# Internet Information Triangulation: Design Theory and Prototype Evaluation

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**Many discussions exist regarding the credibility of information on the Internet. Similar discussions happen on the interpretation of social scientific research data, for which information triangulation has been proposed as a useful method. In this article, we explore a design theory—consisting of a kernel theory, meta-requirements, and meta-designs—for software and services that triangulate Internet information. The kernel theory identifies 5 triangulation methods based on Churchman's inquiring systems theory and related meta-requirements. These meta-requirements are used to search for existing software and services that contain design features for Internet information triangulation tools. We discuss a prototyping study of the use of an information triangulator among 72 college students and how their use contributes to their opinion formation. From these findings, we conclude that triangulation tools can contribute to opinion formation by information consumers, especially when the tool is not a mere fact checker but includes the search and delivery of alternative views. Finally, we discuss other empirical propositions and design propositions for an agenda for triangulator developers and researchers. In particular, we propose investment in theory triangulation, that is, tools to automatically detect ethically and theoretically alternative information and views.**

## Introduction

The Internet has masses of information made available by search engines that automatically index files and enable search and retrieval. However, search engines are always biased by a user's profile, indexing, and page ranking algorithms (Hjørland, 2010), search engine optimization (Davis, 2006), and search engine learning intelligence (Spink, Jansen, & Ozmultu, 2000). This mostly results in *implicit biases,* that is, that it is hard for the searcher to identify these biases. In contrast, expert Internet services use *explicit biases* and can be held responsible if delivered information is not complete or incorrect in some way. Some examples of expert services are www.loc.gov/rr/askalib (a service from the U.S. Library of Congress), and www.madsci.org/submit.html for questions aimed at scientists. Expert services also can consist of information rating services (Beldad, De Jong, & Steehouder, 2010; Poston & Speier, 2005) and reviewing and source certification (Hu, Wu, Wu, & Zhang, 2010; Kim, Steinfield, & Lai, 2008; Metzger, 2007; Wu, Hu, & Wu, 2010). But experts also work within a paradigm (Kuhn, 1962) that includes certain belief structures which are not necessarily agreed upon (Greenberg, 2009). And despite all these efforts, it may remain complicated if not impossible for expert services or search engines to filter out all intentionally or unintentionally incorrect content (Floridi, 2005). Consequently, there is a need for enabling Internet information consumers to critically evaluate the information they gain (Wijnhoven, 2012).

To help information searchers to detect valuable information and identify possible errors and biases, Metzger (2007) proposes two approaches:

1. Providing information consumers with instructions of how to systematically evaluate Internet content themselves. Many good proposals exist for how this can be done through lists of review criteria and score sheets (for example, Fritch & Cromwell, 2001; Meola, 2004; Metzger, Flanagin, & Zwarun, 2003). In general, however, Metzger (2007) regards these review sheets as too labor-intensive for motivating users to use them well and these review sheets also are often too complex to be used.
2. Alternatively, Metzger (2007) proposes to invest in the development of intermediaries on the Internet that can deliver independent quality seals, credibility ratings, directories, and search engines that deliver preapproved and filtered data, and digital signatures to help information consumers avoid running into poor-quality information.

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A third approach is the focus here, which has been touched on marginally by Metzger, and involves delivering tools by which information consumers can evaluate Internet content in an efficient and partially automated way themselves. This contributes to both approaches mentioned by Metzger, by making the first one more feasible and the second one less burdensome. Because this approach involves the development of new Internet tools, we employ a design science approach, which aims at the exploration of relevant requirements and designs for the problem.

We approach this challenge as finding or making tools for Internet information triangulation that together compose a complete triangulator. The term triangulation is rooted in trigonometry and geometry and applied in the fields of cartography and navigation to identify the coordinates of an object (Bagrow & Skelton, 2009). Denzin (2009) describes triangulation as methods for confirming the truth of statements by comparing different data about the same social phenomenon, from multiple investigators, using multiple theoretical perspectives, and multiple research methods.

Denzin (2009) proposes four methods for information triangulation. The first is named data triangulation, which he defines as the affirmative use of different data sources. These data can be criticized by searching for comparable material in different places in time and space. The second method is investigator triangulation, which involves other investigators in a research or the inclusion of articles from different authors in an analysis. By "different," we mean people with different affiliations and background to be sure that the sources are independent and not "non-discriminating reflectors" (Goldman, 2001). The third method is theory triangulation, which involves using multiple perspectives or theories to interpret a single set of data. The fourth method is methodological triangulation and involves the use of multiple methods based on different theories of knowledge, like interpretive and critical methods, empirical, critical rationalist, and analytic methods (Gregor, 2006; Schultze & Leidner, 2002).

These four triangulation methods may work well, but a few questions have never been answered:

1. Why these four methods and how do we know that these are all we need?
2. How can information triangulation be done well in the context of the Internet, that is, with very large amounts of data and often unknown sources?
3. What is the contribution of information triangulation tools on opinion formation?

The first question requires an analysis of the fundamentals of inquiring systems that discuss multiple ways of evidence generation (Churchman, 1971). Inquiring systems include requirements for the quality of information and they give requirements for triangulation methods. The second question requires a search for existing and feasible tools that realize some or several requirements for each triangulator. The third question requires an empirical analysis of the contribution of information triangulation tools. Although ideally the best way of finding these contributions is through controlled experiments (Kumar & Lang, 2007) by which the value for users of existing search engines can be compared with users of search engines that include triangulators, this is not realistic when the independent variable (in our case, the triangulator) is still in development and not a fully developed alternative to existing commercial search engines. Thus, the focus of this study is on exploring the potential of a research prototype by observing how users work with it and how it impacts the dependent variable, that is, opinion formation, with the objective of giving researchers and developers sufficient confidence of investing in its further development. Thus, instead of an experiment, this article presents a prototyping study in its empirical part (Cleven, Gubler, & Hüner, 2009).

For design science, we follow Hevner, March, Park, and Ram (2004), who state that "The design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts" (p. 75). "Such artifacts are not exempt from natural laws and behavioral theories. To the contrary, their creation relies on existing kernel theories that are applied, tested, modified, and extended through the experience, creativity, intuition, and problem solving capabilities of the researcher" (Hevner et al., 2004, p. 76). A product-oriented design theory provides meta-requirements and meta-designs that help to solve classes of problems and create classes of artifacts. On the other hand, a process-oriented design theory focuses on procedures for the construction of artifacts (Walls, Widmeyer, & El Sawy, 1992, pp. 42–43). This article elaborates on triangulation methods following a product-oriented design theory approach (Walls et al., 1992, p. 102), first by the detection of its kernel theory and the identification of its meta-requirements, which in fact results in a set of criteria for evaluating the usefulness of existing tools and the need for new ones. Next, we list possible meta-designs by reviewing existing tools and how these can be integrated in a prototype. Finally, the evaluation of key design propositions is realized by describing the experiences of college students who use the prototype for building their opinion on an important political topic. We chose the political opinion formation of college students because:

1. First, Fernbach, Rogers, Fox, and Sloman (2013) found that when people are asked to express the reasons—that is, their emotional, normative, and subjective states—for their convictions, they tend to become reinforced in their beliefs and develop more extremist views. Alternatively, while asking people for an explanation—a causal reasoning or empirical evidence—they develop more moderate standpoints. Triangulation asks both for reasons and explanations and thus may contribute to more well-balanced standpoints.
2. Second, Metzger et al. (2003) found that college students are less critical towards Internet resources than other Internet users, and thus triangulate less and consequently


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develop less balanced views. A study of college students, although not representing the average population, therefore is especially interesting and important for assessing the contributions of triangulators.

In the following section we further describe the kernel theory and meta-requirements by which we answer the first research question. After that, we present our results from a search for existing information triangulation tools using the meta-requirements. This set of found tools help us to describe possible meta-designs for information triangulators, by which we answer the second research question. Next, we present our prototype, consisting of selected existing tools, and its usage and usefulness, by which we answer the third research question. In the final section we describe the conclusions and discuss empirical and design propositions for further research.

## Triangulation Kernel Theory and Meta-Requirements

In *The Design of Inquiring Systems* (Churchman, 1971), Churchman describes multiple inquiring systems that together provide goals and methods for the production of knowledge. Churchman (1971) identifies Lockean empiricism, Leibnizian rationalism, Kantian idealism, and Hegelian dialectics as the four major inquiring systems. Additionally, he identifies the pragmatic inquiring system (also named "Singerian inquiring system" after his philosophy educator Edgar Singer), which he presents as a further evolution that includes the other inquiring systems as tools for problem solving. These five inquiring systems are used as kernel theories (Walls et al., 1992) for information quality and triangulation methods here.

