

Frames in thought and Schema development: hidden sources of stability and change via frame content

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Abstract

This study leverage two longitudinal experiments visualizing the influence of news-media frames in political issues on frames in thought of individuals. Using the highly salient political issue of schooling and the emerging issue of antimicrobial resistance, I reveal both classic framing effects, using unstructured data, suggest and show mechanisms integrating new considerations into existing frames in thought through changes in frame content. The analysis exploit open-ended responses, through natural language processing, fielded in experimental designs simulating various media consumption modalities such as repetition of exposure, frame shift, choice influence, and sentiment of the stimulus—thereby enhancing external validity and robustness of effects. Mechanisms are theoretically grounded in schema theory and considered as a process of media-effects, focusing on weight of frame content and lexical variation through accommodation and assimilation of information. Methodologically, this approach challenges several common assumptions and relax entrenched statistical restrictions. The results advance our understanding of framing in particular and are of value when considering media effects in general, additionally hidden dynamics and effects speak to the minimal-effects debate by uncovering otherwise obscured gradual change processes via influence of media frames.

Dissertation context

Aim

The overarching aim of my dissertation (Media Effects in Motion: Temporal Processes and Contextual Dynamics in Political Communication) is to enhance our understanding of how dynamic processes shape news media effects on citizens' political perceptions and behaviors within evolving media environments. This involves integrating three key dimensions: the temporal evolution and variation of media content (supply side), the stability and change in citizens' media consumption repertoires (demand side), and the cognitive mechanisms through which individuals process, interpret, and adapt to media influence over time. By emphasizing the interaction between these dimensions, the thesis seeks to contribute a comprehensive and process-oriented perspective on media effects in political communication. The Dissertation is part of the ERC project VARME, Varieties of Media effects.

Research Questions

To systematically approach this aim, the research is guided by the following central research question:

Main Research Question:

How do dynamic processes shape media effects on citizens' political perceptions and behaviors in evolving media environments?

To comprehensively address this question, the thesis investigates several interconnected dimensions, articulated through four integrated sub-questions:

1. **Dynamics of News Consumption:**
How stable or dynamic are citizens' news consumption repertoires over time, and which cognitive factors—such as news interest and media trust—influence the stability or transformation of these repertoires?
2. **Dynamics of Media Frames:**
How can the dynamic interactions and variations among media frames be effectively captured, modeled, and analyzed using computational methods, and how do these frames compete and evolve within changing communicative contexts?
3. **Dynamics of Issue Perception Formation:**
How do media effects, particularly attribute agenda-setting, initially shape and subsequently evolve citizens' perceptions over time, and how do initial media influences interact dynamically with citizens' pre-existing cognitive schemas?
4. **Dynamics of Cognitive Framing Processes:**
How do cognitive processes, specifically assimilation and accommodation, mediate the influence of framing effects, and under what conditions do these processes result in sustained changes in political perceptions and evaluations?

Each sub-question corresponds to distinct empirical investigations, which collectively provide insights into the interplay between news media dynamics, cognitive schema processes, and individual-level media effects:

- **Paper 1** examines stability and change in news consumption patterns, challenging notions of habitual news use and identifying the demographic and cognitive foundations of stable media repertoires.
- **Paper 2** explores the conditional and longitudinal structural dynamics of news framing, clarifying how frames develop and interact through both emphasis and equivalency perspectives, thus laying the groundwork for understanding media effects over time.
- **Paper 3** combines the dynamics of news media salience with individual perception formation in a longitudinal panel study, illuminating how media-driven salience interacts dynamically with cognitive schema formation.
- **Paper 4** experimentally tests the cognitive mechanisms underlying framing effects, specifically assimilation and accommodation, identifying causal processes and conditions that facilitate enduring changes in political cognition and issue perceptions.

Introduction

How can we capture significant, dynamic and gradual change processes over time in media effects? Changes in our perceptions of the world (Lippmann, 1922) potentially develop gradually and dynamically through our everyday interactions with and exposure to news media. We know that how political issues are covered through media effects influences our perceptions and interpretations of them (McCombs & Valenzuela, 2021; Lecheler & de Vreese, 2018). Yet while effects can pull us in one or another direction, change can also be theorized in terms of low-order conceptual content of meaning, alongside rank-order developments of categorical choice preferences, and additive considerations as expansion—aspects seldom considered and evaluated together as one process.

Such concerns brings us close to considerations of persuasion, framing effect, as activation and applicability effect. Effect of a frame, frame content change and persuasive effects (Eagly & Chaiken, 1993; Petty & Cacioppo, 1986; Zaller, 1992). This area of media effects has undergone a maturing process for some time, with both theoretical arguments and empirical models are steadily developing, where attribute agenda setting, framing, and persuasion can seemingly relate to and be qualified on longitudinal dynamics of media effects (see f.i. Shehata, et. al., 2021). Theoretical arguments on gradual change processes and media effects as mechanistic processes in particular aid in separation of otherwise often overlapping arguments.

For instance, this is directly related to another debate: the frame as a concept—the what and how of variation. As we move beyond variations of static attributes of issues (Agenda setting) or emphasis framing (when restricted to prevalence) to gradual, detailed changes and influences, focus naturally turns to the content of frames as a necessary source when considering the equivalence aspect of framing. While emphasis framing (Lecheler & de Vreese, 2019; Sheaffer, 2007) considers the attributes of issue objects highlighted or downplayed in media communications (Entman, 1993, 2004) as one aspect, arguments emphasizing applicability (Cacciatore et al., 2016) instead consider the equivalency aspect of framing (Hameleers & Boukes, 2022; Kahneman & Tversky, 2013). One guide to this debate can be found in the separation of what varies or how it varies—a summary repeatedly stated and effective in structuring the debate (Cacciatore & Iyengar, 2016; Druckman, 2001; Scheufele, 2004). Rather than taking a strong stance for one or another position, or relationship to attribute-level agenda-setting (McCombs, 2005), I consider the potential of a dual process (Lecheler & de Vreese, 2019) related to Framing as changes in weights of consideration (Druckman 2001). To fully consider framing, I argue a need in relating to the what and how of frames, framing effects, and effects of frames (Lecheler & de Vreese, 2019). Although theorized in several ways (Scheufele, 2004; Slothuus, 2008), the influence of frame content in this way has not resulted in prominent or convincing empirical testing, certainly not in parallel to an applicability consideration or one theoretically grounded mechanism describing the process.

Building on these debates and arguments, it is evident that a deeper examination of the psychological mechanisms linking frame content to cognitive schemas is necessary. This approach shifts the focus from solely considering issue attributes emphasized in media communications to understanding how frames can actively reshape or integrate new information within individuals' mental models. By exploring this interaction, there is potential to address the shortcomings in empirical testing and move towards a more comprehensive, theoretically grounded model of framing effects. Such a model would not only consider the what and how of frames but also provide a

nuanced understanding of how, when, and why framing influences occur at the cognitive level, potentially bridging gaps between existing theory and empirical evidence.

While change in, or integration of, information in mental schemas—as increasing complexity or understanding of an issue—has long been discussed as part of a framing effect (Price et al., 1997; Valkenburg et al., 1999; Shah et al., 2004), it has hardly been at the center of considerations. Rather, focus has remained on a classic framing effect, based on a matching logic, as transferring additional weight to an existing accessible attribute or consideration as applicability (Nelson et al., 1997, p. 225; Price & Tewksbury, 1997). And while influential models of dual influence of a framing effect have been significantly clarified (Lecheler & de Vreese, 2019), convincing support of a fully integrated model and theoretically grounded process has yet to materialize. Also, when a theoretical focus on recipients' cognitions via belief content change alone has been put forth (Lecheler, 2010; Shah et al., 2004; Slothuus, 2008; Lecheler & de Vreese, 2012), the empirical basis has remained limited, at least when considering the wealth of potential theoretically derived detail and expectations (Fiske & Taylor, 1991; Crocker, Fiske, & Taylor, 1984; Scheufele, 2004).

Grounding the process of change in frame content—as change of mental schemas via either a matching logic close to applicability arguments—allows us to understand the framing effect as an assimilation mechanism from schema theory. However, we are also aided in explaining the opposite: change that is subsumed in the frame or belief in the minds of individuals, yet does not change the attributes we use in our understanding of the issue object but carries influence through the makeup of the attribute and issue themselves. This is accommodation of information, which changes the meaning of attributes as frame content changes (Fiske & Linville, 1980; Hastie, 1981; Rumelhart & Ortony, 1978; Taylor & Crocker, 1981; Crocker, Fiske, & Taylor, 1984). Previous movements in this direction (Scheufele, 2004; Shehata et al., 2021; Slothuus, 2008) suggested several potential mechanisms, yet did not coherently and stringently focus on a limited set of mechanisms within one effect literature.

The two experiments explore recipient cognition and assess news framing effects via applicability as matching logic, concurrently with the contents of frames in thought as change processes in response to incongruent information or additive considerations. While focused on framing effects and effects of frames, the aim includes a generic contribution to research on gradual change processes in media effects. Following in the footsteps of others (Matthes, 2008; Scheufele, 2004; Shehata et al., 2021) who utilize a schema perspective on media effects while borrowing from persuasion effects (Eagly & Chaiken, 1993; Petty & Cacioppo, 1986; Zaller, 1992), I allow for considerations of an underlying process of framing, clarifying and qualifying classical framing effects of influence by weight (Druckman 2001, see also 2007a; 2007b).

While still primarily considering the theoretical underpinnings of the framing effect and gradual change via frame content, the experimental designs and analytical approach lend rare increased validity and robustness to results, covering commonly theoretically requested features: open-ended items (Scheufele, 2004); longitudinality (Leeper & Slothuus, 2018); repetition and frame-shift (Lecheler & de Vreese, 2013); sentiment (Vishwanath, 2009; Lecheler, Keer, Hänggli, & Schuck, 2015); **choice** (); and domain/obtrusiveness variation (de Vreese, 2004b). Theoretically necessitated, this study further makes a distinct methodological contribution by relaxing key modeling assumptions

(Eisenstein, 2011; Roberts et al., 2014, 2016b), including longitudinal and stimulus biased measurement equality, required to reveal detailed lexical longitudinal change while concurrently maintaining valid estimates of established framing effects via applicability as weight-change (Nelson et al., 1997; Price & Tewksbury, 1997) in one fully integrated Bayesian model.

