

COMENIUS UNIVERSITY BRATISLAVA  
FACULTY OF MATHEMATICS, PHYSICS AND  
INFORMATICS

UNDERSTANDING OPINION FORMATION: A HORIZONTAL MAP OF  
CURRENT EPISTEMOLOGICAL LANDSCAPE

Diploma thesis

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FACULTY OF MATHEMATICS, PHYSICS AND  
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Diploma thesis

Study programme:	Cognitive Science
Field of study:	Computer Science
Department:	Department of Applied Informatics
Supervisor:	Mgr. Jakub Šrol, PhD.

Bratislava, 2023

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**Study programme:** Cognitive Science (Single degree study, master II. deg., full time form)  
**Field of Study:** Computer Science  
**Type of Thesis:** Diploma Thesis  
**Language of Thesis:** English  
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**Title:** Understanding opinion formation: a horizontal map of current epistemological landscape

**Annotation:** How our opinions are formed is a topic that is at a center of many scientific disciplines - from social and cognitive psychology, linguistics, to neurology and philosophy as well. Despite the importance of opinions for people's behavior, there is a serious lack of scoping reviews of opinion formation from a multidisciplinary approach. This project will thus attempt to contribute to the understanding of the factors that influence opinion formation.

**Aim:** To develop a review of scientific disciplines and journals delving into the topic of opinion formation and to provide a multidisciplinary review of factors influencing opinion formation.

**Literature:** Moussaïd, M., Kämmer, J. E., Analytis, P. P., & Neth, H. (2013). Social influence and the collective dynamics of opinion formation. PloS one, 8(11), e78433.

**Keywords:** opinion formation; beliefs; review

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**Názov:** Understanding opinion formation: a horizontal map of current epistemological landscape

*Porozumenie vytvárania názorov: horizontálna mapa súčasného epistemologického terénu*

**Anotácia:** Ako sa formujú naše názory je téma, ktorá je stredobodom mnohých vedeckých disciplín – od sociálnej a kognitívnej psychológie, lingvistiky, až po neurológiu a filozofiu. Napriek dôležitosti názorov ľudí pre ich správanie, existuje vážny nedostatok prehľadových štúdií týkajúcich sa tvorby názorov z multidisciplinárneho pohľadu. Tento projekt sa tak pokúsi prispieť k pochopeniu faktorov, ktoré ovplyvňujú tvorbu názorov.

**Cieľ:** Vypracovať prehľad vedných odborov a časopisov zaoberajúcich sa témou tvorby názorov a poskytnúť multidisciplinárny prehľad faktorov ovplyvňujúcich tvorbu názorov.

**Literatúra:** Moussaïd, M., Kämmer, J. E., Analytis, P. P., & Neth, H. (2013). Social influence and the collective dynamics of opinion formation. PloS one, 8(11), e78433.

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**Declaration:** I hereby declare that I have written this thesis by myself, only with help of referenced literature and consultations with my supervisor.

Bratislava, 2023

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## Abstract

In this work, we map scientific literature on the topic of opinion formation. Our initial research has shown that scientific knowledge on this topic is fragmented among different scientific disciplines. Therefore, as a first step we use bibliometric analysis to quantify representation of different disciplines which study the topic and to determine concepts related to the topic. As a second step, we use content analysis to extract conceptualisations of opinions and information about opinion formation from the most cited articles of the most represented scientific disciplines. Because of similarities between the terms *opinions*, *attitudes* and *beliefs*, we conduct both steps for each of the terms and compare the findings. *Opinions* are studied mostly on the collective level as public opinions, with focus on polarisation and consensus formation. Dominant methods here are mathematical models and computer simulations. *Attitudes* are well and simply conceptualised topic in psychology and applied in marketing studies. *Beliefs* are studied by various disciplines, which define them differently. Such research often focuses on delusions. All *opinions*, *attitudes* and *beliefs* are often used as synonyms, relate to behaviour and social factors. Our bibliometric and content analysis confirmed that scientific knowledge on this topic is fragmented among different disciplines, and we did not find any integrating resource. We consider this work as the first effort in this manner and point out to the problems of current science with the fragmentation of knowledge into narrow (sub-)disciplines.

**Keywords:** opinion formation, attitude formation, belief formation, bibliometrics

## Abstrakt

V tejto práci mapujeme ako vyzerá vedecká literatúra na tému formovania názorov, ako sú názory konceptualizované a čo táto literatúra hovorí o ich formovaní. Náš počiatočný prieskum ukázal, že vedecké poznatky o tejto téme sú rozptýlené v rôznych disciplínach. Preto ako prvý krok práce používame nástroje z bibliometrie, aby sme kvantifikovali zastúpenie vedeckých disciplín a určili najčastejšie pojmy spojené s týmto konceptom. V druhom kroku pomocou obsahovej analýzy najcitovanejších článkov z najzastúpenejších vedeckých disciplín vyberáme informácie o definícii a formovaní názorov. Vzhľadom na zistenú príbuznosť termínov *názor*, *postoje* a *presvedčenie* robíme dané kroky pre každý z pojmov a porovnávame zistenia. *Názory* sa najčastejšie skúmajú na kolektívnej úrovni vo forme verejnej mienky, so zámerom na polarizáciu a konsenzus. Dominantné metódy pre tento pojem sú matematické modely a počítačové simulácie. *Postoje* sú dobre konceptualizované a patria psychológii, s častou aplikáciou v marketingu. *Presvedčenia* študujú rôzne disciplíny, ktoré ich rôzne definujú. Články sú často zamerané na falošné presvedčenia. *Názory*, *postoje* aj *presvedčenia* sú prepojené so správaním a sociálnymi faktormi, často sa navzájom používajú ako synonymá. Aj po daných analýzach platí, že vedecké poznatky o týchto konceptoch sú rozptýlené medzi rôznymi disciplínami. Nepodarilo sa nám objaviť zdroje, ktoré by tieto poznatky prepájali. Našu prácu považujeme za prvú v tomto smere a poukazujeme na problémy súčasnej vedy spojené s fragmentáciou poznatkov do úzkych vedeckých disciplín.

**Kľúčové slová:** formovanie názorov, formovanie postojov, formovanie presvedčení, bibliometria



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# 1 Introduction

## 1.1 Motivation

If you would be asked to state an opinion, it would have been an easy task. You sure have many opinions. Opinions are omnipresent, from everyday topics like what food we like or do not like, what we think about our colleagues, to big societal topics, like political preferences, opinions on immigration laws etc. Many conversations are just exchanges of opinions – what do you think about that new movie? Have you seen the new iPhone? The elections are coming, who will you vote for?

Our opinions often have consequences in terms of different actions – if I think that a vegan diet is healthy, I will not eat meat and I will buy vegan products. If I prefer one political party, I will vote for it in the elections. I may even fight with people which prefer other party! Democracy is based on the assumption that we can make informed opinions.

Put simply, opinions are important. So, what do we know about them? How are opinions conceptualised? What is known about how we form them?

Sometimes, the source of our opinions is clear – for example, an opinion “can openers are useful” is most probably stemming from empirical experience (of trying to open a can without it). But it is much easier to find cases when the formation process is puzzling. Why do some people believe being vegan is healthy and good for the planet and others do not? Why do some people like that new car and others do not? There are probably many factors influencing the opinion formation process – available information, cognitive processing of this information, probably influenced by people around us, our memories, goals, current mood, and so on.

The present thesis aims to map the current scientific knowledge on opinion, attitude, and belief formation. In this section, we will first explain our motivation, then overview possible methods which could be used to reach our aim and finally formalise the aim into research objectives and questions.

Our first step was to find a general resource, which would provide some answers to our questions. This, however, turned out to be more difficult than we expected. To the best of our knowledge, there is no general book or broad review paper on the topic. On the other hand, there were many research articles containing the keyword *opinion formation* across many different disciplines, using very different methods and

targeting very different aspects of opinion formation process. The top 10 most cited articles containing the term *opinion formation* were published in journals on social simulation, consumer research, politics, communication, psychology, economics, physics, and information systems. The content of articles ranged from opinions reduced to single numbers in computer simulations, specific opinions about a product or a brand, collective consensus, various psychological or sociological effects, different contexts and so on. Even the term *opinion* was sometimes exchanged for term *attitude* or *belief* as a seeming synonym. To demonstrate this, we briefly summarise several selected articles.

The most cited article with the keyword *opinion formation* is “Opinion dynamics and bounded confidence: Models, analysis and simulation” by Hegselmann and Krause, published in Journal of Artificial Societies and Social simulation. This article models under which conditions opinion formation within an interactive group (so called “opinion dynamics”) leads to consensus, polarisation or fragmentation of opinions. Opinions are modelled as a real number representing, for example, expert’s opinion on a probability of an event. The model assumes “bounded confidence” – that individuals accommodate their opinion to the opinion of others if the opinion of others is not too far from their own. As further research, authors mention studying opinion spaces of higher dimension (not only one real number) and analyses of the influence of different network structures on the opinion dynamics (Hegselmann & Krause, 2002). To illustrate the field in which this paper originated, the authors, among others, refer to research papers titles “Mixing *beliefs* among interacting agents” and “Mathematical models of the distribution of *attitudes* under controversy.”

Another article, published in the Journal of Communication connects opinion formation with the theory of framing. Framing refers to the use of a so-called *frames* which alter how information is perceived, e.g., Ku Klux Klan rally can be *framed* as a free-speech issue or a public safety issue. This article focuses on *public opinion*, and how framing influences public opinion formation. Related concepts here are *persuasion* and *attitude structure* (Chong & Druckman, 2007). The term *attitude* is mentioned here 39 times.

An article published in The Quarterly Journal of Economics proposes a model of opinion formation, where individuals are subject to *persuasion bias*, i.e., they fail to account for possible repetition in the information they receive. This implies *social influence*, that is, one’s influence on group opinions depends how well connected he is

in the social network. Persuasion bias also implies the phenomenon of unidimensional opinions, when one's opinions over several issues converge to a single "left-right" spectrum. The authors explore the implication of a model in political science and marketing (Demarzo et al., 2003). The term *belief* is mentioned here 214 times, more than twice as much as the term *opinion*.

As illustrated above, beliefs and attitudes seem to be connected to opinions. The most cited article with the keyword *attitude formation* is "Nature and Operation of Attitudes" by Icek Ajzen, published in the Annual Review of Psychology. It is a review of *attitude theory* and covers the conceptualisation of attitudes, attitude formation, activation, structure, strength and function. It also covers attitude-behaviour relation, relation of attitudes to broader values, attitudinal ambivalence, affective and cognitive processes in the formation of attitudes. Most research on these topics was stemming from the theories of planned behaviour and reasoned action. This review also considers the role of accessible beliefs (Ajzen, 2001). The term *belief* is mentioned 69 times.

Most cited article with the keyword *belief formation* is published in Nature Reviews Neuroscience and with the aim to explain positive symptoms of schizophrenia – hallucinations and delusions (false beliefs) – with the Bayesian approach (Fletcher & Frith, 2009).

All the papers mentioned above study and describe aspects of opinion formation, yet the connection between different fields is largely missing. By extension, we may also assume that there is a substantial lack of cross- and interdisciplinary communication in this topic. As we are interested in the cross-disciplinary conceptualisation of opinions, their characteristics, how they relate to other concepts (e.g., beliefs, delusions, attitudes, confidence, values, persuasion, framing, social networks, etc.), to the best of our knowledge, there are no papers offering such an overarching viewpoint.

This striking gap in the literature is the main motivation for the present thesis. Our aim is *not* to review the most current general conceptualisations of opinions and general models of opinion formation, because no field offers such general cross-disciplinary perspectives. Instead, we will try to describe which disciplines study opinions, what fields are connected to the topic of opinion formation, what methods are being used to study opinion formation, what are the discipline-specific conceptualisations (if they are defined) and how do discipline-specific articles describe

opinion formation process, or aspects of it. Because of the common interchange (or, at least, strong connection) with *attitudes* and *beliefs*, we will do the same for those other two concepts and compare the findings. As much as we would like to create a cross-disciplinary model of opinion formation, which would integrate the findings from diverse research fields, this is not possible within the scope of the present thesis. We will thus only describe and compare, i.e., map the topic from different perspectives. A common first step of any research is narrowing down the phenomenon of interest. Here we purposely skip this step and state again – this thesis aims to be a starting point for integration of a fragmented research topic of opinion / belief / attitude formation.

## 1.2 Methods for summarising research findings

Since our aim is to map the topic of opinion formation, we here briefly summarise methods for describing a large body of literature and extracting relevant information from diverse scientific articles.

### 1.2.1 Literature review

According to Schmidt (2008) there are two traditional methods of making sense of earlier findings: the quantitative approach of meta-analysis and the qualitative approach of structured literature review. Meta-analysis requires the studied articles to be of the same type, which is not in line with our integrative approach. Structured literature review matches our needs, because it can handle the diversity of studies and methodological approaches (Zupic & Čater, 2015).

According to Tranfield et al. (2003), literature review can broadly be described as a more or less systematic way of collecting and synthesizing previous research. There are different types of literature reviews, which could be placed on a continuum from integrative to systematic approaches. Systematic literature reviews are best suited for specific research questions, quantitative articles, and quantitative analysis, whereas semi-systematic and integrative reviews are appropriate for broad research questions, various research articles and qualitative analysis. Narrative or integrative review approach is preferable mainly when the review aims to summarize or evaluate a large field of research or even several research areas (Snyder, 2019). According to Wong et al. (2013) the semi-systematic or narrative review approach is designed for topics that have been conceptualized differently and studied by various groups of

researchers within diverse disciplines and that hinder a full systematic review process. Semi-systematic or integrative literature review thus fits our aim.

### *1.2.2 Bibliometric methods*

Apart from the two methods mentioned by Schmidt (2008), Zupic and Čater (2015, p. 429) introduce a third method, which is similarly based on the quantitative approach of bibliometric research methods. According to the authors, bibliometric methods are being increasingly used to map the structure and development of scientific fields and disciplines and can be a useful for literature reviews even before the reading begins by “guiding the researcher to the most influential works and mapping the research field without subjective bias“ (Zupic & Čater, 2015, p. 430). Bibliometric methods are especially useful when the scope of the review is broad and the dataset is too large for manual review (Donthu et al., 2021). There are different bibliometric methods, like citation, co-citation, bibliographic, co-author or co-word analysis (Donthu et al., 2021; Zupic & Čater, 2015). Co-word analysis suits our needs the best, as its result is a network of themes and their relations that represent the conceptual space of a field. According to Borner et al., (2003) this semantic map can help to understand the cognitive structure of the domain. The map is constructed by displaying the most frequent terms from all analysed documents and connecting them if they co-occur in one article. The more often two terms co-occur in different articles, the stronger the connection. There are multiple pieces of software which help with the visualisation and with the extraction of relevant terms from the articles, for example by using natural language processing techniques (van Eck & Waltman, 2010).

### *1.2.3 Content analysis*

A content analysis is a method used to analyse qualitative data, typically texts (White & Marsh, 2006). It was also used to analyse scientific journal articles (Järvelin & Vakkari, 2022; Stansbury & Stansbury, 2002).

The aim of content analysis is to build a model to describe the phenomena in conceptual form. There are two types of content analysis – deductive and inductive. Deductive content analysis is used when the structure of the analysis is operationalized on the basis of previous knowledge and the purpose of the study is theory testing. Inductive content analysis is used when particular instances are observed and then combined into a larger whole or general statement, or when the phenomenon is

fragmented. More specifically, the inductive content analysis consists of open coding, creating categories and abstraction whereas, in the deductive approach, the data are coded according to the categorisation matrix constructed beforehand (Elo & Kyngäs, 2008). The deductive content analysis is in some literature called quantitative, and inductive content analysis qualitative (White & Marsh, 2006).

### 1.3 Research aim, objectives and questions

Scientific literature on the topic of opinion, belief and attitude formation is fragmented – studied in various scientific fields, with the lack of cross-disciplinary review articles or overarching conceptualisations. This thesis **aims** to describe and compare approached articles from different scientific fields on the topic of opinion, belief and attitude formation, mainly from the conceptual perspective.

This can be broken down into several **research objectives (RO)**. Below each research objective, we state **research questions (RQ)**.

- **RO1:** To describe the body of scientific literature on opinion, belief and attitude formation **quantitatively**, using bibliometric methods.
  - **RQ1.1:** How populated is the literature on opinion, belief and attitude formation and what is the time trend?
  - **RQ1.2:** Which scientific disciplines study opinion, belief and attitude formation?
  - **RQ1.3:** What topics are connected to the topic of opinion, belief and attitude formation?
- **RO2:** To describe the body of scientific literature on opinion, belief and attitude formation **qualitatively**, i.e., to analyse most-cited scientific articles from different scientific fields on the opinion, belief and attitude formation using the combination of content analysis and narrative review methods.
  - **RQ2.1:** How are opinions, beliefs and attitudes conceptualised in the most-cited articles from various fields in the opinion, belief and attitude formation literature?
  - **RQ2.2:** How are opinions, beliefs and attitudes formed according to the most-cited articles from various fields in the opinion, belief and attitude formation literature?



- **RQ2.3:** What methods are used in the most-cited articles from various fields in the opinion, belief and attitude formation literature?
- **RQ2.4:** What are other observed categorical differences in how opinions, beliefs or attitudes are studied in the most-cited articles from various fields in the opinion, belief and attitude formation literature?
- **RO3:** To compare the findings from the bibliometric and content analysis of opinion, belief and attitude formation literature.
  - **RQ3.1:** How do answers for RQ1.1 – RQ1.3 differ for terms opinion formation, belief formation and attitude formation?
  - **RQ3.2:** How do answers for RQ2.1 – RQ2.4 differ for terms opinion formation, belief formation and attitude formation?
  - **RQ3.3:** How do findings for RQ1.1 – RQ1.3 and RQ2.1 – RQ2.4 differ?

## 2 Methods

There are existing guidelines for both literature review (Snyder, 2019) and bibliometric studies (Donthu et al., 2021) which we will present in this section. For each step, we will demonstrate how we have adopted and applied methods described in the previous section in our research design.

### 2.1 Bibliometric methods

As stated in RO1, our first aim was to describe the body of scientific literature on opinion, belief and attitude formation using bibliometric methods.

#### 2.1.1 *Search terms*

To construct the corpus which will be analysed, we will use the Scopus database. Scopus database was chosen over Web of Science because of bigger journal coverage (Mongeon & Paul-Hus, 2016).

We will use three search terms:

1. TITLE-ABS-KEY("opinion formation"),
2. TITLE-ABS-KEY("attitude formation") and
3. TITLE-ABS-KEY("belief formation").

TITLE-ABS-KEY means that the search phrase (e.g., "opinion formation") will be searched in the title, abstract and keywords of the indexed articles. This is the "widest" search possible – it is not possible to search in the text of the articles. We expect that results of this search will cover majority of articles on the topic. The quotation marks around the search term mean that the exact term will be searched.

These three search terms yield together approx. 3000 articles.

We have considered using different synonyms for the word "formation" in the search, such as "development", "acquisition", "making of", or "establishment", however these search term yielded orders of magnitude less results than with the word "formation". Therefore, we have only used the word "formation" in the search terms.

#### 2.1.2 *Scopus' tools*

Scopus database offers basic analytical tools, such as ordering the results by citation, plotting the number of articles published by year, extracting most populated journals, most used article keywords, or most populated subject areas. When a journal

is indexed by Scopus, they assign subject areas to the journal based on the journal's aims and scope. Scopus' subject areas are, for example: Computer Science, Neuroscience, or Psychology. The whole list of subject areas can be seen in Appendix in Table 19. One journal can have multiple subject areas assigned, for example Journal of Artificial Societies and Social Simulation has two subject areas - Social Sciences and Computer Science.