### *Lockean Inquiring System and Data Triangulation Meta-Requirements*

The Lockean inquiring system is based on the work of John Locke (1632–1704), who postulated in *An Essay Concerning Human Understanding* that there are no innate ideas that form our understanding of the world, that the mind is a "blank slate" or "tabula rasa," and that people are born without innate ideas. Locke regards language as a key element in forming and codifying understandings, and thus we need to share common meanings to make knowledge sharing feasible. Locke further states that man should use reason, that is, a combination of observation, experience, and rationality, in finding truth. These four principles are the foundation of a theory of knowledge named empiricism, which is a theory of knowledge emphasizing the role of experience, especially sensory perception, in the formation of ideas, while discounting the notion of innate ideas (Meyers, 2006). According to this inquiring system, knowledge is an intersubjective true representation of the world and believed to be "objectively" true by consensus in a community. Information errors in this context contain a lack of correspondence with reality. The Lockean inquiring system thus focuses on the representational veracity and completeness of primary data, that is, data that are direct representations of reality. Following empirical research methodologists (Blumberg, Cooper, & Schindler, 2008; Kerlinger, 1986), the correctness of representations of reality has two dimensions: (a) validity and precision, that is, that the observations should be about the subject that is targeted at and not something else, and (b) reliability, that is, that the observations should be well controlled and not biased by the interference of disturbances. Data triangulation, as proposed by Denzin (2009) is a check of the representativeness of data obtained and the quality and precision of observation, the consistency over multiple observations (i.e., reliability) and the absence of theoretical or normative bias (i.e., applying "a blank sheet"). Currently, data triangulation in politics has become a popular activity, because the Internet enables fast ways of political fact-checking (see Nash, 2012; Schultz, 2012).

### *Leibnizian Inquiring System and Theory Triangulation Meta-Requirements*

Rationalism—partially based on the work of the 17th century philosopher Leibniz (Huenemann, 2008)—is any view appealing to reason as a source of knowledge, which appeals to a key innate capability of humans nearly absent in animals. Rationalism is a method and a theory in which the criterion of truth is not sensory but intellectual and deductive (Jolly, 1998). In this view, the creation of knowledge is not based on the development of consensus (as in the Lockean inquiring system), but any person with the proper kind of reasoning capabilities may be capable to discover knowledge on his or her own. Rationality thus is especially understood as logical and causal reasoning (Look, 2013). According to rationalism people are able to discover logic and causation by their innate capability to detect necessities and contingencies of events. It is not that rationalists state that reason is the only means for understanding, but they especially praise and articulate the value of reasoning (Huenemann, 2008, p. 5). According to the Leibnizian inquiring system, real information is incorporated into the causal models by which we reason about reality (Mason & Mitroff, 1973). Information errors in this context relate to lack of validity of the prime assumption and logical inconsistencies (Faran & Wijnhoven, 2012). These prime assumptions are not necessarily empirical (like knowing the number of people with an average salary), but can be highly subjective and normative, and by that they include a normative constraint or goal variable. Legal systems are rationalist in this sense, and, for example, derive the need of a free press from a normative understanding of democracy. Optimization systems—like decision support systems—are rationalist in the sense of using goal variables and searching for the best means to arrive at them. Theory triangulation, as proposed by Denzin (2009), is a method for the identification of basic assumptions and norms, the inclusion and exclusion of vari-


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ables, and the in–and exclusion of relations among variables, which make evidence debatable from a rationalist's perspective.

### *Kantian Inquiring System and Theory and Method Triangulation Meta-Requirements*

Kant argued that the rational order of the world as known by science could never be accounted for merely by the fortuitous accumulation of sense perceptions, that is, Locke's empiricism. Instead, rational order is assumed to be the product of the rule-based activity of "synthesis" (Hartnack & Hartshorne, 1967). This consists of conceptual unification and integration carried out by the mind through the "categories of the understanding" operating on the perceptual manifold within space and time, which are forms of sensibility that are "a priori" necessary conditions for any possible experience (Hartnack & Hartshorne, 1967). The resulting experiences are what Kant calls "a posteriori" propositions. By identifying "a priori" categories, we are able to detect our own biases and limitations and better understand and appreciate perspectives of others and even may see the similarities with our own understandings (Mason & Mitroff, 1973). According to Kant, space and time are two of these fundamental intuitive "a priories" for understanding in natural sciences and they are sufficient for all mathematical expressions. For the information systems field, concepts like information, system, ontology, representation, entity, relation, process, activity, software, decision, and service are key categories for being able to describe and analyze an information system (Wand & Weber, 2002). Awareness of the prime categories by which we observe and think is most valuable for identifying differences in views on a subject and for integrating partial descriptions and explanations into larger theoretical bodies or systems of knowledge (Hartnack & Hartshorne, 1967). Information errors in this context contain a lack of perspectives (i.e., too much single-sidedness and lack of integration of views). Kantianism thus proposes the need for different perspectives that have to be taken to realize a complete picture of a phenomenon. This corresponds with theory and method triangulation, where the scope of observation is a key limitation, corroboration of insights in an empirical and theoretical sense are vital for scientific progress, and multiple types of categories for relations among phenomena may be searched for by researchers.

### *Hegelian Inquiring System and Investigator and Theory Triangulation Meta-Requirements*

In philosophy, dialectic logic is an exchange of propositions (theses) and counter-propositions (anti-theses) resulting in a synthesis of the opposing assertions, or at least a qualitative transformation in the direction of the dialog. Dialectic logic was introduced by Kant as a way of consolidating different perspectives. In the Hegelian inquiring system, however, theses and anti-theses are carried by different people with antagonistic interests (Churchman, 1971; Mason & Mitroff, 1973) and synthesis involves the development of a higher level of historical consciousness for all actors involved in the dialog (Sinnerbrink, 2007). Consequently, informing becomes part of the political and competitive scene and serves the interests of the information supplier (Sinnerbrink, 2007). As such, Hegelian dialectics provides concepts for interpreting human behavior and critically looking at the status quo (Gregor, 2006; Sinnerbrink, 2007). In the Hegelian perspective "information masters" deliver biased representations depending on their interests (Wijnhoven, 2012). In an open communicative environment (like the Internet), a representation of some historical event (thesis) will cause a representation of the same event by an opponent (anti-thesis). The detection of the sources of bias is a key challenge for the "information slaves" and essential for their ability to create judgments of their own (Churchman, 1971; Wijnhoven, 2012). They can do this by understanding the interests and motives of producers of disinformation. The Hegelian inquiring system corresponds well with investigator triangulation, which focuses on knowing the authors' or publishers' interests from which biases can be uncovered. As such, authors and publishers with opposing interests and positions need to be found to receive more diversity of opinions on a topic and allow them to balance and dialectically synthesize these to a higher level of consciousness regarding the phenomenon.

### *Singerian Inquiring System and Triangulation*

Malachowski (2010) describes pragmatism as built on the thoughts of the philosophers C.S. Pierce, William James, and John Dewey, with three premises: (a) objectivity is historically situated, and none the worse for that, (b) knowledge has no foundations, and (c) philosophy needs to keep connected to first-order inquiry, to real examples, and to real-life experiences (pp. IX–X). Churchman (1971) presents Singerian pragmatism as an overarching epistemology and ethical theory stating that the value of knowledge should be expressed in terms of how knowledge improves the human condition. Here, information is valid from the perspective of how it can help a problem owner, and in contrast to Hegelianism information, is not there only to serve the information supplier. The Lockean, Leibnizian, and Kantian inquiring systems all aim at finding an ultimate truth. The Hegelian approach regards non-absolute truth as part of historical and social reality, and as arguments (subjective data) for certain ideals. The pragmatic (Singerian) inquiring system, in contrast, proposes that the continuous search for new and improved insights is only valuable as far as it results in human progress (Churchman, 1971). The pragmatic approach is open to multiple perspectives, is innovative and adaptive, and is best in complex situations (Courtney, 2001). This will help ensure that multiple, personal viewpoints are represented, rather than getting input from several who think alike. Even more, it helps in delivering substantial complementary knowledge and opinions needed to understand and


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manage complex challenges. The core criteria for pragmatic information are context-relevancy and solution effectiveness. However, this does not point at a specific triangulator, but as a goal and purpose of all triangulators together to assist in decision making and problem solving. A pragmatic perspective needs the support of different triangulation methods and tools.

### *A Summary of Meta-Requirements for Triangulation*

This discussion of inquiring systems and triangulation can be summarized thus:

- The Lockean inquiring system demands checking the validity, reliability, and precision of the data available.
- The Leibnizian inquiring system demands checking the coverage of all relevant variables, causal relations, and goals and values in informative documents.
- The Kantian inquiring system demands the identification of the relevant categories and ontology so that the information consumer can evaluate the completeness or focus of a perspective in a document.
- The Hegelian inquiring systems demands the identification of author and publisher expertise, reputation, affiliations, interests, sentiments, and the presentation of opposing views.
- The Singerian inquiring systems demands the effective use of all the other triangulation methods so that the information can become useful for decision making.

The requirements of the first four mentioned inquiring systems will be used to search for relevant, existing tools as part of the efforts to detect a set of meta-designs in the following section. The requirements for the Singerian inquiring system will be met by proposing an integrated prototype and testing the usefulness of this prototype in the last sections of this article.

