for EIPM and raise some new metaphilosophical issues.

2. Co-citation Analysis

2.1 Data

We queried the Web of Science on September 7th, 2020, by searching all the articles categorized under ‘philosophy’ or ‘history philosophy of science’ and with either ‘mind’ or ‘mental’ occurring in either subject, title, or abstract. This search resulted in 2,761 articles.

These 2,761 articles together cite 11,794 articles (excluding self-citing articles, i.e., ones in which the authors cite their previous works). Figure 1 summarizes the top 18 fields under which these 11,794 articles are categorized. It is worth noting that, in the Web of Science, a single article can simultaneously be categorized under more than one category. This figure gives some rough information about the cross-disciplinarity of the targeted 2,761 philosophy articles, i.e.,

³ In this paper, we use ‘being empirically-informed’ and ‘relying on empirical research’ interchangeably.

⁴ Section 2 and Section 4 are rewritten based on Liao, Chuan-Ya (2022). Measuring the cross-disciplinarity in the empirically-informed philosophy of mind. Master Thesis (in Chinese) (Advisor: Karen Yan). National Yang Ming Chiao Tung University.

what fields the cited articles belong to. The articles in the interdisciplinary social sciences are the most cited non-philosophy articles in EIPM.



















Field	Number of Papers	Percentage	
HISTORY PHILOSOPHY OF SCIENCE	1,746	63.238 %	
PHILOSOPHY	1,510	54.690 %	
SOCIAL SCIENCES INTERDISCIPLINARY	386	13.980 %	
ETHICS	371	13.437 %	
EDUCATION EDUCATIONAL RESEARCH	85	3.079 %	
HEALTH CARE SCIENCES SERVICES	85	3.079 %	
HISTORY OF SOCIAL SCIENCES	80	2.898 %	
HISTORY	73	2.644 %	
MEDICINE RESEARCH EXPERIMENTAL	68	2.463 %	
MULTIDISCIPLINARY SCIENCES	67	2.427 %	
HUMANITIES MULTIDISCIPLINARY	58	2.101 %	
COMMUNICATION	41	1.485 %	
ENGINEERING MULTIDISCIPLINARY	40	1.449 %	
NEUROSCIENCES	40	1.449 %	
LOGIC	34	1.231 %	
AGRICULTURE MULTIDISCIPLINARY	30	1.087 %	
SOCIAL ISSUES	27	0.978 %	
BIOLOGY	23	0.833 %	

Table 1 The top 18 fields of the 11,794 articles cited by the 2,761 philosophy articles.

However, the above information is still insufficient to understand the distinct style of the citing practices of EIPM and hence the way(s) in which philosophers of mind rely on empirical research.

2.2 Method: Co-citation Analysis

To gain more information about the citing practices in EIPM, we conducted a type of co-citation analysis on the 2,761 articles. We chose co-citation analysis because it can map the internal intellectual structure (e.g., different research themes) and the structural and temporal dimensions of a given body of literature. We used a software called CiteSpace to perform our co-citation analysis. Chaomei Chen and his colleagues (Chen et al., 2010; Chen, 2016) designed CiteSpace by using what they call “a multiple-perspective co-citation analysis method” (Chen et al., 2010,

p. 1386). The core of their method involves two major types of analysis. One is co-citation analysis, and the other is cluster analysis.

Small (1973) and Marshakova (1973) introduced the concept of co-citation analysis independently. Figure 1 illustrates this concept in terms of the relationship among documents. Documents A and B are co-cited if and only if a third document C cites both A and B. A and B are co-cited even when it is the case that A and B do not directly cite each other. The co-citation link between A and B is strengthened if more documents cite A and B. Co-citation analysis applied to documents is called Document Co-citation Analysis (DCA).⁵ In DCA, a co-citation network refers to a set of nodes (i.e., cited documents) and co-citation link(s).

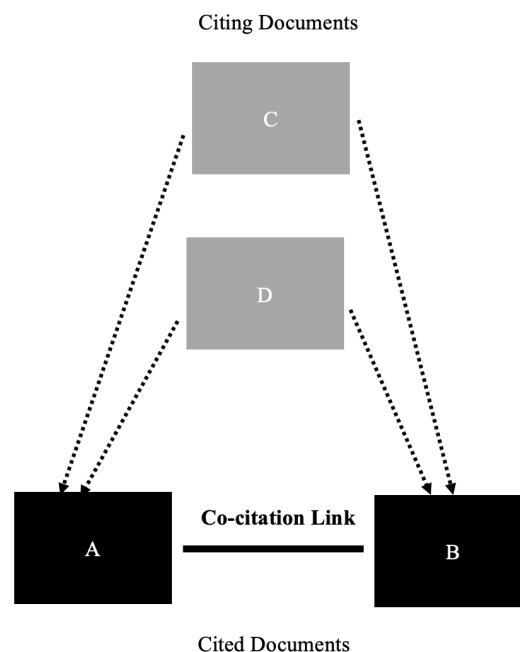


Figure 1 Co-citation relation. Documents A and B are co-cited if and only if a third document C cites both A and B. The co-citation link between A and B strengthens if more documents cite A and B.

Small (1978) found a high degree of uniformity in how specific concepts and references to cited documents were correlated in the chemistry literature. Small then suggested that highly cited documents from DCA can serve as *concept symbols* for scientific ideas, methods, or experiments within a given body of literature. Schneider (2006) then extended Small's notion of concept symbols to clusters of noun phrases extracted from the citation contents of cited documents. Their work forms the basis of the claim that DCA can reveal the concept symbols of a given

⁵ There is also Author Co-citation Analysis (ACA) (Chen, 1999; Leydesdorff, 2005; White & McCain, 1998; Zhao and Strotmann, 2008). In ACA, the cited and citing items are the authors of the documents. Chen's CiteSpace can also perform ACA. But since our analysis is based on DCA, we will leave the methodological details related to ACA aside from now on.

body of literature. In other words, by using DCA to find highly cited articles, one can identify the articles that lay down the core ideas, concepts, methods, or experiments of a body of literature.

In the context of exploring the cross-disciplinarity of EIPM, DCA can help us find highly cited empirical articles that serve as concept symbols for a body of philosophical literature. Our analysis will focus on citing practices regarding those empirical articles that are concept symbols. Once we have identified the relevant empirical articles, we can analyze how the relevant philosophers cite these articles in a content-based way.

We chose CiteSpace to conduct our co-citation analysis because it automates the relevant type of cluster analysis and various types of text analysis. These analyses are needed for interpreting the meaning of the concept symbols of a given body of literature. In statistics, cluster analysis is used to classify items into clusters (or groups) based on similarity among the items. Text analysis is used to classify and extract meaningful information from unstructured text.

It is worth noting that Chen's CiteSpace applies automated text analysis to the noun phrases extracted from citing articles, not from cited articles as Schneider (2006) did. Chen's rationale is that citing articles are responsible for forming co-citation clusters. Hence citing articles should have the most significant role in shaping the content of a cluster's concept symbols. Chen's rationale is another reason why CiteSpace is a good tool for our analysis. Since our goal is to analyze how philosophy articles cite empirical articles to inform their philosophical analysis, text analysis performed on the content of citing articles (i.e., philosophy articles in our case) gives us the information we need to interpret how philosophy articles are informed by or rely on empirical articles.

In short, CiteSpace can perform DCA on a body of literature and then apply cluster analysis and text analysis to analyze a body of literature's concept symbols. We apply DCA to analyze the EIPM literature, identify the highly cited empirical articles, and interpret the contents of the concept symbols of the resulting co-citation clusters.

We imported the bibliographic and citation data of 2,761 articles from the Web of Science into CiteSpace (5.7.R1). This dataset includes 11,794 cited documents and 2,761 citing documents. We then applied CiteSpace's built-in DCA and cluster analysis functions to the data. We also used the various text analysis functions to label the resulting co-citation clusters for interpretive purposes.

Before we present our results, we must introduce two technical metrics used in CiteSpace. First, citation count (ϕ) indicates how often a cited item in a co-citation network is cited by citing articles (Chen, 2012, p. 432). Second, 'silhouette' means "the uncertainty that one needs to take into account when interpreting the nature of the cluster" (Chen et al., 2010, p. 1391). The silhouette value of a cluster ranges from -1 to 1. Chen assumes that if the silhouette value of a cluster is higher than 0.7, then CiteSpace's cluster labeling results for this cluster are reliable.

2.3 Results

By applying DCA and cluster analysis functions, we identify and summarize the five largest clusters in Table 2. The silhouette values of all five clusters are above 0.9 and thus indicate high reliability of the clustering results.

We then applied the text analysis functions to label each cluster. Three different text analysis algorithms implement clustering labeling. These algorithms select the noun phrases (from titles and abstracts) of citing articles from each cluster and rank them. The three algorithms are (1) latent semantic indexing (LSI) (Deerwester, Dumais, Landauer, Furnas, and Harshman 1990), (2) log-likelihood ratio (LLR) tests (Dunning, 1993), and (3) mutual information (MI). The first algorithm tends to select the most salient aspect of a cluster. The second and third algorithms tend to reflect a unique aspect of a cluster. Table 2 presents only the top three-to-five noun phrases from each set of text analysis.