1 Framing and frame content

While individuals may consciously report their attitudes and beliefs as their perceptions of the world, additional subconscious processes are likely active and ongoing without their awareness. One foundational aspect of media effects is schematic transformation, which can be argued forms the basis for framing, agenda-setting, and other individual-level opinion processes. Building on this foundation, this study considers dynamic longitudinal media effects from a cognitive schema perspective situated within framing theory.

To theoretically conceptualize framing, I integrate mechanisms of parallel weight and content processes (Lecheler, & De Vreese 2019), encompassing both applicability and frame content, and accounting for changes in equivalency and emphasis. Specifically, the mechanism of assimilation and accommodation seeks equilibrium between internal considerations and external stimuli. Change can thus be theorized through, rank-order changes of preference, additive considerations as accommodation or change in conceptual content of meaning as assimilation. Moving beyond research of singular classification and rank-ordering, framing as a theory of media effects needs to be conceptualized as a process model. Rather than focusing solely on inputs and outcomes, (Scheufele, 1999).

There is a pressing need for a statistically integrated operationalization to facilitate inference regarding estimations of covariances and the competitiveness of framing environments (Chong & Druckman, 2007a). Reliable estimation has been hindered by the separation of data-generating processes, limiting conclusions to post-hoc comparisons. Secondly, the crucial distinction between emphasis- and presentation-based variations of frames (Cacciatore et al., 2016) remains largely **unaddressed(citation explicitly comparing 2022?)**. While partially explored in experimental designs (Chong & Druckman, 2007b, 2007c; Leeper & Slothuus, 2015), presentation effects occurring concurrently with emphasis have largely been overlooked in computational frame analysis, likely due to limitations within statistical models.

A similar concern, **highlighted by Chong and Druckman (2007a) and Leeper and Slothuus (2015), revolves around the presentation and variation of frames based on a cohesive perspective. Previous restricted operationalizations, often due to imposed measurement invariance or limitations in modeling, impose central assumptions** of construct stationarity, thereby constraining concept and theory testing.

Addressing these gaps, this study further consider contextual hypotheses structuring the framing effect. First sentiment differences between treated groups. As negativity bias increases likelihood of framing (Lecheler, Keer, Hänggli, & Schuck, 2015; Bizer, Larsen, & Petty, 2011; Soroka, 2006; Vishwanath, 2009). As does salience of issues (de Vreese, 2004b), and repetition (Lecheler & de

Vreese, 2013).

- *Hypothesis 1: Negatively framed stimuli increases framing effects.*
- *Hypothesis 2: Low salient issues are more susceptible to framing effects*
- *Hypothesis 3: Repeated treatment increase the Framing effect*

1.1 Change by Schema mechanisms

Schemas are mental frameworks stored in memory that help individuals organize and interpret information, specifying the defining features and attributes of a stimulus domain (Fiske & Linville, 1980; Hastie, 1981; Rumelhart & Ortony, 1978; Taylor & Crocker, 1981). When new information from news media frames is encountered, it can be congruent or incongruent with existing schemas. Congruent information fits within current schemas, requiring minimal cognitive adjustment—a matching and applicability logic described in framing theory. Incongruent information challenges schema validity, prompting cognitive adaptation (Crocker, Fiske, & Taylor, 1984; Scheufele, 2004). This occurs as media emphasize or downplay issue aspects (emphasis framing; Lecheler & de Vreese, 2018; second-level agenda setting; McCombs, 2021) or present logically similar information differently (prospect theory; Kahneman & Tversky, 2013; Hameleers & Boukes, 2022), with nuanced lexical variations (Cacciatore et al., 2016). These processes align with the concepts of assimilation and accommodation from Piaget (Flavell, 1963; Inhelder & Piaget, 1958), similar to constructs in news media framing effects (Shehata et al., 2021).

Assimilation involves integrating new information into existing schemas without altering them, reinterpreting information to fit preexisting beliefs (Rumelhart & Ortony, 1978; Taylor & Crocker, 1981). Accommodation instead modifies schemas to incorporate incongruent information, requiring significant cognitive effort and potentially altering fundamental schema aspects (Fiske & Linville, 1980; Hastie, 1981; Crocker, Fiske, & Taylor, 1984). Due to cognitive biases and resource limitations, assimilation is the default response (Crocker, Fiske, & Taylor, 1984). However, substantial or persistent incongruent information may lead to accommodation, resulting in changes in frames in thought and frame content.

Understanding these processes is critical in news media framing, where framing effects influence the importance individuals assign to issue aspects (Entman, 1993). I therefore join in suggestions that framing effects can be better understood through schema theory (Lecheler & de Vreese, 2019; Slothuus, 2008; Scheufele, 2004).

Considering accommodation and assimilation in schema change provides valuable insights into how hidden frame content affects public opinion, stability, and change in response to media frames. It highlights how frame content can reinforce existing schemas through assimilation or prompt schema change through accommodation. By directly integrating schema theory with framing effects research, we gain a nuanced understanding of media influence at the cognitive level, bridging theoretical gaps as dynamic lexical changes in thought determine when respective media effect processes apply.

Leading to the following theoretical Hypotheses.

- *Hypothesis 4: Framing can act via change in Frame content*
- *Hypothesis 5: Frames are stronger via a baseline matching logic as assimilation of information*
- *Hypothesis 6: Frames can influence via incongruent frame content as accommodation of information*

2 Method

There has for a time been a noticeable trend of using topic modeling to fully or partly model Frames in content. This trend is evident both within the communication literature (Kwon et al., 2019; Nicholls & Culpepper, 2021; Walter & Ophir, 2019a, 2019b) and in disciplines external to communications (Field et al., 2018; Gilardi et al., 2020; Hajdinjak et al., 2020; Heidenreich et al., 2019; Jo & You, 2019). Since the mid-2010s, there has been a notable intensification in the application of and debate surrounding the potential of topic modeling for this task (Van Atteveldt et al., 2014, Nicholls & Culpepper, 2021). Most often the original latent Dirichlet allocation (LDA) topic model by Blei et al. (2003), has been either used alone (DiMaggio et al., 2013; Heidenreich et al., 2019; Maier et al., 2018; Pashakhin, 2016) or in conjunction with other methodologies (Walter & Ophir, 2019a, 2019b, Guo et al., 2022, Eisele 2023), although alternative or extended topic models have also been employed (Field et al., 2018; Gilardi et al., 2020; Hajdinjak et al., 2020; Jo & You, 2019; Klebanov et al., 2008; Kwon et al., 2019; Nguyen et al., 2013; Nicholls & Culpepper, 2021; Roberts et al., 2016, 2019). While operationalizations often directly treat topics as frames, sometimes with vague arguments, applications of topic modeling in communication suffer due to various reasons, some recently addressed in the literature (Chen et al., 2023). Critiques of topic modeling have often correctly criticized the more common approaches, yet in doing so missed manifest best practices as well as occasionally missed important conclusions (Eisele et al., 2023, Hase et al., 2020), such as the significance of input data scale, highlighted by Nicholls & Culpepper "The question then is not whether computational methods can inductively derive frames, but on what kinds of input data are they likely to be successful: scale matters." (2021). It is recommended to employ domain- or issue-specific corpora with a certain narrowness to yield more cohesive and interpretable emphasis frames (DiMaggio et al., 2013; Nicholls & Culpepper, 2021), thus avoiding conflating frames with issues in modeling results. Typically, topic modeling identifies frame compositions and relationships, but limitations in methodology often restrict the depiction of these relationships, affecting conceptual fit, robustness, and validity of applications.

The existing literature acknowledges the utility of topic modeling in identifying issue-specific emphasis frames, as frames in content, although consensus on implementation remains (Boumans & Trilling, 2016; Günter & Quandt, 2016; Hase et al., 2020; Jacobi et al., 2016; Maier, 2018; Nicholls & Culpepper, 2021; Walter & Ophir, 2019a, 2019b). Compared to adjacent fields, communication studies have underutilized recent advances in topic modeling specifically for framing (Field et al., 2018; Gilardi et al., 2020; Hajdinjak et al., 2020; Jo & You, 2019; Roberts et al., 2014, 2016).

2.1 Case

The experiments were performed in Sweden covering first, the somewhat obscure, Antimicrobial resistance, and second, the salient and familiar issue of schooling. Anti microbial resistance though a

potential increasing political issue was at the time firmly placed at the outskirts of consideration. Worth mentioning is that the first experiment took place during December 2020 through early February 2021, at the time just before Covid-19 epidemic spread past china, before heightened media attention and low global confirmed deaths. In the case of Sweden issue salience had not yet materialized as measured by news-media coverage (estimated via prevalence of topical news articles) or public interest (estimated via google search terms). The second experiment instead took place firmly after the Covid-19 pandemic initial and second peak during the summer 2023, covering the issue of schooling. This issue is firmly placed as one of the most salient political issues, and with an added focus in the context of Sweden due to its unique statues, now globally, with a deregulated secondary schooling system (high-school) with open access to private actors. Additionally Sweden has long enjoyed a top position of international scoring of school systems, though in 2016 saw a steep drop, causing concern and international coverage, locally it is still a highly politicized issue.

2.2 Design and sample

Experiment 1 included three waves the first being a base measure without stimulus, fielded, Thursday December 3, 2020, Monday January 25, 2021 and Thursday February 4, 2021. AAPOR RR5: 48,3%, 75,2%, 70,4% Net Participation Rate:51.6%, 77.8%, 73.1%, 2126, 1618 and 1505 respondents respective of wave made complete responses.