## Detecting Meta-Designs of Internet Information Triangulators by Reviewing Existing Tools

### *Searching for Meta-Designs*

A meta-design consists of the collection of components that together can be integrated into a software system or a service. Multiple methods for meta-design detection exist. We distinguish here among requirements: the deductive approach versus the technological opportunities approach as two extremes for bridging the gap between requirements and technical realizations. The first approach aims at deriving design components from the list of requirements, without caring about technical solutions (Goknil, Kurtev, van den Berg, & Veldhuis, 2011). Sometimes this results in interesting ideas that, however, may not be realizable and consequently the other approach starts from what solutions are available (Martin, 2003). This latter approach is also propagated as "agile" methods and "extreme programming." We follow an approach, applied before by Stein and Zwass (1995) in their study of meta-requirements and meta-designs for organizational memory systems, which took the best of both, by using the meta-requirements for searching existing solutions and analyzing these solutions as designs that fit them. Where no working tool is found for a specific meta-requirement, we propose a design for it.

The search for tools was done using the Google search engine on May 1, 2013. The search keywords used are related to the name of the triangulation method, combined with the search terms "online" and "tool," which results in queries like "Investigator triangulation tool." Also, more generic search terms were applied; for example, one search query for data triangulation was "fact checking tool." Search queries for investigator triangulation have focused on checking a person's background. The search for theory triangulation tools have a focus on text analysis and its applications, like fallacy detection. Tools for methodological triangulation require a search for any tool that can identify the type of research method in a text through content analysis fueled by a research method identifying key words. For all the tools, we require them to be web-based or to be a browser plug-in so that users do not need to install specific software. We wanted to make the triangulation process as easy as possible: its use should take little time for a college student. Here, we will discuss the tools found for each triangulation method.

### *Internet Data Triangulation Tools*

For data triangulation, we identified validity of measurements and observations as the first requirement. Many authors have described this in terms of the effectiveness of information retrieval (Baeza-Yates & Ribeiro-Neto, 1999; Spink et al., 2000). An effective search engine should be able to understand the language and terminology of the query creator such that indexed files are found that use the same concept as the query. However, because synonyms and homonyms may be used frequently, a semantic mismatch may easily happen. Search effectiveness thus can be expressed in terms of precision—that is, the number of retrieved files that actually corresponds with the searcher's need, and recall—that is, the number of existing relevant documents that are found in its total population of files. The use of multiple search engines and web crawlers (Lawrence & Giles, 1999) and information feedback and profile learning technologies may improve precision and recall (Spink et al., 2000; Teevan, Dumais, & Horvitz, 2005). Finally, uncertainty handling and providing query uncertainty indicators are proposed when the semantic matches are uncertain, for example, that the same person may use different initials or that two source systems have a slightly different structuring of information (van Keulen & de Keijzer, 2009).

For testing the effectiveness of a query in terms of its semantic match, we identify two types of tools:

1. Terminology extractors. These tools produce a list of the most frequently used terms, by which a user can identify the nature of its content. An example is http://labs.translated.net/terminology-extraction/.


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2. Substantive match identifiers. These tools link a document to formally accepted and described meaningful terminology in a discipline or an encyclopedia. One for the medical field is whatizit, which can be accessed at http://www.ebi.ac.uk/webservices/whatizit/info.jsf.

The second requirement concerns the reliability of observations. This can be realized by fact-checkers, which must be reliable and authoritative sources that can verify the presented data. Multiple fact-checkers have been developed, like:

1. Online fact-checkers, which translate an oral communication in real-time to text that next can be input for a fact-checking site that responds with a trustworthiness conclusion. This was realized by *The Washington Post*'s truthteller (see http://truthteller.washingtonpost.com). Alternatively, the websites JournalistResource.org and JournalistToolbox.org provide links to a lot of resources that can be used in case a journalist (but since the sites are public, everybody) wants to know more about a certain subject. These websites can provide a lot of useful information, but they do not provide it in the most structured way. This can make it difficult to do a quick scan to see if the website is of any use.
2. Statement verifiers, which can scan a page on statements that have been verified by politicfacts.com and give a mark of positive or negative trustworthiness to the text. This is found at http://truthgoggl.es.
3. Claim verifiers, which enable the insertion of a statement and the returning a probability of trustworthiness and possible sources on which this is grounded. There are a great number of websites (e.g., www.politifact.com and Factcheck.org) that fact-check statements from politicians. Most of the websites focus on the United States. These websites have their own editors who decide what will be checked, and they do not provide interfaces for people to request their own content to be checked. One interesting initiative is TrustSquad. Here people can comment on published fact-checks, and give also their view of the case. This website is no longer maintained.
4. Internet information virus detector, which is a database with articles that debunk Internet myths. This is maintained by Snopes.com. An alternative web service of this kind is Skeptive.com, which is a toolbar for Firefox that underlines sentences on the Internet that are false.
5. Consistency checkers, which aim at comparing data from different and independent sources and calculate the level of correspondence between data presented on the same topic in different documents. Here, MS-Word offers an easy and effective method by its file comparison tool under its Review menu. Adobe Acrobat has a similar feature for pdfs and other tools are available on the web like WinMerge's xdocdiff and diffpdf. These document comparison tools are also available online as diffnow.com and i-tools.org/diff. "Churnalism" tools do a similar job. http://churnalism.sunlightfoundation.com/ checks if texts are copied from Wikipedia or press releases from Fortune 500 companies. http://churnalism.com/ checks if texts are copied from BBC news.

Furthermore, there are a lot of niche fact-checking websites, but they do not always clearly reveal where they get their funding and who is running the website.

*Internet Investigator Triangulation Tools*

For the Hegelian investigator triangulator, Wijnhoven (2012) suggested the identification of the author, the publisher, their affiliations, context and interests, and dialectically opposing views. Note that in contrast to Denzin's conceptualization of investigator triangulation, which he developed for case study research, in Internet triangulation it is the information consumer who triangulates the sources. It does not involve multiple information consumers who check the data, but an information consumer who searches and compares different authors and sources of information. In this method, multiple information consumers can also evaluate information sources, as in social filtering methods and wisdom-of-the-crowd methods. For investigator triangulation we propose multiple existing tools, like:

1. Author identifier. For this a lot of information about a person or other entity can be found on social media nowadays. Websites like 123People and Pipl provide search engines to search through a large number of social networking websites and other public sources. However, everybody can enter information about her/himself on a social medium like Facebook. That does not mean that the information is necessarily true.
2. Expert-based relevancy checking of academic papers. For this we can distinguish between academic paper reviews and reviews of nonacademic papers by experts. For the first, Institute for Scientific Information (ISI; now Thomson Reuters) impact factors give a reasonable indication of quality, because ISI publications are only accepted in the ISI index by Thomson Reuters corporation after a rigorous review of scientific quality and its persistence. For these, see http://thomsonreuters.com/products_services/science/free/essays/impact_factor/.
   Each ISI journal publishes its impact factor on its introduction page.
3. Expert professional document ratings and evaluations. Documents on Wikipedia have been discussed frequently in terms of their expert quality (Adler, De Alfaro, Mola-Velasco, Rosso, & West, 2011; Fallis, 2008; Niederer & Van Dijck, 2010) and Wikipedia has launched an expert review service: http://en.wikipedia.org/wiki/Wikipedia:Expert_review. In some professional fields, experts are available who can certify the quality and accuracy of websites, like the Health on the Internet service http://www.hon.ch/. An attempt to develop a dynamic expert document rating tool has been proposed by Kim and Chung (2003), but to our knowledge has never been implemented.
4. Internet search engines. One may query an author's name in combination with the institution the author is affiliated with, and probably can find the personal page of this person reliably. For example, if someone claims to be "Olli Rehn," the European Union (EU) Commissioner for Economic and Monetary Affairs, the query "site:Europe.eu 'olli rehn' " will be quite effective.


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5. Author extraction from texts. One can extract the possible author of an article by inserting the text in www.alchemyapi.com and may receive a possible author name. Gnosis Firefox plugin performs a similar service. Gnosis enables analyzing a news article in real time, and provide quick links to companies, people, and job positions mentioned in the article.
6. Author and publisher sentiment extraction. One may detect more about an author by mining what is said about this person in diverse media using a sentiment analyzer. This is, for example, facilitated by http://semanticengines.com.
7. Whois tools, where one can insert a website name and find information about the site owner's location and name, which can give important clues as to the geographical and cultural context of documents. An example whois-tool is http://www.who.is.
8. Several author reputation mechanisms exist. For nonscientific publications, newspaper and publisher reputations are important. For nonformal publications, like blogs, reputation management mechanisms may be useful, which let readers review and score the quality of work. These reputation scoring systems, however, can be easily manipulated (Beel, Gipp, & Wilde, 2010; Duan & Liu, 2012; Poston & Speier, 2005). For scientific papers the journal's impact factor is important. However, several techniques exist that manipulate these scores (Beel et al., 2010) even in academic communities (Greenberg, 2009).
9. Dialectic search. Dialectic search implies that information consumers analyze the opinion and sentiment in an article to detect its (implicit) normative goal variable and next search for another article that has an opposing normative standpoint. This can be done partially by document sentiment identifiers like www.lexalytics.com and www.AlchemyAPI.com, but the automatic search for an alternative has not yet received an implementation. Because of this, Wijnhoven (2012) proposed using a manual process in which the information consumer first defines the thesis and uses this statement for the query and next defines the anti-thesis and uses that statement as the query.