Cluster ID	Size	Silhouette	Mean (Year)	Label (LSI)	Label (LLR)	Label (MI)
0	84	0.918	2013	mind; computational framework; autopoiesis; cognitivism; scientific knowledge...	computational framework; anticipating brain; free-energy principle...	predictive coder; social cognition
1	67	0.946	2010	theory; animals; mind; progress; ways...	evaluating two-systems view; propositional attitude folk psychology; developmental dogma...	comparative cognition; social cognition
2	60	0.979	1996	empathy; face; practice; simulation; developing mental abilities...	deep ethology; resisting speciesism; social bond...	consciousness; empathy; contrastive
3	57	0.922	2006	folk psychology; narrative practice; false-belief understanding; non-reflective self-awareness; self-transparent mind innate...	folk psychology; narrative practice; false-belief understanding...	social cognition; physicalism; grand

4	52	0.941	1998	body problem; other recent options; emergence; philosophic overview; wild disjunction; property...	other recent option; body problem; philosophic overview...	physicalism; social cognition; grand i ⁶
---	----	-------	------	---	--	--

Table 2 Summary of the five largest clusters.

The mean year column of Table 2 indicates the average published year of all the articles in a cluster. In the largest five clusters, we see that the mean year of each cluster ranges from 1996 to 2013, and the size of each cluster ranges from 52 articles to 84 articles. In Section 4.3, we will go into detail regarding each cluster's content to explain each cluster's topics and other content-based characteristics.

⁶ The term 'grand i' is what is shown in our original data. We think it means grand illusion, which is a research topic in the philosophy of perception, attention, and consciousness.

Next, we go into each cluster to identify the top three cited empirical articles (if any) and rank them by their citation counts, as shown in Table 3.

No.	ϕ	Author	Year	Source	Cluster ID
C01	17	Friston KJ	2010	NAT REV NEUROSCI	0
C02	6	Bruineberg J	2014	FRONT HUM NEUROSCI	0
C03	4	Friston KJ	2012	FRONT PSYCHOL	0
C11	12	Apperly IA	2009	PSYCHOL REV	1
C12	10	Baillargeon R	2010	TRENDS COGN SCI	1
C13	9	Call J	2008	TRENDS COGN SCI	1
C21	5	Jack AI	2001	COGNITION	2
C22	5	Frith CD	1999	SCIENCE	2
C23	4	Jack AI	2002	TRENDS COGN SCI	2
C31	6	Onishi KH	2005	SCIENCE	3
C32	4	Carpendale JIM	2004	BEHAV BRAIN SCI	3
C33	2	Becchio C	2012	FRONT HUM NEUROSCI	3
C41	2	Crick F	2003	NAT NEUROSCI	4

Table 3 Most frequently cited empirical articles in the five largest document co-citation clusters ranked by citation count ϕ .

Section 4.3 will detail the content of each top-cited empirical article and its relationship to those philosophy articles citing it.

3. Philosophy of Cross-Disciplinarity

Cross-disciplinary activities are those that utilize epistemological, cognitive, or methodological resources from more than one intellectual community, field, or discipline. Social scientists and science policy scholars have analyzed the concept of cross-disciplinarity (CD) since the 1970s (Jantsch, 1972; Klein, 1990, 1996, 2010). This literature is abundant with conceptual categorizations of CD. But, as Huutoniemi et al. (2010, p. 80) note, these conceptual categorizations, even the well-argued ones, have little substantive impact on empirical analyses of CD. Most of the conceptual categorizations have been treated as ideal types only. It is unclear how well they can describe actual CD research.

Huutoniemi et al.'s (2010) novel contribution to the literature is to link the extant conceptual categorizations of CD with actual CD research in the context of research proposals submitted to the Academy of Finland. On the one hand, they reviewed the extant categorizations of CD (Huutoniemi et al. 2010, Table 1) and modified them. On the other hand, they analyzed the content of the relevant research proposals to categorize the form of their CD research. These two analyses mutually inform and constrain each other. The resulting outcome is their proposed typology of CD. In the following, we will summarize the relevant part of Huutoniemi et al.'s typology of CD. Our goal is to adapt their empirically-tested framework to categorize forms of CD in EIPM.

In Huutoniemi et al.'s framework, the most relevant dimension for our purpose concerns the types of cross-disciplinary interaction. This is also the most detailed dimension in their framework. Traditionally, scholars distinguish two prominent types of cross-disciplinary interaction: multidisciplinary (MD) and interdisciplinarity (ID).⁷ MD refers to scholarly activities that juxtapose or apply components from different intellectual communities. ID refers to combining, synthesizing, or integrating various intellectual components. Huutoniemi et al. further distinguished three sub-types of MD and ID, respectively. We adapt five of the six sub-types they propose.⁸

It is worth noting a point here to avoid potential confusion. In the following, we will summarize how Huutoniemi et al. characterize each type of CD, then explain how we modify their original formulations. The modification is required because Huutoniemi et al. focus on research proposals and how each researcher or research team from different fields interacts within the context of a research proposal. However, our goal is to analyze how a philosophy article cites (a form of interaction) an empirical article and for what purpose. Moreover, most philosophical articles are structured argumentatively and aim to argue for some claim. Some adjustments of Huutoniemi et al.'s original formulations are needed to reflect the citing interaction within the context of a philosophical article.

The first type is *Encyclopedic MD*. In Huutoniemi et al.'s original formulation, Encyclopedic MD involves juxtaposing components from different research teams in different fields without substantive interactions among them within a research proposal. However, in the context of our analysis, it is about how a philosophy article cites an empirical article and for what purpose. We will modify Encyclopedic MD as follows: A citing article cites an article from a different field because the content of the cited article is loosely connected with the topic addressed by the citing article, and the citing article does not use the cited article to set up its research question or build its main line of argument. In other words, the substantive content of the citing article remains the same, whether or not the cited articles are cited.

The second type is *Contextualizing MD*. Huutoniemi et al. initially characterize it as combining components from different research teams in different fields to set up the research question within the context of a research proposal, but there is no further substantive interaction after the

⁷ Transdisciplinarity (TD) is another prominent type of CD. TD refers to the interdisciplinary type of activities that involve non-academic stakeholders such as industry representatives and non-governmental organizations (Klein 2010). Since this form of CD is less relevant to EIPM research, we will not discuss TD in this article further.

⁸ The one we left out is called Composite MD, which more relevant to the context and the format of research proposals.

problem-setting task is done. Unlike research proposals, most philosophical papers are structured argumentatively, so we will center on the argument-building aspect when we characterize contextualizing ways of using empirical work. We thus modify Contextualizing MD as follows: A citing article cites an article from a different field because the content of the cited article is directly related to the research question or the argument presented in the paper. The citing article does not engage in further substantive interaction with the content of the cited articles after it uses the cited article to set up its research question or build its main line of argument. It is worth noting that our modification here goes beyond Huutoniemi et al.’s original characterization. We expand the scope of contextualizing to include argument building.

The third type is *Empirical ID*. All ID types involve ways of integrating components from different fields. Huutoniemi et al. initially formulate Empirical ID as integrating data from different research teams in different fields to investigate the relationship between phenomena or test a hypothesis. In our analysis, we modify Empirical ID as follows: A citing article cites an article from a different field because it aims to integrate the data of the cited article with its data to investigate the relationship between phenomena or test a hypothesis.

The fourth type is *Methodological ID*. In Huutoniemi et al.’s original formulation, this type involves combining methods from different research teams in different fields in the context of a research proposal and developing them into a functioning whole in a new context. We modify Methodological ID as follows: A citing article cites an article from a different field to integrate the method(s) of the cited article with the methods of the citing article to produce a functioning methodological framework in a new context.

The fifth type is *Theoretical ID*. Huutoniemi et al. initially define Theoretical ID as synthesizing theoretical components from different research teams in different fields in the context of a research proposal, e.g., concepts, models, or theories, and developing new theoretical tools for further analysis. In the context of philosophical papers, it is more natural to construe what Huutoniemi et al. called “theoretical tools” (p. 84) as theoretical claims. We thus modify Theoretical ID as follows: A citing article cites an article from a different field to synthesize concepts, models, or theories from other fields and propose a new theoretical claim that goes beyond the original materials.

Type	Feature
Encyclopedic MD	A citing article cites an article from a different field because the content of the cited article is loosely connected with the topic addressed by the citing article. The citing article does not use the cited article to set up its research question or build its main line of argument.
Contextualizing MD	A citing article cites an article from a different field because the content of the cited article is directly related to the research question or the argument presented in the paper. The citing article does not engage in further substantive interaction with the content of the cited articles after it uses the cited article to set up its research question or build its main line of argument.

Empirical ID	A citing article cites an article from a different field because it aims to integrate the data of the cited article with its data to investigate the relationship between phenomena or test a hypothesis.
Methodological ID	A citing article cites an article from a different field to integrate the method(s) of the cited article with the methods of the citing article to produce a functioning methodological framework in a new context.
Theoretical ID	A citing article cites an article from a different field to synthesize concepts, models, or theories from other fields and propose a new theoretical claim that goes beyond the original materials.

Table 4 Five types of CD and their features.

We have refined the above five categories of CD from the extant literature in the philosophy of interdisciplinarity. Our next goal is to use these categories to categorize the citation practices in EIPM. This, in turn, will help us identify the most prominent type(s) of CD in EIPM and hence understand how philosophers of EIPM rely on empirical research.

4. Categorization Analysis of Citation Practices

One major strength of co-citation analysis is to find highly cited articles, the contents of which are the concept symbols of a set of articles. Moreover, with the help of the text-analysis tools built into CiteSpace, we can also glimpse the general trends based on the phrases identified by various algorithms (Table 2). But these quantitative tools are weak when it comes to providing information regarding how and why philosophy articles cite a specific empirical article. Therefore, in the following, we also conduct a categorization analysis by reading the relevant articles' contents and analyzing how and why philosophy articles cite a specific highly cited empirical article. The analysis will use the five categories of CD elaborated in Section 3. Using these CD categories, the results of our categorization analysis will show how and why the philosophy articles cite the highly cited empirical articles.