To answer the RQ1.1 (How populated is the literature on opinion, belief and attitude formation and what is the time trend?), we will note down the number of results for each search terms. Also, we will calculate the ratio of number of items returned by the search terms to total number of articles indexed in Scopus for each year. By this, we want to account for the total increase of articles published each year.

To answer the RQ1.2 (What sciences study opinion, belief and attitude formation?) we will plot most populated subject areas and the most populated journals.

RQ1.3 (What topics are connected to the topic of opinion, belief and attitude formation?) will be answered with the analysis of most frequent keywords used in articles. We will also group the keywords semantically.

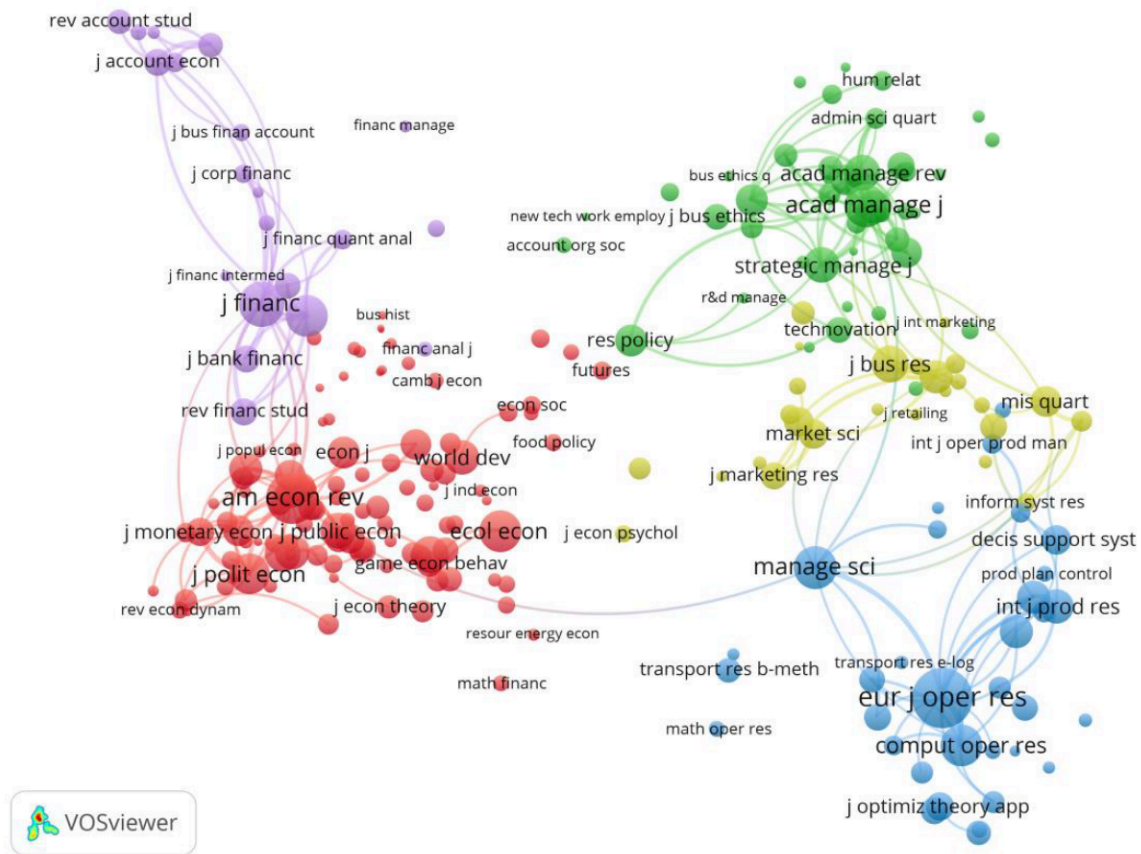
### *2.1.3 VOSViewer software*

To further explore keywords to answer RQ1.3, we will construct keywords and terms co-occurrence maps using the VOSViewer software. VOSViewer is a freely available computer program for constructing and viewing such graphical representations of large bibliometric maps (van Eck & Waltman, 2010).

**Keywords co-occurrence map** is a graphical representation of bibliographical data. Keywords are represented by a circle with a label. The size of the label and the circle of an item is determined by the weight of the item – number of items containing the keyword. The higher the weight of an item, the larger the label and the circle of the item. For some items the label may not be displayed in order to avoid overlapping labels. The colour of an item is determined by the cluster to which the item belongs. Clustering is done automatically by VOSViewer's clustering algorithm. Lines between items represent links. In general, the closer two items are to each other, the stronger the link between them. Only the strongest links are displayed. (Jan van Eck & Waltman, 2022). Example of a network visualisation can be seen in Figure 1.

**Figure 1**

*Example of network visualisation from VOSViewer*



*Note:* From Jan van Eck and Waltman (2022).

To construct the keywords co-occurrence map, we will use the following protocol for each search term:

1. Download results of the search from Scopus in a CSV format
2. In VOSViewer menu choose Create..., then Create a map based on bibliographic data
3. In Choose data source dialog, choose Read data from bibliographic database files
4. In Select files dialog, choose Scopus and upload the downloaded CSV file with search results
5. In Choose type of analysis and counting method dialog, select Co-occurrence map as the Type of analysis, All keywords as the Unit of analysis and Full counting as the Counting method

6. In Choose threshold dialog, choose such Minimum number of occurrences of keywords that results in roughly 100 keywords to be displayed
7. In Choose number of keywords dialog, keep the number of keywords without a change
8. In Verify selected keywords dialog, deselect ambiguous keywords (this is a manual and to some extent subjective process, therefore note down deselected keywords so they can be presented in results)

**Terms co-occurrence map** is the same map as keywords co-occurrence map, where terms are displayed instead of keywords. The terms are nouns or noun phrases, which are extracted from titles and abstracts of the articles using natural language processing and other methods (Jan van Eck & Waltman, 2022).

To construct the terms co-occurrence map, we will use the following protocol:

1. Download results of the search from Scopus in a CSV format
2. In VOSViewer menu choose Create..., then Create a map based on text data
3. In Choose data source dialog, choose Read data from bibliographic database files
4. In Select files dialog, choose Scopus and upload the downloaded CSV file with search results
5. In Choose fields dialog, choose Title and abstract fields as Fields from which terms will be extracted. Keep the Ignore structured abstract labels and Ignore copyright statements checkboxes checked
6. In Choose counting method choose Binary counting
7. In Choose threshold dialog, choose such Minimum number of occurrences of a term that results in roughly 160 terms to be displayed
8. In Choose number of terms dialog, keep the default 60% of most relevant terms (this should result in roughly 100 terms)
9. In Verify selected keywords dialog, deselect ambiguous keywords (this is a manual and to some extent subjective process, therefore note down deselected keywords so they can be presented in results)

#### *2.1.4 Following guidelines for bibliometric analysis*

In this section, we want to briefly demonstrate how we have followed guidelines according to Donthu et al. (2021, p. 294). The guidelines are quoted, and our commentary follows after arrow sign.

“Step 1. Define the aims and scope of the bibliometric study”

- “Define the aims and the scope of the study” → The aim was described, and the scope is approx. 3000 articles.
- “Definition should be broad enough to warrant the use of bibliometric analysis” → The scope is within recommended hundreds to thousands of articles.

“Step 2. Choose the techniques for bibliometric analysis”

- “Choose the appropriate bibliometric analysis techniques according to the aims of the study” → The aim of the study is to describe and compare scientific literature on the topic of opinion, belief and attitude formation, mainly from the conceptual perspective. Basic bibliometric technique like analysis of most populated journals and subject areas should show which sciences study opinions, beliefs, and attitudes. Co-word analysis should show what are the most common connected topic and what are the relationships between them. We will not perform co-authorship or co-citation analysis, as we are not interested in most cited authors or publications but want to describe the concepts in the literature.

“Step 3. Collect the data for bibliometric analysis”

- “Design the search term based on scope defined in Step 1” → The search terms yield recommended hundreds to thousands of articles.
- “Select the database based on the adequacy of its coverage” → Scopus database was chosen as it covers more articles than Web of Science database.
- “Fetch the bibliometric data based on the choice of bibliometric analysis technique in Step 2” → The data were extracted from the Scopus database using the standard CSV export which is accepted by the VOSViewer software.
- “Clean the data before proceeding. Eliminate errors such as duplicates and erroneous entries” → The data are considered clean,

as only one search term is used to obtain unit of analysis, so no duplicates are expected. Erroneous entries are considered to be treated by Scopus side.

“Step 4: Run the bibliometric analysis and report the findings”

- “Science mapping – Summarize the bibliometric structure and the intellectual structure using techniques for science mapping (e.g., citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, co-authorship analysis) and bibliometric analysis enhancement techniques (e.g., network metrics, clustering, visualization)” → Co-word analysis will be used with enhancement techniques – clustering and visualisation – provided by VOSViewer software.
- “Curate a bibliometric summary and write the discussion of the findings along with its implications” → Summary and discussion will be written in following section.

## 2.2 Narrative review and content analysis

As stated in the RO2, we want to describe the body of scientific literature on opinion, belief and attitude formation using the combination of content analysis and narrative review methods.

### 2.2.1 *Article selection – sampling*

Bibliometric methods allow us to describe large body of literature, thanks to the use of computer software. While there are some pieces of software which can be used to assist with content analysis (White & Marsh, 2006), we will conduct it manually, together with narrative review. This limits the number of articles we will be able to analyse, due to our restricted capacity (one researcher and small timeframe). Since we will be analysing only a small sample of articles, we want them to be as representative of the whole dataset as possible.

#### 2.2.1.1 **Sampling methods considered**

In this subsection, we will briefly describe what sampling methods, i.e., methods to choose articles for narrative review and content analysis, we have considered. By this, we want to explain why we have decided to use the sampling method described in next subsection.

The search terms (“opinion formation”, “attitude formation”, “belief formation”) returns a pool of approx. 3 000 articles. Initially, we intended to split each topic (search term) into distinct subtopics and choose representative articles of such subtopics into our sample. By doing this, we would be able to reduce the number of articles and keep the sample representative of the diversity of the full pool of articles.

This process however turned more difficult than expected. First, we wanted to use the keyword co-citation analysis for the identification of subtopics – in the keyword map, we have expected to see clusters of themes or topics, as it is described by the authors of VOSViewer (van Eck & Waltman, 2010a), e.g., cluster on consensus formation, marketing cluster, political science cluster etc. This was however not the case as will be described in the Results section. The clusters were heavily interconnected and multiple clusters shared aspects of the same topics.

We have then tried to identify the subtopics by manually analysing the keywords, but the process was too subjective, and it was hard to assess meaning of the keywords outside of the context.



Finally, we have made a pragmatic decision of using the Scopus' subject areas to represent subtopics within the search terms results. As mentioned above, Scopus assigns a subject area to each indexed journal. We have thus shifted from our aim of splitting the search terms to *subtopics* to splitting them into *subject areas* (or, in other words, *research fields*).

We will use the most cited article to represent each subject area. It is, again, a pragmatic step. It is far too naive to claim that the most cited article is the most (semantically) representative of the research field, but there is no measure of representativeness available. There are other measures, such as network centrality measures of degree, betweenness or eigenvector (Khan & Wood, 2015), but claiming that some of these measures will yield a semantically representative result is as problematic as with the citation measure. On the other hand, assessing study's importance based on number of citations is common and assumes that authors cite articles which they consider important (Zupic & Čater, 2015).

#### **2.2.1.2 Sampling method used**

The procedure of choosing the articles will be as follows. For every search term ("opinion formation", "attitude formation", "belief formation"), we will choose top 10 subject areas (subject areas are ordered in descending order by number of articles in that subject area). For each subject area, we will choose the most cited article and include it into the sample if A. and B. is true, otherwise we will continue to the next most cited article.

- A. Article is about opinion / attitude / belief formation (some articles contained the search term only a few times and were focused on a different topic)
- B. Article was not yet included (article can have multiple subject areas, so it may have been chosen before within a more populated subject area)

This procedure will yield sample of 30 articles which will be analysed in the content analysis and review process. Final number of 30 articles was chosen to fit our capacity.

This sampling method is both systematic with the aim to allow for generalisation as well as purposeful. It is a combination of sampling methods used in quantitative and qualitative content analysis, respectively (White & Marsh, 2006).

### 2.2.2 Content analysis

Unit of analysis is the whole article. Each of the 30 selected articles will be analysed according to the following analysis matrix. In each article, will be looking for 6 variables (numbered level of the list) with possible categories, or codes (lettered level of the list):

1. How are opinions / attitudes / beliefs conceptualised according to the article
  - a. – (Open coding)
2. How are opinions / attitudes / beliefs formed according to the article
  - a. – (Open coding)
3. Method (what is the method used in the article)
  - a. – (Open coding)
4. Context (in what context are the opinions / attitudes / beliefs described)
  - a. – (Open coding)
5. General or specific opinions / attitudes / beliefs?
  - a. General (opinions / attitudes / beliefs in the article are treated generally, e.g., when opinions are modelled as number, or in article on general theory of attitudes)
  - b. Specific (opinions / attitudes / beliefs are specified in the article, e.g., attitudes towards nanotechnology, opinion about a product)
6. Opinion / attitude / belief formation or change?
  - a. Formation (the article describes how are opinions / attitudes / beliefs formed, e.g., person is forming an opinion about a product which he sees for the first time)
  - b. Change (the article describes how are opinions / attitudes / beliefs changed, e.g., person had an opinion towards nanotechnology and is changing it based on new information)

Open coding (not having categories set before the analysis, writing them freely as the material is being read) is part of inductive content analysis (variables 1. – 4., the opposite is true for deductive analysis (variables 2. – 4.) (Elo & Kyngäs, 2008).

Only the first two variables were created before the initial reading, next four variables were additionally added as the articles were being analysed in the first iteration. Since the categories were both created before the analysis and emerged from it, it is again a combination of the deductive and inductive method of content analysis

(Elo & Kyngäs, 2008), or quantitative and qualitative approach to content analysis (White & Marsh, 2006).

First two (deductive) variables provide an answer to RQ2.1 and RQ2.2, the third variable provides an answer to RQ2.3 and the last three variables provide an answer to RQ2.4.

### *2.2.3 Narrative review*

We are combining the method of content analysis with narrative review. Content analysis provides a structure for our review, while the narrative review will provide more freedom for interpretation than content analysis.

The key feature of all content analysis is that the many words of the text are classified into much smaller content categories (Elo & Kyngäs, 2008). We take this as a main principle, trying to reduce the amount of information, which will allow us to look at the information from higher perspective and compare them.

Findings from the content analysis will be summarised narratively for each domain (opinion, attitude and belief formation) separately and then compared.

We will also compare the results of content analysis with the results of bibliometric analysis. This serves both ways: first to assess how representative was the selected sample (30 articles) when compared to the keyword map (constructed from 3 000 articles) and second to explain the keyword map with the findings from content analysis of the sample.

### *2.2.4 Following guidelines*

In this section, we want to comment on how we follow the content analysis process described in Elo & Kyngäs (2008, p. 110) and follow guidelines for narrative review from Snyder (2019, p. 336). The guidelines are quoted, and our commentary follows arrow sign.

## **Content analysis**

Note: ordered list represent succession, unordered list represent branching  
“Preparation phase”

1. “Selecting the unit of analysis” → The unit of analysis is the whole article.

2. “Making sense of the data and whole” → This is a subjective process, where the researcher strives to make sense of the data and to learn ‘what is going on’ (Elo & Kyngäs, 2008).

#### “Organising phase”

- “Inductive approach”
  1. “Open coding” → We open code the variables 1 to 4 as described in the Content analysis section
  2. “Grouping” → This step is substituted by the narrative review
  3. “Categorisation” → This step is substituted by the narrative review
  4. “Abstraction” → This step is substituted by the narrative review
- “Deductive approach”
  1. “Developing analysis matrix” → Analysis matrix was developed as described in Content analysis section
  2. “Grouping” → This step is substituted by the narrative review
  3. “Categorisation” → This step is substituted by the narrative review
  4. “Abstraction” → This step is substituted by the narrative review

#### “Reporting the analysing process and the results”

1. “Model, conceptual system, conceptual map, or categories” → This step is substituted by the narrative review

### **Narrative review**

“Important questions to consider in each step of the review:”

#### “Phase 1: design”

- “Is this review needed and what is the contribution of conducting this review?” → To our best knowledge there is no review of opinion /attitude / belief formation. Connecting the concepts and findings from various research fields can help to conceptualise the constructs and discover research gaps and areas for further research.
- “What is the potential audience of this review?” → Ideally, this review will be useful to scholars from various disciplines that focus on researching opinions / attitudes / beliefs or scholars interested in

orientating themselves in the topic and/or cross-disciplinary collaboration.

- “What is the specific purpose and research question(s) this review will be addressing?” → These are described above, the review targets mainly the RQ2 – RQ5.
- “What is an appropriate method to use of this review's specific purpose?” → Narrative review as the RQs are broad and the sample is diverse.
- “What is the search strategy for this specific review? (Including search terms, databases, inclusion, and exclusion criteria etc.)” → These were described above.

#### “Phase 2: conduct”

- “Does the search plan developed in phase one work to produce an appropriate sample, or does it need adjustment?” → Yes, the sample is appropriate for the exploratory purposes of this study.
- “What is the practical plan for selecting articles?” → Was described above.
- “How will the search process and selection be documented?” → The search process is described above together with inclusion and exclusion criteria. As these are simple, we will not document the process further.
- “How will the quality of the search process and selection be assessed?” → The limitations were described above and will be described below after conducting the review.

#### “Phase 3: analysis”

- “What type of information needs to be abstracted to fulfil the purpose of the specific review?” → Is described above, mainly the definition of opinions / attitudes / beliefs according to the articles and information about the opinion / attitude / belief formation process.
- “What type of information is needed to conduct the specific analysis?” → Textual information will be extracted from the article.

- “How will reviewers be trained to ensure the quality of this process?”  
→ There is only one researcher, which is a significant limitation of this study because of subjective bias.
- “How will this process be documented and reported?” → The relevant information extracted will be noted down in a table in a “raw form”, i.e., before the synthesis, and thus will be open to review.

“Phase 4: structuring and writing the review”

- “Are the motivation and the need for this review clearly communicated?” → Yes, we believe.
- “What standards of reporting are appropriate for this specific review?” → We have considered the RAMSES standard, developed for systematic narrative and guidelines for integrative reviews by Wong et al. and Torraco, respectively (as cited in Snyder (2019) and decided that the guidelines provided by Snyder are sufficient for our purposes.
- “Is the level of information provided enough and appropriate to allow for transparency so readers can judge the quality of the review?” → As mentioned above, we try to document every step of the process.
- “The results clearly presented and explained?” → Will be our best effort.
- “Is the contribution of the review clearly communicated?” → Will be communicated further after the review process, we expect the contribution to lie in conceptual model / categorisation and agenda for further research.

### 3 Results

This section is split to two main parts – bibliometrics and narrative review with content analysis. In each of these two sections, we state results for opinion formation, attitude formation and belief formation and then compare them. Finally, we compare the findings from the bibliometrics section to the findings of narrative review with content analysis section.