### *Internet Theory Triangulation Tools*

Theory triangulation requires identifying the perspectives of a published document. At a more detailed level, theories consist of constructs (in empirical theories named variables, in explanatory theories named causes and effects, in normative theories these are motives and values, and in pragmatic theories they are named means and goals) and logical relations between these constructs (Eisenhardt, 1989; Gregor, 2006; Sutton & Straw, 1995; Weick, 1989). This implies that an effective theory triangulator must be able to (a) identify constructs, (b) identify relations among these constructs, and (c) identify the sentiments and norms of a document. For easing the interpretation of the results, all three need a visual output, that is, a list of constructs, a visual representation of (causal) relations, and for norms and values analysis a score of overall positive or negative sentiments.

For the identification of variables and categories, text analyzers may be useful, like Nelsenso. By these tools, a user can gain a very speedy insight into the content of a document and can evaluate if the document delivers what is searched for. One text summarizer is http://www.nelsenso.net/summazer.aspx. This tool may also avoid bias that an author has in his abstract and which does not cover the actual content of the paper very well.

For sentiment analysis, we found the following tools (Pang & Lee, 2008):

1. Web query sentiment finder. Sensebot.net or www.opinioncrawl.com is a semantic search engine that generates a text summary of multiple web pages on the topic of a search query. It uses text mining and multi-document summarization to extract sentiments from web pages. SenseBot.net gives a "Semantic Cloud" of concepts above the summary, allowing one to steer the focus of the results. This is not specifically relevant for a document, but may be appropriate for comparing the sentiments held among many documents.
2. Document sentiment identifier. Lexalytics—from www.lexalytics.com/technical-info/sentiment-analysis-measuring-emotional-tone-states that it can identify the emotive phrases within a document and then scores these phrases (roughly −1 to +1) and then combines them to discern the overall sentiment of the sentence. This is highly useful on blogs and larger texts. A similar job can be done by AlchemyAPI's sentiment tool.
3. Informal short text sentiment identifier. SensiStrength from http://sentistrength.wlv.ac.uk estimates the strength of positive and negative sentiments in short texts, even for informal language. It claims human-level accuracy for short social web texts in English, except political texts. SentiStrength reports two sentiment strengths: −1 (*not negative*) to −5 (*extremely negative*) and 1 (*not positive*) to 5 (*extremely positive*). It can also report binary (positive/negative), trinary (positive/negative/neutral), and single scale (−4 to +4) results. SentiStrength was originally developed for English and optimized for general short social web texts, but it can be configured for other languages and contexts by changing its input files. This is useful for Twitter texts analysis.
4. Document subjectivity annotator. Emotiblog is a fine-grained annotation scheme for labeling subjectivity in nontraditional textual genres (web data). This is useful when human evaluations are needed for sentiment identification or where an automatic method has low reliability, for example, when relevant sentiment word lists do not exist. Hypothes.is provides a similar service as an annotation tool that can create the wisdom-of-the-crowd.

Methods for causal relations identification have been discussed by Li and Larsen (2011), who developed techniques to infer causal relations from academic papers by natural language text mining. Because academic papers mostly have a rather formal language, concepts like "variable," "construct," "cause," "correlation," "hypothesis," "inference," "proposition," "effect," and "consequence" may be detected by a text analyzer, which next can deliver a visual representation of the causal structure of the theory. We considered a similar natural language processing technique in order to extract relations


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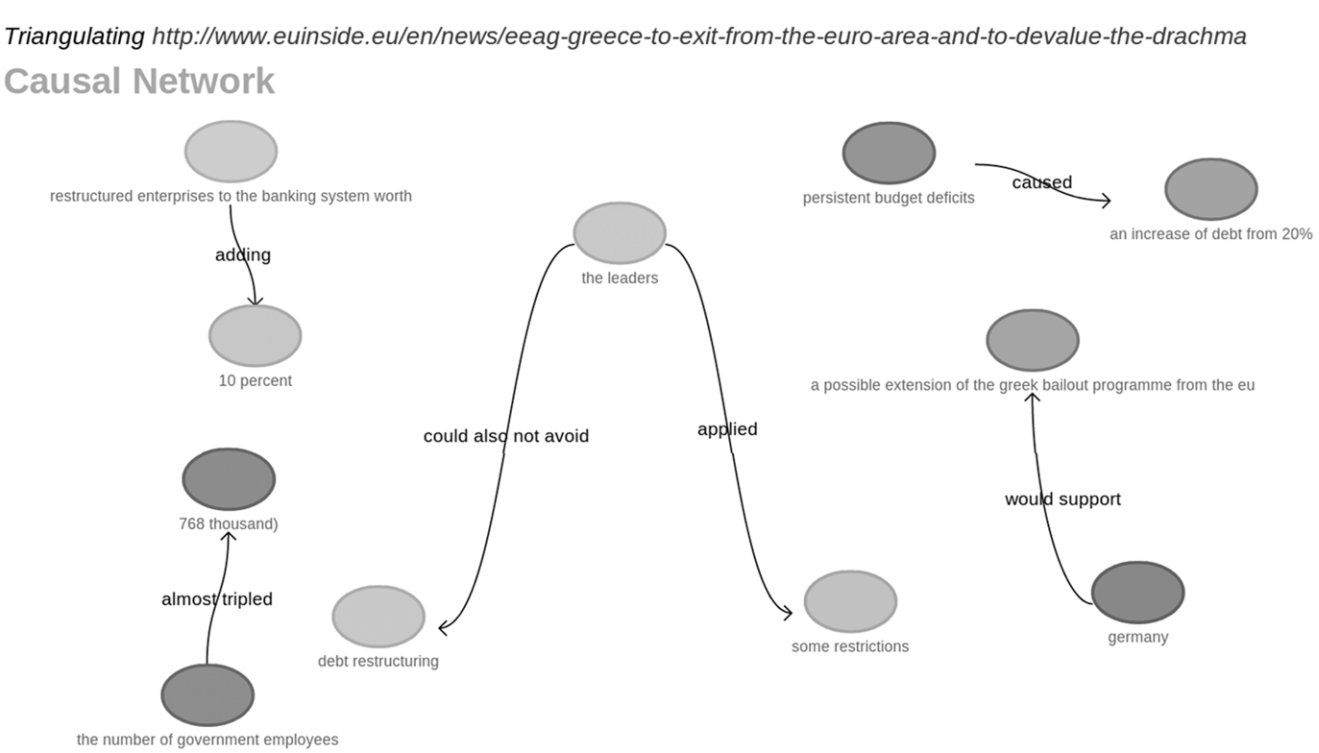


FIG. 1. Extracted causal network from a given Internet document.

from Internet documents, but we found this difficult because Internet documents mostly have a less formal language. Therefore, we searched the Internet further for natural language processing tools. We found that the AlchemyAPI has a relation extraction method which extracts subject-action-object relations. Most often "action" is a verb, performed by the "subject" onto the object and thus indicates causal change. Girju and Moldovan (2002) compiled a list of verbs which indicate a causal relation, like "induce," "produce," "effect," "stir up," "contribute to," and "bring about." This list has been added to our tryout of AlchemyAPI (see the complete list of 60 words in Girju and Moldovan's paper). The causal network we draw using the Dracula Graph Library. To render the causal network the server has to send a list of edges to the client. The "subject" corresponds to the "from" node and the "object" to the "to" node. The action corresponds to the relation between the nodes. Furthermore, identical subjects and objects correspond to the same node, thus building a network. The approach has been tried out by triangulating an Internet document on the European credit crisis. These relations gave a visualization of the theories in the document as in Figure 1, but still are hard to interpret.

As stated before, theory triangulation has multiple inquiring systems purposes:

1. It helps the Hegelian inquiring system by the identification of norms and values in a text, which thus represent elements of normative theories. These norms and values can be stated as thesis or anti-thesis, which can be pursued by dialectically querying the Internet.
2. The Leibnizian inquiring system can be served by theory triangulation by the identification of independent and dependent variables and causalities. By attempting to uncover a logical chain of reasoning, the theory triangulator is able to identify logical weaknesses and inconsistencies. Current tools, however, are still poor at uncovering causal relations in an informal text, as illustrated in Figure 1, but the identification of key variables is possible.
3. The Kantian inquiring system is served by theory triangulation by the identification of key terms as categories indicating a certain approach or perspective. The integration of multiple perspectives into a coherent nomological network by common and linking categories as discussed by Li and Larson (2011) is prevented because of the same difficulties of finding causalities in informal texts as with the Leibnizian inquiring system.