4.1 Data

We queried the Web of Science on September 13th, 2021 to assess the citation data of C01, C02, C03, C11, C12, C13, C21, C22, C23, C31, C32, C33, and C41. We selected the citing articles under the 'philosophy' and 'history philosophy of science' categories. This selection process resulted in 278 journal articles. It is worth noting that this way of collecting data might include articles that do not have the terms 'mental' or 'mind' in their titles and abstracts. We considered this as an advantage at this stage of our analysis since not all EIPM articles have the term 'mental' or 'mind' in their titles and abstracts. We therefore complemented our co-citation analysis by including all the articles under the 'philosophy' and 'history philosophy of science' categories at this stage. Our rationale is that, since there is no strict definition of what counts as EIPM, it is better to be inclusive than exclusive when selecting our sample. All 278 philosophy papers cite some of the top-cited empirical articles that stand for the concept symbols in EIPM. If an article satisfies this standard, it is enough to count it as an EIPM article minimally.

We numbered the above 278 journal articles. For example, the philosophy articles citing C01 were numbered as C011, C012, C013, and so on. The philosophy articles citing C23 were numbered as C231, C232, C233, and so on.⁹

The assigned number of the highly cited empirical articles	The number of articles under the 'philosophy' or 'history philosophy of science' categories from the Web of Science
C01	57
C02	26
C03	5
	Total: 88
C11	28
C12	25
C13	39
	Total: 92
C21	13
C22	10
C23	4
	Total: 27
C31	35
C32	7
C33	4
	Total: 46
C41	25

Table 5 The assigned number of each highly cited empirical article and the number of citing philosophy articles from the Web of Science.

⁹ We numbered some of the citing articles downloaded from the Web of Science before reading those articles. After reading the articles, we realized they were not journal articles (e.g., book reviews) and excluded them. Thus, the assigned number for each article does not reflect the total number of articles we categorized.

4.2 Method: Categorization Analysis

The procedure of our categorization is as follows: (1) read the highly cited empirical articles (C01, C02, C03, C11, C12, C13, C21, C22, C23, C31, C32, C33, and C41) to understand their main contributions and the relevant empirical details, (2) read the abstracts and section titles of the citing philosophy articles to understand the overall structure and the central claims of the articles, (3) search where the cited empirical articles are cited in the philosophy articles, and (4) categorize the citing philosophy articles in terms of the five types of CD presented in Section 3.

Moreover, after one coder completed the categorization analysis of 278 philosophy articles, the other coder categorized 60 randomly selected articles out of the 278 articles to check inter-rater reliability. We used Excel to choose articles from each cluster randomly. If a cluster has only four articles, we randomly select 1 out of 4. If a cluster has 20 articles, we randomly select 5 out of 20. This results in 60 randomly selected articles.

Our categorization analysis uses a single article as our unit of analysis rather than a single citation. Based on our reading experience, a single philosophy article tends to cite the targeted empirical article multiple times or cite similar articles authored by (some of) the same author(s) of the targeted empirical article. To categorize which form of CD a citing philosophy article belongs to, we think it is more informative to evaluate the most significant role of the target empirical article (and related empirical articles with the same authors) in this philosophy article.

4.3 Results

We coded each philosophy article based on which CD category it belongs to using the procedure of our categorization analysis. The inter-rater reliability was 0.8. We present our results cluster by cluster because each cluster focuses on different research topics and questions. By identifying the differences and similarities among these clusters, we can understand the cross-disciplinarity of EIPM in a fine-grained way.

4.3.1 Cluster 0

Before we get to the results regarding Cluster 0, let us review three aspects of Cluster 0: (1) The text-analysis results from CiteSpace, (2) the content-based analysis of the top three cited articles in Cluster 0, and (3) the article types of the top three cited articles.

First, according to the results of our text analysis of Cluster 0, this Cluster has the following three sets of labels:

- 1) The most salient aspects based on the LSI algorithm are: computational framework, autopoiesis, and cognitivism.
- 2) The most unique aspects based on the LLR algorithm are: computational framework, anticipating brain, and free-energy principle.
- 3) The most unique aspects based on the MI algorithm are: predictive coder and social cognition.

Second, our content-based analyses of C01, C02, and C03 converge with the above results of our text analysis, and they are as follows:

- 1) C01: Friston, K. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience*.

This article is about a computational framework called the free-energy framework. The author aims to show that this framework can unify several extant global brain theories.

- 2) C02: Bruineberg, J and Rietveld, E. (2014). Self-organization, free energy minimization, and optimal grip on a field of affordances. *Frontiers in Human Neuroscience*.

This article employs some of Friston's work on the free-energy principle, among other resources, to develop a theoretical and conceptual framework for a new field called radical embodied cognitive neuroscience.

- 3) C03: Bubic, A., Cramon, D., and Schubotz, R. (2010). Prediction, cognition, and the brain. *Frontiers in Human Neuroscience*.

This article reviews the extant theories of the predictive brain and proposes some hypotheses about the mechanism of predictive processing. It also cautiously notes that any attempt to postulate a unified theory of predictive processing needs to address the remaining unresolved issues.

Third, one distinct feature of C01, C02, and C03 is that they are all scientific review or theoretically-oriented articles in neuroscience. In these three articles, the scientists¹⁰ synthesized the relevant research and proposed some theoretical frameworks.

Here are the categorization results of Cluster 0. The top three types of CD are Theoretical ID, Contextualizing MD, and Encyclopedic MD (Figure 2).

¹⁰ Among the authors of C01, C02, and C03, only one author is cross-listed in a philosophy institution and two scientific institutions simultaneously. Other authors are all listed in scientific institutions.

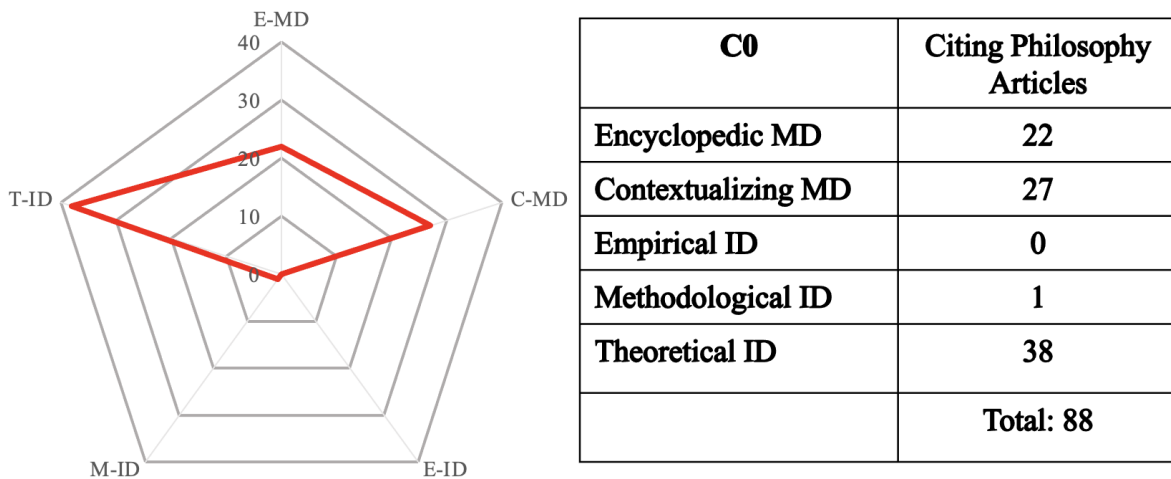


Figure 2 The categorization results of Cluster 0.

38 out of 88 philosophy articles citing C01, C02, or C03 are categorized as Theoretical ID. The critical feature of Theoretical ID is to synthesize concepts, models, or theories from other fields and propose new theoretical claims that go beyond the original materials. Based on our analysis, EIPM's significant interdisciplinary contribution in Cluster 0 is to argue against, modify, or extend the scientists' theoretical claims in C01, C02, or C03. For example, Constant (2021) cites C01 and 14 other articles authored by Friston. He goes into the conceptual and formal details of the free-energy principle, argues against a philosophical interpretation of the free-energy principle, and argues for his interpretation. Fabry (2019) cites C01 and 13 other articles authored by Friston. She also goes into the conceptual details of Friston's free-energy principle and proposes an account of irony comprehension partly based on Friston's free-energy principle.

4.3.2 Cluster 1

Before we get to the results regarding Cluster 1, let's review three aspects of Cluster 1: (1) The text-analysis results from CiteSpace, (2) the content-based analysis of the top three cited articles in Cluster 1, and (3) the article types of the top three cited articles.

First, Cluster 1 has the following three sets of labels:

- 1) The most salient aspects based on the LSI algorithm are: theory, animals, and mind.
- 2) The most unique aspects based on the LLR algorithm are: evaluating two-systems view, propositional attitude folk psychology, and developmental dogma.
- 3) The most unique aspects based on the MI algorithm are: comparative cognition and social cognition.

Second, our content-based analyses of C11, C12, and C13 converge with the above results of our text analysis, and they are as follows:

- 1) C1 is: Apperly I. and Butterfill, S. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review*.

This article hypothesizes a two-system view for reasoning about beliefs. One is a cognitively efficient but inflexible system, and the other is a cognitively demanding but flexible system. The authors synthesize the converging evidence from infants, adults, and nonhumans to support their hypothesis.

- 2) C12 is: Baillargeon, R., Scott, R.M., and He, Z. (2010). False-belief understanding in infants. *Trends in Cognitive Sciences*.