The sample where of high quality probability recruited respondents pre-stratified by age, sex, and education, age frame was 18-80, 25 individual time-use outliers cleared from data.

Experiment 2 also included three waves the first being a base measure without stimulus, fielded, Thursday June 29, 2023, Wednesday August 23, 2023, and Monday September 4, 2023. AAPOR RR5: 48,3%, 75,2%, 70,4% Net Participation Rate:59%, 74%, 81%, 2862, 2148 and 1912 respondents made responses covering at least 80% of the items.

The sample where non probability recruited respondents pre-stratified by age, sex, and education, age frame was 18-85.

Both experiments where fielded by The SOM Institute and Laboratory of Opinion Research (LORE), university based research organization as well as a national infrastructure for survey data, managing the oldest cross-sectional, and largest panel datasets in Sweden on public opinion.

2.3 Measures

Both experiments employ open-items and resulting unstructured data for all analysis, constructed survey scales where included for demographic data, and experiment 2 included some constructed survey scales on the school issue answerable in all experimental conditions.

The item in experiment 1 was of a thought listing passive design. Loosely translated; *"When you think about how antibiotic resistance affects society, what do you think? will be the biggest problem going forward?"* And respondents could opt out by choosing *"I have no idea how antibiotic resistance*

affects society” avoiding increased error due to the low saliency of the AMR issue.

The item in experiment 2 was a guided design, directing the respondent to **answer within a problem-set**. Loosely translated; *”What do you think is the biggest problem in Swedish schools today?”* Respondents could opt out by choosing *”I see no problems in Swedish schools.”*

2.4 Analytical approach

2.4.1 Experimental design

In both cases the experiments are longitudinal with a base measure, which uses the open item without stimulus. In experiment one the second wave has three groups, control and two groups with stimulus material, either emphasizing the Public Health or Economic Considerations of the Antimicrobial resistance (AMR) issue. In a third wave those groups that received stimulus are split in either, no stimulus (one shot) repeated same stimulus, or frame-shift, receiving the opposite stimulus material (material at wave three is not identical in anything but issue and intended frame, see the supplemental appendix). Experiment 2 instead has a baseline followed by a design with either control, a positive or a negative angled stimulus, while the main communicative content of the stimulus is the same, it has a positive or negative take, this design is also repeated in wave three. In addition to just receiving one of the designed stimulus or control another group are given the option to actively choose a positive or negative article (choice-condition).

Together these many contextual aspects of the experiments, speak to the oft-criticized lack of valid external validity in experimental designs from a structural standpoint, **as the mode of news-media consumption allows for multiple context within which we consume news and are subject to framed content.**

2.4.2 Model selection

The choice of model (and data) in topic modeling can significantly block variance of interest, depending on central differences in the generative process that constructs topics. For example, the original topic model, Latent Dirichlet Allocation (LDA) (Blei et al., 2003), should be approached with caution due to a limitation in its core specification, which assumes full independence among topics drawn from a Dirichlet distribution. This limitation, highlighted in the general methodological literature, leads to increased sensitivity to parameterization, risk of overfitting, and an inability to identify highly correlated topics as underlined by the originators of the model themselves (Blei & Lafferty, 2006; Jo et al., 2007).

Beyond general issues of reliability, variations in the generative processes of topic models are specifically applicable to the framing literature, as frames can be expected to correlate with each other, not being fully independent (Chong & Druckman, 2007b; Entman, 1991). In the case of LDA, the inability to model correlation would then work against a capability to identify and correctly separate such frames. Still, LDA is used often, although in light of its weakness, it was promptly complimented in the correlational topic model (CTM), again by the originators of LDA themselves

(Blei & Lafferty, 2006, 2007).

Expanding beyond the identification of individual attributes, to encompass the framing environment and variation by covariates, the Structural Topic Modeling (STM) framework (Roberts et al., 2013) utilize the adaptable nature of Bayesian specification. In previous applications of topic modeling and framing environments, separate data-generating processes (DGP) were required to anchor topics and elements of common interest, such as news outlets or time, **in detached statistical processes, such as post hoc regression on LDA output.** These limitations compromise precision in inference and certainty estimations, potentially yielding questionable results. To address such fundamental sources of uncertainty, STM employs Dirichlet Multinomial Regression (DMR) (Mimno & McCallum, 2008), incorporating covariates of interest into the same generative process.

In tackling the issue of additional theoretical dimensions of variance, I employ the STM framework and configure its core generative process using Sparse Additive Generative Models of Text (SAGE) (Eisenstein et al., 2011), as opposed to the standard CTM specification. The incorporation of sparse terms enables the detection of variations previously obscured by the statistical assumptions of other models. SAGE effectively constructs attributes composed of deviating terms (words) from an issue-specific baseline, identified as a background distribution of terms determined by the specific issue corpus. This approach differs from conventional topic modeling, where topics are typically dense compositions of unique term distributions governed by a Dirichlet distribution in LDA or a logistic normal in CTM. In SAGE, a topic represents a distribution over deviations from a corpus-determined background distribution of words. Unlike LDA and CTM, where topics are distributions over words, SAGE focuses on significant deviations, thereby addressing issues of overfitting and promoting sparsity. It is the added sparsity which facilitates the identification of additional variations at a third level, as a variations along a content covariate, such as experimental condition over time (Roberts et al., 2013, 2016). Allowing for modeling of frames shifting across time and experimental condition in one data generating process, as frame content lexical changes, which enable robust results with increased precision, and valid estimations of error. Answering questions on changing discourse, longitudinally and across conditions via lexical developments. Specifically the co-occurrence matrices generated by the SAGE model can be examined for incremental variances of each topic(emphasis-frame/attribute) not just in estimations of prevalence(STM) but also in lexical expression(SAGE) in relations to covariates, also assisted by use of further dimensionality reduction/visualization techniques. Such as; t-SNE, PCA, or Clustering of the generated lexical matrices.

Speaking for this model selection, previous arguments have underscored two key measures of model fit using established benchmark datasets. Firstly, results indicate that measures of held-out likelihood are comparable across the models under consideration. Secondly, it is observed that SAGE outperforms LDA in terms of perplexity (Eisenstein et al., 2011; Roberts et al., 2016b). Additionally, incorporating covariates through STM specification yields measurable improvements in related aspects, as demonstrated in prior research (Roberts et al., 2016a), while the internal coherence of topics is further found to be more robust and interpretable for SAGE (Eisenstein et al., 2011).

In summary, the core SAGE model allow for identification of potential frame content change across a content covariate that may be waves and/or interaction with experimental groups. This allow for

evaluation of potential assimilation and or accomodation effects parallel to a general rank-order effects, since experimental design and longitudinal collection are able to relax the common assumption of attribute lexical make-up across these covariates showing incremental development.

2.4.3 Model implementation

In addition to the selection of the core model, defining the initiation procedure is critical, as initial starting values significantly influence the optimization of the posterior distribution and consequently affect final model outcomes. Careful optimization of this initiation phase helps mitigate the risk of the model converging to local rather than global maxima. Typically, candidate models are selected from a large set of converged solutions based on specific criteria, a common practice in existing literature. However, both the choice of selection criteria and the number of candidate models considered can vary significantly. This paper employs an alternative model selection method designed to ensure global consistency and deterministic, replicable results, drawing on methodological advances in model initiation (Arora et al., 2013; Roberts et al., 2016).

Another crucial consideration involves tuning the hyperparameters that control model convergence. Robust model implementation requires combining multiple evaluation metrics, including measures of density, distance, perplexity, internal fit, and construct validity (Cao & Juan, 2009; Griffiths & Steyvers, 2004; Airolidi & Bischof, 2016; Bischof & Airolidi, 2012). Although assessing global fit through these measures is essential for overall robustness, it is equally important to separately evaluate internal cohesion and fit for individual attributes/topics. Thus, candidate model evaluation involves not only a holistic appraisal but also detailed scrutiny of each topic, including visualization of strong and weak attributes, stability, and attribute centrality to the focal issue.

Further details regarding specific estimations guiding model implementation are provided in the supplemental appendix. These details contribute to a consistent and replicable analytical framework, mitigating potential researcher biases during model selection and enhancing the validity of the resulting analyses.

3 Results

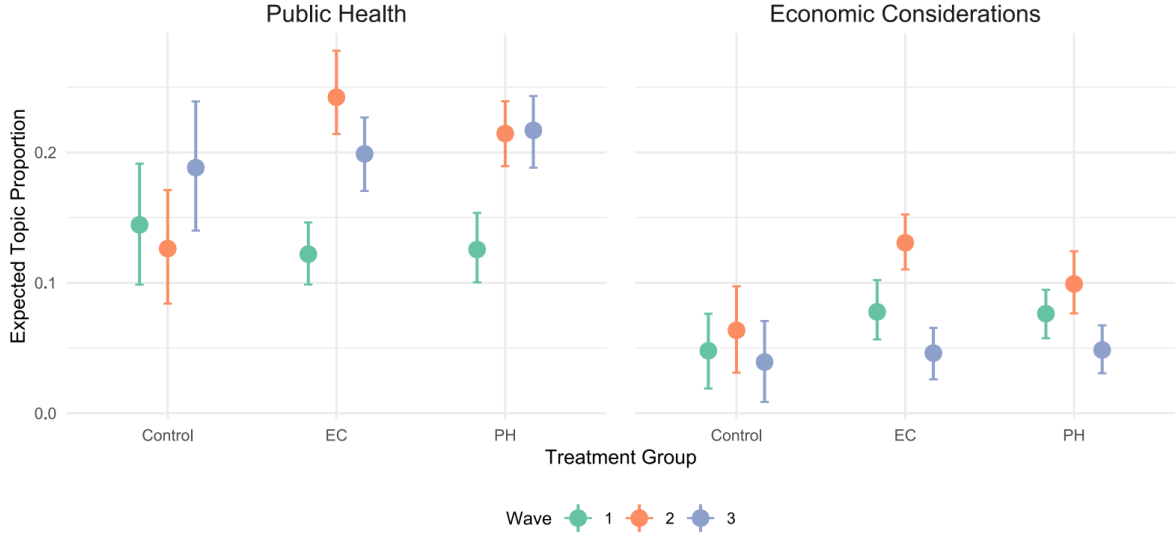
Results are separated by experiment, and rank-order point estimate measures, as well as the lexical properties by SAGE content covariate.