#### 3.1 Bibliometrics

In this section, we state results according to the research objective RO1 (To describe the body of scientific literature on opinion, belief and attitude formation **quantitatively**, using bibliometric methods.) by answering the RQ1.1 (**How populated is the literature** on opinion, belief and attitude formation and **what is the time trend?**), RQ1.2 (Which **scientific disciplines** study opinion, belief and attitude formation?) and RQ1.3 (What **topics** are connected to the topic of opinion, belief and attitude formation?). Also, in accord with RO3 (To **compare** the findings from the bibliometric and content analysis of opinion, belief and attitude formation literature), we compare the findings to answer RQ3.1 (How do answers for RQ1.1 – RQ1.3 differ for terms opinion formation, belief formation and attitude formation?)

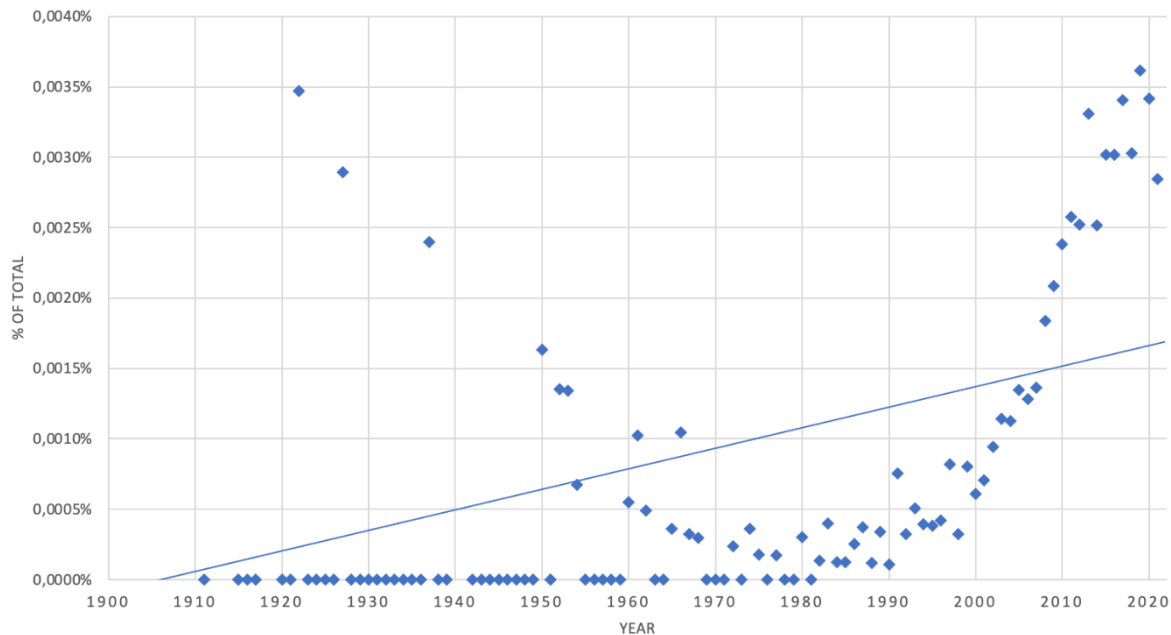
##### 3.1.1 “Opinion formation” search term

###### 3.1.1.1 Timeline

Search term: TITLE-ABS-KEY(“opinion formation”). 1 506 results were returned (all searches were performed in august 2022). For comparison, search term TITLE-ABS-KEY(“decision making”) returns 929 851 results. In Figure 2, we have calculated the ratio of number of items returned by this search term to total number of articles indexed in Scopus for each year. We did this to account for the total increase of articles published each year. As seen on the chart, the ratio started increasing in what seems an exponential matter around 1990s. The trendline shows positive trend.

**Figure 2**

*% of items returned by TITLE-ABS-KEY("opinion formation") from total articles published per year*



### 3.1.1.2 Subject areas

Three most and almost equally populated subject areas for search term TITLE-ABS-KEY("opinion formation") are Social sciences, Computer science and Mathematics. If we assume that there is a large overlap of articles in similar subject areas, then there are following significant subject area groups:

1. Computer science + Mathematics + Physics and Astronomy + Engineering,
2. Social sciences + Arts and Humanities + Psychology + Decision sciences,
3. Business management and Accounting + Economics, Econometrics and Finance.

It is surprising that for this topic, Computer science subject area is 7 times more frequent than Psychology. Apart from Social sciences, top 5 subject areas are from natural sciences. The fact that large part of items containing "opinion formation" fall under Computer science subject area could explain the increase of the curve in Figure 2 from 1980 as internet started to be adapted world-wide from this decade onwards and advances in the computational capacities allowed for more complex social simulation.

All subject areas with numbers of corresponding articles are plotted on the Figure 8 in the Appendix.



### 3.1.1.3 Journals

Journal names also show that majority of items returned by TITLE-ABS-KEY(“opinion formation”) fall under natural sciences, mainly physics (7 journals) and computer science (2). If this is not the case, public opinion (2) is the most dominant journal scope. Interesting to see are some hybrid journals, connecting natural sciences with humanities like mathematical sociology or artificial societies and social simulation (2).

Journal names with numbers of corresponding articles are plotted on the Figure 9 in the Appendix.

### 3.1.1.4 Keywords manual analysis

To better understand previous statistics, we have looked at the 100 most frequent keywords. Top 50 keywords can be seen in Appendix in Table 20. First, general keywords like “human”, “article”, “adult”, “male”, “female” or “united states” were filtered out. Then, top 5 semantically not connected keywords (e.g., keyword “dynamics” was skipped because keyword “opinion dynamics” was already included) and their frequencies were: opinion dynamics - 211, social networking (online) - 151, public opinion - 93, social aspects - 85, opinion formation models - 82. For other keywords, we have created semantical groups:

- *group name: example keyword 1, example keyword 2, ...*
- opinion dynamics modelling: opinion dynamics, computer simulation, complex networks, multi agent systems, mathematical / computational models, sociophysics
- social media: social networking (online), social media, internet
- public opinion: public opinion, voter models, democracy, politics
- social aspects: social network, social aspects, social influence, social behaviour, opinion leaders
- psychology: attitude, perception, communication, human experiment
- consensus and polarisation: consensus, polarization, information diffusion
- marketing and mass media: marketing, mass media, commerce

Apart from these major keyword groups, there were following relatively frequent and interesting but solitary keywords: decision making, artificial intelligence,



keywords. Even though the clusters are not unambiguous, since keywords with higher co-occurrence are displayed closer to each other, we can observe two main poles, or topics – **computer modelling of opinion dynamics** on left and public opinion plus some **psychological and social keywords** on the right. In the middle, connecting these two topics, are **social media and networking** keywords.

### 3.1.1.6 Terms co-occurrence map

Top 50 terms extracted from the articles and terms co-occurrence map are shown in Table 21 and Figure 10 respectively in the Appendix.

The terms person, impact, level, way, factor, topic, use, and concept were omitted before creating the map because of low semantic value. Two distinct clusters were created. First connects terms related to classical research articles (study, analysis, theory, literature, research, evidence, implication), political terms (public opinion formation, public opinion, citizen, support) and terms which can possibly be connected to the opinion formation process (medium, context, view, attitude, communication, evidence, issue, information). Second cluster connects terms related to modelling of opinion dynamics: networks (network, node, neighbour, degree, link, structure), dynamical systems (dynamic, system, state, phase transition, transition, emergence), multiagent modelling (agent) and a term consensus.

### 3.1.1.7 Summary

This initial query TITLE-ABS-KEY(“opinion formation”) results analysis consisted of results indexed per year, “histogram” of subject areas, “histogram” of journals and analysis of most frequent keyword and terms, both manually and with the use of visualisation software. It showed the following:

- “Opinion formation” is increasingly more popular term in scientific literature from 1980s.
- Natural sciences have a seemingly stronger stake in studying “opinion formation” than humanities. Based on most frequent keywords, they mainly focus on opinion dynamics using various modelling techniques.
- Based on keywords like complex networks, multi-agent modelling, social networks, social influence etc., opinion formation seems to be studied mainly in social context.

- Based on created keywords groups and graph clusters, there are three main topics studied under term “opinion formation”: social dynamics modelling, social media and public opinion. Then there are minor topics, like social aspects, psychological aspects, decision making, consensus and polarisation, mass media.

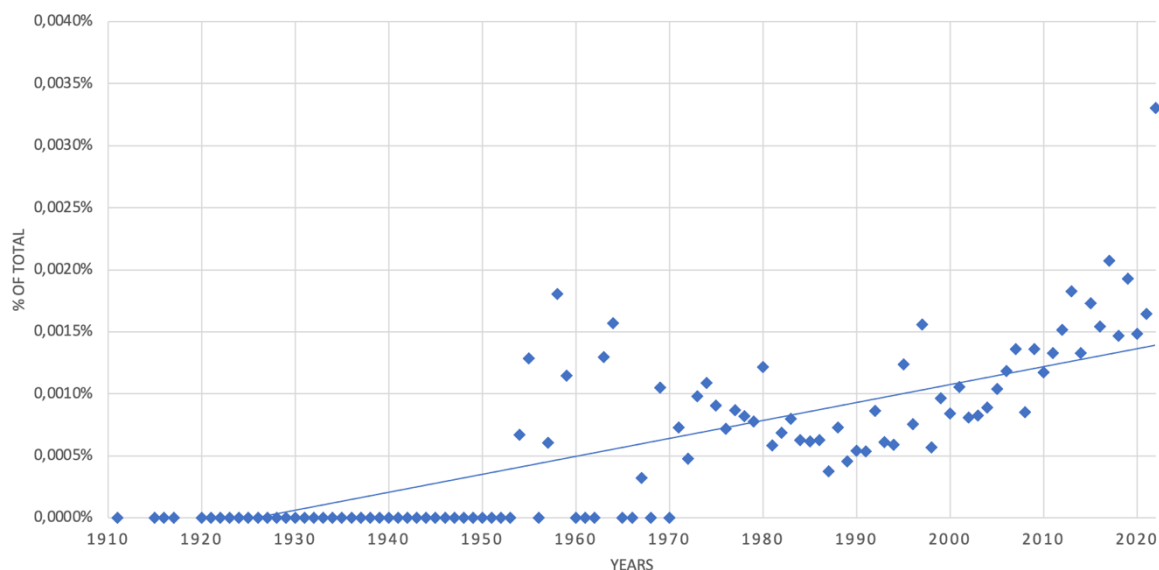
### 3.1.2 “Attitude formation” search term

#### 3.1.2.1 Timeline

The search term TITLE-ABS-KEY(“attitude formation”) returned 1 016 results. As can be seen on Figure 4, the proportion of “attitude formation” articles shifted in around 1970s and steadily increases from around 1990s, which can be seen on the trendline. This trend seems to be linear.

**Figure 4**

*% of items returned by TITLE-ABS-KEY(“attitude formation”) from total articles published per year*



#### 3.1.2.2 Subject areas

The most populated subject area is Social sciences. It is followed by Psychology and then Business, Management and Accounting. Next significant subject areas (although together having approx. as many articles as Social Sciences on its own) are Arts and Humanities, Medicine, Computer Science, Economics, Econometrics and Finance, Engineering and Environmental sciences.

Social sciences thus are by far the most populated subject area. Interesting to see is, that Business, Management and Accounting are almost as populated as Psychology. The question is, how are attitudes conceptualised in Business, Management and Accounting and what is this science field's stake in studying attitudes.

All subject areas with numbers of corresponding articles are plotted on the Figure 11 in the Appendix.

### **3.1.2.3 Journals**

Grouping top 16 attitude formation journals based on their names yield following categories: Social psychology (4 journals), Marketing, business, and consumer (6), Psychology (2), Other (3).

This is approximately in accord with the subject areas, moreover, the presence of marketing journals offers an explanation for the Business, Management and Accounting subject area – there is no subject area which covers marketing, so marketing journals most probably fall under this subject area. Attitudes in marketing science seem more understandable than in Business, Management and Accounting – there are costumers' brand and product attitudes, which probably play an important role in this field.

Journal names with numbers of corresponding articles are plotted on the Figure 12 in the Appendix.

### **3.1.2.4 Keywords manual analysis**

For the manual keyword analysis, we have looked at the 100 most frequent keywords. Top 50 keywords can be seen in Table 22 in the Appendix. Keywords with low semantic value like “attitude formation”, “human”, “attitude”, “article”, “humans” or “female” were omitted. Then, top 5 semantically not connected keywords and their frequencies were: Decision making (40), Cognition + Perception (34+34), Learning (31), Attitude to health (30), Public attitude (28).

We have also manually grouped the keywords to semantical groups:

- *Group name (sum of occurrences of keywords): keyword 1, keyword 2, ...*
- **Psychology and cognition (351):** cognition, perception, learning, affect, awareness, emotion(s), information processing, knowledge, attention, memory, psychology, evaluative conditioning, motivation, “models,

psychological”, psychological model, personality, conditioning, conditioning (psychology)

- **Marketing and communication (88):** communication, persuasion, advertising, marketing, interpersonal communication, persuasive communication, mass media
- **Social aspects (84):** social behavior, human relation, social perception, interpersonal relation, social influence, social psychology, polarisation
- **Consumer research (79):** consumer behaviour, consumer attitude, brand attitude, purchase intentions, consumer
- **Health attitudes (69):** attitude to health personnel, health personnel attitude, “health knowledge, attitudes, practice”
- **Public attitude (56):** public attitude, public opinion, politics
- **Behaviour (32):** behavioral research, behavior
- **Internet and social media (30):** social networking (online), social media, internet

Apart from these major keyword groups, there were following relatively frequent and relevant but solitary keywords: decision making, education, attitude change, implicit attitudes, attitude control, prejudice, ambivalence, theory of planned behavior.

Keywords offer a more detailed look on the semantic structure of attitude formation research than journals or subject areas. Perhaps the most interesting are the keywords which suggest what influences the formation of attitudes, like perception, awareness, memory, personality, conditioning, education, or persuasion, but this is only a possibility and must be validated using qualitative (narrative) analysis. Also noteworthy is the presence of the keyword behavior, suggesting a connection with attitudes.

### **3.1.2.5 Keywords co-occurrence map**

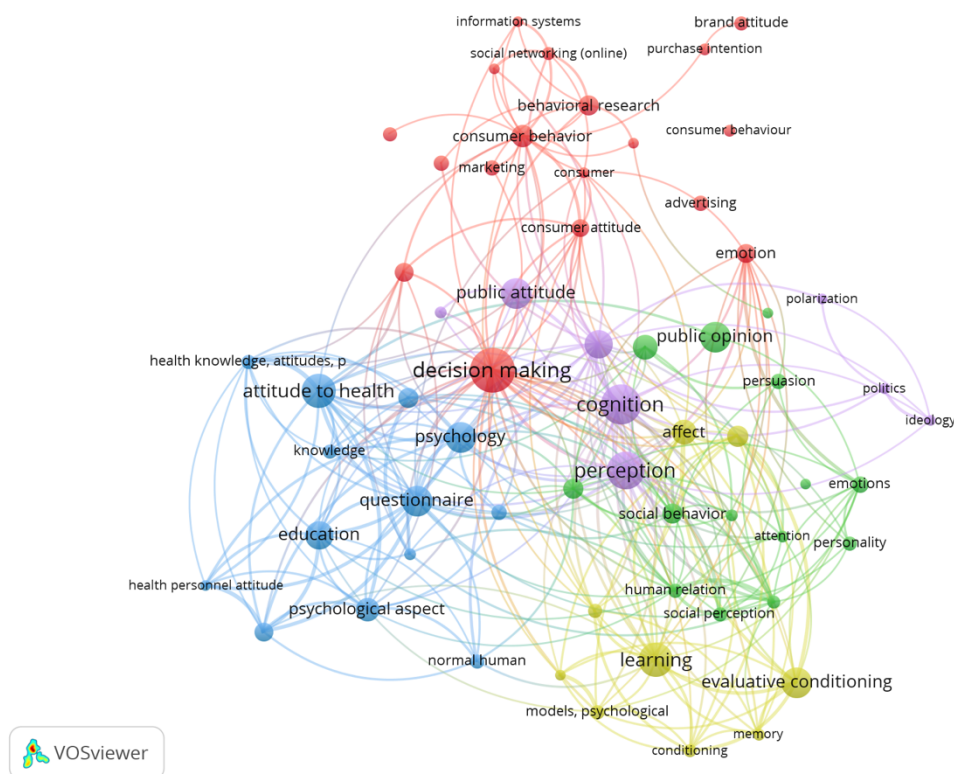
To see the connections between the keywords, we have constructed a co-occurrence map using VOSViewer software. Threshold of minimum 10 occurrences was used, which resulted in top 86 keywords. Keywords attitude formation, human, attitude, article, humans, female, male adult, attitudes, adolescent, controlled study, young adult, middle aged, united states, priority journal major clinical study, aged, student, methodology, students, China, Germany and India were excluded because of

low semantic value. Keyword attitude control was not connected to other keywords therefore it was also omitted.

Keyword co-occurrence map with coloured clusters can be seen in Figure 5.

**Figure 5**

*Keywords co-occurrence network visualisation from VOSViewer for attitude formation*



The red cluster at the top connects consumer research, marketing, social networking, and media with decision making and emotion. Decision making is also the most occurring and central keyword. The blue cluster on the left connects health attitudes with psychology and education. The main keywords of the yellow cluster at the bottom are learning and conditioning. The green cluster on the right connects public opinion with minor keywords like attitude change, persuasion and social behaviour. The last and central cluster, the purple one, represents big keywords of perception and cognition and connects them with public attitude and human experiment.

The connection of seemingly separate topic in one cluster may be caused by the number of clusters, setting resolution parameter (parameter which changes the number of cluster) to a higher number would probably help to distinguish such topics.

The layout however is independent from the clustering and is worth observation. The most central (and thus interconnected with others) nodes are decision making, public attitude, perception, and cognition. Separate from the rest are the consumer research keywords at the top. Peripheral are also health attitudes related keywords, learning and conditioning keywords, and keywords politics, polarisation, and ideology.

### **3.1.2.6 Terms co-occurrence map**

For the terms visualisation, threshold of at least 35 occurrences was selected to produce approx. 100 keywords. Unfortunately, we have manually filtered out almost half of those keywords because of their low semantic value. These were: attitude formation, attitude, analysis, paper, person, article, student, literature, sample, condition, time, measure, relation, mechanism, work, area, way, question, country, year, respondent, function, concept, addition, order, part, subject, positive attitude, basis, originality value, design methodology approach, practical implication, age, self and turn. These keywords are typical research article terms, and the terms extraction algorithm probably cannot account for them. Or there were too few other frequent terms (the research field may use too diverse, or use too different terms), which would “make their way” to the final list.

The resulting map is presented in the Figure 13 in the Appendix. There is one significant term, which made it to this list, and it is change, or attitude change. This is a concept which was not that significant in the keywords context. The consumer research keywords are peripheral as at the keywords co-occurrence visualisation. Also, decision making is again central. Noteworthy is also the presence of terms belief and opinion, which justifies our focus on the three terms – opinions, beliefs, attitudes.