This paper reviews a new set of empirical evidence for determining what age children can attribute false beliefs to others, considers alternative interpretations, and discusses the nature of the relevant behavioral tests. The past empirical evidence was produced by using the elicited-responses behavioral test and showed that children about age four could attribute false beliefs to others. However, new empirical evidence is produced using the spontaneous-response behavioral test. It shows that children about age two can already attribute false beliefs to others.

- 3) C13 is: Call, J. and Tomasello, M. (2008). Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Science*.

This article reviews the evidence produced after Premack and Woodruff's (1978) seminal paper on whether chimpanzees have a theory of mind. The authors synthesize the extant evidence from different experimental paradigms and conclude that chimpanzees understand others in a perception-goal way but not in a human-like belief-desire way.

Third, one distinct feature of C11, C12, and C13 is that they are all scientific review or theoretically-oriented articles in either psychology or cognitive science. In these three articles, the scientists¹¹ synthesized the extant empirical evidence and discussed or provided interpretations of the evidence. Some authors further proposed a theoretical framework.

Here are the categorization results of Cluster 1. The top two types of CD are Contextualizing MD and Encyclopedic MD (Figure 3).

¹¹ Among the authors of C11, C12, and C13, only one author is listed in a philosophy institution, and all the other authors are listed in either psychology or evolutionary anthropology.

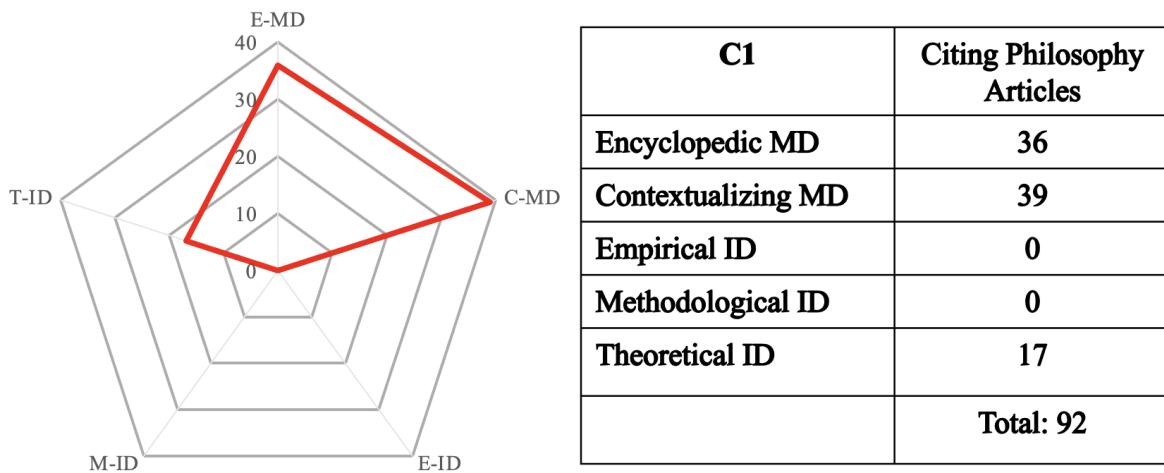


Figure 3 The categorization results of Cluster 1.

39 out of 92 philosophy articles citing C11, C12, or C13 are categorized as Contextualizing MD. The critical feature of Contextualizing MD is that the content of a cited article is directly related to the research question or the argument of a citing article. The citing article does not engage in further substantive interaction with the content of the cited articles after it uses the cited article to set up its research question or build its main line of argument.

Furthermore, 36 out of 92 philosophy articles citing C11, C12, or C13 are categorized as Encyclopedic MD. The critical feature of Encyclopedic MD is that a citing article cites an article from a different field because the content of the cited article is loosely connected with the topic addressed by the citing article.

Based on our analysis, EIPM's significant multidisciplinary contribution in Cluster 1 is to utilize the extant empirical work on the cognitive capacities of infants, children, and nonhumans to introduce some relevant background for their philosophy articles or contextualize their research questions, theses, or arguments. The philosophers citing C11, C12, or C13 tended to engage less with the empirical details or claims in C11, C12, or C13 when they presented their philosophical analyses or arguments. For example, Spaulding (2017) cites C11 and another article by Apperly to contextualize her research question and main argument regarding the theory of mind literature. Westra (2017) cites C12 and another article by Baillargeon to note his knowledge of their work and how his main line of argument does not depend on it.

4.3.3 Cluster 2

This subsection is structured the same as Sections 4.3.1 and 4.3.2. First, Cluster 2 has the following three sets of labels:

- 1) The most salient aspects based on the LSI algorithm are: empathy, face, practice, simulation, and developing mental abilities.
- 2) The most unique aspects based on the LLR algorithm are: deep ethology, resisting speciesism, and social bond.
- 3) The most unique aspects based on the MI algorithm are: consciousness, empathy, and contrastive.

Second, our content-based analyses of C21, C22, and C23 converge with the above results of our text analysis, and they are as follows:

- 1) C21 is: Jack, A. and Shallice, T. (2001). Introspective physicalism as an approach to the science of consciousness. *Cognition*.

This article proposes an empirical framework for studying consciousness. This framework centers on the scientific use of introspective evidence to relate perceptual consciousness to consciously performed actions in experiments.

- 2) C22 is: Frith C. and Frith, U. (1999). Interacting minds—a biological basis. *Science*.

This paper reviews the evidence from functional imaging and single-cell recording studies on the ability to understand and manipulate other people's mental states and behaviors. It also suggests that this ability has evolved from the ability to represent the action of others.

- 3) C23 is: Povinelli D. and Preuss, T. (1995). Theory of mind: Evolutionary history of a cognitive specialization. *Trends in Neuroscience*.

This article reviews the behavioral studies on introspecting one's mental states and understanding other's mental states in children and chimpanzees. It points out both the similarities and striking differences in the developmental pathways between the two groups. It suggests that the abilities might result from evolutionary changes in the prefrontal cortex.

Third, C21, C22, and C23 are all review or theoretically-oriented articles. In these three articles, the scientists synthesized the extant empirical evidence and discussed or provided interpretations of the evidence. Some authors proposed a theoretical framework.¹²

Here are the categorization results of Cluster 2. The top type of CD is Contextualizing MD (Figure 4).

¹² Among the authors of C21, C22, and C23, one author is listed in comparative behavioral biology, one in neurology, and all the others in psychology.

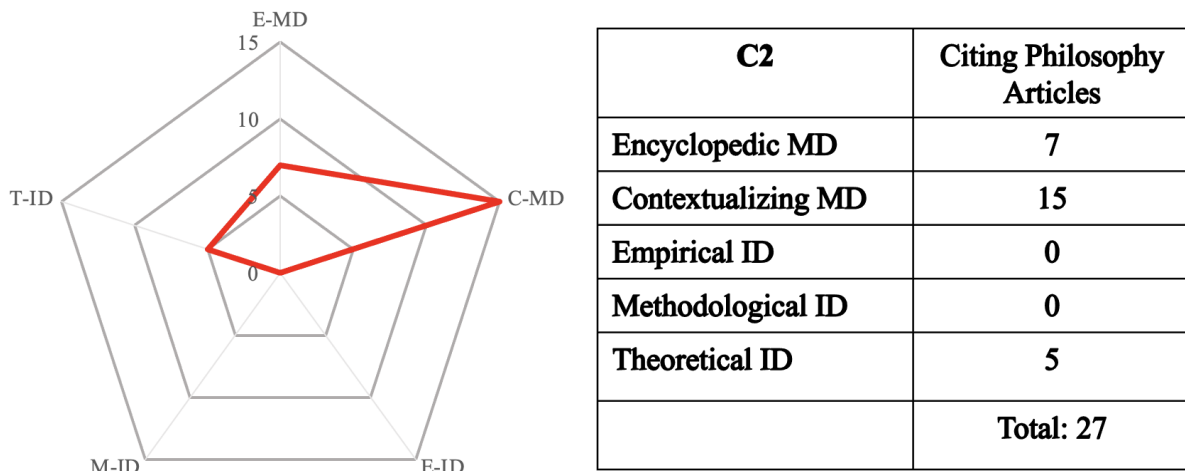


Figure 4 The categorization results of Cluster 2.

15 out of 27 philosophy articles citing C21, C22, or C23 are categorized as Contextualizing MD. EIPM’s significant multidisciplinary contribution in Cluster 2 is contextualizing the philosophical articles with the extant empirical work on the ability to introspect about one’s mental states and understand and manipulate other people’s mental states. For example, Hohwy and Frith (2004) cite C21 and another article by Jack to contextualize their research question and main claim that there can be a good neuroscientific explanation of conscious states, despite the subjective nature of introspective reports.

4.3.4 Cluster 3

This subsection is structured the same as Sections 4.3.1 and 4.3.2. First, Cluster 3 has the following three sets of labels:

- 1) The most salient aspects based on the LSI algorithm are: folk psychology, narrative practice, and false-belief understanding.
- 2) The most unique aspects based on the LLR algorithm are: folk psychology, narrative practice, and false-belief understanding.
- 3) The most unique aspects based on the MI algorithm are: social cognition and physicalism.

Second, our content-based analyses of C31, C32, and C33 converge with the above results of our text analysis, and they are as follows:

- 1) C31 is: Onishi, K. and Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science*.

This original research article presents Onishi and Baillargeon’s nonverbal task experiment to challenge an established claim that young children do not understand that

others may hold false beliefs. Their nonverbal task experiment shows that 15-month-old infants can predict an actor’s behavior based on the actor’s true or false beliefs.

- 2) C32 is: Carpendale, J. and Lewis, C. (2004). Constructing an understanding of mind: The development of children’s social understanding within social interaction. *Behavioral and Brain Science*.