3.0.1 Experiment 1

First, I evaluated whether the experiment produced the anticipated framing effects—specifically, if respondents whose stimulus matched their pre-treatment baseline showed increased probabilities and proportions for the corresponding attributes. Figure 1 illustrates that, for the public health attribute, there was no significant longitudinal effect observed in the control group (respondents who neither received stimulus material nor initially indicated Public Health or Economic Considerations as their modal attribute). However, a clear positive effect emerged for respondents whose stimulus

matched their baseline: the Economic Considerations stimulus positively impacted the economic attribute, while the Public Health stimulus yielded a stable and positive effect for the public health attribute. Notably, even respondents receiving the Economic stimulus showed some spillover effects, likely due to the inherent relevance of public health to the AMR issue, regardless of framing angle. For the economic attribute, significant positive effects appeared only during the first wave among those receiving the matching Economic Considerations stimulus, with no effects observed for control or non-matching groups.

Figure 1: Experiment 1, AMR issue Pointestimate Wave by Treatment



Note. Integrated Dirichlet regression on SAGE model, treatment groups necessarily collapsed for power, EC=Economic considerations, PH=Public Health Confidence interval at 0.05. wave 1 is baseline condition with no stimulus

In table 1 the estimated top words related to each attribute/topic is shown. These are what are used to identify or label a attribute/topic as well as the most likely responses per attribute, each term is also representing a value and matrices of these can and will be analyzed further for instance as in Figure 3 in regard to weighted lexical distributions.

Table 1: Attribute Specification of Open Survey Measures, Experiment 1

	Public Health	Economic Considerations
Marginal Prob:	[healthcare, bacteria, burden, suffering, water, healthcare, society]	[may, countries, works, reduce, must, use, poor]
Marginal Frex:	[burden, healthcare, water, bacteria, healthcare, clean, suffering]	[countries, reduce, get, works, poor, use, must]
Marginal Lift:	[clean, load, water, healthcare, healthcare, germs, suffering]	[poor, countries, use, reduce, works, get, rich]
Marginal Score:	[healthcare, bacteria, burden, water, healthcare, clean, suffering]	[get, countries, works, reduce, use, must, poor]
Topic Kappa:	[clean, strain, water, healthcare, healthcare, bacteria, suffering]	[poor, countries, use, reduce, works, get, rich]
Kappa Baseline:	[healthcare, bacteria, load, suffering, water, healthcare, society]	[may, countries, works, reduce, must, use, poor]

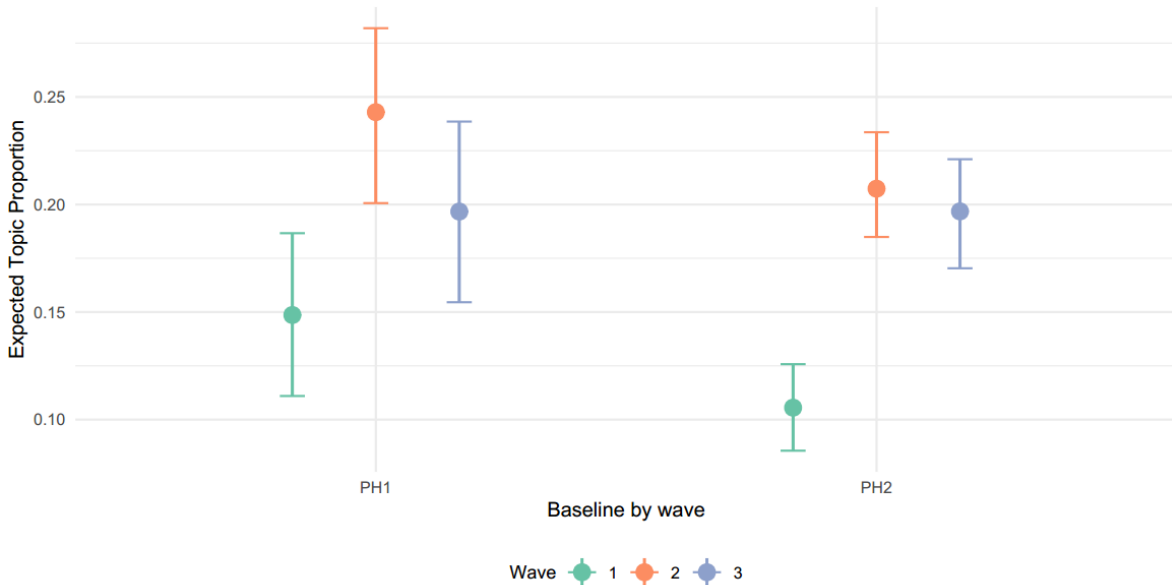
Note. Top terms by STM(SAGE) on open-item survey responses, stopwords have been dropped, plural and singular representation into one, loosely translated terms, FREX = Marginal frequency and exclusivity measure, Prob = Marginal probability, Score = Marginal conditional log probability with smoothing. From the SAGE specification, Topic kappa = and Kappa with baseline. FREX is the weighted harmonic mean of the word's rank in terms of exclusivity and frequency (Airoldi & Bischof, 2016; Bischof & Airoldi, 2012). EC considerations include differences between comparably wealthy and poor countries and effects of such contexts, including over-use of antibiotics.

Interpretations of these findings suggest that AMR, being a low-salience issue, allowed any stimulus to exert an effect, particularly evident due to the differential centrality of attributes to the issue. Public Health, closely linked to AMR, naturally attracted more responses. It is also important to note the stable effects observed during the third wave despite a mixed stimulus design (frame shift, repeated, or no stimulus). This stability underscores the lasting influence of initial framing effects (Druckman et al. 2012; Matthes & Schemer, 2012). Conversely, the economic attribute showed clearer attenuation by the third wave, with no significant effects when the stimuli varied considerably.

3.0.2 Experiment 1, Hypothesis testing

Given the limited power of Experiment 1 and the complexity introduced by interactions between baseline, wave, and experimental groups, several analytical limitations arose. However, supportive evidence for Hypothesis 5 emerged from the results. Figure 2 shows that respondents whose baseline attribute matched the stimulus consistently exhibited significant increases in their modal response proportions after receiving the stimulus, especially for the public health attributes (PH1 and PH2, differing slightly by modeling results). These results indicate that alignment between pre-existing cognitive schemas and stimulus content strengthened subsequent framing effects.

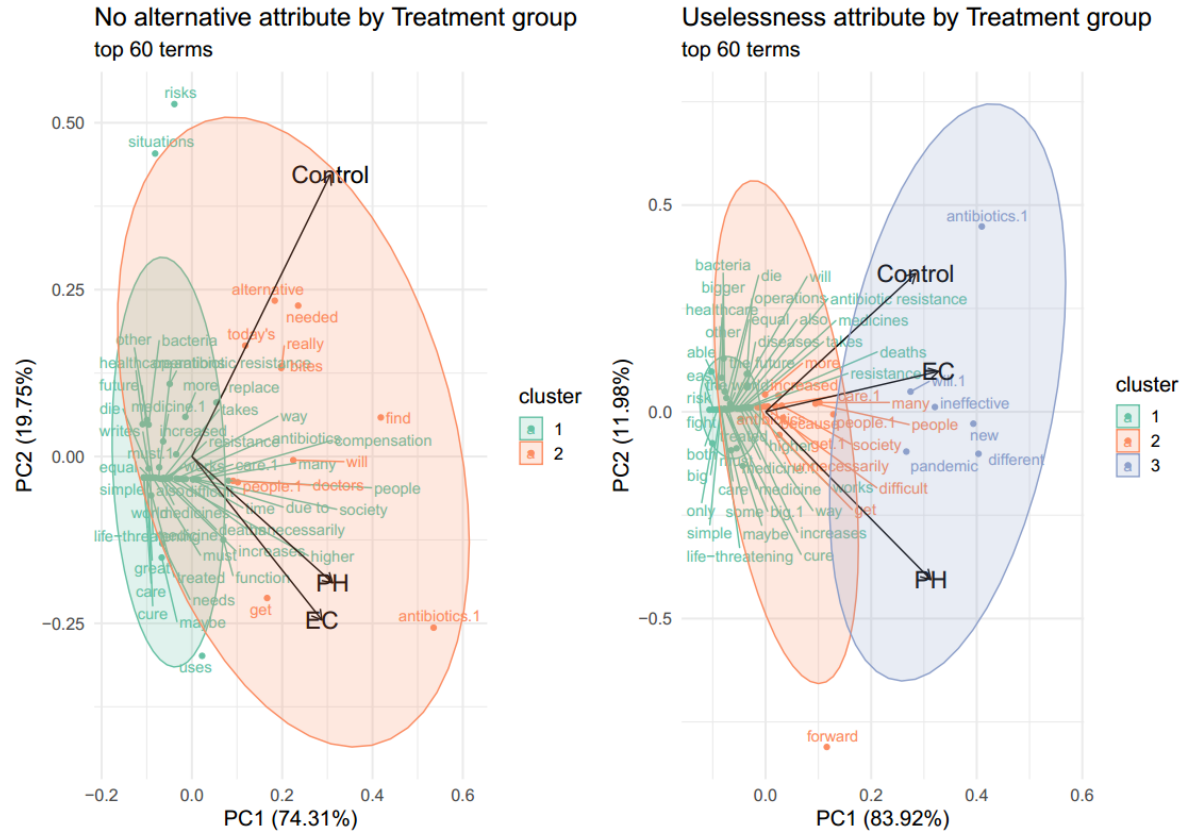
Figure 2: Experiment 1 AMR issue SAGE-deviation by Baseline By wave On Public Health attribute



Note. Integrated Dirichlet regression on SAGE model, all topics, Confidence interval at 0.05. Full model results By baseline in teh supplemental appendix

of accommodation processes.