### **3.1.2.7 Summary**

Analysis of the results of the TITLE-ABS-KEY(“attitude formation”) search term showed the following:

- Attitude formation is an increasingly popular topic from around 1970s



- It is most published in journals with subject area social sciences, then psychology and “business, management and accounting”
- “Business, management and accounting” subject areas can be explained by articles on marketing and consumer research where brand attitudes are a topic of interest
- Biggest keyword themes (based on manually constructed keyword groups) are cognitive and psychological aspects, marketing and consumer research, social aspects, health attitudes, public attitude, internet, and social media
- Keyword behavior was present in various forms
- Decision making, public attitude, attention and cognition seem to be a “central topic” in a sense that they are connected to other topics
- On the contrary, “peripheral topics”, in a sense that they are not that much connected to other topics, are consumer research health attitudes, learning and conditioning, and politics
- Terms visualisation showed “(attitude) change” as an important term
- Terms opinions and beliefs were also identified, justifying our focus on the three terms – opinions, attitudes, and beliefs

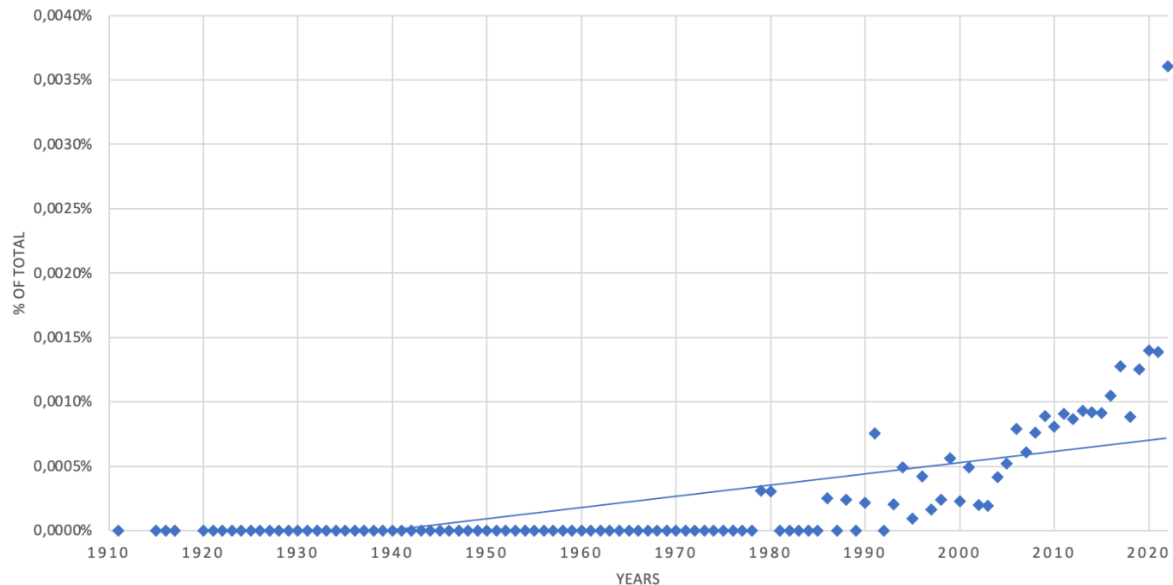
### 3.1.3 *“Belief formation” search term*

#### **3.1.3.1 Timeline**

574 results were returned by search term TITLE-ABS-KEY(“belief formation”). Ratio of belief formation literature to total started steadily increasing around 1990s in a linear matter, as can be seen in the Figure 6.

**Figure 6**

*% of items returned by TITLE-ABS-KEY("belief formation") from total articles published per year*



### **3.1.3.2 Journals**

We grouped most populated journals from similar sciences. The group with by far the most articles is Philosophy (4 journals). This explain the Arts and Humanities subject area being at the top – philosophy falls under this subject area. Two of these journals are focused on Epistemology. Next journal groups are Economics (4) Brain sciences and cognition (3), Psychology (2). Solitary journals' science fields are computer science, decision science and mixed. Economics thus holds a second place as in subject areas.

Journal names with numbers of corresponding articles are plotted on the Figure 15 in the Appendix.

### **3.1.3.3 Manual analysis of keywords**

Top 50 keywords can be seen in Table 23 in the Appendix. 100 most frequent keywords were manually analysed. First, keywords with low semantic value, like human, belief formation, article, male or adult were filtered out. This resulted in 68 final keywords being analysed – grouped to semantical groups.

Top 5 semantically not connected keywords were: delusion(s) (65), cognition (36), decision making (31), learning (29) and schizophrenia (23).

The grouping resulted in following groups:

- *Group name (sum of occurrences of keywords): keyword 1, keyword 2, ...*
- Cognitive aspects (127): cognition, learning, knowledge, perception, attention, memory, emotion, cognitive systems
- Delusions (89): delusion, delusions, self-deception, deception, irrationality
- Thinking and rationality (68): rationality, thinking, judgment, problem solving, reasoning, bounded rationality, justification
- Mental pathology (68): schizophrenia, psychosis, depression, schizophrenic psychology, psychotic disorders, cognitive defect
- Physiology and brain (52): physiology, neuropsychology, pathophysiology, brain, brain function, dopamine
- Psychology (44): psychology, psychological aspects, “models, psychological”, psychological theory, psychological model
- Probability (38): probability, uncertainty, bayes theorem, prediction, decision theory
- Culture (38): culture, religion, cultural anthropology
- Philosophy (36): epistemology, doxastic voluntarism, evidentialist, ethics of belief
- Social aspects (27): social belief, social learning, persuasion, communication
- Computers and mathematics (23): artificial intelligence, information systems, computation theory, mathematical models

There were also other solitary noteworthy keywords: decision making, behavior, motivation, climate change or bias.

There are several interesting observations. Perhaps the first is the strong presence of false beliefs – delusions, and keywords connected to pathology of “normal” belief formation systems, like deception, irrationality, psychosis, and schizophrenia, or even bias.

Then, thinking has the most attention from cognitive aspects, we can connect this theme with rationality and probability.

Epistemology seems to be the focus of philosophy in belief formation context.

### 3.1.3.4 Keywords co-occurrence map

We have changed the usual threshold of 10 occurrences minimum to 6, to get 93 keywords which meet the threshold instead of 40. From these 93 keywords, following 22 keywords were omitted for low semantic value: human, belief formation, humans, article, male, female, adult, belief(s), priority journal, controlled study, review, human experiment, clinical article, task performance, adolescent, middle aged, child, experiments, questionnaire, prediction, and belief-formation, which resulted in final 71 keywords being used to construct the map displayed in Figure 7.

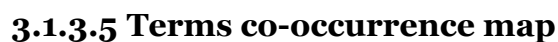
Top left, purple, cluster connects keywords of (pato)physiology, brain, and MRI. Top right, cyan, connects perception with climate change, communication, persuasion, attitude, and psychological model. Red cluster at the right connects knowledge, rationality, problem solving, reasoning with self-deception and irrationality and philosophical keywords like ethics of belief, doxastic voluntarism and evidentialism. Green bottom cluster connects minor computer science keywords like AI, mathematical models, information systems or computer circuits with major keywords like learning, decision making and attention. There are two central clusters – yellow one on the left and blue one on the right. Yellow one connects delusions, schizophrenia, psychosis, and psychology. Blue one connects cognition, culture and cultural anthropology and religion, motivation, social behavior and social belief.

The topology shows that the central topics are delusions (and schizophrenia), cognition, decision making and learning. Heavily interconnected cluster connected with schizophrenia is on the topic of MRI and brain research. Separate peripheral topics are communication and climate change, philosophical topics, and computer science keywords.

If we would be supposed to create clusters based on topology and semantics, we would split the keywords to following topics:

- delusions, schizophrenia, and brain research
- philosophical studies of belief formation
- computer science studies of belief formation
- cognition
- decision making
- climate change

*Keywords co-occurrence network visualisation from VOSViewer for the belief formation*



It is hard to assess whether a term is used in a belief formation context or just as a common research article term (e.g. hypothesis – Is it a hypothesis in a sense of possible belief or just a research hypothesis?; Information – is it a piece of information which led to the belief formation or is it used in a common sentence like “this is an important piece of information”?; Change – is it a belief change or common verb, e.g. “we changed our focus to ...”?). Terms, where it is on contrary hard to imagine a common context are probably only – delusion, game, and epistemology. The fact that they “made it through” competing ambiguous common terms suggest that they must be important for the topic of belief formation.

There are three clusters on the map – first connects terms related to philosophy, second connects terms related to probability and the third connects terms related to delusions. Central seem to be ambiguous terms like information, change, hypothesis, behaviour and decision.

### **3.1.3.6 Summary**

We have summarised the finding from previous sections as follows:

- Proportion of literature on belief formation increases linearly since 1990s
- The most populated subject area is Art and Humanities, probably because of philosophy articles which fall under this subject area. There were also 4 philosophy journals in the top 15 most populated journals. Dominant keyword and term in philosophy is epistemology.
- Subject area Social sciences was second most populated, although social keywords (social belief, social learning, persuasion, communication) were not that common.
- Subject area Economics, Econometrics and Finance was third most popular, however, there were no clear keywords from this area. Possibly, it may be the keywords on probability theory and rationality.
- Psychology was the fourth most populated subject area. The biggest group of keywords was cognition, a group containing word “psychology” in various keywords was also dominant.
- Computer science subject area was characterised by keywords like artificial intelligence, mathematical models, computation theory and information systems
- Neuroscience subject area was evident both in manual analysis of keywords and in keywords map - keywords like brain, MRI and physiology characterise this area
- Delusions seem to be a dominant topic in belief formation research with keywords like delusions, schizophrenia, psychosis, or deception being very common.
- Keywords delusions, decision making, cognition and behavior are central.
- Cultural keywords like culture, religion, or cultural anthropology were present.

- Solitary keywords and terms present were decision making, behavior, bias, motivation.
- There is probably a body of research on climate change beliefs.
- Based on keywords, beliefs seem to play a role in thinking.

### 3.1.4 Comparison of opinion, attitude, and belief formation

In this section, our aim will be to compare bibliometric findings from the opinion, attitude, and belief formation search terms analysis. We have constructed a Table 1 to Table 8 to display findings from the previous section in a comparative manner. Common values are marked with different types of underlines.

#### 3.1.4.1 Research size and time trend

Opinion formation is the biggest research filed, followed by attitude formation then belief formation.

All research fields are growing from around 1980s / 1990s. Opinion formation research field is growing exponentially, attitude and belief formation field grow linearly.

**Table 1**

*Comparison of opinion / attitude / belief formation research size*

Category	Opinion formation	Attitude formation	Belief formation
Results returned	~ 1 500	~ 1 000	~ 500

**Table 2**

*Comparison of opinion / attitude / belief formation research time trend*

Category	Opinion formation	Attitude formation	Belief formation
Articles published steadily from	1980s (2.)	1970s (1.)	1990s (3.)

<b>Increasing trend started from</b>	1980s (1.)	1990s (2.)	1990s (2.)
<b>Incr. trend type</b>	Exponential	Linear	Linear

### 3.1.4.2 Dominant sciences

ALL: Social science

Opinion formation: Computer science/Physics/Mathematics, Political science

Attitude formation: Psychology, Consumer research

Belief formation: Philosophy, Brain research, Economics, Psychopathology

**Table 3**

*Comparison of opinion / attitude / belief formation subject areas*

<b>Category</b>	<b>Opinion formation</b>	<b>Attitude formation</b>	<b>Belief formation</b>
<b>#1 Subject area</b>	<u>Social Sciences</u>	<u>Social Sciences</u>	Arts and Humanities
<b>#2 Subject area</b>	Computer Science	Psychology	<u>Social Sciences</u>
<b>#3 Subject area</b>	Mathematics	Business, Management and Accounting	Economics, Econometrics and Science

**Table 4**

*Comparison of opinion / attitude / belief formation journal groups*

<b>Category</b>	<b>Opinion formation</b>	<b>Attitude formation</b>	<b>Belief formation</b>
<b>#1 Journal group</b>	Physics	Social psychology	Philosophy
<b>#2 Journal group</b>	Computer science	Marketing, business, and consumer	Economics



<b>#3 Journal group</b>	Public opinion	<u>Psychology</u>	Brain sciences and cognition
<b>#4 Journal group</b>	Sociological simulation	Other	<u>Psychology</u>

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### 3.1.4.3 Dominant and minor themes

ALL: decision making (is central!), social (influence), behavior

Opinion formation: opinion dynamics (+ consensus and polarisation), public opinion, social networking / media, marketing, and media

Attitude formation: cognition, marketing and consumer research, health attitude

Belief formation: delusions, schizophrenia, cognition, epistemology, rationality, culture

Minor themes:

Opinion formation: management, climate change

Attitude formation: public attitude, education, attitude change, politics

Belief formation: computers and mathematics, climate change, bias

**Table 5**

*Comparison of opinion / attitude / belief formation top 5 keywords*

<b>Category</b>	<b>Opinion formation</b>	<b>Attitude formation</b>	<b>Belief formation</b>
<b>#1 Keyword</b>	Opinion dynamics (211)	<u>Decision making (40)</u>	Delusion(s) (65)
<b>#2 Keyword</b>	Social networking (online) (151)	<u>Cognition + Perception (34+34)</u>	<u>Cognition (36)</u>
<b>#3 Keyword</b>	<u>Public opinion (93)</u>	<u>Learning (31)</u>	<u>Decision making (31)</u>

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<b>#4 Keyword</b>	Social aspects (85)	Attitude to health (30)	<u>Learning (29)</u>
<b>#5 Keyword</b>	Opinion formation models (82)	<u>Public attitude (28)</u>	Schizophrenia (23)

**Table 6**

*Comparison of opinion / attitude / belief formation manual analysis of keywords*

<b>Category</b>	<b>Opinion formation</b>	<b>Attitude formation</b>	<b>Belief formation</b>
<b>Keyword groups</b>	<ul style="list-style-type: none"> <li>- Opinion dynamics modelling</li> <li>- <u>Social media</u></li> <li>- <u>Public opinion</u></li> <li>- <u>Social aspects</u></li> <li>- <u>Psychology</u></li> <li>- Consensus and polarisation</li> <li>- <u>Marketing and mass media</u></li> </ul>	<ul style="list-style-type: none"> <li>- <u>Cognitive concepts</u></li> <li>- <u>Psychological aspects</u></li> <li>- <u>Marketing</u></li> <li>- Consumer research</li> <li>- <u>Social aspects</u></li> <li>- Health attitudes</li> <li>- <u>Public attitude</u></li> <li>- <u>Internet and social media</u></li> </ul>	<ul style="list-style-type: none"> <li>- <u>Cognitive aspects</u></li> <li>- Delusions</li> <li>- Thinking and rationality</li> <li>- Mental pathology</li> <li>- Physiology and brain</li> <li>- <u>Psychology</u></li> <li>- Probability</li> <li>- Culture</li> <li>- Philosophy</li> <li>- <u>Social aspects</u></li> <li>- Computers and mathematics</li> </ul>
<b>Unique keyword groups (extracted from the row above)</b>	<ul style="list-style-type: none"> <li>- Opinion dynamics modelling</li> <li>- Consensus and polarisation</li> </ul>	<ul style="list-style-type: none"> <li>- Consumer research</li> <li>- Health attitudes</li> </ul>	<ul style="list-style-type: none"> <li>- Delusions</li> <li>- Mental pathology</li> <li>- Physiology and brain</li> <li>- Thinking and rationality</li> <li>- Probability</li> <li>- Culture</li> <li>- Philosophy</li> </ul>

<b>Solitary frequent keywords</b>	- <u>decision making</u> , - economic and social effects, - <u>behavioural research</u> , - management science, - <u>climate change</u> , - theoretical model	- <u>decision making</u> , - education, - attitude change, - implicit attitudes, - attitude control, - prejudice, - ambivalence, - <u>theory of planned behavior</u>	- <u>decision making</u> , - <u>behavior</u> , - motivation, - <u>climate change</u> - bias

**Table 7**

*Comparison of opinion / attitude / belief formation keywords co-occurrence maps*

Category	Opinion formation	Attitude formation	Belief formation
<b>Map size (keywords)</b>	127	86	71
<b>Topic clusters (either observed or selected by algorithm)</b>	- computer modelling of opinion dynamics - social networking, influence - public opinion, consensus	- consumer research and marketing - health attitudes - learning and conditioning - decision making - cognition and perception	- (patho)physiology, brain, and MRI - delusions, schizophrenia - learning, cognition, decision making - rationality - philosophy - computer science
<b>Central keywords</b>	- opinion dynamics and computer simulation - social network(ing) - <u>decision making</u>	- <u>decision making</u> - <u>cognition and perception</u> - public attitude / opinion	- delusions (and schizophrenia) - <u>cognition</u> - <u>decision making</u> - learning
<b>Discrete peripheral topics</b>	- public opinion	- consumer research - health attitudes	- communication - climate change

Category	Opinion formation	Attitude formation	Belief formation
		- learning and conditioning - politics, polarisation, and ideology	- philosophical topics - computer science

**Table 8**

*Comparison of opinion / attitude / belief formation terms co-occurrence maps*

Category	Opinion formation	Attitude formation	Belief formation
<b>Non-ambiguous terms</b>	- computer simulation of opinion dynamics - public opinion - social medium - citizen	- attitude change - decision making, cognition - consumer - brand - (opinion) - (belief)	- delusion - patient - bias - behavior - game - rationality - epistemology

## Conclusion

All fields are studied by social sciences and social keywords, like social influence, are often present. Decision making and behaviour are two concepts strongly connected to all fields.

Opinion formation is the biggest and exponentially growing field mainly characterised by computer / physical simulations of opinion dynamics and public opinion studies. Common themes are consensus and polarisation, social networking or marketing and media.

Attitude formation is the second biggest field, where main themes are psychological studies of cognitive aspects of attitude formation and consumer research of for example brand attitudes.

Belief formation is the smallest field, characterised by either neuroscientific or psychological research on delusions, for example present in schizophrenic patients, philosophical epistemological inquiries and rationality studied in probabilistic terms.

It is also interesting that ratio of most frequent attitude formation keywords to total is smaller than compared to opinion formation or belief formation, it suggests that the research in this field is “flatter”, with no dominant topics.

Beliefs are the only concept which have a sort of an opposite – delusions. They are also the only concept studied by neuroscientific as well as philosophical methods.

Overall, despite all fields having similar connotation, they are also being researched by different methods (e.g., opinions computer simulations, attitudes psychological experiments, beliefs by brain research and philosophical methods) and have specific subtopics (e.g., public opinions, brand attitudes, delusions).

### 3.2 Narrative review and content analysis

In this section, in accord with research objective RO2 (To describe the body of scientific literature on opinion, belief and attitude formation **qualitatively**) we provide answers to RQ2.1 (How are opinions, beliefs and attitudes **conceptualised** in the most-cited articles from various fields in the opinion, belief and attitude formation literature?), RQ2.2 (How are opinions, beliefs and attitudes **formed** according to the most-cited articles from various fields in the opinion, belief and attitude formation literature?), RQ2.3 (What **methods** are used in the most-cited articles from various fields in the opinion, belief and attitude formation literature?) and RQ2.4 (What are other observed **categorical differences** in how opinions, beliefs or attitudes are studied in the most-cited articles from various fields in the opinion, belief and attitude formation literature?). We do this first for opinion formation, then attitude formation and then belief formation. Finally, in line with research objective RO3 (To **compare** the findings from the bibliometric and content analysis of opinion, belief and attitude formation literature.) we answer RQ3.2 (How do answers for RQ2.1 – RQ2.4 differ for terms opinion formation, belief formation and attitude formation?) and RQ3.3 (How do findings for RQ1.1 – RQ1.3 and RQ2.1 – RQ2.4 differ?)

We analysed 30 articles: 10 for opinion formation, 10 for attitude formation and 10 for belief formation. As mentioned in the Methods section, for every domain (OF, AF, BF) for every one of the top 10 most populated subject areas, one most cited article was chosen for the analysis (if this article was chosen before in another subject area, or was not about opinion, belief or attitude formation, it was skipped, and the next most cited article was chosen).

For every domain, we present three tables:

1. First table shows:
  - a. subject area,
  - b. article's title and citation,
  - c. number of citations and
  - d. FWCI<sup>1</sup>.