### *Internet Method Triangulation Tools*

We identified, after the analysis of the Kantian inquiry system, the following meta-requirements for method triangulation: identification of scope, grounding theory and ontology, categories that are used, research method, and replications. Because the first three have considerable similarity with theory triangulation (identification of variables and relations), we focus on the research method and replications here.

To develop the method triangulation, a list of business research methods has been created as presented in column 1 of Table 1. For this, Blumberg et al. (2008) was used, which


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TABLE 1. List of indicative terms for research methods.

| Method | Indicating words |
|---|---|
| Appreciative Inquiry | appreciating, envisioning, dialogue, giving meaning, understanding |
| Interviews | unstructured, semi-structured, structured, open questions, closed questions |
| Focus Groups | interactive, feedback, two-way, dual moderator, dueling moderator, respondent moderator, client participant subject focus, opinions, group work |
| Case Studies | prospective, retrospective, context holistic |
| Action Research | community of practice, problem solving, collaborative context, interaction of researcher |
| Questionnaires | statistical analysis, scale, index, variable, dichotomous, nominal-polytomous, ordinal-polytomous, continuous, attitudes, motives, opinions |
| Surveys | response rate |
| Experiments | hypothesis, cause-and-effect, controlled, natural, field |
| Observational Studies | control group, unlimited factors, real world, detecting, behavior |
| Secondary Data | background work, reviews, personal contacts |
| Literature studies | articles, facts, opinions, systematic search, bibliometrics, snow ball |
| Sampling | random, matching, selective |
| Structural equations | factor analysis, path analysis, regression, confirmatory, exploratory, latent variables |

elaborates extensively on the different existing research methods. After finishing this list, the methods needed to be extended with keywords for method identification in documents, as presented in column 2 of Table 1. To validate this list, a professor of research methodology reviewed and complemented the list.

After creating the list of methods and its keywords, the triangulator needs to check whether these keywords are present. To add content analysis to the triangulator, a tool is needed that is easy in use, is able to check documents on multiple word frequencies at the same time, is able to manage large documents and articles, and is free. Tools that can perform such a multiple term search and identification easily are Termine from http://www.nactem.ac.uk/software/termine/ and a tool we present later as part of the prototype.

## Research Prototype

The previous discussion of triangulator meta-designs is summarized by comparing the meta-requirements and meta-design components in Table 2. All the tools in Table 2 are candidate design components for a triangulation prototype. As one can see, several tools serve multiple meta-requirements. Also note that the inquiring systems are not fully mutually exclusive. For example, the Kantian inquiring system is to no small extent a synthesis of the Lockean and Leibnizian, and thus partially includes both but adds something (categories for integration of knowledge) on top. Thus, we only classify requirements for an inquiring systems in so far as these requirements are unique for them and an addition to the those previously mentioned. Some tools clearly serve multiple requirements, because these tools are what we found on the market and have very likely not been explicitly developed from our theory. For example, tools that enable the detection of a document's sentiment are useful for the Leibnizian perspective (identification of goal variables), the Kantian perspective (as a category for integrating theories), and the Hegelian perspective (identification of sentiment, thesis, and anti-thesis in a document).

We built a web-based prototype to be used by participants in a pilot for finding the possible contribution of an Internet triangulator for opinion formation. We selected some of the tools from Table 2 based on their availability for our prototype. Several tools were not available for free, did not operate well, or did not have an application programming interface (API) to have them included in the prototype. Some basically usable tools were not selected because of a lack of time and resources, and because they would make the prototype unnecessarily complex. Some tools are irrelevant (because they do not have a relation with politics). These are excluded. The tools are integrated into a working prototype, which runs in a web browser. See Table 3 for an overview of useful tools and our selections.

We realized the data triangulator (Figure 2) by providing an input field for Wolfram Alpha. Also, an integrated customized Google Search field is included, which makes it possible to search quickly through Snopes.com, Politifact.com, and Factcheck.org. Furthermore, there is a list of the 10 most-used keywords in the article, combined with quick links to search Google and Wikipedia.

For the investigator triangulator (Figure 3), we use the AlchemyAPI to extract the name of the author of the article. The prototype will then give prepared links to do a quick search on 123People.com, Facebook, LinkedIn, and Twitter. The tool also recognizes people mentioned in the found articles, also by AlchemyAPI, and provides the same set of links as for the author.

We realized the theory triangulator (Figure 4) by a word cloud creator by using a free PHP script. Next to that, the most-used keyword—as determined during the data triangulation step—is used as input to the document sentiment identifier by AlchemyAPI. This returns the overall sentiment, and gives insight into the number of positive, negative, and neutral occurrences of the word in the article. We did not implement the causality extractor because the output of our Internet document causality extractor (Figure 1) was difficult to interpret and in need of substantial further development. Additionally, the Nelsenso.net is integrated in the prototype (Figure 5). Nelsenso.net does not provide an API, and to make it as easy as possible to use in our experiment, the participants were given screenshots of the summaries of two articles, depending on which URL is entered. So this triangulation method only works for the two selected articles, not for other articles that people might want to triangulate.

The methodological triangulator (Figure 6) is realized by a self-developed PHP-script that uses the earlier-mentioned concept of determining which research methods have been used in the article. It returns the category of the keyword,


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TABLE 2. Internet triangulator meta designs

| Meta-requirements | Corresponding meta-designs | Example tools |
|---|---|---|
| *Lockean empiricism & data triangulator* | | |
| MRD1: Verify data validity. | MDD1.1: Terminology extractors | labs.translated.net/terminology-extraction |
| | MDD1.2: Substantive match identifier | whatizit (only for medical field). |
| MRD2: Check data reliability & precision | MDD2.1: On-line fact checker | http://truthteller.washingtonpost.com |
| | MDD2.2: Statement verifier | Truthgoggl.es |
| | MDD2.3: Claim verifier | www.politifact.com |
| | MDD2.4: Information virus detector | Skeptive.com |
| | MDD2.5: Document consistency checker | WinMerge's xdocdiff; diffpdf; diffnow.com; i-tools.org/diff. |
| *Leibnizian rationalism & theory triangulator* | | |
| MRT1: Identify variables & causalities | MDT1: Variables and causality extractor | Li & Larson (2011) tool for formal texts; AlchemiAPI word-mining & Dracula Graph visualization. |
| MRT2: Identify goals & values | MDT2.1: Document sentiment identifier | Lexalytics; AlchemyAPI; SensiStrength (short texts) |
| | MDT2.2: Document subjectivity annotator | Emotiblog |
| *Kantianism & theory triangulator* | | |
| MRT3: Identify the perspective | MDT3: text summarizers | http://www.nelsenso.net |
| MRT4: Identify the ontology | MDT4: text summarizers | http://www.nelsenso.net |
| MRT5: Identify categories | MDT5: Construct identifiers; wordcounts | AlchemyAPI; wordle.net |
| *Kantianism & method triangulator* | | |
| MRM1: Identify the research method | MDM1: Method indicators processor over a document | Multi-word search tool as prototype in this paper |
| MRM2: Identify document replications | MDM2: Plagiary checkers & (near-) duplicates identifiers | https://www.writecheck.com/static/home.html; https://www.ephorus.com/ |
| *Hegelian dialectics & investigator triangulation* | | |
| MRI1: Identify author & publisher. | MDI1.1: Author identifiers | Piple/123; facebook; twitter. |
| | MDI1.2: Whois tool; | Whois.com |
| | MDI1.3: Author from text extractor | www.alchemyapi.com; Firefox plugin gnosis. |
| MRI2: Identify expertise of author | MDI2: Author reputation checker | Google or Publish& Perish H-index. |
| MRI3: Identify site reputation | MDI3: Information site certification | For medical field "http://www.hon.ch. For wikipedia page reviews and indicators |
| MRI4: Identify author's affiliation(s) | MDI4: Google search and social media search | Google search |
| MRI5: Identify the interests of an author | MDI5: Author & publisher sentiment extraction | http://semanticengines.com |
| MRI6: Identify an author's sentiment. | MDI6: Author & publisher sentiment extraction | http://semanticengines.com |
| MRI7: Presenting opposing views | MDI7: Dialectic search | Only a manual procedure; no tools at the moment |

which keyword is detected, and how many times the keyword appears in the article.

In the following two sections we describe how our prototype is used and what contributions it gives to opinion formation.