Figure 4: Experiment 1, AMR issue SAGE-deviation by Treatment: Accommodation



Note. Treatment as SAGE content covariate, deviations from baseline distributions, treatment groups necessarily collapsed for power, visualization of lexical matrices using clustering via partition around medoids (PAM), selection via within cluster sum of squares, gap-statistics, silhouette, and PCA selection via, Eigenvalues, Optimal coordinates and acceleration factor. Loose translation from Swedish to English, numbers after terms equal doubles in translation, different Swedish terms translating to the same English term

3.0.3 Experiment 2

In Experiment 2, though the issue (schooling) was more salient, the stimulus material was not explicitly matched to specific attributes. Instead, the experimental design emphasized positive versus negative stimuli relating broadly to equality in schooling contexts. Moreover, part of the experimental group had the option to choose between positive or negative news, simulating contemporary media consumption behavior.

The analysis focused primarily on two attributes significantly responsive to experimental stimuli: "Differences & Conditions" and "Private Interest & Resources". These attributes closely reflect ongoing political and media debates in Sweden, particularly regarding increased school differentiation and the role of private interests.

Also should be noted a part of the experimental group had the choice option to prefer positive or negative news, simulating some of the different modes of online news consumption in a mixed media context of today.

Attributes demonstrating significant effects—either individually from baseline through wave 2 to wave 3 or across experimental conditions (control, positive stimulus, negative stimulus)—were primarily "Differences & Conditions" and "Private Interest & Resources." These attributes closely align with the Swedish educational context, mirroring recent political and media discussions emphasizing the increased differentiation of school quality and the unique role of private interests in secondary education.

The "Differences & Conditions" attribute exhibited significantly stronger stimulus effects over time, with negative stimuli having the most pronounced impact. This finding supports contextual Hypothesis 1, which posits that negative stimuli are typically more influential. Additionally, the stable yet meaningful effect observed in the control group indicates the inherent salience of the schooling issue. These results also provide nuanced support for contextual Hypothesis 2, suggesting that highly salient issues encourage more complex and stable cognitive frames, making them relatively resistant to alteration from single instances of framing.

Table 2: Experiment 2, Attribute Specification of Open Survey Measures

	Private Interest & Resources Terms
Marginal Highest Prob:	[skolan, ska, barn, kommer, bara, får, skola, finns, andra, elever, vill, få, in, helt, göra]
Marginal FREX:	[rektorn, son, rektor, ali, skolan, bråk, skolledningen, eleverna, föräldrarna, bor, ord, föräldrar, skolor, skolans, gå]
Marginal Lift:	[atypisk, behandlingsmetod, attackerats, aspergerdåre, björkskolan, bergsåker, amatörpsykolog, andledning, 4chans, #detvareninvandrare, desvärre, disponerar, dsm, dss, evidensbaserad]
Marginal Score:	[skolan, ali, rektorn, rektor, son, bråk, skåp, vargen, eva, skola, bamse, grupperingar, elever, skolledningen, hamilton]
Topic Kappa:	[förfaller, fostrat, byar, förstörelsen, urminnes, verkställa, brevlåda, kvällstid, föregående, oförsämd, fråntar, härvan, lagstadgad, otal, regelmässigt]
Kappa with Baseline:	[skolan, ska, andra, skola, svenska, få, elever, in]

Note. Top terms by STM(SAGE) on open-item survey responses, stopwords have been dropped, plural and singular representation into one, loosely translated terms, FREX = Marginal frequency and exclusivity measure, Prob = Marginal probability, Score = Marginal conditional log probability with smoothing. From the SAGE specification, Topic kappa = and Kappa with baseline. FREX is the weighted harmonic mean of the word's rank in terms of exclusivity and frequency (Airoldi & Bischof, 2016; Bischof & Airoldi, 2012). Loose translation from Swedish to English.

Table 3: Experiment 2, Attribute Specification of Open Survey Measures

	Differences & Conditions Terms	Private Interest & Resources Terms
Marginal Highest Prob:	[students, schools, different, independent schools, difference, low-achieving, increasing]	[the school, resources, conditions, profits, the schools, pass, tax money]
Marginal FREX:	[low-performing, independent schools, students, schools, the difference, for-profit, high-performing]	[profits, conditions, resources, the school, tax money, the municipalities, manage]
Marginal Lift:	[school community company, teacher, breathing exercise, morning, routines, yoga, designed]	[the municipalities, resources, conditions, profits, tax money, the school, experts]
Marginal Score:	[students, schools, different, independent schools, low-performing, difference, for-profit]	[the school, resources, profits, conditions, tax money, copes, the municipalities]
Topic Kappa:	[special, independent schools, for-profit, municipal, schools, students, various]	[the municipalities, profits, the school, conditions, tax money, resources, cope]
Kappa with Baseline:	[students, schools, independent schools, diverse, for-profit, municipal, the difference]	[the school, resources, profits, conditions, copes, the municipalities, tax money]

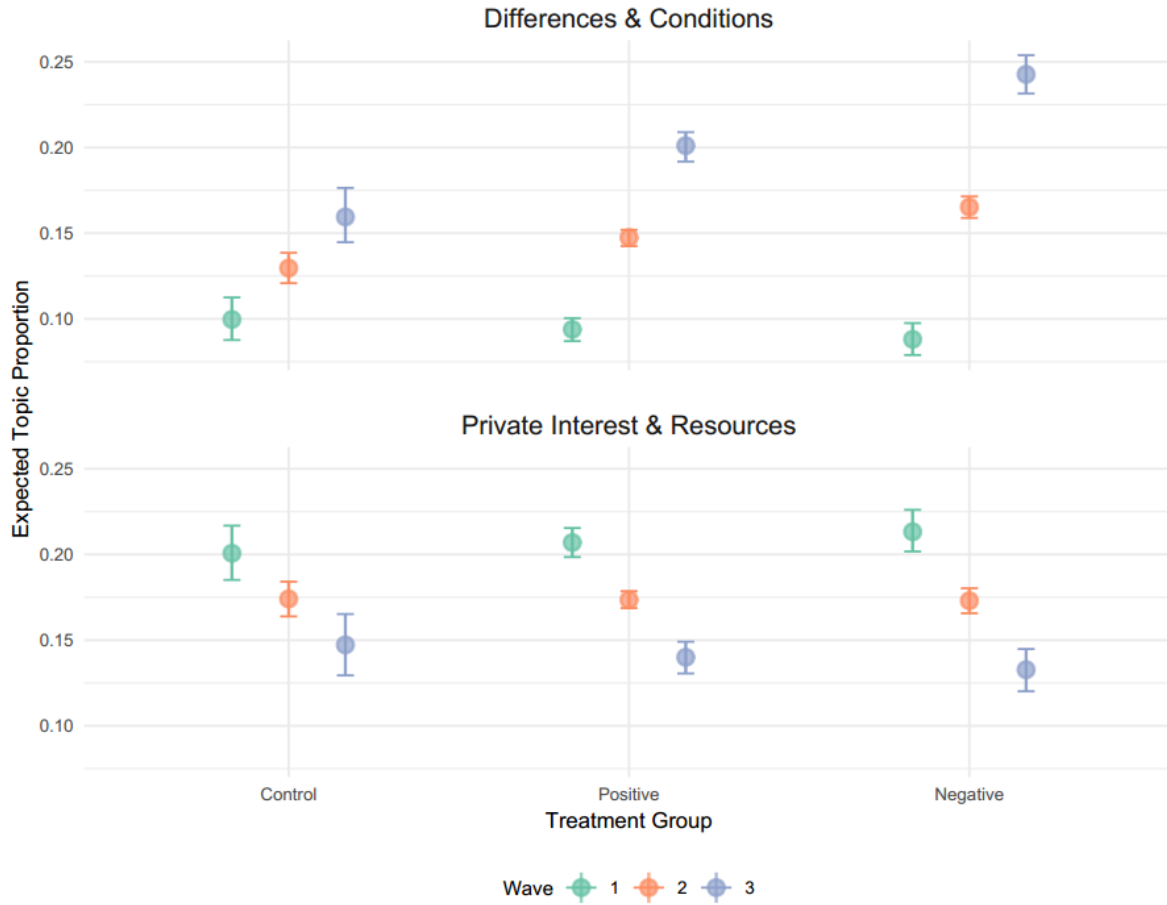
Note. Top terms by STM(SAGE) on open-item survey responses, stopwords have been dropped, plural and singular representation into one, loosely translated terms, FREX = Marginal frequency and exclusivity measure, Prob = Marginal probability, Score = Marginal conditional log probability with smoothing. From the SAGE specification, Topic kappa = and Kappa with baseline. FREX is the weighted harmonic mean of the word’s rank in terms of exclusivity and frequency (Airoldi & Bischof, 2016; Bischof & Airoldi, 2012). Loose translation from Swedish to English

3.0.4 Experiment 2, Hypothesis testing

Examining the matching logic hypothesis (Hypothesis 5) further, Figure 6 demonstrates that responses concerning ”Differences & Conditions” varied significantly only when participants received a positive stimulus aligned with their baseline attribute, indicating that congruence between stimulus positivity and baseline predispositions amplified framing effects. Conversely, the ”Private Interest & Resources” attribute showed no significant changes when baseline and subsequent waves matched, irrespective of stimulus condition. However, significant negative shifts occurred if the respondents’ baseline differed from subsequent waves and they experienced negative or no stimulus, while positive stimuli helped maintain baseline stability. This pattern underscores how attribute-stimulus matching critically shapes the direction and strength of framing effects.