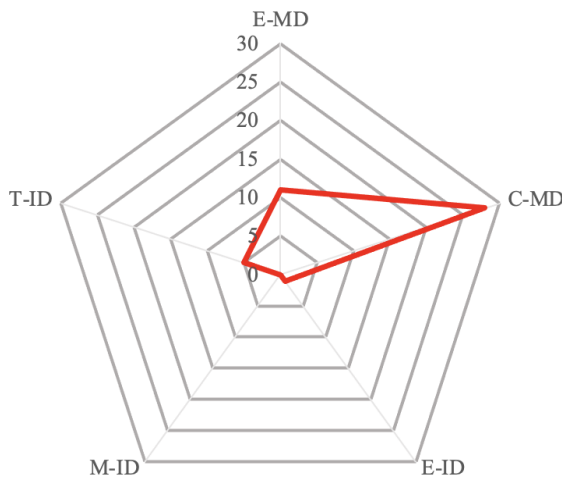
This article reviews the extant theories of the development of children’s social understanding and the new evidence that supports Carpendale and Lewis’s alternative account, which emphasizes the role of social interaction.

- 3) C33 is: Becchio, Manera, Sartori, Cavallo and Castiello (2012). Grasping intentions: From thought experiment to empirical evidence. *Frontiers in Human Neuroscience*.

This article is a theoretically-oriented scientific article. It synthesizes the relevant empirical evidence to argue against the claim that one cannot understand others’ intentions (or goals) by simply observing others’ movements (or actions) and highlighting the role of social interaction.

Third, the highly cited empirical articles in this cluster are heterogeneous. C31 is an original research article in the sense of reporting their original empirical results. C32 and C33 are review or theoretically-oriented articles in the sense that it proposes some theoretical framework within a scientific research context.¹³

Here are the categorization results of Cluster 3. The top type of CD is Contextualizing MD (Figure 5).



C3	Citing Philosophy Articles
Encyclopedic MD	12
Contextualizing MD	28
Empirical ID	1
Methodological ID	0
Theoretical ID	5
	Total: 46

¹³ Among the authors of C31, C32, and C33, all authors are listed in psychology.

Figure 5 The categorization results of Cluster 3.

28 of 45 philosophy articles citing C31, C32, or C33 are categorized as Contextualizing MD. EIPM's significant multidisciplinary contribution in Cluster 3 is to utilize the extant empirical work on the ability to understand others' intentions (or goals) by observing their behaviors in the context of social interaction. The authors of these philosophy articles used the relevant empirical work to set up their research questions or build their arguments. For example, Berio (2020) cites C31 and other articles authored by Onishi and Baillargeon to set up her research question and build her main argument in terms of the literature on false belief reasoning

4.3.5 Cluster 4

Before we get to the results regarding Cluster 4, let us review two aspects of Cluster 4: (1) The text-analysis results from CiteSpace, and (2) the content-based analysis of the top-cited article in Cluster 4.

First, Cluster 4 has the following three sets of labels:

- 1) The most salient aspects based on the LSI algorithm are: body problem, other recent options, and emergence.
- 2) The most unique aspects based on the LLR algorithm are: other recent option, body problem, and philosophic overview.
- 3) The most unique aspects based on the MI algorithm are physicalism and social cognition.

Cluster 4 only has one top-cited empirical article because the other top-cited empirical works are all books, according to CiteSpace data. The relationships between journal articles and books are beyond the scope of our analysis. Thus, we will not include these four books in our analysis here.

Second, our content-based analyses of C41 converge with the above results of our text analysis:

C41 is: Crick, E. and Koch, C. (2003). A framework for consciousness. *Nature Neuroscience*.

Crick and Koch summarize their framework for studying consciousness. Their framework synthesizes the available ideas and combines them in an original way. They also suggest some future experimental work that can be done to fill the relevant knowledge gaps.

Here are the categorization results of Cluster 4. Encyclopedic MD, Contextualizing MD, and Theoretical ID have roughly equal distribution (Figure 6).

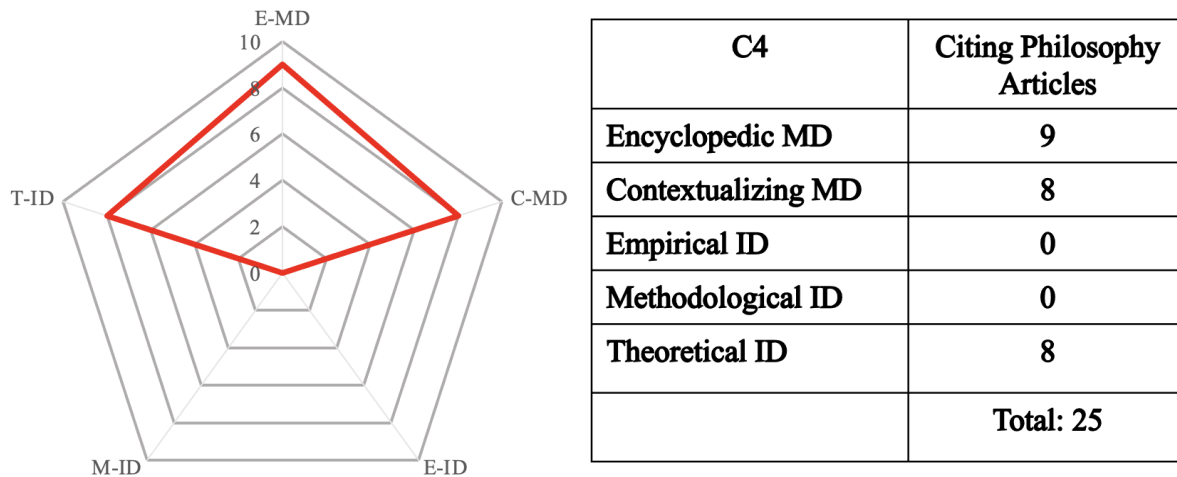


Figure 6 The categorization results of Cluster 4.

One unique feature of Cluster 4 is that it only has one highly cited article published in a scientific journal, i.e., C41. Moreover, C41 is highly theoretical on its own. This shows that this cluster is more concerned with theoretical or conceptual questions that require less engagement with detailed empirical work. For example, Hoerl (2017) cites C41 in a footnote to note C41 as an example of recent proponents of the view that we cannot perceive instances of movement and changes. This view is Hoerl’s primary target. But Hoerl’s philosophical analysis involves drawing historical resources from Locke and Reid to show that the view can be further distinguished conceptually into two varieties. C41 plays a dispensable role in his article.

4.3.6 Summary of Data

We analyzed how 13 highly cited scientific articles are cited in 278 philosophical articles. Out of the 278 philosophical articles we have categorized, 117 are in Contextualizing MD, 86 are in Encyclopedic MD, 73 are in Theoretical ID, 1 is in Empirical ID, and 1 is in Methodological ID (Figure 7).

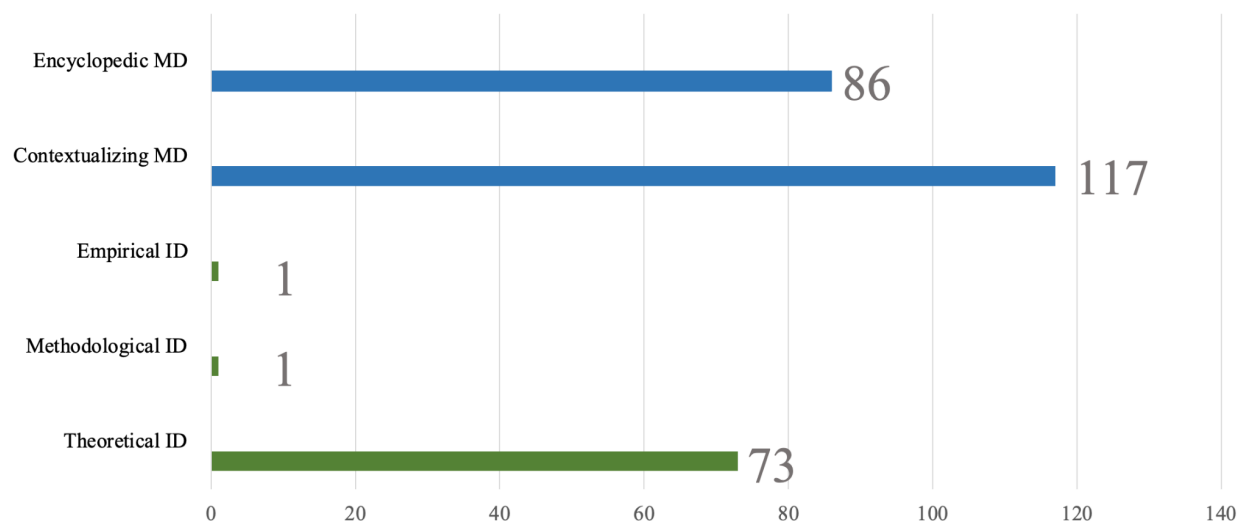


Figure 7 The categorization results of all clusters.

Of the 13 highly cited scientific articles, 12 are review or theoretically-oriented scientific articles, and 1 original empirical study article. Review or theoretically-oriented scientific articles review and comment on the extant literature and evidence. The relevant comments can come in several forms (even within a single article): Some are insights about how to conduct further empirical works, some are cautious notes about the controversies in the extant literature, and some are theoretical insights, hypotheses, or frameworks. An original empirical study article reports the researchers' own empirical study and results. In Table 6, we summarize the key results from each cluster.