## Prototyping Research Design

Design scientists (Hevner et al., 2004; March & Smith, 1995; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007; Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011; Walls et al., 1992) have frequently pointed out the need to incorporate empirical research into design science efforts for both testing the theoretical assumptions behind a design and for validating the design's contributions. In prototyping, actual use experiences with the artifact are used to prioritize possible further developments (Chiasson & Dexter, 2001; Fitton et al., 2005; Hardgrave, Wilson, & Eastman, 1999). An overview of the many ways evaluation studies can be done for design science is given by Cleven et al. (2009). They identify multiple evaluation study designs on the basis of the approach taken (quantitative vs. qualitative), the type of (organizational) contribution at stake (technical, organizational, or strategic decision making), the artifact type at focus (constructs, models, methods, instantiation of theories), the preferred epistemology (positivism or interpretivism), the function of the evaluation (knowledge, control, development, or legitimization), the method taken (action research, case studies, field experiments, formal proofs, controlled experiments, prototype, survey), the object of evaluation (the artifact itself vs. the process of artifact construction), the ontology (realism vs. nominalism), the perspective (economic, deployment, or engineering), the position of the researcher(s) (external people or people involved in the construction), the reference point for evaluation (evaluating the artifact against its requirements, or evaluating the artifact against its contributions to the real world), and time (ex ante when technologies are evaluated before they are chosen and ex post when selected artifacts are evaluated after implementation). Reviewing this large list of options, we aim at a quantitative approach to achieve strategic (better decision-making) objectives, by an instantiation of a prototype grounded in a Churchmanian design theory, positivistic (i.e., regardless of individualist characteristics of users), to develop better theoretical insights and insights for further development, through prototyping (i.e.,


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TABLE 3. Usable and used tools for the pilot prototype

| Site | Usable in prototype |
|---|---|
| http://truthteller.washingtonpost.com | No, because own input cannot be entered. |
| Truthgoggl.es | No, uses a browser plug in. Current only source is Politifact.com, and this website will be included. |
| NewsTrust.net/truthsquad | No, the website was a pilot and is not actively adding current topics anymore. |
| Snopes.com | Yes. Used. |
| Politifact.com | Yes. Used. |
| Skeptive.com | Yes. Not used because the topics "Greece" and "Europe" are not discussed on this website. |
| Journaliststoolbox.org | Yes. Not used because the topics "Greece" and "Europe" are not discussed on this website. |
| Diffnow.com | No. Only useful for comparing near duplicate articles. Not useful for comparing opposite papers. |
| i-tools.org/diff | No. Only useful for comparing near duplicate articles. Not useful for comparing opposite papers. |
| http://oilsandsfactcheck.org/ | No. This tool has no relation with European politics. |
| EnergyFactcheck.org | No. Not politics related. |
| borderfactcheck.com/ | No. Not politics related. |
| Africacheck.org | No. Not politics related. |
| wral.com/news/political/page/11620438/ | No. Out-dated and only for American politics. |
| Factcheck.org | Yes. Used. |
| FullFact.org | Yes. Not used because the topic "Greece" is not discussed on this website. |
| Journalistsresource.org | Yes. Not used because the topic "Greece" is not discussed on this website. |
| WolframAlpha | Yes. Used. |
| washingtonpost.com/blogs/fact-checker | No. Focus only on the U.S. |
| Pipl.com | Yes. Not used because of overlap with 123People.com |
| 123People.com | Yes. Used. |
| Google | Yes. Used. |
| Semantic API (http://semanticengines.com/) | Yes. Used. |
| Alchemy API Author Extraction | Yes. Used. |
| Gnosis Firefox plugin | No. Is a browser plug-in. |
| Poligraft.com | Yes. Not used: impossible to integrate in the prototype. |
| churnalism.sunlightfoundation.com/ | Yes. Used. |
| Sensebot.net | Yes. We used their "Semantic API" |
| AlchemyAPI (http://www.alchemyapi.com/api/sentiment/textc.html) | Yes. Used. |
| http://www.lexalytics.com/technical-info/sentiment-analysis -measuring-emotional-tone | Yes. Not used because of overlap with AlchemyAPI |
| http://sentistrength.wlv.ac.uk/ | No. Only for short texts. |
| Emotiblog | No. There is no working prototype available. |
| Hypothes.is | No. Only available as web toolbar. |
| Self-developed multi-word search tool | Yes. Used. |
| General Inquirer, VBPro, Wordsmith, Textpack, TACT, TextStat, Verbastat, Statpac | No. None of them is web based. |
| Termine http://www.nactem.ac.uk/software/termine/ | Yes. Not used because of implementation requirements. |
| CLiPS Pattern http://www.clips.ua.ac.be/pages/pattern | No. The tool is webbased and the Python language cannot be used. |
| whatizit: http://www.ebi.ac.uk/webservices/whatizit/info.jsf | No. Current focus is on political subjects, so medical information is not needed. |
| Terminology extraction: http://labs.translated.net/terminology-extraction/ | Yes. Not used because no open API available. |
| Nelsenso http://www.nelsenso.net/summazer.aspx | Yes. Used. |
| Lexalytics.com | Yes. Not used because no open API available. |

assessment of a solution's suitability) with an artifact and a realist ontology, from a deployment perspective, done by internal actors (the researchers are tool developers as well) but with a transparent evaluation procedure allowing for review and replication by externals, both aiming at contributions to the research gap and real world, ex post. This approach is summarized in Table 4.

The goal of the user test is to see if and what features of the triangulation process contributes to the opinion of the student. These contributions we operationalize by observing whether opinions on a topic change during the different steps of using our prototype. The more changes that happen after use of the prototype, the more we think that overconfidence and confirmation bias (Fischer et al., 2011; Jonas, Traut-Mattausch, Frey, & Greenberg, 2008; Schulz-Hardt, Jochims, & Frey, 2002) have been minimized. As a second proposition, we expect, following Fernbach et al. (2013), that if people hold extreme opinions, the use of triangulators


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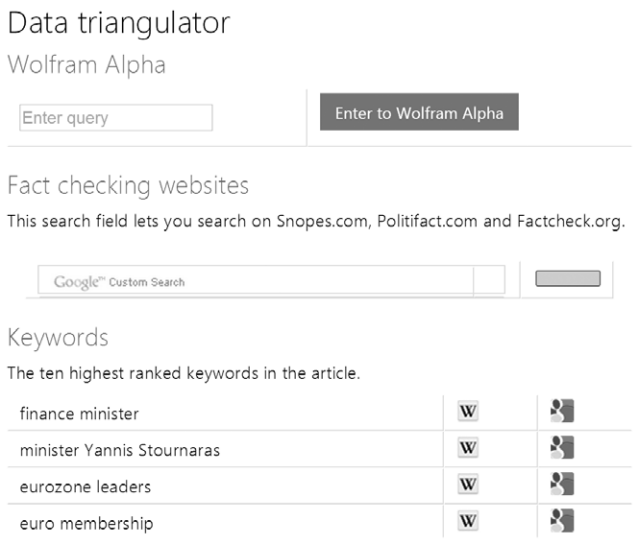


FIG. 2. The data triangulator screen.

will have a moderating effect, because triangulators require users to critically review their causal chain (theory triangulations), their evidence (data triangulation and method triangulation), and also their value perspective (investigator triangulation). We do this by a prototyping study, that is, a study in which we want to observe the actual use of a tool to develop ideas of what design characteristics caused an opinion moderating or confirmation bias reduction effect. To avoid respondent fatigue (as we will explain later, the test is intense and time-consuming) we do not know for sure if the desired effect is actually the result of the tool or some other noncontrolled event or feature. To be more precise, an experiment would require letting students work with both our tool and features and with a tool that lacks these features (for a good example on different search engines, see Kumar & Lang, 2007). However, this would make the experiment overcomplex and we are more interested in also checking respondents reactions in the process of using the multiple

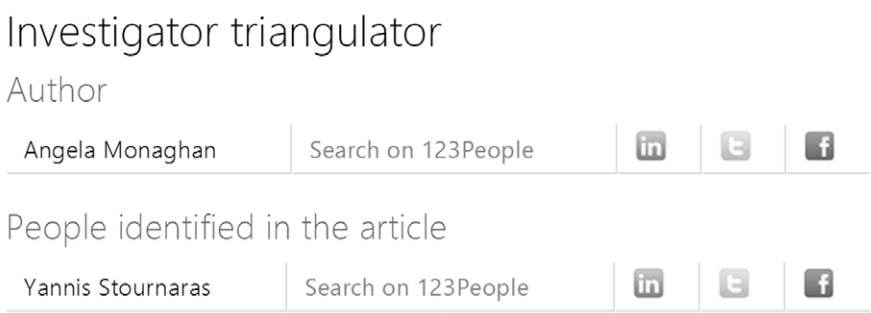


FIG. 3. The investigator triangulator screen.


FIG. 4. The theory triangulator.