Further analyzing ”Differences & Conditions,” results revealed cumulative stimulus effects over time, with increasingly significant outcomes across waves and experimental conditions. Interestingly, merely considering the highly salient schooling issue without direct stimulus (control condition) already produced stable longitudinal effects. Positive stimuli further increased this influence, and negative stimuli showed the strongest impact, reinforcing contextual Hypothesis 1 regarding the greater impact of negative frames. One plausible interpretation is that the high salience of the issue enabled participants to readily access complex cognitive frames, activated simply by responding to related survey items. In contrast, low-salience issues might be more susceptible to strong framing effects due to their less-developed cognitive structures, aligning with contextual Hypothesis 2 that low-salience issues are more easily influenced by frame content and salience shifts.

Figure 5: Experiment 2, School issue Pointestimate Wave by Treatment, main effects



Note. Integrated Dirichlet regression on SAGE model, all topics, Confidence interval at 0.05.

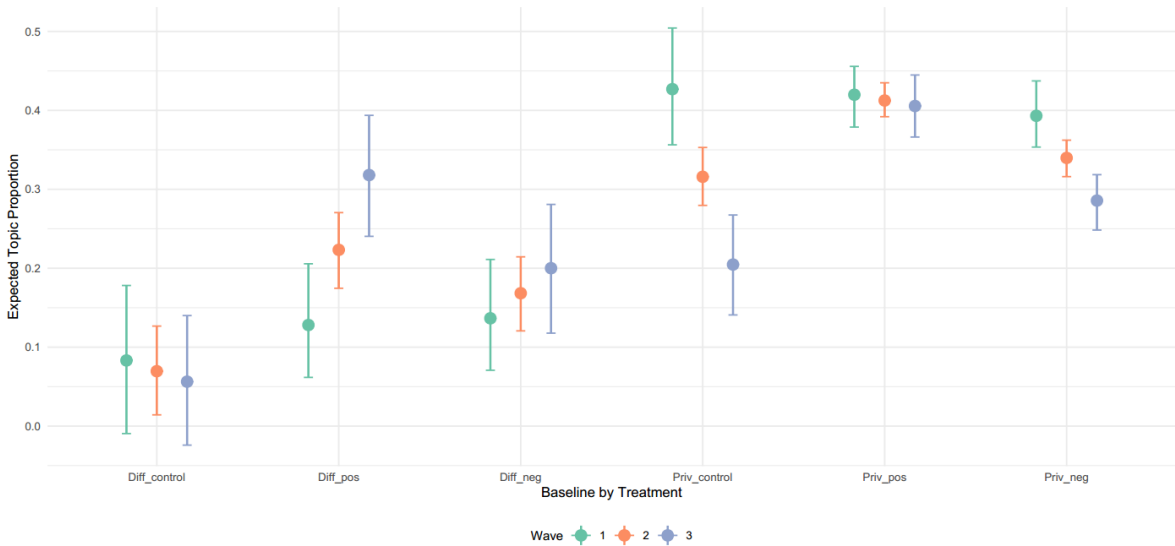
Moving on to the central hypothesis regarding the nature of framing effects, I examine whether framing occurs primarily when there is a "matching logic"—that is, when an individual's existing cognitive frame aligns with the presented media frame, enabling content assimilation without significant barriers. While the experimental design here does not explicitly establish a clear attribute-matching scenario, it is feasible to examine potential framing effects by closely analyzing attributes related to the stimulus content. Specifically, the stimulus addressed attributes concerning differentiation and changes within the schooling context. It is important to note, however, that these attributes are not traditionally seen as constitutive elements of the schooling issue object, adding complexity to the interpretation of the results.

To evaluate this frame-matching logic hypothesis, I considered how baseline modal attributes ("Differences & Conditions" and "Private Interest") influenced responses to stimuli, as illustrated in Figure 6. Results indicated no significant change for respondents whose modal baseline matched the tested attribute and who received no stimulus. Conversely, respondents with a matching baseline who received positive stimuli showed a significant increase in attribute expression from baseline to wave 3, while those receiving negative stimuli showed no significant change. This pattern suggests that the "Differences & Conditions" attribute may inherently align with a positive frame, and thus, a

matching positive stimulus successfully reinforced the attribute, consistent with Hypothesis 5.

Further examining the second significant attribute, "Private Interest & Resources," revealed nuanced effects based on baseline matches. When respondents' modal baseline did not align with the tested attribute, responses showed a significant decrease from baseline to wave 3 under both control and negative stimulus conditions. However, a positive stimulus maintained stable relationships, even with non-matching baselines. This suggests that positive framing stabilized respondents' pre-existing considerations, while negative or no stimuli gradually diminished attention toward the "Private Interest" attribute. In essence, these results imply that simply engaging with the issue of schooling longitudinally (without reinforcement through positive stimuli) tended to shift respondents away from emphasizing private interests.

Figure 6: Experiment 2, Pointestimate Wave by Treatment, by baseline ON Differences & Conditions attribute

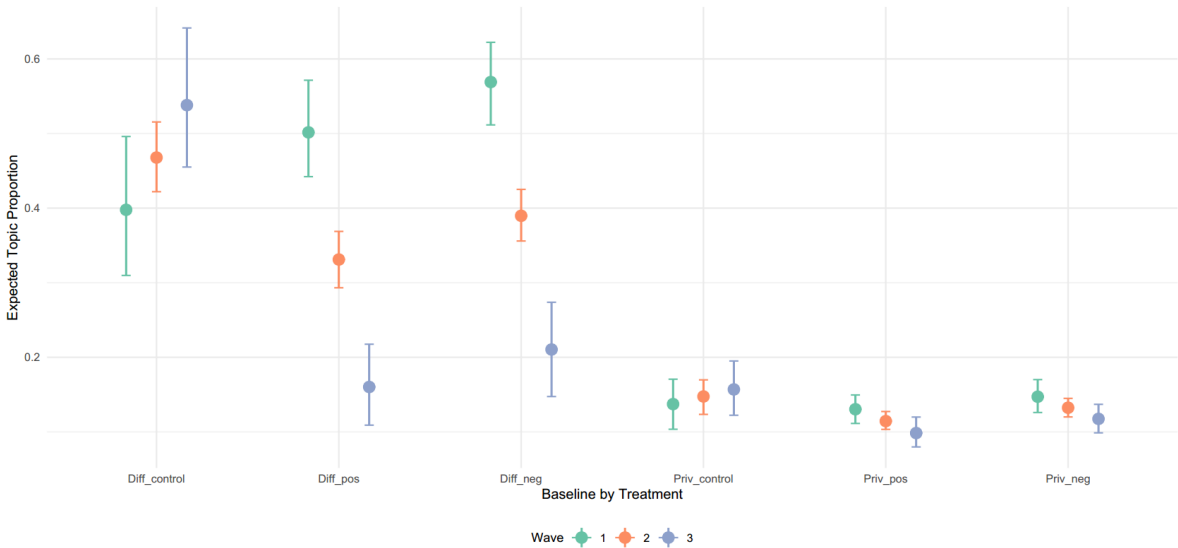


Note. Integrated Dirichlet regression on SAGE model, all topics, Confidence interval at 0.05. Full model results By baseline in the supplemental appendix

Regarding the "Private Interest & Resources" attribute, no significant differences were observed when respondents' modal attribute at wave 1 remained consistent across subsequent waves, regardless of stimulus condition. These individuals generally exhibited stable responses over time. Full baseline results, including all modal combinations, are available in the supplemental appendix. Overall, wave 1 modal baselines showed no statistically significant relationships—aside from one minor outlier. Notably, only respondents whose baseline was "Differences & Conditions" and who received either positive or negative stimuli demonstrated significant change over time. In these cases, successive stimuli gradually shifted respondents away from their original, non-matching baseline toward the attribute emphasized by the stimulus. One interpretation of this pattern is that the stimulus material did not centrally focus on private interests. Instead, it more closely resembled horse-race journalism, emphasizing trends and comparisons—aligning more closely with the "Differences & Conditions" attribute. No significant differences emerged between stimulus groups; all showed a general decline in the expected probability of selecting the "Private Interest & Resources"

attribute over time, suggesting an overarching stimulus effect.

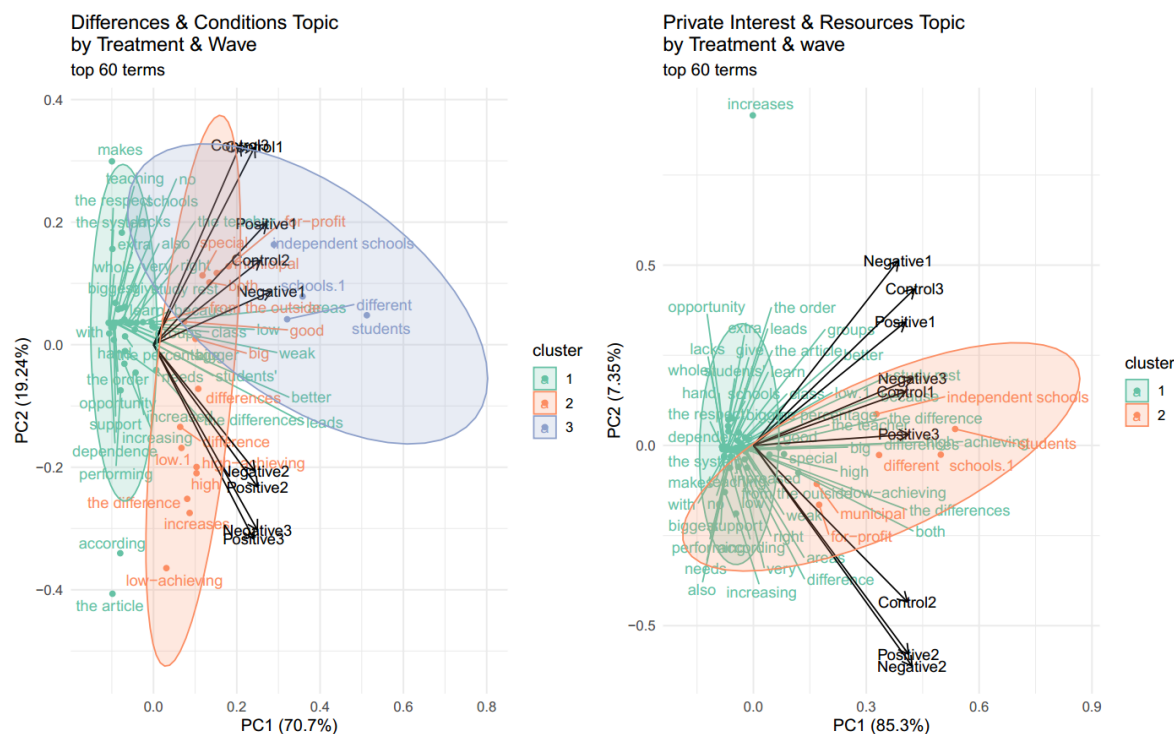
Figure 7: Experiment 2, Pointestimate Wave by Treatment, by baseline ON Private Interest & Resources



Note. Integrated Dirichlet regression on SAGE model, all topics, Confidence interval at 0.05. Full model results By baseline in teh supplemental appendix

In the following figure, the attribute associated with differentiation—closely aligned with both the positive and negative stimulus materials—exhibited potential assimilation effects. All four post-stimulus groups displayed distinct lexical structures in how they expressed this attribute, indicating that the framing material had a shaping influence. In contrast, the second attribute showed a distinct wave effect, with wave 2 responses diverging from other waves, including the control group. This wave-specific shift warrants further investigation, potentially through content analysis of the corresponding time frame.