Cluster No.	Key text-analysis results	Types of the top 3 cited scientific articles	Major CD type(s)
Cluster 0	Computational framework Free-energy principle Predictive coder	3 review or theoretically-oriented scientific articles	Theoretical ID
Cluster 1	Theory Evaluating two-systems view Social cognition	3 review or theoretically-oriented scientific articles	Contextualizing MD Encyclopedic MD

Cluster 2	Empathy Deep ethology Consciousness	3 review or theoretically-oriented scientific articles	Contextualizing MD
Cluster 3	Folk psychology False-belief understanding Social cognition	1 original empirical study article 2 review or theoretically-oriented scientific articles	Contextualizing MD
Cluster 4	Body problem Philosophic overview Physicalism	1 review or theoretically-oriented scientific articles	Encyclopedic MD; Contextualizing MD; Theoretical ID

Table 6 Summary of the main results from each cluster.

Cluster 0 is mainly centered on Friston’s free-energy principle and computational framework, and Theoretical ID is the major type of CD. Many philosophers argue against, modify, or extend the scientists’ theoretical claims.

Cluster 1 is centered around Apperly and Butterfill’s proposed two-system view of belief reasoning and false-belief understanding in infants and chimpanzees. Contextualizing MD and Encyclopedic MD are the major types of CD. Many philosophers utilize the extant empirical work on the cognitive capacities of infants, children, and nonhumans to introduce some relevant background for their philosophy articles or contextualize their works.

Cluster 2 shows the connection between the literature on consciousness research and the literature on introspecting and understanding one’s mind in adults, children, and chimpanzees. Contextualizing MD is a significant type of CD. To contextualize their work, many philosophers utilize the extant empirical work on the ability to introspect and to understand and manipulate other people’s mental states.

Cluster 3 centers on the empirical research on infants’ and children’s ability to understand others’ intentions based on their behaviors in social interactions. Many philosophers in this cluster use this empirical literature to contextualize their work. Thus, Contextualizing MD is the primary type of CD in Cluster 3.

Cluster 4 is centered on Crick and Koch’s proposed framework for studying consciousness. Encyclopedic MD, Contextualizing MD, and Theoretical ID are all significant types of CD.

5. Metaphilosophical Challenges Regarding Interdisciplinary Interactions in EIPM

We have produced a robust empirical description of EIPM which focuses on how philosophers of EIPM cite empirical articles. Through the results of our co-citation, text, and categorization analyses, we can now characterize the forms of cross-disciplinarity of EIPM and hence how philosophers of EIPM rely on empirical research. In this section, we show how our empirical description of EIPM enables metaphilosophers to evaluate the cross-disciplinarity of EIPM.

Though there are three major types of CD in EIPM, we will only discuss Contextualizing MD and Theoretical ID. We assume Encyclopedic MD is just a typical citing practice across disciplines when scholars do literature reviews, introductions, or note some tangential points. But EIPM's Contextualizing MD opens up some metaphilosophical issues worth addressing, and EIPM's Theoretical ID generates some insights into the epistemic role or identity of EIPM philosophers.

When philosophers of EIPM cite empirical articles in a Contextualizing MD way, they use cited articles' content to set up their research questions or build their reasoning. The main challenges here concern how they incorporate empirical evidence into their philosophical narrative or reasoning in ways that respect the context in which the original evidence was produced and debated.

In order to metaphilosophically evaluate how EIPM philosophers incorporate empirical evidence into their work, we perform two sets of content-based analyses to categorize how EIPM philosophers within the same cluster cite an original empirical study article and a review (or theoretically-oriented) article, respectively.

We pick Cluster 3 as our sample case because it is the only cluster with an original empirical study article as one of its top-cited articles. Among the articles citing C31 (an original empirical study) or C32 (a review or theoretically-oriented article), we selected those categorized as Contextualizing MD in Section 4.3.4. This selection results in 20 Contextualizing MD articles citing C31 and 5 Contextualizing MD articles citing C32. We analyzed how these 25 articles cite C31 or C32 as evidence in their philosophical narrative or reasoning. In the following, we will present our two sets of analyses in detail and discuss what metaphilosophical lessons we can learn from them.

5.1 How EIPM philosophers cite an original empirical study article

C31 (Onishi & Baillargeon, 2005) presents their nonverbal task experiment to challenge an established claim that young children do not understand that others may hold false beliefs. However, since the publication of C31, many scholars have challenged whether Onishi and Baillargeon's (2005) interpretation of their experimental data is the best. Several scholars have proposed alternative interpretations of Onishi and Baillargeon's experimental data. In our analyses of 20 Contextualizing MD articles, 60% of philosophy articles acknowledge or involve themselves in the above debate.

We categorized 20 Contextualizing MD articles citing C31 in terms of the following three categories:

- (A) Respect the original epistemic context: Citing X as empirical evidence but acknowledging or participating in the controversy regarding how to best interpret what the experimental data of X shows.
- (B) Misuse the original epistemic context: Citing X as an authoritative or uncontroversial piece of empirical evidence while it is not or without giving sufficient justification for the epistemic quality of X.
- (C) Neutral: Not an evidential use of C31, e.g., citing C31 to note how other scholars use C31.

Here are three examples for each category based on our analysis.

Paper No.	Original text showing how they cite C31 as evidence	Evaluation	Category
C3110	<p>“Since the measures of false belief understanding used in early paradigms relied upon on children’s understanding of verbal questions, it was possible that young children really did understand false belief—they just did not understand the questions asked in these studies. A series of false belief tasks appeared that use children’s gaze behaviour to determine whether they anticipate that agents with false beliefs will act as if they had true beliefs, and it was found that pre-verbal children perform well in these tasks (e.g. Onishi and Baillargeon 2005; Kovács et al. 2010)...Whether tasks like this one really give evidence of ‘full blown’ false belief understanding is still being debated (Apperly and Butterfill 2009; Heyes 2017)...” (Moore, 2017, p. 801, emphases added).</p>	C3110 cites C31 as evidence but notes that it is still under debate.	A
C3116	<p>“Well-known experiments show that children as young as 25 months (Southgate et al. 2007) and even 15 months (Onishi and Baillargeon 2005) can pass language-free versions of false-belief tasks. Taken at face value the infant data</p>	C3116 cites C31 as evidence and interprets what this piece of evidence means or implies further with the remark “children must have some command of the concept of belief.”	B

	suggests that very young children must have some command of the concept of belief in place very early on. ” (Hutto, 2017, p. 831, emphases added)	This use of C31 as evidence does not respect the epistemic context of C31 and overinterprets it with the strong term ‘must’	
C3113	“If the implicit mindreading system is not present in adults, this also casts doubt on the developmental claims of the two-systems view. Part of the two-systems approach to development has been to propose that younger children’s early theory-of-mind abilities (e.g. Onishi and Baillargeon 2005) are products of the implicit mindreading system , and thus subject to “signature limits” on their representational abilities (Butterfill and Apperly 2013)” (Westra, 2017, p. 4576, emphases added).	C3113 cites C31 to explain how the two-systems approach accounts for C31. This is not a case of evidential use of C31.	C

Figure 8 shows our categorization result of 20 Contextualizing MD articles citing C31:

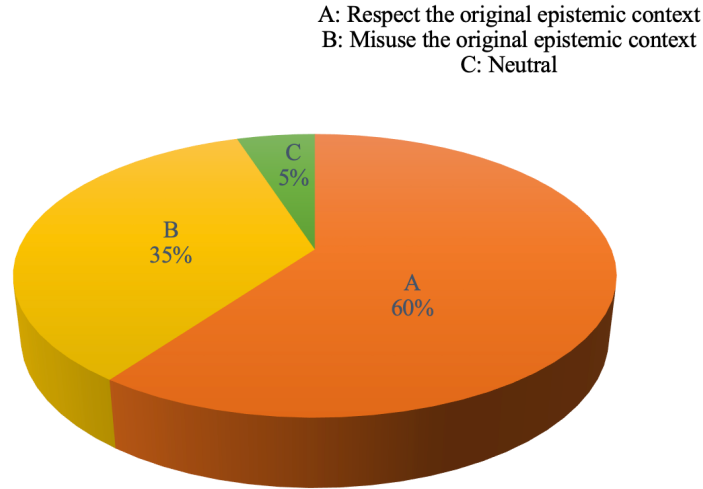


Figure 8 How EIPM philosophers cite an original empirical study article

5.2 How EIPM philosophers cite a review or theoretically-oriented article

C32 (Carpendale & Lewis, 2004) reviews the extant theories of the development of children’s social understanding and the new evidence that supports Carpendale and Lewis’s alternative

account, which emphasizes the role of social interaction. There are only 5 Contextualizing MD articles citing C32. We thus document and evaluate how each article cites C32 in detail and we categorize them with the same set of categories in the previous section:

Paper No.	Original text showing how they cite C31 as evidence	Evaluation	Category
C322	<p>“In this paper, we aimed to discuss the implications of two constructivist frameworks on children’s developing understanding of the mental world of agents. We argued that while these two approaches share in their endorsement of the child as an active meaning maker, they differ in terms their views on whether meaning making is as much a co-constructive process as it is a constructive process. In the SC approach, children’s meaning making is embedded in social contexts that are fundamentally affected by the specifics of their experiential histories. As such, both mental state conceptions (e.g., belief, desire) as well as the ability to take and coordinate perspectives emerges out of the perspectival aspects of their interactions with social partners (Carpendale and Lewis 2004...” (Ilgaz and Allen, 2021, p. 8479).</p>	<p>C322 cites Carpendale and Lewis’s multiple articles (2004, 2006, 2014) and uses their work as one of the prominent examples of the social-cultural approach to the development of children’s social understanding. This is not a case of evidential use of C32.</p>	C
C324	<p>“Even in non-autistic children, a great deal of ‘theory of mind’ development takes place after the point at which false-belief tests are passed (Carpendale & Lewis, 2004).” (Belmonte, 2009, p. 122)</p>	<p>C324 cites C32 as evidence to support a claim. But it is unclear which set of empirical work reviewed or cited by C32 justifies this claim and no comments about the epistemic quality of the relevant empirical work.</p>	B
C325	<p>“While some basic capacities for social navigation and interaction are undoubtedly built-in, others — perhaps even the core aspects of FP — may be acquired or soft-assembled</p>	<p>C325 is an introductory paper to a special issue. The goal of the paper is to introduce three different approaches to folk psychology. C32 is used as an example to illustrate</p>	C