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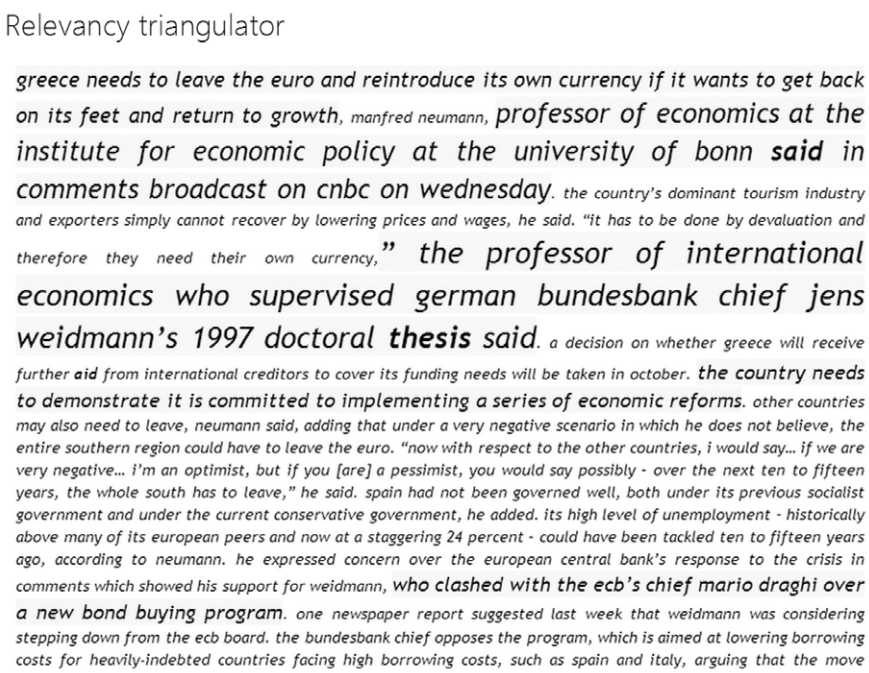


FIG. 5. Theory triangulation by Nelsenso.net output.

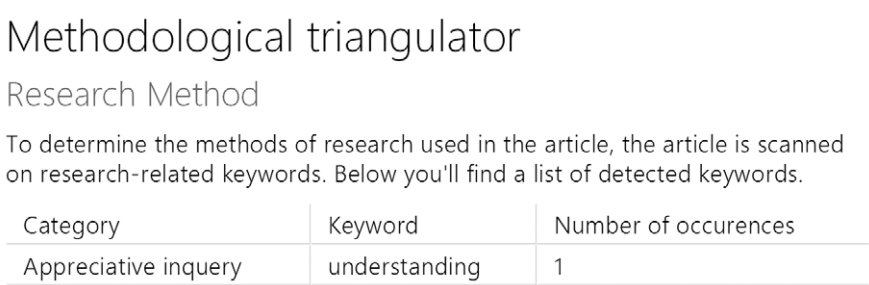


FIG. 6. Methodological triangulator.

features we offer. Additionally, our prototype type tool is not comparable with a mature well-developed tool on the market. Thus, a pure experiment that compares our prototype with a fully developed tool (e.g., the Google search engine) would result in the wrong conclusions because both have different levels of development. Consequently, we will analyze what happens when students use each of our features separately and from there we want to develop further research and development agendas.

For our test, we implemented the dialectic search by providing opposing documents on the thesis: "Greece should leave the Eurozone." One article states that Greece should stay in the Eurozone (http://www.telegraph.co.uk/finance/financialcrisis/9486188/Debt-crisis-Greece-must-remain-in-eurozone-minister-warns.html) and the other article states that Greece should leave the Eurozone (http://www.cnbc.com/id/48893471). To simulate the situation of an everyday life Internet information search, the papers were selected with the following criteria in mind:

TABLE 4. Design science evaluation research design.

| Research design variable | Value |
|---|---|
| Approach | Qualitative; quantitative |
| Contribution scope | Technical, organizational, strategic decision making |
| Artifact type | Construct, model, method, instantiation, theory |
| Epistemology | Positivism, interpretivism |
| Function of evaluation | Knowledge, control, development, legitimization |
| Method | Action research, case study, field experiment, formal proof, controlled experiment, prototype, survey |
| Object | Artifact, artifact construction |
| Ontology | Realism, nominalism |
| Perspective | Economic, deployment, engineering, epistemological |
| Position | External, internal |
| Reference point | Artifact against research, artifact against real world |
| Time | Ex ante, ex post |

*Note*. Chosen options are underlined.


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1. The documents should be easily searchable on the Internet by the Google search engine by using the thesis and anti-thesis as the query.
2. The documents should be available for free.
3. The documents should be about the credit crisis and Greece's situation in particular.
4. The documents should be available from a well-respected news site.
5. The documents should not be larger than two pages to enable a full read within 5 minutes.
6. The experiment participants should not have read the articles before.
7. The articles need to be citing a person, and not be opinion articles.
8. The selected articles where the highest ranked that matched these criteria. Also, we checked their publication dates to be less than 2 months from each other.

We measure the contribution of the tool on opinion formation in multiple steps:

1. First, participants are asked to state their opinion about the Greece situation on a 7-grade scale before reading the article.
2. Next, they will read one article (Greece should stay in the Eurozone), afterwards give their opinion again, and indicate their trust in several triangulation methods.
3. Then they triangulate the first article, and again indicate their trust in several triangulation methods.
4. Afterwards, they again give their opinion.
5. Steps 2–4 are repeated for the second (anti-thesis) article.

The full set of questions that we used to measure the students opinion is in the Appendix and is offered to the participants by a Google docs form.

The order of presentation of the articles is thus first the "thesis" article (Greece should stay in the Eurozone) and next the "anti-thesis" article (Greece should exit the Eurozone). This order was chosen because the anti-thesis is more far-reaching and complicated than the thesis because the thesis is about the current situation, about which much is known, and the anti-thesis is about a hypothetical future situation, about which more can be known.

The actually used prototype for the test works as follows:

1. When a URL to a news article is entered in the prototype the Alchemy API is queried to get the 10 highest-ranked keywords (which is part of the data triangulator), determine the persons mentioned in the article (part of investigator triangulation), and also the author is determined by this API. These highest-ranked keywords are shown in a table, with links to Google and Wikipedia where the keyword is prefilled as search query. The same, but now with links to 123People, LinkedIn, Twitter, and Facebook, is done for the identified persons and author.
2. Furthermore, the prototype displays a query field to enter a query on Wolfram Alpha, which will open Wolfram Alpha in a new screen with the search results. Also, as part of the data triangulator, a custom Google Search bar is shown which is configured to only search on Snopes.com, Politifact.com, and Factcheck.org. The results are displayed using an overlay display.
3. The word cloud in Theory Triangulation is generated using a PHP-script (open source, available at http://sheriframadan.com). Also the main keyword (which is the first item in the "highest ranked keywords" list) is sent to the Sensebot.net API, which will do a sentiment analysis on the article for the provided keyword. The number of positive, neutral, and negative mentions is shown. Nelsenso.net is next used to identify key terms that can be interpreted as main variables, scope, and theoretical approach in the text.
4. For methodology triangulation, an own PHP script is used, which counts appearances of predefined keywords and groups these counts into categories.

By following these steps it will become clear that if the opinion of a person changes it is because they read an article, or because they triangulated an article. Thus, we will test the following hypotheses:

H1: Information triangulation changes the opinion of the user to a more moderate standpoint.

H2: Information triangulation reduces the user's confirmation bias.

Our participants all were business administration college freshmen between ages 18 and 20 at a university in the Netherlands. Their social-economic background has not been registered but in general the university students population in the Netherlands is comprised of higher socio-economic groups, as in most countries in the world. In total, 76 students participated in the experiment of which 20 were females and 56 were male. For their participation they were rewarded with two bonus points for an information management course for which they could gain a maximum of 100 points (55 points in that scale implies a course pass). Four males did not complete the test, and thus data for 52 males and 20 females are analyzed.

The test was conducted between May 30, 2013 and June 11, 2013 via the Internet after a class demonstration and instruction on May 30, 2013. This was at the moment that the European Committee, the European Central Bank, most credit suppliers to Greece, and the International Monetary Fund (IMF) had just agreed to a reform and support plan for Greece of over 100 billion USD. At that moment the Greek economy was in great trouble, with over 25% unemployment. High dissatisfaction among the Greek population about salary cuts and declining government services were the cause of many demonstrations in the streets of Athens against the European Committee and the Greek government.

## Results

### *Impact of Internet Information Triangulation on Opinions*

Before reading the articles, the average student opinion regarding the thesis ("Greece should stay in Eurozone") was 4.4 positive on a 7-point Likert scale. As is evident from


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TABLE 5. Change in opinion per step.

| Opinion about thesis before reading | Disagree fully | | | | Agree fully | | | | Average opinion |
|---|---|---|---|---|---|---|---|---|---|
| 1-7 likert scale | 0 | 10 | 17 | 8 | 18 | 19 | 4 | | 4.4 |
| | Number of changes | | | | Average changes | | | Significance | |
| Read 1st thesis article | 36 | | | | 0.69 | | | 0.028060295* | 4.7 |
| Triangulate 1st article | 35 | | | | 0.61 | | | 0.457110561 | 4.6 |
| Read 2nd anti-thesis article | 48 | | | | 1.08 | | | 0.0000914550* | 3.9 |
| Triangulate 2nd article | 23 | | | | 0.44 | | | 0.349350179 | 4.0 |
| Total process | 50 | | | | 1.11 | | | 0.036440381* | |

*Note*. *$\alpha = .05$.