---

<sup>1</sup> \* FWCI is Field-Weighted Citation Impact shows how well cited this document is when compared to similar documents. A value greater than 1.00 means the document is more cited than expected according to the average. It considers:

2. Second table shows:

- a. Methods used in the article
- b. Context - in what context where the opinion / attitude / belief researched
- c. “G/S” - abbreviation for General / Specific – whether the article treated opinions / attitudes / beliefs as general (e.g., a number or a general belief in philosophical articles) or specific (e.g., opinion towards biotechnology or delusional belief that someone is inserting thoughts into patient’s head).
- d. How are opinions / attitudes / beliefs defined according to the article.

3. Third table shows:

- a. whether the article targeted opinion / attitude / belief formation or change (e.g., I already had an opinion towards biotechnology, but I changed it) or something else (e.g., correlates of existing attitudes) and
- b. how are the opinions / attitudes / beliefs formed according to the article.

All tables have id as a first column for easier orientation – for example row with id number 1 represents one article data of which are split into three tables. We did this for readability

- 
- The year of publication
  - Document type, and
  - Disciplines associated with its source.

The FWCI is the ratio of the document's citations to the average number of citations received by all similar documents over a three-year window. Each discipline makes an equal contribution to the metric, which eliminates differences in researcher citation behaviour. (Scopus, 2022)

### 3.2.1 Opinion formation

**Table 9**

*Opinion formation articles review, part 1 out of 3*

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
1	Social Sciences	Opinion dynamics and bounded confidence: Models, analysis, and simulation (Hegselmann & Krause, 2002)	1 883	20.22
2	Computer Science	Individualization as driving force of clustering phenomena in humans (Mäs et al., 2010)	129	1.7
3	Mathematics	Nonequilibrium phase transition in the coevolution of networks and opinions (Holme & Newman, 2006)	415	9.89
4	Physics and Astronomy	Incomplete ordering of the voter model on small-world networks (Castellano et al., 2003)	175	3.25
5	Engineering	The "trust gap" hypothesis: Predicting support for biotechnology across national cultures as a function of trust in actors (Hornig et al., 2003)	161	3.08
6	Arts and Humanities	A theory of framing and opinion formation in competitive elite environments (Chong & Druckman, 2007)	624	20.1
7	Psychology	Social comparison: Why, with whom, and with what effect? (Suls et al., 2002)	549	6.1



<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
8	Business, Management and Accounting	Is diversity in Delphi panelist groups useful? Evidence from a French forecasting exercise on the future of nuclear energy (Hussler et al., 2011)	76	2.69
9	Decision Sciences	Detecting opinion leaders and trends in online social networks (Bodendorf & Kaiser, 2009)	71	1.06
10	Economics, Econometrics and Finance	Persuasion bias, social influence, and unidimensional opinions (Demarzo et al., 2003)	438	2.68

**Table 10**

*Opinion formation articles review, part 2 out of 3*

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/S</b>	<b>What are opinions according to this article?</b>
1	Computer simulation; Analytical	Interacting group (of agents, e.g., experts)	G	Real number
2	Computer simulation; Mathematical model	Social clustering	G	Real number
3	Computer simulation; Mathematical model	Convergence of opinion in social systems	G	Discrete number
4	Computer simulation; Mathematical model	Voter model in small world network	G	Binary - A or B

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/S</b>	<b>What are opinions according to this article?</b>
5	Survey; Meta-analysis	Biotechnology; trust towards institutions	S	Discrete: agree, don't know, disagree (Survey responses towards biotechnology)
6	Theory; theoretical	Framing and Public opinion	G	Not defined, despite being used frequently. Definition of attitudes as a seeming synonym: "An attitude toward an object, in this view, is the weighted sum of a series of evaluative beliefs about that object."
7	Narrative review	Social comparison	G	3 types: current preferences - personal opinions concerning liking or appropriateness ("Do I like X?"); beliefs (e.g., "I am expecting terrorists to attack again.") ; future preferences ("Will I like X?")
8	Case study: Survey (Delphi methodology) + Empirical analysis	Group of experts in a panel	S	Discrete (A date period in which a nuclear technology will be developed.)
9	Text mining and social network analysis	Forum posts about a product	S	Opinion is the attitude of a user towards a product. Attitudes are characterized by their polarity, which is modelled by the three classes 'positive', 'neutral', and 'negative'.
10	Mathematical model + Computer simulation	Model, persuasion bias, social influence	G	Real number

Most common method in the selected articles is mathematical model, often in combination with computer simulation. Phenomenon modelled is opinion dynamics.

All contexts of articles are social – social influence, experts changing their opinion based on opinion of other experts, interacting group of agents in modelling articles.

In the modelling articles, opinions are treated generally, modelled as a number with arbitrary meaning, e.g., expert's estimate of a probability of an event. In other articles, opinions are specific towards an object, e.g., biotechnology, or a product.

In the modelling articles, opinions are simply defined as a number (again, representing for example an expert's estimate of a probability of an event). When not defined as a number, they are defined using a similar concept, like attitude or preference or belief.

**Table 11**

*Opinion formation articles review, part 3 out of 3*

<b>Id</b>	<b>Formation?</b>	<b>How do individuals form opinions according to this article?</b>
1	Change	Individual averages his (real number) opinion with opinions of other agents whose opinions are not too far from his own.
2	Change	Weighted average over (real number) opinions of other agents - the closer the agent's opinion is to mine, the stronger weight it has. Striving for uniqueness - the more similar are the opinions of others to mine, the more I want to change mine opinion to a very different one.
3	Change	Individual either changes his (discrete number) opinion to opinion of one of his neighbours or changes his social connection from a neighbour which has a different opinion to a neighbour which has the same opinion.
4	Change	Individual changes his (binary) opinion randomly to one of his neighbours.
5	Formation	Trust towards institutions is a better predictor of positive attitude towards biotechnology than knowledge.
6	Change	Under certain conditions, a frame can change opinion.

Id	Formation?	How do individuals form opinions according to this article?
7	Change	<p>For current preferences - person compares his preference with similar other (person sharing similar related attributes, e.g., background, general worldview). For beliefs - person compares his belief with similar expert (someone who is similar in some ways but not others, e.g., similar in fundamental religious, political, and social values). For future preferences - person compares his preference history with the preference history of similar other. (Triadic model)</p> <p>Note: How the person forms the opinion initially is not explained!</p>
8	Change	<p>Individuals, who have less expertise, are more likely to change their (discrete) opinion when shown opinions of others.</p>
9	Formation	<p>Opinion leaders spread opinions on a network. Their special position – centrality, and their communication habits within the network allow them to influence other users.</p>
10	Change	<p>Persuasion bias - "repetition of statements increases the subjects' belief in their validity [...] repetition makes the statements more familiar, and familiarity serves as a cue to validity [...] repetition can have an effect because it makes statements more salient/available in the subjects' memory. [...] persuasion bias can explain why individuals' beliefs often seem to evolve in a predictable manner toward the standard, and publicly known, views of groups with which they interact (be they professional, social, political, or geographical groups)—a phenomenon considered indisputable and foundational by most sociologists." Persuasion bias has two implications:</p> <p>1) Social influence - "well-connected individuals often seem to be very influential in a way that is not necessarily related to the accuracy of their information."</p> <p>2) Unidimensional opinions - "many individuals' opinions on a wide range of essentially unrelated issues, ranging from free trade to military spending to environmental regulation to abortion, can be</p>

<b>Id</b>	<b>Formation?</b>	<b>How do individuals form opinions according to this article?</b>
		characterized by the single measure of how conservative or liberal they are"

Mostly opinion change is described – that means, a person already holds an opinion and updates it based on some information. How the original opinion was acquired is not described in these articles.

Opinion formation (or change) is described in various ways. Each article focuses on different aspect of opinion formation or connects it with a different concept. Most commonly, mainly in the simulation articles, an individual changes his or her opinion based on opinion of others. The more similar or close the opinion of the other is to mine, the bigger weight it has. If the opinion of the other is not similar to mine, I can completely ignore it, or even change the social connection to another individual, which has a similar opinion. Also, the similarity of general world view or values makes one more influential on the opinion of others.

Trust, framing (putting the information in specific context), expertise (experts have more influence, people with lower expertise are more likely to change their opinion), opinion leaders (people with high centrality within a network) and persuasion bias (repetition of statements increases the subjects' belief in their validity) also play role in opinion formation.

### 3.2.2 Attitude formation

**Table 12**

*Attitude formation articles review, part 1 out of 3*

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
1	Social sciences	Public attitudes toward immigration (Hainmueller & Hopkins, 2014)	653	21.29
2	Psychology	Nature and operation of attitudes	2321	18.93

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
		(Ajzen, 2001)		
3	Business, Management and Accounting	Determinants of consumer attitudes and purchase intentions with regard to genetically modified foods - results of a cross-national survey (Bredahl, 2001)	400	13.59
4	Arts and Humanities	Responses to information incongruity in advertising: The role of expectancy, relevancy, and humor (Lee & Mason, 1999)	174	3.01
5	Medicine	Attitudes established by classical conditioning (Staats & Staats, 1958)	233	n/a
6	Computer Science	The effects of web personalization on user attitude and behavior: An integration of the elaboration likelihood model and consumer search theory (Ying Ho & Bodoff, 2014)	170	6.29
7	Engineering	The role of trust in the affective evaluation of novel risks: The case of CO <sub>2</sub> storage (Midden & Huijts, 2009)	126	1.94
8	Economics, Econometrics and Finance	Play, flow, and the online search experience (Mathwick & Rigdon, 2004)	358	4.01
9	Environmental Science	The New Ecological Paradigm in Social- Psychological Context (Stern et al., 1995)	667	n/a

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
10	Agricultural and Biological Sciences	Subjective norms, attitudes, and intentions of Finnish consumers in buying organic food (Tarkiainen & Sundqvist, 2005)	500	2.16

**Table 13**

*Attitude formation articles review, part 2 out of 3*

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/ S</b>	<b>What are attitudes according to this article?</b>
1	Review	Attitudes towards immigrants	S	Attitudes towards immigrants expressed in surveys and experiments.
2	Review	Review of attitude theory	G	<ul style="list-style-type: none"> <li>- There is general agreement that attitude represents a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikeable</li> <li>- It is possible that people can hold multiple attitudes towards the same object, some may be explicit, some implicit, or depending on the context</li> <li>- Attitude strength has been operationalized in different ways, including importance of the issue, extremity of the attitude, its stability over time, certainty in one's position, vested interest, involvement, affective-cognitive consistency, knowledge about the issue, frequency of thinking about it, and latency of conscious, deliberate responses to attitudinal inquiries</li> <li>- Ambivalence reflects the co-existence of positive and negative dispositions toward an attitude object. This ambivalence can result from simultaneously accessible conflicting beliefs within the cognitive component, or from a conflict between cognition and affect</li> <li>- Favourable valences associated with such abstract concepts as freedom and equality are known as values</li> </ul>

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/ S</b>	<b>What are attitudes according to this article?</b>
3	Survey	Consumer attitudes and purchase intentions regarding GMO foods	S	<ul style="list-style-type: none"> <li>- Values can be characterized as enduring beliefs about desirable goals that serve as guiding principles in people's lives</li> <li>- Attitude towards genetic modification in food production was measured globally by the three items:               <ol style="list-style-type: none"> <li>1) "Applying gene technology in food production is extremely bad – extremely good,"</li> <li>2) "Applying gene technology in food production is extremely foolish – extremely wise,"</li> <li>3) "I am strongly against – strongly for applying gene technology in food production."</li> </ol> </li> </ul>
4	Experiments	Ads' expectancy, relevancy, and humour	S	<ul style="list-style-type: none"> <li>- Extent of agreement with attitudinal statements using seven-point scales.</li> <li>- To evaluate attitude toward the ad, the statements were as follows:               <ol style="list-style-type: none"> <li>1) I dislike the ad;</li> <li>2) the ad is appealing to me;</li> <li>3) the ad is attractive to me;</li> <li>4) the ad is interesting to me; and</li> <li>5) I think the ad is bad.</li> </ol> </li> <li>- To evaluate attitude toward the brand, the statements were as follows:               <ol style="list-style-type: none"> <li>1) the brand in the ad is likely to possess the stated ad claims;</li> <li>2) I react favourably to the brand;</li> <li>3) I feel positive toward the brand;</li> <li>4) I dislike the brand.</li> </ol> </li> </ul>
5	Experiments	Learning word pairs; classical conditioning	S	<ul style="list-style-type: none"> <li>- Attitudes evoked by concepts are considered part of the total meaning of the concepts - "evaluative meaning"</li> <li>- An attitude is an implicit response [...] which is considered socially significant in the individual's society</li> <li>- 7-point scale pleasant - unpleasant, towards male names and national names</li> </ul>
6	Experiments	Personalisation agent recommending books on a	S	<p>Questionnaire answers:</p> <ol style="list-style-type: none"> <li>1) object (personalisation agent) is good / bad,</li> <li>2) using it is pleasant / unpleasant,</li> </ol>



<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/ S</b>	<b>What are attitudes according to this article?</b>
		bookstore webpage		3) I like / dislike using it 3 aspects of attitudes: valence, persistence, confidence
7	Structural equation modelling on survey data	Role of trust in attitudes towards risky CO2 storage	S	Questionnaire answers, 1 to 5: 1) CO2 storage is desirable / undesirable, 2) CO2 in general is useful / useless, 3) it is a good/ bad solution to climate problem
8	Experiment	Internet search	S	Attitude toward the brand: 1) I say positive things about XYZ products to other people 2) I have a favourable attitude toward doing business with XYZ over the next few years 3) To me, XYZ is clearly the best company of its kind with which to do business 4) I believe this is a good company
				Attitude toward focal Web site: 1) Good—Bad, 2) High quality—Low quality, 3) Dislike very much—Like very much
9	Survey / interviews	Ecology	S	Not mentioned, they measured environmental beliefs (awareness of consequences) and behavioral intentions.
10	Structural equation modelling	Buying organic food (consumer behaviour)	S	The degree to which a person has a favourable or unfavourable evaluation or appraisal. "I think that buying organic X is reasonable" agree / disagree on 5-point Likert scale

Methods used in the selected articles were experiments, surveys and reviews.

Context of articles were diverse: attitudes towards specific object (e.g., immigrants, GMO food), purchase intentions, evaluating an advertisement, learning.

Apart from an article on attitude theory, articles were focused on specific attitudes - towards immigrants, products, ads, technology, ecology, etc.

The definitions and operationalisations of attitudes are very consistent. Attitude is described in theory as “summary evaluation of a psychological object captured in such

attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikeable”. In experimental articles or surveys, it is operationalised as answers on such “attribute dimensions” scales with 2 or more possible answers.

Concepts related to attitudes are values (values are favourable attitudes towards abstract concepts such as freedom), beliefs (attitudes are based on them) and behaviour (attitude can cause behavioural intentions).

Attitudes can be implicit or explicit, have a level of strength (valence) and persistence. Attitude can be ambivalent, which can result from conflicting beliefs, or conflicting cognitive and affective factors. One can hold multiple attitudes towards an object – these are expressed based on context. Also, one has a level of confidence in the attitude.

**Table 14**

*Attitude formation articles review, part 3 out of 3*

<b>Id</b>	<b>Formation?</b>	<b>How do individuals form attitudes according to this article?</b>
1	Formation (determinants or correlates of existing attitudes)	<p>What had effect:</p> <ul style="list-style-type: none"> <li>- Fear of impact on country's culture and social life,</li> <li>- stereotypes,</li> <li>- thinking there are already more immigrants that there is,</li> <li>- elite and media rhetoric, framing,</li> <li>- anxiety induces negative attitudes.</li> </ul> <p>What did not have effect:</p> <ul style="list-style-type: none"> <li>- Personal economic circumstances.</li> </ul>
2	Formation, (but not belief formation from which attitudes arise)	<ul style="list-style-type: none"> <li>- Respondents high in the need to evaluate were found to be more likely to hold attitudes toward various social and political issues and to list more evaluative thoughts about unfamiliar paintings and about a typical day in their lives</li> <li>- Expectancy-value model attitudes arises spontaneously and inevitably as we form beliefs about the object (see Ajzen &amp; Fishbein 2000). Each belief associates the object with a certain attribute, and a person's overall attitude toward an object is determined by the subjective values of the object's attributes in interaction with the</li> </ul>

Id	Formation?	How do individuals form attitudes according to this article?
3	Formation (determinants or correlates of existing attitudes)	<p>strength of the associations. Although people can form many different beliefs about an object, it is assumed that only beliefs that are readily accessible in memory influence attitude at any given moment</p> <ul style="list-style-type: none"> <li>- Evidence indicating that evaluative reactions tend to be immediate and fast, and can occur outside of awareness.</li> <li>- There is a joint effect of cognition and affect - both have influence on the resulting attitude, in some situations one is more dominant than the other (e.g. with experience, when the person identifies as thinker / feeler, hedonic objects (affect) vs functional (cognition)) - In sum, it has been found that individuals differ in their reliance on cognition versus affect as determinants of attitude, and that the two components also take on different degrees of importance for different attitude objects.</li> <li>- Negativity bias - Whether cognitive or affective in nature, it is well known that negative information tends to have a greater impact on overall evaluations than comparably extreme positive information.</li> <li>- In short, personal and contextual factors combine to increase or decrease the accessibility of different kinds of beliefs, with potentially important ramifications for evaluative judgments and behavioral decisions.</li> <li>- Attitudes formed under conditions of high involvement were found to be significantly more accessible compared to those formed under low levels of involvement</li> </ul>
4	Formation	<p>Expectancy, relevancy, and humour of ads influence ad attitudes differently based on the combination of the three.</p>

Id	Formation?	How do individuals form attitudes according to this article?
5	Formation	<p>Attitude formation is classically conditioned, for example the sentence, "Dutch people are honest," would condition the positive attitude elicited by "honest" to "Dutch"—and presumably to any person called "Dutch," If, in an individual's history, many words eliciting a positive attitude were paired with "Dutch," then a very positive attitude toward this nationality would arise.' This happens outside of Ss awareness.</p>
6	Formation	<p>Extended elaboration likelihood model + Consumer Search Theory: (CST:) Amount of behavioral experience or information samples + (ELM:) Argument quality + depth of its processing results in perceived usefulness of a technology and that forms the attitude.</p>
7	Formation	<p>In self-relevant issues, attitudes are based on affective reactions and trust. In general, non-self-relevant issues attitudes are influenced by beliefs concerning perceived benefits (cognitive factors). In attitudes towards new objects, trust may be an important guide.</p>
8	Formation	<p>The perception of play will cause positive attitudes towards the object.</p>
9	Formation (determinants or correlates of existing attitudes)	<p>Specific beliefs and attitudes are derived from general beliefs (worldview) and values (e.g., Nature is important -&gt; wilderness preservations are important). Values are formed from social structure.</p>
10	Formation (determinants or correlates of existing attitudes)	<p>Causal pathway from subjective norms to attitudes (and then to behaviour). Norms were measured by items like "People, who are important to me, think that I should buy organic X"</p>

The articles did not focus on attitude change, but formation. More specifically, what are the determinants or correlates of existing attitudes.

Attitude formation is spontaneous, fast, immediate, and unconscious. There are many factors influencing attitude formation: contextual factors (e.g., the person is distracted), cognitive factors (e.g., previous knowledge, stereotypes), affective factors, personality (e.g., whether person is a thinker or feeler, is in general more evaluative), accessible beliefs, subjective norms, previous general beliefs, attitudes, or values.

Negative aspects (e.g., beliefs, emotions) have a stronger influence on resulting attitude than positive aspects. There is a joint effect of cognition and affect. In some situations (e.g., self-relevant situations, hedonic objects) affect is dominant, in other (e.g., self-non-relevant situations, functional objects) cognition is dominant.