	<p>in ontogeny, where the drivers of this development will be socially scaffolded engagements and not active scientific theorizing (Carpendale and Lewis, 2004...) (Hutto, 2009, p. 19)</p> <p>“It is interesting, in this context, that ‘Proponents of the dominant theories have been notably quiet about what happens in development after the child’s fifth birthday. However research that explores whether 5-year-olds can use simple false belief knowledge to make inferences about their own and other’s perspectives finds that they singularly fail to do so’ (Carpendale and Lewis, 2004, p. 91).” (Hutto, 2009, p. 23)</p>	<p>one of the three approaches. This is not a case of evidential use of C32.</p>	
C326	<p>“The skeleton framework of narrative is the simple action sequence, implicating the intentions and goals of the actors, and there is ample evidence of children’s engagement with such sequences in everyday life. Infants and toddlers are expert at learning action routines and scripts (Bauer & Mandler, 1989; Nelson, 1986) and are attentive to the intentions and goals of self and others (Carpendale & Lewis, 2004...). (Nelson, 2009, p. 79)</p>	<p>C326 cites C32 as evidence to support a claim. But it is unclear which set of empirical work reviewed or cited by C32 justifies this claim and no comments about the epistemic quality of the relevant empirical work.</p>	B
C327	<p>“The fact that Hutto says that children start being exposed to (folk-psychological) narratives in between the ages of 3 and 4 does not mean that his claim is that by the age of 4 children have a rudimentary grasp of FP. On the contrary, while TT-ists claim that when children can pass the false belief test by the age of 4 (see, however, Carpendale & Lewis, 2004) this marks their ability to wield</p>	<p>C327 cites C32 as a counter-claim to TT-ists’ claim to note the controversy related to this claim.</p>	A

	<p>a primitive version of FP, Hutto argues that it is precisely the fact that children are only able to understand reason explanations at later ages — approximately from the age of 5 onwards — that illustrates the fact that passing the test is not enough for FP. The continued exposure to narratives, apparently, is needed, according to Hutto, for true FP competence.” (Slors, 2009, p. 350)</p>		
--	--	--	--

Figure 9 shows our categorization result of 5 Contextualizing MD articles citing C32:

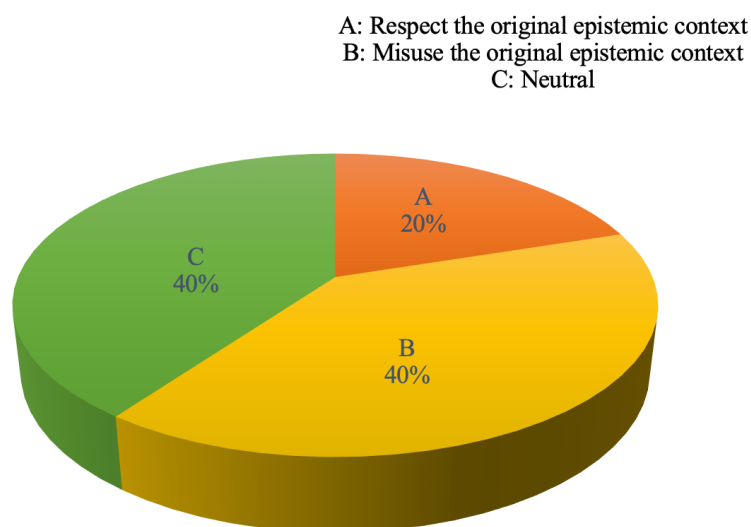


Figure 9 How EIPM philosophers cite a review or theoretically-oriented article

According to our results, philosophers citing original empirical study articles are more likely to respect the targeted empirical article’s original epistemic context by noting the controversy or debate about the target article. On the other hand, philosophers citing a review or theoretically-oriented article are more likely to misuse the original epistemic context of the targeted empirical article. Based on the above two sets of analyses, we think EIPM philosophers must be cautious about importing empirical evidence into their philosophical narrative or reasoning. Thus, we suggest using the following metaphilosophical norms to improve the quality-control procedure for conducting a work of empirically-informed philosophy: (1) research about whether the targeted article is under debate or not, (2) note clearly how much epistemic weight one gives to this piece of evidence in one’s philosophical reasoning, and (3) justify why the chosen epistemic weight is adequate on both empirical and philosophical grounds.

Another critical observation based on our results concerns EIPM philosophers' epistemic role or identity as philosophers. We have observed that most EIPM philosophers under the Theoretical ID category are not developing their philosophical theories. Their roles are more like theory-tinkerers, i.e., tinkering with scientific theories proposed by leading scientists. Moreover, their tinkering work can be roughly categorized into four types: (1) revise a scientific theory given some philosophical concerns or some philosophical interpretation of the theory that the EIPM philosopher offers, (2) object to some part of the theory and propose an alternative, and (3) extend or apply the theory to account for something new. Take the EIPM philosophers citing Friston's (2010) free-energy principle, for example. Constant (2021) argues against a philosophical interpretation of the free-energy principle and argues for his interpretation. Dolega and Dewhurst (2015) object to Friston's appeal to the Cartesian theater metaphor in his work and propose replacing it with other expressions. Fabry (2019) extends Friston's free-energy principle to account for irony comprehension. In the above examples, we can see that EIPM philosophers tinker with Friston's free-energy principle in various ways depending on what interests them philosophically.

Our observation about EIPM philosophers' epistemic role as theory-tinkerers offers an alternative interpretation to Irvine's (2014) criticism of EIPM. Irvine identifies two works on consciousness (Prinz, 2012; O'Regan & Noë, 2001) and claims that the philosophers in these works act as theory-unifiers in reinterpreting empirical findings with philosophical concepts and terms and organizing them into grand, unifying theories of consciousness. According to Irvine, these grand, unifying theories are not good scientific theories because they are often "vague, qualitative, not specifying boundary conditions of the theory, not generating predictions and so on" (2014, p. 193). We agree with what Irvine identifies and criticizes, but the two problematic cases she discusses are not representative of the overall trends in EIPM. Based on our empirical analysis, theory-tinkering, not theory-unifying, is the more common pattern in EIPM.

However, there are also corresponding metaphilosophical issues concerning EIPM philosophers' role as theory-tinkerers. What theoretical virtues should philosophers aim for when tinkering with scientific theories? Presumably, there are many virtues: predictive power, descriptive power, explanatory power, empirical testability, quantifiability, computability, simplicity, generality, and so on. Which should be the norms regulating the tinkering of scientific theories? To complicate the matter, different scientific disciplines or different scientists from the same discipline probably aim for different kinds of theoretical virtues, and scientists might disagree with philosophers about the sorts of theoretical virtues we should aim for. If so, EIPM philosophers need to develop sensitivity to this kind of discrepancy regarding theoretical virtues and provide some justification for their selection of virtues when they tinker.

6. Conclusion

EIPM philosophers rely on empirical results in various ways. However, the extant literature lacks empirical descriptions of how EIPM philosophers rely on empirical results. Moreover, though EIPM is essentially a form of cross-disciplinary research, it has yet to be analyzed as cross-disciplinary research. We filled the above two literature gaps by producing quantitative and qualitative descriptions of EIPM as cross-disciplinary research. Our analyses include a co-

citation analysis that uses CiteSpace and a categorization analysis informed by the literature on interdisciplinarity.

Our CiteSpace analysis employs statistical methods to map a given body of literature's internal intellectual structure (i.e., different research themes). We analyzed 2,761 philosophy journal articles published between 1950 and 2020 and 11,794 articles cited by those 2,761 philosophy articles. We found five statistically significant clusters of articles with different research themes in EIPM. We then picked the top three most cited scientific articles within each cluster. We downloaded all philosophy journal articles citing these selected scientific articles from the Web of Science (278 philosophy articles total).

Our quantitative results are robust because we use a well-defined procedure to produce them. It is well-defined in that the literature data is collected with an explicit protocol and analyzed using a fixed set of algorithms from CiteSpace. In other words, it reaches what Leonelli (2018, p. 135) calls computational replicability, i.e., different persons using the same data set and algorithms will produce the same quantitative results.

We adapted Huutoniemi et al.'s (2010) empirically-tested typology of CD for categorizing cross-disciplinary research types in EIPM. The different types of CD that we used are Encyclopedic MD, Contextualizing MD, Empirical ID, Methodological ID, and Theoretical ID.

We then applied these five categories to categorize 278 philosophy articles based on how they cite the top three most cited scientific articles in their cluster, as well as how they cite related articles, i.e., other articles published by the authors of the top three most cited articles. Our results show that the three most common citing practices in EIPM are Contextualizing MD, Encyclopedic MD, and Theoretical ID.

Our qualitative results are robust because two coders coded the targeted articles independently, and the interrater reliability was 0.8.

Moreover, our quantitative and quantitative results are also robust in the sense that different sources of data converge. This is because the labels of each cluster (Table 2) produced by the quantitative tools are consistent with our content-based analyses of the top-cited articles.

The resulting descriptions enable us to locate two metaphilosophical challenges for EIPM philosophers. One concerns how they should incorporate empirical results in the Contextualizing MD type of EIPM, and the other concerns which theoretical virtue(s) they should aim for when they tinker with scientific theories in the Theoretical ID type of EIPM.