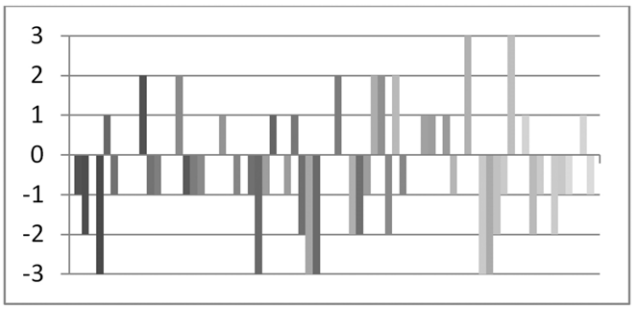


FIG. 7. Change of opinion per participant after the whole process.

Table 5, 50 of the 72 participants changed their opinion during the process of reading and triangulating, with an average change of 1.11 points.

Figure 7 also illustrates that more people changed their opinion to the left. This means they agree less that "Greece should leave the Eurozone." Following Fernbach et al. (2013), we regard the view of Greece having to leave as a more extreme opinion than the opinion that Greece should stay, because the last statement is more in contrast to the general opinion held by leading politicians and experts (who settled in favor of staying). After reading and triangulating, a moderating effect thus seems to have resulted.

The results have been tested using a two-tailed paired *t*-test, and with $\alpha = .05$, by which we conclude that the whole test did significantly influence their opinion. The individual triangulation steps did have an influence on the opinion of a part of the participants, but it is not statistically significant. This implies that feeding participants with relevant views by nonexperts has more impact than triangulation, which is consistent with Metzger et al.'s (2003) finding among college students.

### *Impact of Internet Information Triangulation on Opinion Confidence*

We hypothesized (H2) that triangulation reduces a person's confidence in their opinions and thus reduces confirmation bias. If a triangulation tool gives people more opportunities for criticizing documents, it could especially help to reduce overconfidence in opinions. We checked the impact of triangulation on opinion confidence by asking the participants to state their confidence in the document after using each of the triangulation functions of our prototype. Tables 6 and 7 give the data for the triangulation of the pro and con articles.

As can be seen from the data of the thesis article, the impact of the individual triangulators on opinion confidence is not significant. Regarding the thesis article, the confidence level improved significantly but it only marginally improved the decision ability (pragmatic value). Given the pro-Greece in Eurozone in the beginning, students seem to have become slightly more open to the views of authors that present opposing views. Although our sample is small and limited to students, these data would suggest that information triangulation does not significantly impact opinion confidence.

## Conclusions and Discussion

We started this article with three questions, which we now can answer. Regarding question 1 about what triangulation methods are needed, we proposed Churchman's inquiring systems theory as the kernel theory for Internet information triangulation, because this theory proposes teleological systems for knowledge creation that also include norms for the quality of information. We found on the basis of Churchman's inquiring systems theory that besides the classical four triangulation methods (data, investigator, theory, and method) there is a fifth usefulness triangulator. This fifth triangulator is at a meta-level related to the others because it requires input from the other four to decide on the usefulness of Internet information. We thus have not identified a specific usefulness triangulator separate from the others. Applying this theory resulted in the meta-requirements as summarized in Table 2. Regarding question 2, which asked how information triangulation can be done on the Internet, we can say after a search that multiple existing tools are full or partial realizations of one or more meta-requirements. However, three meta-requirements are not well served by the tools industry (as far as we know), MDT1 (the causal theory extractor), MDM1 (the method identifier), and MDI7 (the dialectic search). For MDT1 and


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TABLE 6. Opinion confidence for article 1 "Greece should stay in the Eurozone" (thesis)

| | After reading (A) Average opinion regarding credibility of document | After triangulation (B) Average opinion regarding credibility of document | Difference (B-A) | T-test |
|---|---|---|---|---|
| The facts in the article are true | 3.521127 | 3.408451 | -0.112676056 | 0.219458 |
| The author is an authority in this field | 2.830986 | 2.746479 | -0.084507042 | 0.464092 |
| The people mentioned are authorities in their field | 4.070423 | 4 | -0.070422535 | 0.43878 |
| The information in the article is consistent | 3.521127 | 3.352113 | -0.169014085 | 0.134636 |
| The conclusions are sufficiently methodologically sound | 2.985915 | 2.774648 | 0.211267606 | 0.066485 |
| This article helped me to decide regarding what should be done regarding Greece | 2.732394 | 2.816901 | 0.084507042 | 0.409233 |

TABLE 7. Opinion confidence for article 2 "Greece should leave the Eurozone" (anti-thesis)

| | After reading (A) Average opinion regarding credibility of document | After triangulation (B) Average opinion regarding credibility of document | Difference (B-A) | T-test |
|---|---|---|---|---|
| The facts in the article are true | 3.514286 | 3.528571 | 0.014285714 | 0.867189621 |
| The author is an authority in this field | 3.428571 | 3.657143 | 0.228571429 | 0.028392868* |
| The people mentioned are authorities in their field | 3.842857 | 3.814286 | -0.028571429 | 0.717806361 |
| The information in the article is consistent | 3.714286 | 3.542857 | -0.171428571 | 0.128421636 |
| The conclusions are sufficiently methodologically sound | 3.2 | 3.142857 | -0.057142857 | 0.62055533 |
| This article helped me to decide regarding what should be done regarding Greece | 3.085714 | 3.114286 | 0.028571429 | 0.70833802 |

*Note*. *$\alpha = .05$.

MDM1, we proposed a prototype to complete the list of meta-designs. The causal theory extractor was not used in our prototype, because the results are hard to interpret well. The method identifier also is in need of further professional development. For the dialectic search, we applied a manual procedure in our test, to find out if a dialectic search could contribute. Our conclusion is that a dialectic search tool is valuable and search engine companies can improve their services by offering this. Regarding MDI8 (crowd-based investigator triangulation), we think that this may be useful, but we did not include it in this study because asking "the crowd" to perform a task requires waiting for replies, which conflicts with the goal of the triangulation tool to provide speedy feedback. Taking more time for the test would not have been feasible, but also in the context of querying the Internet this may not always be useful.

Regarding question 3, on the contributions of an information triangulation prototype on opinion formation, we have evidence from our test with 72 students. As the results show, the whole process of reading two opposing articles, and triangulating these articles, has a significant influence on the opinion of people. During the use of the prototype, 50 people changed their opinion, but in between the beginning and end of the experiment, 50 people changed their opinion, and in total 142 times opinions changed during the stages of the experiment. This is an interesting result related to previous research. It gives an explanation for Fernbach et al.'s (2013) previous finding that when people are asked to more substantively present reasons for their opinion they would move from their extremist opinion and go more to a moderate opinion. Where Fernbach et al. state that values and norms reinforce opinions and that reasons (i.e., data and causal models) moderate opinions, we tend to believe that value and norms statements if presented dialectically in a triangulator can become very productive in the development of respect for the anti-thesis and the development of synthesis. Thus, this is not so because of a reduction in overconfidence but because of an increase in alternative views, which is a key aspect of the Hegelian dialectic inquiring system (Wijnhoven, 2012). Information triangulation is thus more an opinion formation tool and less a reducer of over- or under confidence in information. Consequently, we suggest further research and development of search engines that will make it possible to automatically provide the user with two dialectically opposite relevant articles. This is what we call "dialectic search."

However, although our search for meta-designs was driven by a kernel theory and related meta-requirements, the world of triangulator tools development is highly dynamic, meaning that some triangulation tools may not exist at the moment of publication of this article and that many more will have appeared in the meanwhile. However, the set of meta-requirements is now grounded on theory by this article, which gives a relatively stable foundation for readers to replicate, extend, and update the presented survey of tools. The list of meta-requirements also may be used by tools developers to gain inspiration for developing new tools.


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Further research also may test the key empirical propositions as implicitly present in the kernel theory. These empirical propositions can be described, following the Lockean, Leibnizian, Kantian, Hegelian, and Singerian inquiring systems respectively, as: (a) the use of triangulation tools results in a better insight of the real world via Internet documents; (b) the use of triangulation methods helps in making better decisions; (c) the use of triangulation methods helps in gaining a more complete and integrated perspective on a phenomenon via Internet documents; (d) the use of Internet triangulation helps in more consciously developing opinions on a topic independent of information masters; and (e) the use of Internet triangulation helps in improving problem solving. This is a research agenda in itself.

Because of the theoretical and empirically-demonstrated importance of the fifth usefulness triangulator, we particularly encourage further research into usability triangulation and the development of additional tools for it. Usability can be evaluated by a problem owner, problem and solution experts, and the crowd. Looking at this, any rating platform that asks for reviews of solutions by problem owners and experts may be usefully integrated into an Internet information triangulator. Many open innovation platforms exist (see the list from http://www.openinnovators.net/list-open-innovation-crowdsourcing-examples/ accessed March 27, 2013), but they do not specifically generate usefulness reports on documented solutions on the Internet, and thus information triangulation theory may help in improving the effectiveness and value of open innovation platforms.

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## Appendix: Questionnaire

The questionnaire can be accessed using the following url: https://docs.google.com/a/student.utwente.nl/spreadsheet/viewform?formkey=dDR2Q182N2pGZ2tkWExLQUhwQ0J3UGc6MQ#gid=0.


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