Attitude formation is subject to classical conditioning.

### 3.2.3 Belief formation

**Table 15**

*Belief formation articles review, part 1 out of 3*

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
1	Arts and Humanities	Perceiving is believing: A Bayesian approach to explaining the positive symptoms of schizophrenia (Fletcher & Frith, 2009)	849	20.22
2	Social Sciences	Availability Cascades and Risk Regulation (Kuran et al., 1999)	456	1.7
3	Economics, Econometrics and Finance	An empirical study on consumer first purchase intention in online shopping: Integrating initial trust and TAM (Kim, 2012)	168	9.89
4	Psychology	The evolution of misbelief	284	3.25

<b>Id</b>	<b>Subject Area</b>	<b>Article and citation</b>	<b>Citations</b>	<b>FWCI</b>
		(McKay & Dennett, 2009)		
5	Computer Science	Explicit and implicit antecedents of users' behavioral beliefs in information systems: A neuropsychological investigation (de Guinea et al., 2014)	81	3.08
6	Neuroscience	Explaining delusions: a cognitive perspective (Bell et al., 2006)	154	20.1
7	Business, Management and Accounting	Belief formation in ethical consumer groups: An exploratory study (Shaw & Clarke, 1999)	225	6.1
8	Medicine	Reasoning in deluded schizophrenic and paranoid patients biases in performance on a probabilistic inference task (Garety et al., 1991)	491	2.69
9	Mathematics	Combining probability distributions: A critique and an annotated bibliography (Genest & Zidek, 1986)	639	1.06
10	Decision Sciences	Evidence-based electronic contract performance monitoring (Daskalopulu et al., 2002)	38	2.68

**Table 16***Belief formation articles review, part 2 out of 3*

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/S</b>	<b>What are beliefs according to this article?</b>
1	Review	Schizophrenia	Semi*	<p>- Delusions [or later related to as false beliefs] are persistent bizarre or irrational beliefs (e.g., sufferers may believe people can hear their thoughts or that the government is monitoring their every action)."</p> <p>- Beliefs about the world are internal records of probability of perceptions</p> <p>* General beliefs of schizophrenic patients</p>
2	Theoretical	Risk judgments; Public issues;	Semi*	<p>Not defined, but specific examples: e.g. "The land is contaminated with chemicals, it is harmful to health" or "Alar pesticide is a chemical hazard". These beliefs are not based on facts.</p> <p>* General beliefs that caused mass panic</p>
3	Theoretical	First purchase mechanism in online shopping	Semi*	<p>Trust beliefs = The extent to which a trustor believes, with feelings of relative security, that a trustee has characteristics beneficial to the trustor, e.g., "consumers' overall perceptions towards the ability, benevolence, and integrity of an e-vendor"</p> <p>* General trust beliefs</p>
4	Theoretical; Philosophical	Misbeliefs	Semi*	<p>There is no philosophical consensus about just what a belief actually is. In what follows we intend to avoid this question, but we offer here the following working definition of belief, general enough to cover most</p>

<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/S</b>	<b>What are beliefs according to this article?</b>
				<p>representationalist and dispositional accounts: A belief is a functional state of an organism that implements or embodies that organism's endorsement of a particular state of affairs as actual.</p> <p>* General misbeliefs</p>
5	Experimental	Information system acceptance; behavioural beliefs	S*	<p>Antecedents of two specific beliefs explored:</p> <p>1) Perceived Usefulness: "The degree to which a person believes that using a particular system would enhance his or her job performance,"</p> <p>2) Perceived Ease Of Use: "The degree to which a person believes that using a particular system would be free from effort"</p> <p>* Specific beliefs about ease of use and usefulness (towards MS Access and educational game software)</p>
6	Theoretical; Review	Delusions	Semi*	<p>Propositions or dispositions to respond and experience internal mental events or states, including conscious experiences and emotions.</p> <p>* General delusions</p>
7	Exploratory, focus groups + questionnaire	Ethical consumer beliefs	Semi*	<p>Not specified</p> <p>* General ethical beliefs</p>
8	Experiment	Schizophrenia	S	<p>A hypothesis in a probability experiment - which jar the patients thought the bead came from.</p>



<b>Id</b>	<b>Method</b>	<b>Context</b>	<b>G/S</b>	<b>What are beliefs according to this article?</b>
9	Theoretical	Consensus belief formation of experts	G	The word "opinion" will refer to an arbitrary collection of numerical statements expressing an individual's degrees of belief about the world. Opinions will be encoded as subjective probability distributions.
10	Theoretical	Contract performance monitoring	G	Opinion about a proposition $\phi$ is a representation of a belief.

*Note:* codes marked with an asterisk (\*) in the “G/S” column are explained in the same row, at the end of a cell in the last columns.

Selected articles on belief formation are mostly theoretical, with a few experimental articles.

Delusions and schizophrenia are only the context which were in more than one article, other contexts were: risk judgment, first purchase, misbeliefs, information system acceptance, ethical consumer beliefs, consensus formation, contract performance monitoring.

In most articles, beliefs were treated generally, but limited to a specific types of beliefs – general beliefs of schizophrenic patients, general beliefs that caused mass panic, general trust beliefs, general misbeliefs, general delusions and general ethical beliefs. We have marked these cases with the code “semi” in the table. In two articles, beliefs were synonyms of opinions.

Definition of beliefs are as various as contexts. We can cite McKay & Dennett (2009) “There is no philosophical consensus about just what a belief actually is” (p. 493).

Same authors offer a working definition: “A belief is a functional state of an organism that implements or embodies that organism’s endorsement of a particular state of affairs as actual” (p. 493). Other authors state that beliefs about the world are internal records of probability of perceptions. In another article, beliefs are propositions or dispositions to respond and experience internal mental events or states, including conscious experiences and emotions.

Beliefs are connected to opinions in articles, where: “Opinion about a proposition  $\phi$  is a representation of a belief.” or “The word ‘opinion’ will refer to an arbitrary collection of numerical statements expressing an individual's degrees of belief about the world. Opinions will be encoded as subjective probability distributions.”

Delusions are persistent bizarre or irrational beliefs.

Trust beliefs are the extent to which a trustor believes, with feelings of relative security, that a trustee has characteristics beneficial to the trustor.

Specific beliefs in the articles were: "The land is contaminated with chemicals, it is harmful to health", "Alar pesticide is a chemical hazard", or a hypothesis in a probability experiment - which jar the patients thought the bead came from.

Perceptions are a concept often mentioned with beliefs.

**Table 17**

*Belief formation articles review, part 3 out of 3*

<b>Id</b>	<b>Formation?</b>	<b>How do individuals form beliefs according to this article?</b>
1	Formation	<ul style="list-style-type: none"> <li>- Delusions follow as a secondary consequence of attempts to understand the anomalous sensory experience. For example, if patients can hear their own thoughts being spoken aloud (hallucination), it would seem logical to conclude that other people can also hear them (delusion).</li> <li>- Bayesian approach to belief formation: "[...] a belief is the subjective probability that some proposition about the world is true. This probability is continually updated by new evidence. Abnormal belief formation occurs when beliefs are not updated appropriately on the basis of new evidence"</li> <li>- We suggest that the formation of beliefs about the world can be equated with probabilistic learning (Bayesian inference)</li> </ul>
2	Formation	<ul style="list-style-type: none"> <li>- People with incomplete personal information on a particular matter base their own beliefs on the apparent beliefs of others, because they may be more knowledgeable.</li> <li>- To earn social approval or avoid disapproval people speak and act</li> </ul>

Id	Formation?	How do individuals form beliefs according to this article?
		as if they share, or at least do not reject what they view as the dominant belief
3	Formation (but attitude formation)	<p>Attitude formation described in the IT usage context - Two beliefs were significantly related to attitudes:</p> <p>1) Perceived Ease Of Use: the degree to which the prospective user expects the target system to be free of effort</p> <p>2) Perceived Usefulness: the prospective user's subjective probability that using a specific application system will increase his/her performance within an organizational context</p>
4	Formation	<p>The belief formation system is an information processing system that takes certain inputs (e.g., perceptual inputs) and (via manipulations of these inputs) produces certain outputs (beliefs, e.g., beliefs about the environment that the perceptual apparatus is directed upon).</p>
5	Formation	<p>- Explicit or perceptual factors (in individuals' awareness; individuals can report on them): cognitive constructs such as social presence, social influence, perceived accessibility, and availability of user training and support have been proposed and studied as factors that affect cognitive beliefs. On the other hand, more emotional constructs such as those that capture states related to frustration, psychological ownership, and engagement have been linked to behavioural beliefs (beliefs that the behaviour will produce a given outcome or experience).</p> <p>- Beliefs are formed as experiences take place</p> <p>- Engagement, frustration and neurophysiological distraction influence formation of specific beliefs (perceived usefulness, perceived ease of use)</p>
6	Formation	<p>2 factors lead to hypothesis generation, comparison and selection which results into a belief / delusion:</p> <p>1) First factor – 1<sup>st</sup> person experience:</p> <p>- Need for explanation (Experience seems abnormal)</p>

Id	Formation?	How do individuals form beliefs according to this article?
		<ul style="list-style-type: none"> <li>- Veridical acceptance (Experience seems normal)</li> <li>2) Second factor:               <ul style="list-style-type: none"> <li>- Stored encyclopaedic knowledge + possible reasoning, memory, attribution biases etc.</li> <li>- Testimony from others + possible theory of mind, social psychological bias</li> </ul> </li> </ul>
7	Formation	<p>Beliefs are influenced by quantity of available information on the topic and normative beliefs. Normative beliefs are influenced by social influence, religion, and corporations.</p>
8	Formation + Change	<p>Different stages of the formation and evaluation of a hypothesis (belief):</p> <ol style="list-style-type: none"> <li>1) the identification of the data sources that are most useful for discriminating between competing hypotheses</li> <li>2) the assessment of the implications of an observed datum vis-à-vis the truth of competing hypotheses</li> <li>3) an aggregation of implications of different data with an over-all appraisal of the relative likelihood of the truth of the hypothesis</li> <li>4) the selection, based on that appraisal, of the appropriate course of action.</li> </ol>
9	Change (but opinion change)	<p>Beliefs are formed according to Bayesian inference</p>
10	Formation	<ul style="list-style-type: none"> <li>- An agent's forming of opinions on the basis of information supplied by other agents is subject to trust.</li> <li>- Subjective logic calculus</li> </ul>

Majority of selected articles covered belief formation.

The belief formation process was described differently, but the explanations are mostly compatible. Beliefs are formed based of perceptions. One look on the belief formation system is as on an information processing system that takes certain inputs and via manipulations of these inputs produces certain outputs – beliefs. This can be

specified in the terms of probability – belief is a probability, and it is updated based on new information (perceptions) according to probabilistic learning (Bayesian inference). In other articles, there the manipulation has a form of subjective logic calculus. Belief formation is subject to cognitive and affective factors.

There are also social factors – people can base their beliefs on the apparent beliefs of others or can act as they share the dominant belief to earn social approval.

### 3.2.4 Comparison of the opinion, attitude, and belief literature

In the Table 18 below, we compare the findings from the previous section. In-text summary follows beneath the table.

**Table 18**

*Comparison of opinion, attitude, and belief formation articles analysis*

Category	Opinion formation	Attitude formation	Belief formation
<b>Dominant methods</b>	computer simulations of social opinion dynamics	experiments, surveys, or reviews	mostly theoretical articles
<b>Dominant context</b>	interacting group of agents	attitudes towards something	various, delusions and schizophrenia are common
<b>Specific or general?</b>	general - modelled as a number without specific meaning	specific - towards immigrants, products, ads, technology, ecology, etc.	semi - delusions, trust beliefs, misbeliefs, ethical beliefs
<b>Definitions</b>	a binary, discrete or continuous number, or same as attitude	questionnaire answers with unidimensional valence like I like / dislike, I think it is good / bad, useful / not useful towards various	various, e.g., internal record of probability of a perception or experience

Category	Opinion formation	Attitude formation	Belief formation
		objects; based on beliefs about the object	
<b>Formation or change?</b>	opinion change – how was the opinion initially formed is not described	attitude formation, or correlates of specific attitudes	formation
<b>Formation process</b>	<ul style="list-style-type: none"> <li>- Our opinions are changed based on opinions of other similar individuals (have similar opinion to ours, had similar opinions to ours, have similar values, etc.).</li> <li>- Experts, opinion leaders or trusted sources may influence our opinions as well.</li> <li>- Persuasion bias – repeated information seems more valid and have stronger influence on formation of our opinions</li> </ul>	<ul style="list-style-type: none"> <li>- Attitudes are formed based on available beliefs about the object</li> <li>- Belief which forms attitudes may stem from worldviews, values, and social structure</li> <li>- There is a joint effect of cognition and affect. In some situations (e.g., self-relevant situations, hedonic objects) affect is dominant, in other (e.g., self-non-relevant situations, functional objects) cognition is dominant</li> <li>- Specific attitudes may be derived from general attitudes or values</li> <li>- Attitudes can be classically conditioned</li> </ul>	<ul style="list-style-type: none"> <li>- Probabilistic reasoning and learning: a belief as a subjective probability is continually updated by new evidence.</li> <li>- People with incomplete information form their beliefs on the beliefs of others</li> <li>- People act as they accept or do not reject the dominant belief</li> <li>- First person experience, own knowledge, and testimony from others</li> <li>- Quantity of available information plus normative beliefs</li> </ul>

Category	Opinion formation	Attitude formation	Belief formation
		- There are individual and situational differences	
		- Negative information have greater impact on attitudes than positive	
		- There may be a role of subjective norms in attitude formation	

### 3.2.5 Summary

All selected articles with defined FWCI had it above 1, which means that they were more cited than expected when compared to similar articles.

Sometimes, it was hard to extract the definition of opinions / attitudes / beliefs as well as the how authors describe the process. Despite using the term “formation”, it was not always described. Some articles were concerned with implication or functions of opinions / attitudes / beliefs, like for action selection in behaviour, but this was not the focus of our study.

Opinion formation, attitude formation and belief formation are fields which overlap and relate in the concepts they study, but still have their specifics:

- They overlap in definitions (one concept uses another in various definitions), some article types (e.g., experts’ consensus *beliefs* formation and experts’ consensus *opinion* formation; ethical consumer *beliefs* and ecological *attitudes*; role of trust in *opinion* formation towards new technology and role of trust in *attitude* formation towards new technology)

- They differ in dominant methods (computer simulation for opinion formation, experiments and surveys for attitude formation, theoretical papers for belief formation), different levels of abstraction (opinions are modelled generally, attitudes are usually specific towards some type of object, there are different types of beliefs studied separately).

Attitude formation was described in the most detail and the studies were most coherent, as well as the definition of attitudes themselves. However, specific attitudes are usually studied, such as new technology or ecological attitudes. Such attitudes have also specific determinants of how they are formed, like nature related values, or trust towards institutions – further research is needed to generalise such findings. Several articles mentioned that attitudes are formed based on beliefs about the object but did not mention how beliefs are formed. Sometimes, another term was used for attitudes, like evaluative meaning, valance, or even opinion.

This was not true in belief formation, the belief formation process was not always described in detail, often only used as a term without further definitions. When defined, the definitions varied. Same was true about the concept of belief, it was not clearly defined. There were various types of beliefs, like false beliefs (delusions), misbeliefs, trust beliefs, behavioural beliefs etc. Beliefs are the only concept connected to the notion of truth – there is obviously no such connection in attitudes, but surprisingly also not in opinions. Also, beliefs are the only concept which exists in a verb form – to believe something.

Opinion formation process was never described in an individual context, always based on social influence of others. Global phenomena were usually observed, such as opinion dynamics (how opinions spread across population) or social clustering. Conceptualisation of opinions was very weak, in the computer simulation articles, they were only defined as number with arbitrary meaning (e.g., expert's opinion on probability of an event). If computer simulation was not used in the article, opinions were obtained via a survey, or defined as another concept – attitudes, beliefs, or preferences.

### *3.2.6 Comparison with the bibliometric findings*

In this section, our aim is to compare the findings from the bibliometric analysis to findings from the literature review. Bibliometric findings should represent the whole research field and capture or dominant themes. We tried to select the review articles in such a way, that they cover different research fields (approximated by subject areas), so they should possibly be in line with themes discovered in bibliometric analysis.

Below, we repeat findings from the bibliometric analysis and comment them with the findings from the literature review.



### 3.2.6.1 Dominant sciences

*ALL: Social science*

*Opinion formation: Computer science/Physics/Mathematics, Political science*

- Mostly computer simulation articles were analysed. No political science article was analysed.

*Attitude formation: Psychology, Consumer research*

- Psychological as well as consumer research articles were analysed, although also other disciplines were present (medicine, economics, environmental science, ...)

*Belief formation: Philosophy, Brain research, Economics, Psychopathology*

- Philosophical, psychopathological, and economical articles were analysed. No neuroscientific article was analysed.

### 3.2.6.2 Dominant themes

*ALL: decision making (is central!), social (influence), behavior*

- We did not find an article which would explain the decision-making process in relation to opinion / attitude / belief formation. Social influence was present in all RFs, mainly OF. Link to behaviour was strong in AF research.

*Opinion formation: opinion dynamics (+ consensus and polarisation), public opinion, social networking / media, marketing, and media*

- Opinion dynamics were a topic of majority of analysed articles, as well as social networks. Social media, marketing and public opinion were not analysed.

*Attitude formation: cognition, marketing and consumer research, health attitudes*

- Mainly diverse specific attitudes were analysed, including consumer and marketing attitudes, cognitive aspects were also mentioned. Health attitudes were not mentioned in the selected articles.

*Belief formation: delusions, schizophrenia, cognition, epistemology, rationality, culture*

- All themes were present, except the culture.

### 3.2.6.3 Minor themes

*Opinion formation: management, climate change*

- Not present

*Attitude formation: public attitude, education, attitude change, politics*

- Not present

*Belief formation: computers and mathematics, climate change, bias*

- Not present

### 3.2.6.4 Conclusion

*All fields – opinion, belief and attitude formation – are studied by social sciences and social keywords, like social influence, are often present. Decision making and behaviour are two concepts strongly connected to all fields.*

- Social aspects were present. Relationship of one topic to another was not mentioned, however. Link to behaviour was strong especially in attitude formation.

*Opinion formation is the biggest and exponentially growing field mainly characterised by computer / physical simulations of opinion dynamics and public opinion studies. Common themes are consensus and polarisation, social networking or marketing and media.*

- Mainly consensus theme was present.

*Attitude formation is the second biggest field, where main themes are psychological studies of cognitive aspects of attitude formation and consumer research of for example brand attitudes.*

- Mainly specific attitudes were studied, cognitive aspects were not studied in detail.

*Belief formation is the smallest field, characterised by either neuroscientific or psychological research on delusions, for example present in schizophrenic patients, philosophical epistemological inquiries and rationality studied in probabilistic terms.*

- Delusions, philosophical and rationality themes were present in our literature sample.

*It is also interesting that ratio of most frequent attitude formation keywords to total is smaller than compared to opinion formation or belief formation, it suggests that the research in this field is “flatter”, with no dominant topics.*

- This was also present in our sample – various specific attitudes with specific determinants were studied.

*Beliefs are the only concept which have a sort of an opposite – delusions. They are also the only concept studied by neuroscientific as well as philosophical methods.*

- This was also true in our literature sample, although no neuroscientific study was present.

*Overall, despite all topics having similar connotation, they are also being researched by different methods (e.g., opinions computer simulations, attitudes psychological experiments, beliefs by brain research and philosophical methods) and have specific subtopics (e.g., public opinions, brand attitudes, delusions).*

- This is very accurate also for our sample.