Figure 8: Experiment 2, School issue SAGE-deviation by Treatment potential Assimilation



Note. Treatment as SAGE content covariate, deviations from baseline distributions, visualization of lexical matrices using clustering via partition around medoids (PAM), selection via within cluster sum of squares, gap-statistics, silhouette, and PCA selection via, Eigenvalues, Optimal coordinates and acceleration factor. Loose translation from Swedish to English, numbers after terms equal doubles in translation, different Swedish terms translating to the same English term

Potential accommodation effects were also observed in Experiment 2—similar to findings in Experiment 1, though under fewer experimental constraints. Three issue attributes showed signs of lexical or conceptual change following exposure. These preliminary results suggest four positive accommodation effects, which will be further elaborated through dimensionality reduction and robustness analyses. Such as on the Marginal FREX Matrices (Airoldi & Bischof, 2016; Bischof & Airoldi, 2012) and Kappa metrics calculated with and without baseline conditioning.

3.1 Contextual effects

The analysis considered several potentially strong contextual effects, each grounded in distinct theoretical mechanisms and reflecting diverse modalities of media use more aligned with today’s fragmented media environment (van Aelst et al., 2017). In Experiment 1, treatment conditions at wave two followed a baseline measurement and included either direct stimulus, control, or one of two treatment texts. By wave three, participants were randomly assigned to one of three groups: repetition, no stimulus, or frame-shift. Due to statistical power constraints, the analysis collapsed these into a single category, thereby making the identification of effects at this stage especially demanding. Nevertheless, several significant effects were observed at wave three, suggesting possible lasting impacts of the initial treatment on a low-salience issue—supporting Hypothesis 2.

Experiment 2 instead involved a highly salient issue and applied a more indirect treatment and

measurement design. Notably, it included a choice condition: of the 6655 responses, 53 percent came from participants who could choose which article to read beforehand. While further analysis of this component is ongoing, the setup provides increased ecological validity by reflecting contemporary media consumption behavior, where individuals often select news content in line with their preferences.

3.2 Effect by rank-order changes

Figure 1 (Experiment 1) illustrates the expected treatment effects. Interestingly, the economic stimulus also influenced the competing attribute, public health. This crossover effect is plausible, as public health is a central attribute of the AMR issue, making it likely to register some response regardless of the framing emphasis. The enduring effect seen in the matching public health condition, even at wave three, suggests a lasting influence. Given the low salience of the issue, the rank-order effects may be attributed to respondents re-evaluating their previously rated attribute importance. In contrast, the economic matching condition showed a significant effect only after the initial stimulus, with the effect diminishing thereafter—likely due to the economic angle being less intrinsically tied to the issue.

In Experiment 2, significant longitudinal and between-group treatment effects were found for the attribute emphasizing differences and inequality in the school system (see Figure 5). Other attributes remained largely stable, except for the "Private Interest and Conditions" attribute, which showed a slight but significant decrease in importance over time.

To test the hypothesis that framing effects are contingent upon a match between the frame in thought and the frame in content (Hypothesis 5), a baseline approach was employed. Figure 2 (Experiment 1) shows significant effects only for respondents whose baseline was public health and who received matching stimulus. These respondents showed increased alignment with the public health attribute following treatment, whereas no such pattern was evident for other baseline groups (see also Figure 9 in the supplemental appendix).

However, due to limited statistical power in Experiment 1, it was not possible to include interactions with the treatment group variable. In Experiment 2, although the treatment was not directly aligned with a specific attribute constitutive of the schooling issue, the attribute most affected—differences/inequality—was conceptually close to the stimulus. Figure 6 confirms this: significant increases were observed from baseline to wave three under the positive stimulus, providing support against Hypothesis 1's negativity bias assumption and reinforcing Hypothesis 5 regarding the importance of baseline alignment.

Also in Figure 6, another longitudinally changing attribute exhibited a stable relationship with the differences attribute under the positive treatment, while negative and control conditions showed a significant decline. This suggests that the positive treatment preserved respondents' pre-existing framing, aligning with—but also refining—Hypothesis 1.

3.3 Effect by Frame content changes

As a foundational mechanism in framing theory, Hypothesis 4 posits that stimulus exposure should result in changes in the lexical composition of reported attributes, reflecting shifts in underlying cognitive schemas. Although previous research often focuses on rank-order change alone, this study simultaneously evaluates both rank-order and content-level variation, enabling the identification of both assimilation and accommodation mechanisms in response to stimulus exposure.

3.4 Effect by Schema assimilation

To assess assimilation effects, baseline matching was analyzed in conjunction with treatment exposure. In Experiment 1, Figure 3 reveals significant differences in the lexical structure of attributes depending on whether the stimulus aligned with the respondent’s baseline attribute. These differences were consistent even across the complex wave three design and despite added noise from baseline measurement. Although the design did not permit wave interaction, the persistence of effects indicates a robust assimilation process.

In Experiment 2, Figure 8 further supports Hypothesis 5. Respondents who received stimuli aligned with the “Differences” attribute showed consistent lexical divergence across waves, suggesting assimilation. In contrast, a second, longitudinally changing attribute displayed a distinct wave effect, particularly separating wave two from other conditions—an area requiring further content analysis for full interpretation.

3.5 Effect by Schema accommodation

Accommodation effects—where the meaning of a given attribute changes while the label remains constant—offer deeper insight into framing dynamics. In Experiment 1, Figure 4 shows two attributes within the AMR issue exhibiting clear signs of accommodation. Even though they were not the focus of the stimulus, lexical expression of these attributes shifted following treatment, suggesting that meaning was adapted post-stimulus. These findings emerged despite a crude covariate structure, indicating robust effects.

Experiment 3 presented three additional signs of accommodation, particularly concerning attributes like discipline, authority, and teacher shortages in the school issue. While more detailed analysis is forthcoming, initial visualizations suggest longitudinal and treatment-based variation, aligning with Hypothesis 6.

4 Conclusion

Political issues evolve over time through public debate and media contestation, with competing frames shaping how these issues are understood. This study examined the influence of both timing and frame content on individual interpretations of such issues. The results support several well-established theories while also advancing the literature by uncovering underexplored mechanisms—particularly those tied to frame content and individual-level schema shifts. Theoretical

mechanisms were not only identified but also empirically traced through the results, paving the way for new research questions and approaches.

Although further analysis and theoretical refinement are needed, this work offers promising evidence of framing effects as dynamic processes, shaped by both media context and cognitive response. These findings contribute to a growing body of literature that views media effects not as static outcomes but as part of an ongoing, interpretive interaction between individuals and the evolving media landscape.

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6 Supplemental appendix

6.1 Experiment 1

6.1.1 Summary statistics

Table 4: Summary Statistics for Experiment 1 DFM by Wave

Corpus	N	Mean Terms/Document	Trimmed Mean	Std. Dev.	Min	Max
Total	2053	5.466634	4.627511	5.172133	1	78
Wave 1	688	6.245640	5.163043	6.302594	1	78
Wave 2	715	5.279720	4.523560	4.926072	1	56
Wave 3	650	4.847692	4.219231	3.843214	1	35

Note. Data is presented post minor preprocessing stages. Trimmed means are robust estimators of central tendency dropping top and bottom 10 percent, excluding systematic outliers.

6.1.2 Stimulus article 1 wave 2 Public Health

More and more people are dying from resistant bacteria worldwide. The overuse of antibiotics is having severe consequences for public health, with infections potentially becoming as common a cause of death as cancer. The growing problem of bacteria that few antibiotics can effectively combat is becoming increasingly acute. The UN warns that in 30 years, millions of people could die each year from infections that cannot be treated.

"Infections are becoming a more common cause of death than cancer globally," says Christina Åhrén, a researcher in antibiotic resistance. For more than 70 years, antibiotics have been used to cure infections caused by bacteria.

However, what was once humanity's miracle medicine has been overused and applied unnecessarily.

By 2050, as many as ten million people may die each year worldwide from infections that are no longer treatable, according to a 2019 UN report. It's important to note that this report accounts for all types of resistance, including resistant forms of HIV and malaria. Christina Åhrén, a doctor at Sahlgrenska University Hospital, studies antibiotic resistance and states that it is difficult to provide an exact figure for annual deaths caused by bacterial infections.

However, she estimates that in 30 years, this number could reach millions.

Currently, every year, two million people worldwide become ill from antibiotic-resistant bacteria. Åhrén believes that the issue of resistant bacteria will not resolve itself. "It will become more common to die from a bacterial infection than from cancer or cardiovascular diseases. This situation is undeniably worrying. We don't know the exact rate of increase, but once it begins to rise significantly, it usually escalates quickly," she says.