References:

- Apperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review*, *116*(4), 953–970. <https://doi.org/10.1037/a0016923>
- Ashton, Z., & Mizrahi, M. (2018). Show Me the Argument: Empirically Testing the Armchair Philosophy Picture. *Metaphilosophy*, *49*(1–2), 58–70. <https://doi.org/10.1111/meta.12279>
- Baillargeon, R., Scott, R. M., & He, Z. (2010). False-belief understanding in infants. *Trends in Cognitive Sciences*, *14*(3), 110–118. <https://doi.org/10.1016/j.tics.2009.12.006>

- Becchio, C., Manera, V., Sartori, L., Cavallo, A., & Castiello, U. (2012). Grasping intentions: From thought experiments to empirical evidence. *Frontiers in Human Neuroscience*, 6. <https://www.frontiersin.org/articles/10.3389/fnhum.2012.00117>
- Berio, L. (2021). Culturally embedded schemata for false belief reasoning. *Synthese*, 199(1), 285–314. <https://doi.org/10.1007/s11229-020-02655-7>
- Bruineberg, J., & Rietveld, E. (2014). Self-organization, free energy minimization, and optimal grip on a field of affordances. *Frontiers in Human Neuroscience*, 8. <https://www.frontiersin.org/articles/10.3389/fnhum.2014.00599>
- Bubic, A., Von Cramon, D. Y., & Schubotz, R. (2010). Prediction, cognition and the brain. *Frontiers in Human Neuroscience*, 4. <https://www.frontiersin.org/articles/10.3389/fnhum.2010.00025>
- Call, J., & Tomasello, M. (2008). Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Sciences*, 12(5), 187–192. <https://doi.org/10.1016/j.tics.2008.02.010>
- Carpendale, J. I. M., & Lewis, C. (2004). Constructing an understanding of mind: The development of children's social understanding within social interaction. *Behavioral and Brain Sciences*, 27(1), 79–96. <https://doi.org/10.1017/S0140525X04000032>
- Chen, C. (1999). Visualising semantic spaces and author co-citation networks in digital libraries. *Information Processing & Management*, 35(3), 401–420. [https://doi.org/10.1016/S0306-4573\(98\)00068-5](https://doi.org/10.1016/S0306-4573(98)00068-5)
- Chen, C. (2012). Predictive effects of structural variation on citation counts. *Journal of the American Society for Information Science and Technology*, 63(3), 431–449. <https://doi.org/10.1002/asi.21694>
- Chen, C. (2016). *CiteSpace: A practical guide for mapping scientific literature*. <https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=1406256>
- Chen, C., Ibekwe-SanJuan, F., & Hou, J. (2010). The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. *Journal of the American Society for Information Science and Technology*, 61(7), 1386–1409. <https://doi.org/10.1002/asi.21309>
- Constant, A. (2021). The free energy principle: It's not about what it takes, it's about what took you there. *Biology & Philosophy*, 36(2), 10. <https://doi.org/10.1007/s10539-021-09787-1>
- Crick, F., & Koch, C. (2003). A framework for consciousness. *Nature Neuroscience*, 6(2), Article 2. <https://doi.org/10.1038/nn0203-119>
- Deerwester, S., Dumais, S. T., Furnas, G. W., Landauer, T. K., & Harshman, R. (1990). Indexing by latent semantic analysis. *Journal of the American Society for Information Science*, 41(6), 391–407. [https://doi.org/10.1002/\(SICI\)1097-4571\(199009\)41:6<391::AID-ASII>3.0.CO;2-9](https://doi.org/10.1002/(SICI)1097-4571(199009)41:6<391::AID-ASII>3.0.CO;2-9)
- Dolega, K., & DEWHURST, J. (2015). CURTAIN CALL AT THE CARTESIAN THEATRE. *Journal of Consciousness Studies*, 22(9–10), 109–128.
- Dunning, T. (1993). Accurate methods for the statistics of surprise and coincidence. *Computational Linguistics*, 19(1), 61–74.
- Fabry, R. E. (2021). Getting it: A predictive processing approach to irony comprehension. *Synthese*, 198(7), 6455–6489. <https://doi.org/10.1007/s11229-019-02470-9>
- Friston, K. (2010). The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience*, 11(2), Article 2. <https://doi.org/10.1038/nrn2787>
- Frith, C. D., & Frith, U. (1999). Interacting Minds—A Biological Basis. *Science*, 286(5445), 1692–1695. <https://doi.org/10.1126/science.286.5445.1692>

- Henderson, D., & Horgan, T. (2013). On the Armchair Justification of Conceptually Grounded Necessary Truth. In A. Casullo & J. C. Thurow (Eds.), *The A Priori in Philosophy* (pp. 111–133). Oxford University Press.
- Hoerl, C. (2017). On the View that We Cannot Perceive Movement and Change: Lessons from Locke and Reid. *Journal of Consciousness Studies*, 24(3–4), 88–102.
- Hohwy, J., & Frith, C. D. (2004). Can Neuroscience Explain Consciousness? *Journal of Consciousness Studies*, 11(7–8), 180–198.
- Huutoniemi, K., Klein, J. T., Bruun, H., & Hukkinen, J. (2010). Analyzing interdisciplinarity: Typology and indicators. *Research Policy*, 39(1), 79–88. <https://doi.org/10.1016/j.respol.2009.09.011>
- Jack, A. I., & Shallice, T. (2001). Introspective physicalism as an approach to the science of consciousness. *Cognition*, 79(1), 161–196. [https://doi.org/10.1016/S0010-0277\(00\)00128-1](https://doi.org/10.1016/S0010-0277(00)00128-1)
- Jantsch, E. (1972). Inter- and transdisciplinary university: A systems approach to education and innovation. *Higher Education*, 1(1), 7–37. <https://doi.org/10.1007/BF01956879>
- Kirchhoff, M. D. (2018). Autopoiesis, free energy, and the life–mind continuity thesis. *Synthese*, 195(6), 2519–2540. <https://doi.org/10.1007/s11229-016-1100-6>
- Klein, J. T. (1990). *Interdisciplinarity: History, theory, and practice*. Wayne State University Press.
- Klein, J. T. (1996). *Crossing Boundaries: Knowledge, Disciplinarity, and Interdisciplinarity*. University Press of Virginia.
- Klein, J. T. (2010). A taxonomy of interdisciplinarity. In R. Frodeman, J. T. Klein, & C. Mitcham (Eds.), *The Oxford handbook of interdisciplinarity* (pp. 15–30). Oxford University Press.
- Knobe, J. (2015). Philosophers Are Doing Something Different Now: Quantitative Data. *Cognition*, 135, 36–38. <https://doi.org/10.1016/j.cognition.2014.11.011>
- Knobe, J. (2019). Philosophical Intuitions Are Surprisingly Robust Across Demographic Differences. *Epistemology and Philosophy of Science*, 56(2), 29–36. <https://doi.org/10.5840/eps201956225>
- Leydesdorff, L. (2005). Similarity measures, author cocitation analysis, and information theory. *Journal of the American Society for Information Science and Technology*, 56(7), 769–772. <https://doi.org/10.1002/asi.20130>
- Liao, C. (2022). *Measuring the Cross-Disciplinarity in the Empirically-Informed Philosophy of Mind*. Master Thesis (Advisor: Karen Yan). National Yang Ming Chiao Tung University.
- Marshakova, I. V. (1973). System of document connections based on references. *Nauchno-Tekhnicheskaya Informatsiya Seriya 2-Informatsionnye Protsessy I Sistemy*, 6, 3–8.
- Onishi, K. H., & Baillargeon, R. (2005). Do 15-Month-Old Infants Understand False Beliefs? *Science*, 308(5719), 255–258. <https://doi.org/10.1126/science.1107621>
- Povinelli, D. J., & Preuss, T. M. (1995). Theory of mind: Evolutionary history of a cognitive specialization. *Trends in Neurosciences*, 18(9), 418–424. [https://doi.org/10.1016/0166-2236\(95\)93939-U](https://doi.org/10.1016/0166-2236(95)93939-U)
- Schneider, J. W. (2006). Concept symbols revisited: Naming clusters by parsing and filtering of noun phrases from citation contexts of concept symbols. *Scientometrics*, 68(3), 573–593. <https://doi.org/10.1007/s11192-006-0131-z>
- Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. *Journal of the American Society for Information Science*, 24(4), 265–269. <https://doi.org/10.1002/asi.4630240406>

- Small, H. G. (1978). Cited Documents as Concept Symbols. *Social Studies of Science*, 8(3), 327–340. <https://doi.org/10.1177/030631277800800305>
- Spaulding, S. (2018). Do you see what I see? How social differences influence mindreading. *Synthese*, 195(9), 4009–4030. <https://doi.org/10.1007/s11229-017-1404-1>
- White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972–1995. *Journal of the American Society for Information Science*, 49(4), 327–355. [https://doi.org/10.1002/\(SICI\)1097-4571\(19980401\)49:4<327::AID-ASI4>3.0.CO;2-4](https://doi.org/10.1002/(SICI)1097-4571(19980401)49:4<327::AID-ASI4>3.0.CO;2-4)
- Williamson, T. (2007). *The Philosophy of Philosophy*. Wiley.
- Witten, I. H., & Frank, E. (2000). *Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations*. Morgan Kaufmann.
- Zhao, D., & Strotmann, A. (2008). Information science during the first decade of the web: An enriched author cocitation analysis. *Journal of the American Society for Information Science and Technology*, 59(6), 916–937. <https://doi.org/10.1002/asi.20799>