Overall, we conclude that our literature review sample has a significant overlap with the themes discovered in the bibliometric analysis.

## 4 Discussion

In this chapter, we first summarise and evaluate the research aim, objectives and questions, then consider the limitations and finally conclude with discussing the findings.

### 4.1 Research aim, objectives and questions

In this section, we briefly summarise the most important findings structured by research objectives and questions.

**RO1:** *To describe the body of scientific literature on opinion, belief and attitude formation **quantitatively**, using bibliometric methods.*

We have analysed approx. 3000 articles – 1500 articles on opinion formation, 1000 articles on attitude formation and 500 articles on belief formation – using the bibliometric methods. Using Scopus, we have extracted each article’s subject areas and name. We have then analysed the aggregated data. Using VOSViewer we have constructed keywords co-occurrence map, extracted terms from abstracts of articles and constructed terms co-occurrence map. We have then again analysed these data.

**RQ1.1:** *How populated is the literature on opinion, belief and attitude formation and what is the time trend?*

Literature on opinion formation was the most populated, followed by attitude formation literature and then belief formation literature. All topics have a rising tendency – there are increasingly more articles published on the topic every year, even when accounted for general rising tendency of all research. This tendency started around 1990s. Opinion formation literature is growing exponentially, while attitude and belief formation literature is growing linearly.

**RQ1.2:** *Which scientific disciplines study opinion, belief and attitude formation?*

Opinion formation is studied by both natural sciences and social sciences. In natural sciences, models of opinion formation dynamics are created, usually with the focus on consensus vs polarisation. In the social sciences, opinions are studied in the

form of public opinions. Marketing also has a strong stake in opinion formation literature.

Attitudes are studied mainly in (social) psychology and consumer research / marketing disciplines. Attitudes are well established and conceptualised in psychology. In consumer research and marketing, various types of specific attitudes are studied, like attitudes towards health, new technology, ecology etc.

Dominant scientific disciplines studying belief formation are philosophy, psychology, neuroscience and economics. Delusions are a dominant concept in psychological and neuroscientific belief formation studies. In economics, beliefs are often treated in probabilistic terms.

**RQ1.3:** *What topics are connected to the topic of opinion, belief and attitude formation?*

Based on keyword analysis, social aspects (like social influence), psychological aspects (like perception, cognition, memory, learning), decision making, and behaviour topics are connected to all opinion, belief and attitude formation.

For opinion formation, the dominant topics are opinion dynamics (with consensus and polarisation), public opinion, social networking

For attitude formation, the dominant topics are cognition, marketing and consumer research

For belief formation, the dominant topics are delusions, schizophrenia, and rationality.

**RO2:** *To describe the body of scientific literature on opinion, belief and attitude formation **qualitatively**, i.e., to analyse most-cited scientific articles from different scientific fields on the opinion, belief and attitude formation using the combination of content analysis and narrative review methods.*

We have analysed 30 articles, 10 for opinion formation, 10 for attitude formation, 10 for belief formation. Each of these articles was most cited in one of ten most populated subject area for each search term. By this, we aimed to increase representativeness of the sample. Each article was analysed in a combined method of content analysis and narrative review.

**RQ2.1:** *How are opinions, beliefs and attitudes conceptualised in the most-cited articles from various fields in the opinion, belief and attitude formation literature?*

In most of the analysed articles, opinions are modelled in opinion dynamics models. In such articles, opinions are conceptualised as a number with arbitrary meaning, e.g., expert's estimate of a probability of an event. In other articles, the conceptualisation varies – opinions as synonym of attitudes, synonym of preferences, opinions as one of discrete set of options. Most consistent were thus the modelling articles.

Attitudes are the most consistently conceptualised concept. It was the only concept, where we have found an impactful theoretical article (Ajzen, 2001). Ajzen defines attitudes as “There is general agreement that attitude represents a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikeable.” (p. 28). This was true in all the articles which we have analysed.

Beliefs were the least consistent concept. Various types of beliefs are studied, like beliefs of schizophrenic patients, beliefs that caused massed panic, trust beliefs, misbeliefs, perceived usefulness and perceived ease of use, delusions, ethical beliefs. We can cite McKay & Dennett (2009) “There is no philosophical consensus about just what a belief actually is” (p. 493). Same authors offer a working definition: “A belief is a functional state of an organism that implements or embodies that organism's endorsement of a particular state of affairs as actual” (p. 493). Other authors offer somewhat similar definitions like beliefs are internal records of probability of perceptions. These definitions are usually not explicitly stated. Probabilistic terms are common. Other authors define beliefs with the use of opinions.

**RQ2.2:** *How are opinions, beliefs and attitudes formed according to the most-cited articles from various fields in the opinion, belief and attitude formation literature?*

Mostly opinion change was described. Most commonly, mainly in the simulation articles, an individual changes his or her opinion based on opinion of others. The more similar or close the opinion of an other is to the opinion of an individual, the bigger weight it has. If the opinion of the other is not similar to the individual's opinion, it is ignored, or the social connection is changed to another

individual, which has a similar opinion. Also, the similarity of general world view or values makes one more influential on the opinion of others. Trust, framing, expertise, opinion leaders and persuasion bias also play role in opinion formation.

Attitude formation is spontaneous, fast, immediate, and unconscious. There are many factors influencing attitude formation: contextual, cognitive factors, affective factors, personality, accessible beliefs, subjective norms, previous general beliefs, attitudes, or values. Negative aspects (e.g., beliefs, emotions) have a stronger influence on resulting attitude than positive aspects. There is a joint effect of cognition and affect. In some situations (e.g., self-relevant situations, hedonic objects) affect is dominant, in other (e.g., self-non-relevant situations, functional objects) cognition is dominant. Attitude formation is subject to classical conditioning.

The belief formation process was described in various ways, but the explanations are mostly compatible. Beliefs are formed based of perceptions. One view on the belief formation system is as on an information processing system that takes certain inputs and via manipulations of these inputs produces certain outputs – beliefs. This can be specified in the terms of probability – belief is a probability, and it is updated based on new information (perceptions) according to probabilistic learning (Bayesian inference). In other articles, the manipulation has a form of subjective logic calculus. Belief formation is subject to cognitive and affective factors. Social factors are also influencing belief formation – people can base their beliefs on the apparent beliefs of others or can act as they share the dominant belief to earn social approval.

**RQ2.3:** *What methods are used in the most-cited articles from various fields in the opinion, belief and attitude formation literature?*

For opinion formation, computer simulations and mathematical models are dominant.

For attitude formation, experiments, surveys and reviews are dominant.

For belief formation, theoretical articles dominate.

**RQ2.4:** *What are other observed categorical differences in how opinions, beliefs or attitudes are studied in the most-cited articles from various fields in the opinion, belief and attitude formation literature?*

General opinions are studied, their object is not specified. Instead of opinion formation, opinion change is usually studied and that in social context.

Mostly specific attitudes are studied, that is, towards a specified object. Articles always focus on attitude formation.

Mostly specific beliefs are studied, towards a specified object. There are specific types of beliefs, like delusions. Articles focus on belief formation.

**RO3:** *To compare the findings from the bibliometric and content analysis of opinion, belief and attitude formation literature.*

We have presented the findings in such form, that finding on opinion, attitude and belief formation can be compared. We have also compared the findings from the bibliometric part with the findings from narrative review and content analysis part.

**RQ3.1:** *How do answers for RQ1.1 – RQ1.3 differ for terms opinion formation, belief formation and attitude formation?*

This can be seen from the summary in this section.

**RQ3.2:** *How do answers for RQ2.1 – RQ2.4 differ for terms opinion formation, belief formation and attitude formation?*

This can be seen from the summary in this section.

**RQ3.3:** *How do findings for RQ1.1 – RQ1.3 and RQ2.1 – RQ2.4 differ?*

Overall, the narrative review and content analysis sample had a significant overlap with the major themes discovered in the bibliometric analysis. This is a positive finding.

Overall, we believe that we have managed *to describe and compare approached articles from different scientific fields on the topic of opinion, belief and attitude formation, mainly from the conceptual perspective*, as was the aim of this thesis.

## 4.2 Limitations

Firstly, despite using well established methods, we had to adapt them for a very atypical context. Usually, bibliometric methods are employed to all articles of a specific journal and focus on the citation structure. Literature reviews are usually conducted for quite narrow research questions. This was not the case in our work, where our aim was to review a topic which not only does not have a specific science which it is studied



by, it does not even have a stable name and definition. These flaws could be accounted for in further similar research:

- We did not set a time frame in our database queries – this was done because we could not find arguments for specific dates to be chosen. This probably resulted into presence of already re-evaluated our outdated research findings in our sample. Moreover, in the literature review part, article which cited another included, older article was present. If this study would be repeated, we would only include articles which are from for example last 20 years.
- Top 100 keywords selected for the analyses could have been ordered not by number of occurrences, but total link strength (sum of number of citations of each article which cited the article containing the keywords). This would favour the keywords which are in highly cited articles.
- If it would be possible, we would order articles by FWCI and not number of citations – as mentioned above, FWCI accounts for domain specific citation culture and thus should better represent the article's quality, especially when articles from different research fields are “competing” for the inclusion.
- Maybe most importantly, we would try to look for review, or theoretical articles, such as the one from Ajzen (2000). This article, because of being theoretical and conceptualising, provided the most insight to attitude formation, especially when compared to articles which were focused on specific attitudes in a specific context. However, we had problems finding such articles and we are still unaware of how to locate them.
- It would maybe be possible to divide the research field semantically not by subject areas (which has many downsides as discussed above), but by search terms from identified themes combined by AND and NOT operators. For example – TITLE-ABS-KEY(“opinion formation”) AND TITLE-ABS-KEY(“opinion dynamics”); TITLE-ABS-KEY(“opinion formation”) AND TITLE-ABS-KEY(“public opinion”); TITLE-ABS-KEY(“opinion formation”) AND NOT TITLE-ABS-KEY(“opinion dynamics”) AND NOT TITLE-ABS-KEY(“opinion formation”). This would let us explore specific subtopics of the researched concepts, but would require, on the other hand, more planning, and iterations.

- There are other, more elaborate methods to discover topics in large number of articles, which we could have used – e.g. topic modelling method. Also, using the whole article texts produces better results than when just abstracts are used (Song et al., 2020).

Secondly, qualitative, and broad studies are usually done by multiple researchers in a yearly timescale, which was not possible in this study. This inherently leads to low reliability of the results because all manual analysis was probably influenced by subjective bias. Example of such situation would be the selection of keywords and terms which will not be used by a map – those with low semantic value. This was judged solely subjectively and would probably be different when executed by a different researcher. This situation is even more fundamental in the review of the articles, where the relevant data were extracted manually and even more manually summarised in multiple steps.

### 4.3 Conclusion

In this section, we aim to discuss broader context of this thesis and the process of its creation chronologically.

This thesis started by our motivation to know more about how people form opinions. Opinions are omnipresent in everyday life, and important. They are a commonly known term. However, despite their omnipresence, importance and common understanding, we were not able to find any major integrative scientific work on the topic. More generally, it was our attempt to find scientific literature on a real-world topic, scientific counterpart to a folk concept.

We assume that this process is difficult in general – when one is new to a scientific field, it takes a lot of time to orientate in a field's terminology, history, current competing theories etc. Books, review articles or broad theoretical articles are of great help in such cases. Especially when the field or topic is scattered among multiple disciplines. In such case, multidisciplinary integrative and bridging articles are of substantial importance.

Since we were not able to find such articles for the opinion formation topic, we have shifted our aim to creating a map of the topic. That would not only help us – researchers new to the field - to orientate, but also provide an integrative force in current fragmented science.

To map the topic, we have used bibliometric methods. We were new to this field, and assuming based on our university education, these methods are not well known. We hope that our work demonstrates that they could be excellent for navigation in a broad research field, for example as a starting point for researchers which aim to do a literature review on a to them novel topic.

Bibliometric methods can help with grasping the *structure* of a field. To better the *content*, we have combined these methods with content analysis and narrative review. Content analysis was used to help us extract relevant information from the articles and narrative review to allow for more free analysis of texts, since we were dealing with such a variety of disciplines and methods.

We consider this combination of methods as useful and compatible. Finding from narrative review with content analysis helped to explain keywords and terms from bibliometric analysis. There was a significant overlap of findings from bibliometric part and narrative review with content analysis part. We attribute this to the selection method of articles in the narrative review with content analysis part – the 30 articles were selected with an aim to represent the most populated subject areas.

Undoubtedly, our use of these methods has flaws due to our inexperience. Plus, they were modified to suite our needs (e.g., the content analysis). Limitations were discussed in the Limitations section. Furthermore, there are probably better methods for our aims, like topic modelling method (Song et al., 2020) , only we were or are unaware of them.

On the other hand, we still believe that our methods lead to results which are useful in describing the main characteristics of the issue.

Detailed findings are already present in the results and discussion sections. We would like to highlight the following findings.

All opinions, attitudes and beliefs are mostly studied in a social context. One gets his opinions, beliefs, and attitudes from his important others. Opinion formation is unconscious and subject to many biases, like persuasion bias. We think that this is not reflected in folk knowledge, people consider themselves to be more independent and rational.

Opinions create extensively studied phenomena, like polarisation, which are only amplified in online social networks.

All opinions, beliefs and attitudes were connected with behaviour.

Apart from content-related findings, we have also described the structure of literature on opinion, attitude and belief formation. All three are rising topics. We have decided to study these three topics because of their interconnectedness. In many articles, these terms were used as synonyms or used to define each other.

Despite their similarities, all three terms have their specifics in terms of how they are treated in the literature. Opinions are studied mostly on the collective level of public opinions, with focus on polarisation and consensus formation. Dominant methods here are mathematical models and computer simulations. Attitudes are well and simply conceptualised topic in psychology. Beliefs are much more blurred, with the focus of delusions.

All opinion, attitude and belief formation are studied by psychology, but also marketing and consumer research. Actually, large number of various disciplines have a stake in studying these concepts, which make it a truly multidisciplinary topic.

To conclude, the topic of opinion, attitude and belief formation is fragmented across multiple disciplines. To our best knowledge, there are no bridging works on the topic, which makes this thesis unique and beneficial. It could provide a starting point for anyone interested in the topic of opinion, belief, or attitude formation.

But we also view as only a pilot, done by a junior researcher in a limited timeframe. It would be best done again by a multidisciplinary team of experts knowledgeable in the respective fields and methods which allow to map, analyse and most importantly synthesise findings from diverse fields.

Similar problems with fragmentation happened also in whole disciplines, like communication or network science. Both these disciplines are related to opinion formation and are also interdisciplinary – for example, networks are studied by both sociologists and mathematicians. Suggested solution for integrating these disciplines is forming interdisciplinary teams and focus on common topics. (Hidalgo, 2016; Song et al., 2020) Could opinion formation be such topic?

We would like to end with a quote from 1993 by Robert M. Entman, where he writes about framing, a topic again related to opinion formation.

The idea of 'framing' offers a case study of just the kind of scattered conceptualization I have identified. Despite its omnipresence across the social sciences and humanities, nowhere is there a general statement of framing theory [...] We should identify our mission as bringing together insights and theories that would otherwise remain scattered in other disciplines. (p.51)

We call for the same mission, only for opinion formation.

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# Appendix

## Additional tables and figures

**Table 19**

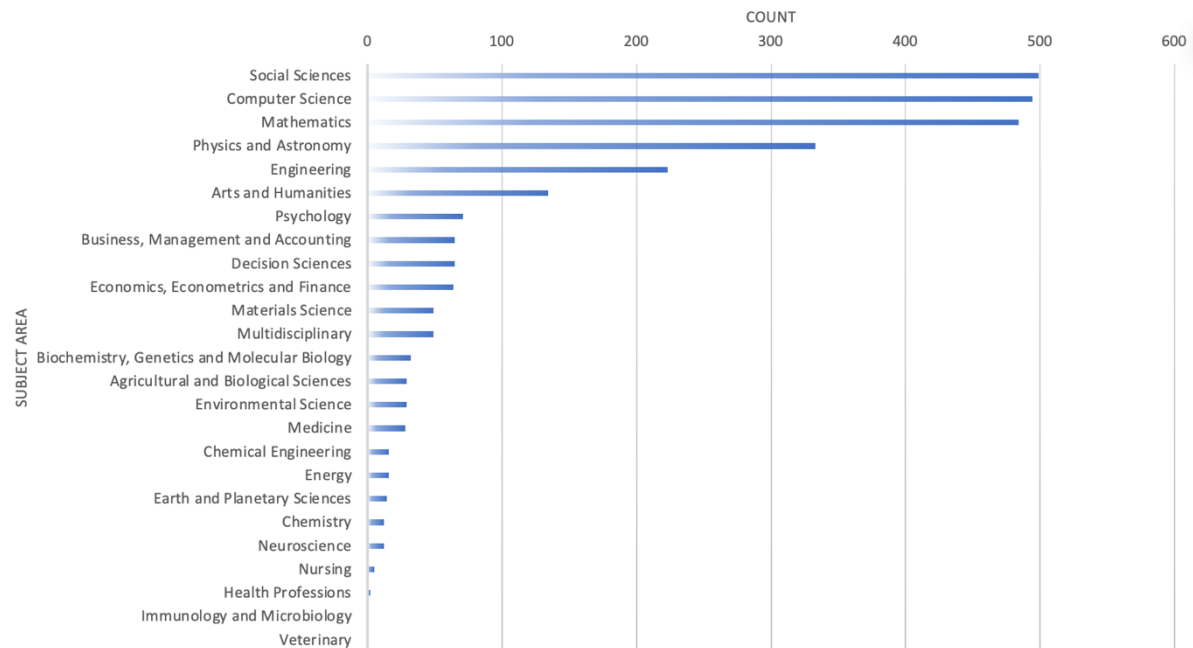
*List of Scopus' subject areas*

Subject Area	Subject Area Classifications
<b>Physical Sciences</b>	Chemical Engineering
	Chemistry
	Computer Science
	Earth and Planetary Sciences
	Energy
	Engineering
	Environmental Science
	Material Science
	Mathematics
	Physics and Astronomy
	Multidisciplinary
<b>Health Sciences</b>	Medicine
	Nursing
	Veterinary
	Dentistry
	Health Professions
	Multidisciplinary
<b>Social Sciences</b>	Arts and Humanities
	Business, Management and Accounting
	Decision Sciences
	Economics, Econometrics and Finance
	Psychology
	Social Sciences
	Multidisciplinary
<b>Life Sciences</b>	Agricultural and Biological Sciences
	Biochemistry, Genetics and Molecular Biology
	Immunology and Microbiology
	Neuroscience
	Pharmacology, Toxicology and Pharmaceutics
	Multidisciplinary

Source: Scopus (*What Are Scopus Subject Area Categories and ASJC Codes?*, 2022)

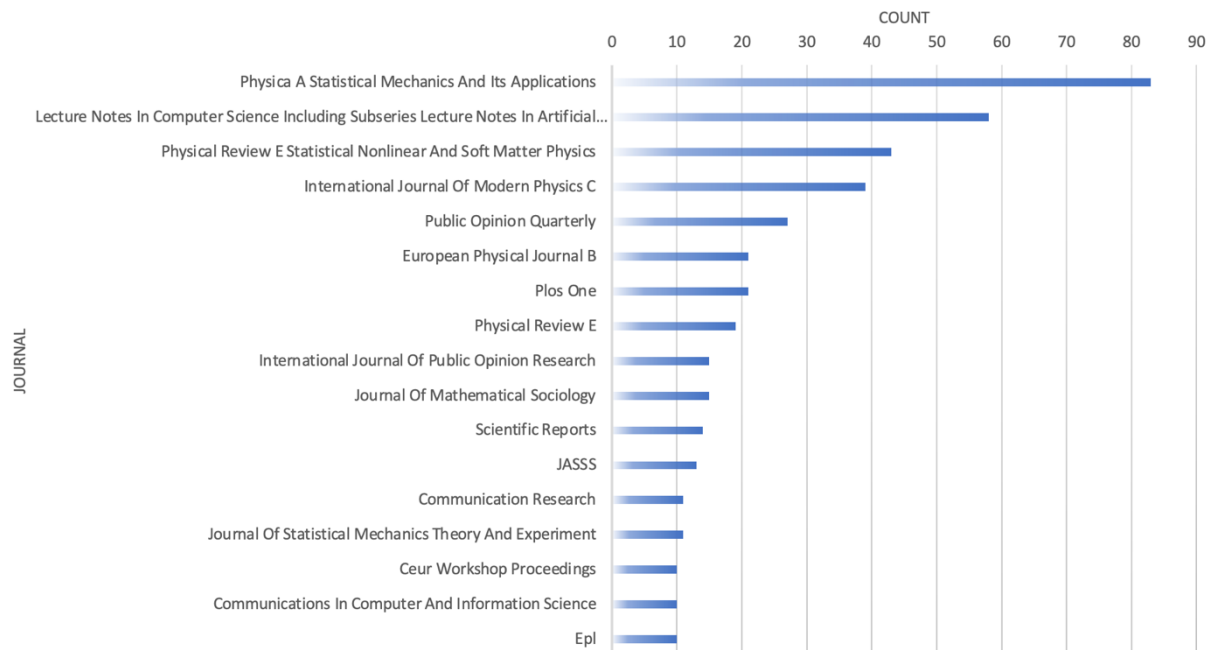
**Figure 8**

*Frequency of Subject areas for items returned by TITLE-ABS-KEY("opinion formation")*



**Figure 9**

*Frequency of Journals for items returned by TITLE-ABS-KEY("opinion formation")*



**Table 20***Top 50 keywords for TITLE-ABS-KEY("opinion formation")*

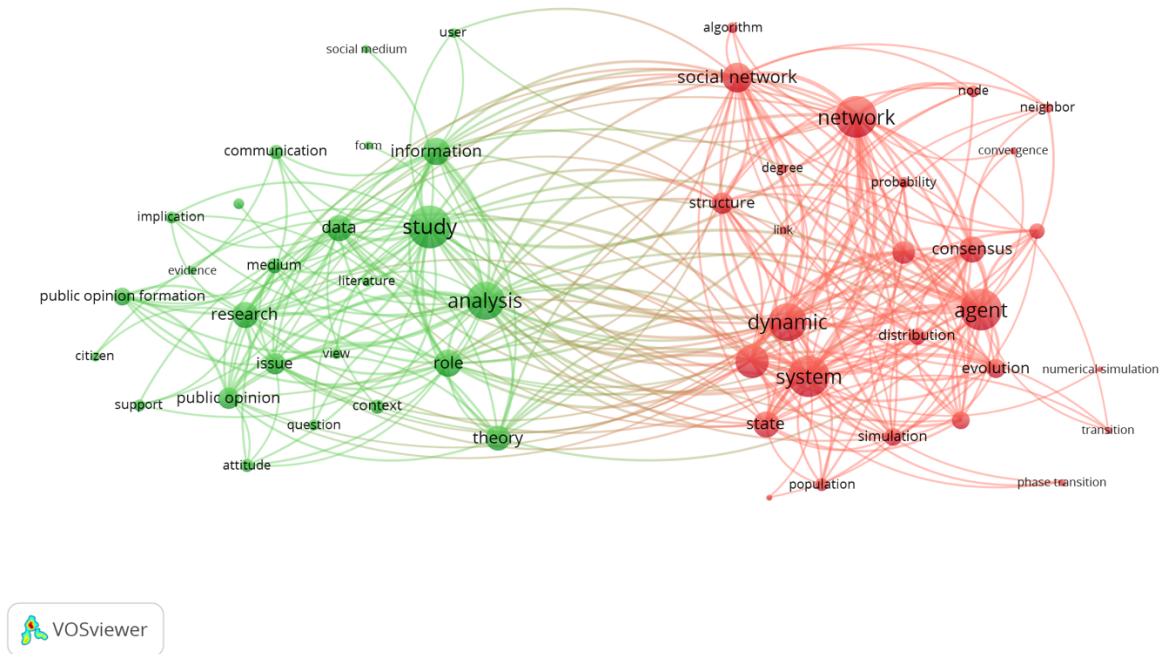
<b>KEYWORDS 1 - 25</b>	<b>FREQ</b>	<b>KEYWORDS 26 - 50</b>	<b>FREQ</b>
Opinion Formation	553	Bounded Confidences	35
Opinion Dynamics	211	Social Influence	35
Social Networking (online)	151	Artificial Intelligence	32
Dynamics	114	Ising Model	32
Public Opinion	93	Sociophysics	32
Social Networks	89	Economic And Social Effects	31
Human	88	Physics	29
Social Aspects	85	Behavioral Research	28
Opinion Formation Models	82	Bounded Confidence	27
Article	76	On-line Social Networks	27
Computer Simulation	73	Attitude	25
Consensus	68	Management Science	25
Social Network	68	Phase Transitions	25
Decision Making	66	Stochastic Systems	25
Humans	61	Internet	24
Complex Networks	59	Probability	24
Social Media	59	Social Interactions	24
Multi Agent Systems	55	Algorithms	23
Mathematical Models	47	Game Theory	23
Public Opinions	47	Adult	22
Autonomous Agents	46	Models, Theoretical	22
Computational Methods	46	Male	21
Polarization	45	Online Systems	21
Agent-based Model	42	Social Behavior	21
Topology	36	Female	20

**Table 21***Top 50 terms for TITLE-ABS-KEY("opinion formation")*

<b>TERMS 1 - 25</b>	<b>FREQ</b>	<b>TERMS 26 - 50</b>	<b>FREQ</b>
agent	381	rule	111
network	361	property	109
system	353	support	108
dynamic	336	node	108
interaction	309	question	105
social network	277	survey	100
data	244	view	99
consensus	242	probability	99
research	232	policy	99
opinion dynamic	206	understanding	98
issue	203	algorithm	98
public opinion	203	perspective	97
public opinion formation	168	phenomena	97
article	167	size	97
parameter	162	use	96
opinion formation model	147	leader	96
distribution	144	citizen	96
evolution	144	degree	93
medium	136	literature	91
context	133	development	90
communication	132	user	87
simulation	132	neighbor	87
attitude	128	evidence	86
population	127	form	84
implication	115	politic	84

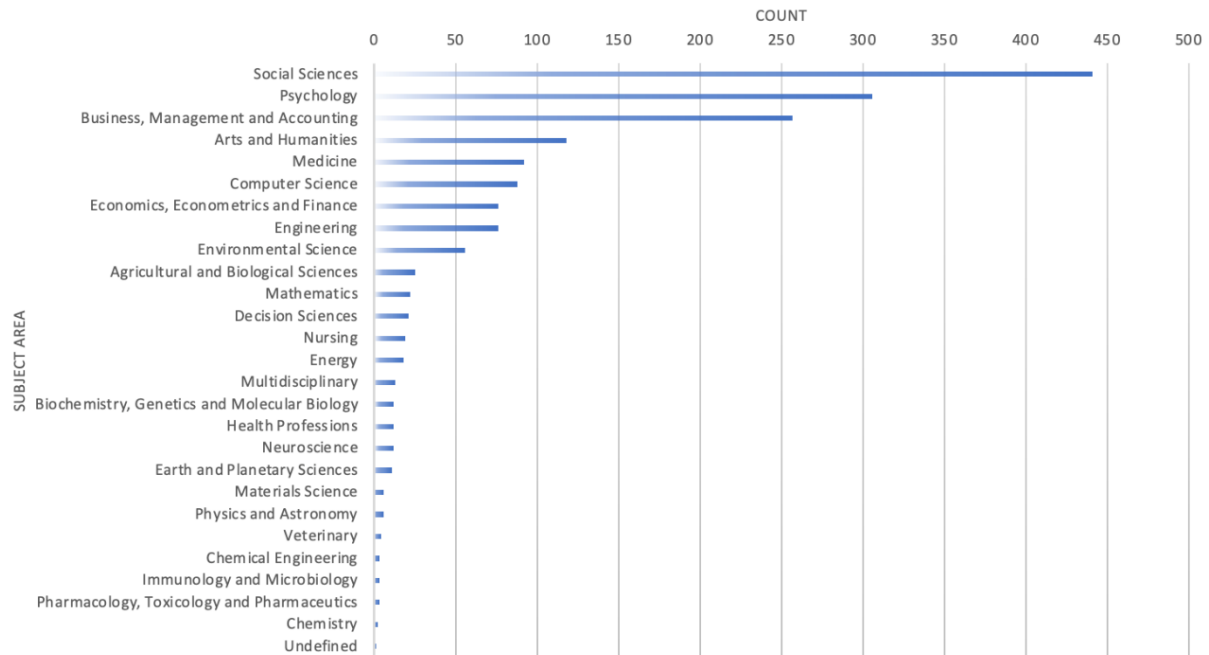
**Figure 10**

*Terms co-occurrence network visualisation from VOSViewer for the opinion formation*



**Figure 11**

*Frequency of Subject areas for items returned by TITLE-ABS-KEY("attitude formation")*



**Figure 12**

*Frequency of Journals for items returned by TITLE-ABS-KEY("attitude formation")*



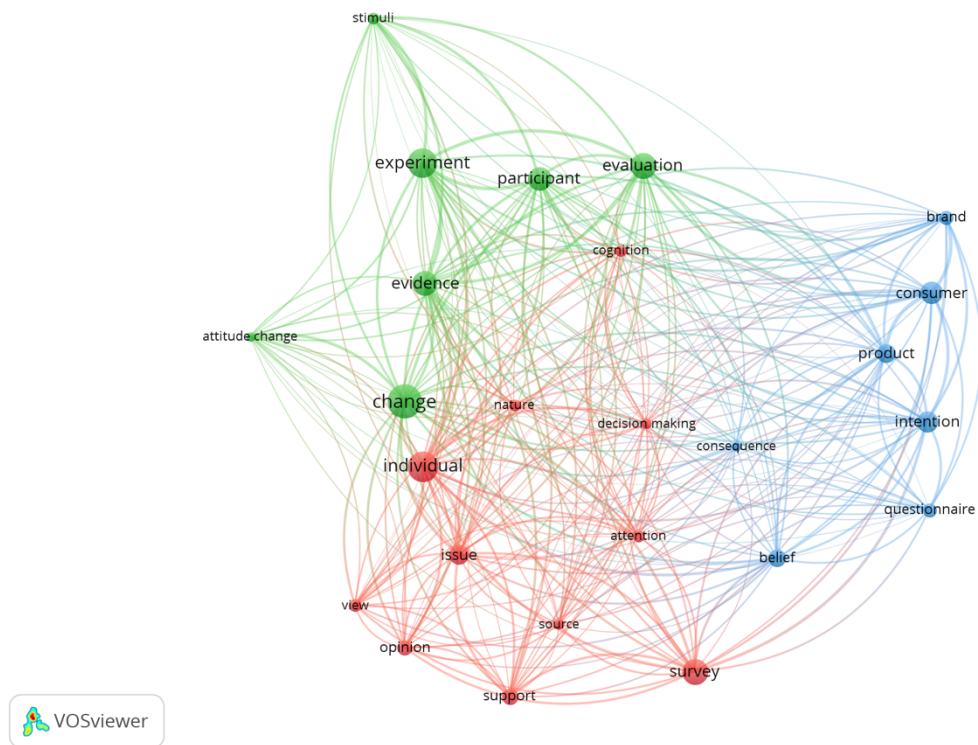


**Table 22***Top 50 keywords for TITLE-ABS-KEY("attitude formation")*

<b>KEYWORDS 1 - 25</b>	<b>FREQ</b>	<b>KEYWORDS 26 - 50</b>	<b>FREQ</b>
Attitude Formation	181	Attitude Change	23
Human	162	Middle Aged	22
Attitude	147	Psychological Aspect	21
Article	125	United States	21
Humans	105	Consumer Behavior	20
Female	102	Priority Journal	20
Male	93	Awareness	19
Adult	84	Major Clinical Study	19
Attitudes	81	Behavioral Research	18
Decision Making	40	Communication	18
Cognition	34	Motivation	18
Perception	34	Social Behavior	18
Adolescent	32	Attitude Of Health Personnel	17
Learning	31	Emotion	17
Attitude To Health	30	Information Processing	17
Controlled Study	29	Consumer Attitude	16
Public Attitude	28	Aged	15
Public Opinion	28	Emotions	15
Questionnaire	28	Advertising	14
Young Adult	28	Behavior	14
Evaluative Conditioning	27	Marketing	14
Psychology	27	Methodology	14
Education	26	Persuasion	14
Human Experiment	26	Structural Equation Modelling	14
Affect	23	Student	14

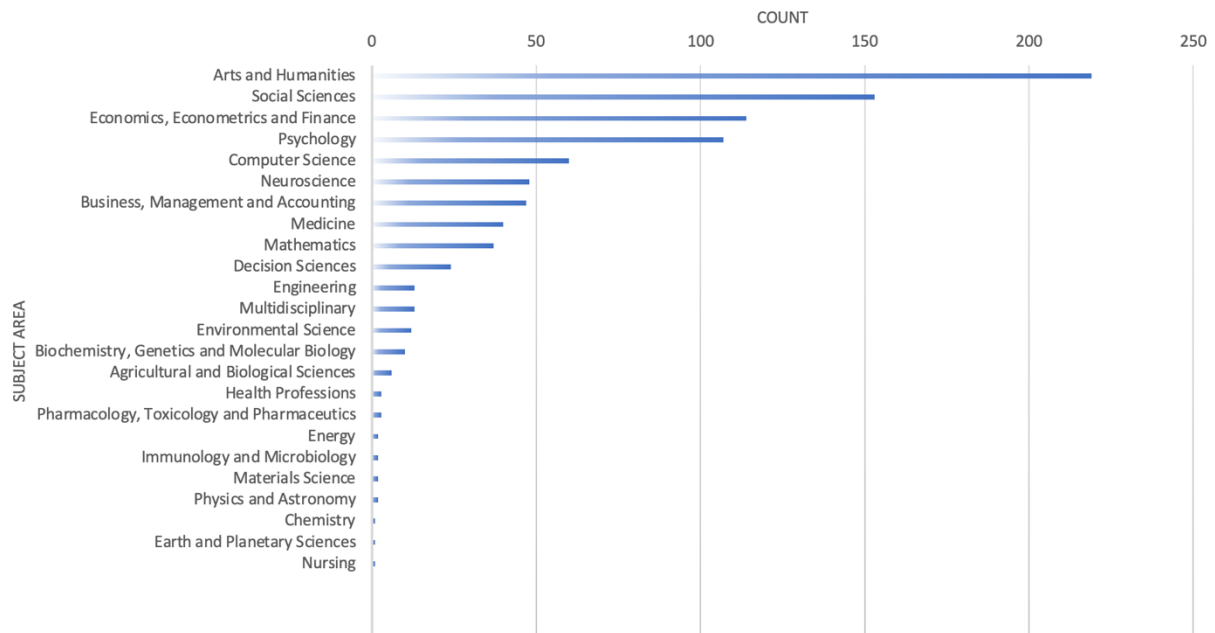
**Figure 13**

*Terms co-occurrence network visualisation from VOSViewer for the attitude formation*



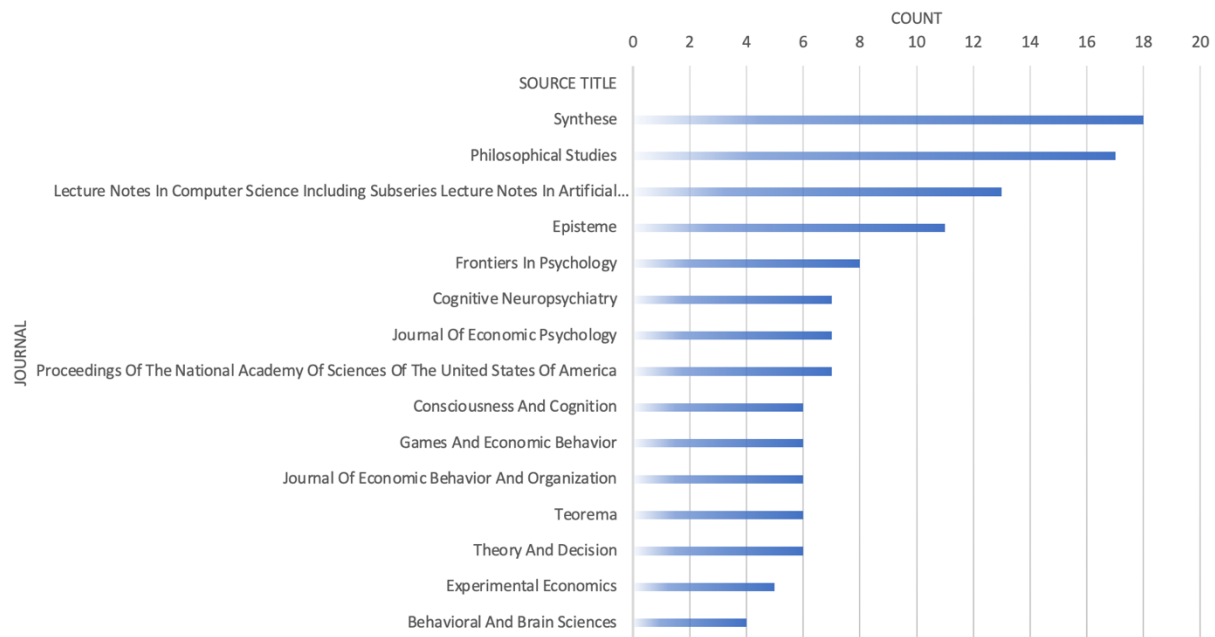
**Figure 14**

*Frequency of Subject areas for items returned by TITLE-ABS-KEY("belief formation")*



**Figure 15**

*Frequency of Journals for items returned by TITLE-ABS-KEY("belief formation")*



**Table 23***Top 50 keywords for TITLE-ABS-KEY("belief formation")*

<b>KEYWORDS 1 - 25</b>	<b>FREQ</b>	<b>KEYWORDS 26 - 50</b>	<b>FREQ</b>
Human	88	Psychosis	15
Belief Formation	86	Review	15
Humans	74	Young Adult	15
Article	58	Thinking	13
Male	43	Attention	12
Female	42	Human Experiment	12
Adult	38	Climate Change	11
Delusion	38	Cultural Anthropology	11
Cognition	36	Judgment	11
Decision Making	31	Self-deception	11
Belief	29	Clinical Article	10
Learning	29	Neuropsychology	10
Delusions	27	Probability	10
Beliefs	26	Religion	10
Schizophrenia	23	Schizophrenic Psychology	10
Priority Journal	22	Adolescent	9
Controlled Study	18	Bias	9
Physiology	18	Magnetic Resonance Imaging	9
Culture	17	Task Performance	9
Knowledge	17	Uncertainty	9
Perception	16	Child	8
Psychology	16	Cognitive Neuropsychiatry	8
Rationality	16	Communication	8
Epistemology	15	Depression	8
Motivation	15	Doxastic Voluntarism	8

**Figure 16**

*Terms co-occurrence network visualisation from VOSViewer for the belief formation*