The UN urges world leaders to act, emphasizing that solutions to combat antibiotic resistance must involve the entire community. Åhrén also believes that antibiotic use must be reduced on a global scale, as resistant bacteria spread rapidly when people travel and trade goods. "There are significant consequences for public health at stake. The most crucial factor is ensuring that people have access to clean water, as resistant bacteria spread through contaminated water. Additionally, healthcare systems in developing countries need improved conditions for proper treatment and to maintain good healthcare hygiene," Åhrén emphasizes.

Note. Loosely translated from Swedish

6.1.3 Stimulus article 3, wave 3 Public Health

Urinary tract infections can become life-threatening as antibiotic resistance increases in Sweden.

The overuse of antibiotics poses a significant threat to public health in Sweden, as common infections become increasingly difficult to treat.

There is a rising number of cases of resistant bacteria being discovered among the Swedish population. These bacteria are becoming resistant to a growing variety of antibiotics, which can lead to severe infections. "For example, we are observing that the prophylactic antibiotics administered during certain surgical procedures are not as effective as they once were," says Christina Åhrén, a researcher in antibiotic resistance. While Sweden is often highlighted as a pioneering country in the fight against antibiotic resistance, resistant bacteria do not recognize national borders. The global increase in antibiotic resistance allows bacteria to spread to Sweden.

Lack of effective treatment is becoming a significant concern. The Public Health Agency has warned in its 2019 annual report on the antibiotic situation that an increasing number of cases of highly resistant bacteria are being identified in

Sweden. One notable type is ESBL-CARBA, for which there is currently a lack of antibiotics that can effectively treat severe infections. The rise of resistant bacteria in Sweden is projected to continue, with forecasts indicating that the number of cases of multi-resistant bacteria reported to authorities will quadruple by 2050, reaching approximately 70,000 cases annually.

Christina Åhrén, a doctor at Sahlgrenska University Hospital, emphasizes that even the bacteria responsible for urinary tract infections and sepsis are becoming increasingly resistant to antibiotics. "These are the most common bacteria that cause our most frequent infections, and their growing resistance is concerning. What were once easily treatable infections can now become life-threatening," Åhrén warns.

Fast sampling and efficient monitoring are crucial in addressing this issue. Prompt detection of resistant bacteria can help reduce the risk of further spread. Although Sweden currently maintains a low level of antibiotic resistance compared to other countries, Åhrén stresses the need for close monitoring of the situation to mitigate the risks of increased morbidity and mortality. "Sweden has made significant progress in reducing antibiotic use, and it is vital that we continue this work. However, antibiotic resistance is a global issue that requires a collaborative solution among those in power," concludes Christina Åhrén.

Note. Loosely translated from Swedish

6.1.4 Stimulus article 2 wave 2 Economic Considerations

The costs of antibiotic resistance impact the global economy.

The overuse of antibiotics can have consequences for the world economy as significant as those experienced during the financial crisis of 2008 and 2009. The increasing prevalence of resistant bacteria is poised to have a major impact on the global economy. The UN warns that the costs could rival those of the previous financial crisis.

"This is an important eye-opener that illustrates the extent of the problem," says Christina Åhrén, a researcher in antibiotic resistance. For more than 70 years, antibiotics have been used to treat bacterial infections, but what was once humanity's miracle medicine has been overused and applied unnecessarily.

Reduced economic growth is a significant concern. When infections can no longer be treated effectively, the impact on the global economy will be substantial. The UN estimates in a 2019 report that by 2050, the costs associated with antibiotic resistance could be so immense that they would be comparable to the financial crisis of 2008 and 2009. This includes greatly increased healthcare costs and the fact that many countries currently use large amounts of antibiotics in food production, which is believed to decrease productivity as the effectiveness of antibiotics wanes. This situation could lead to increased unemployment and, subsequently, heightened poverty and inequality.

Christina Åhrén, a doctor at Sahlgrenska University Hospital, studies antibiotic resistance and believes that the report demonstrates how resistance not only escalates healthcare costs but also affects the entire social economy. "This results in a significant overall impact on society due to deteriorating food production, rising unemployment, and increasing illness. All of these factors cost money. In the past, decision-makers have failed to recognize the broader economic consequences of antibiotic resistance. Calculations and comparisons can help those in power understand the urgency of addressing this issue," Åhrén explains.

More research and strict regulations are essential. The UN emphasizes the need for increased research into new antibiotics and immediate measures to reduce their use. The report also notes that costs will be significantly lower if action is taken to combat antibiotic resistance now rather than waiting.

Åhrén believes that antibiotic use must be reduced on a global scale, as resistant bacteria spread rapidly through international travel and trade. "There are substantial economic stakes involved when antibiotics are used in food production across many countries. This problem must be prioritized at the political level so that decision-makers understand the economic consequences that antibiotic resistance can have," Åhrén concludes.

Note. Loosely translated from Swedish

6.1.5 Stimulus article 4 wave 3 Economic Considerations

Billions in costs await as antibiotic resistance increases in Sweden.

The overuse of antibiotics can result in billions of costs for the public economy in Sweden as common infections become increasingly difficult to treat.

The growing problem of antibiotic-resistant bacteria is projected to incur substantial costs for the Swedish economy.

"This is only the tip of the iceberg," says Christina Åhrén, a researcher in antibiotic resistance. Sweden is often recognized as a leading country in efforts to combat antibiotic resistance; however, resistant bacteria do not respect national borders. The global increase in antibiotic resistance is causing these bacteria to spread to Sweden as well. Close to 16 billion kronor is at stake. The number of cases involving resistant bacteria is rising in Sweden, leading to significant economic costs. Forecasts indicate that between 2018 and 2050, the costs associated with multi-resistant bacteria could total nearly SEK 16 billion. This estimate is based on a report from the Public Health Authority in

2017, which accounted for healthcare-related costs, such as longer hospital stays and increased resources for infection tracking.

However, antibiotic resistance also has broader economic implications. For instance, productivity is expected to decline as sickness absenteeism rises, with more individuals falling ill from infections that were previously easy to treat.

Christina Åhrén, a doctor at Sahlgrenska University Hospital, emphasizes that the forecasts have only considered multi-resistant bacteria that must be reported to authorities, representing only a fraction of the overall resistance problem. "In reality, the costs could be even higher. There is much more resistance that has not been included in these financial calculations," Åhrén states.

Early sampling and effective monitoring are crucial. There is a strong emphasis on the need for efficient monitoring and rapid sampling in the event of infections. This approach allows for the early detection of resistant bacteria, thereby reducing the risk of further spread. Although Sweden currently maintains a low level of antibiotic resistance compared to other countries, Åhrén stresses that decision-makers must recognize the economic impact of increased resistance. "It is important to conduct calculations and comparisons so that decision-makers understand the economic implications of antibiotic resistance. If we can overcome this resistance, we can reallocate funds to other areas of healthcare," concludes Christina Åhrén.

Note. Loosely translated from Swedish

6.1.6 Descriptive data

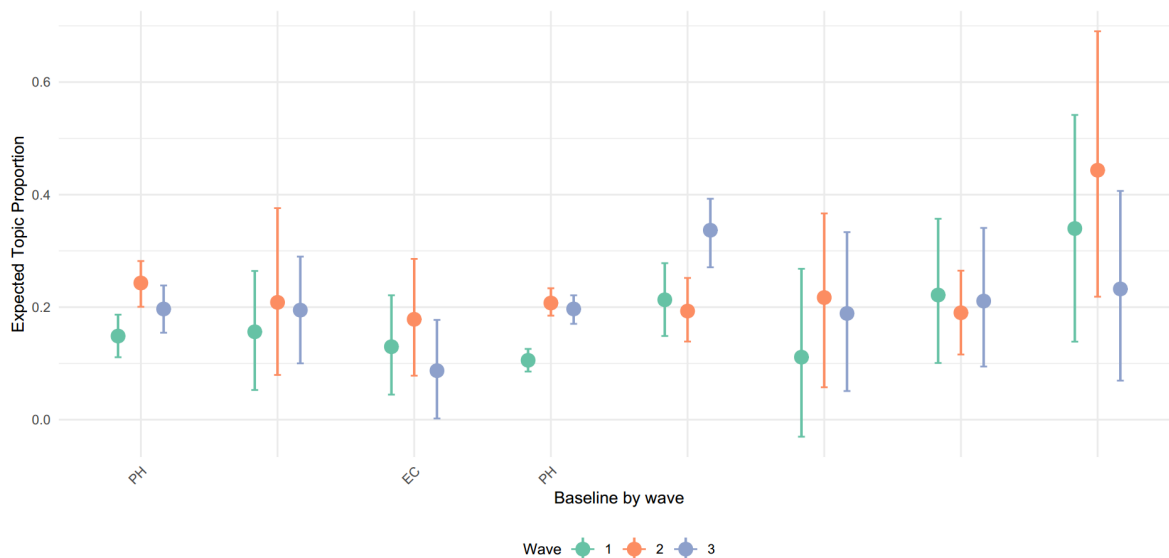
Table 5: Experiment 1, Non-Matching Attribute Specification of Open Survey Measures

	No Alternative	Uselessness
Marginal Highest Prob:	[antibiotic, find, get, needed, will, really, alternative]	[new, forward, antibiotic, different, ineffective, pandemic, coming]
Marginal FREX:	[find, alternative, antibiotic, really, needed, bite, get]	[new, different, forward, ineffective, pandemic, antibiotic, degree]
Marginal Lift:	[Situations, Alternatives, Widespread, Existing, Peas Eaters, Antibiotic Use, Excessive]	[new, pandemic, different, social, status, capture, variants]
Marginal Score:	[antibiotic, find, really, get, needed, alternative, bite]	[new, different, advanced, ineffective, antibiotics, pandemic, prerequisites]
Topic Kappa:	[find, really, alternative, today's, bites, uses, replaces]	[ineffective, different, pandemic, new, antibiotic]
Kappa with Baseline:	[find, antibiotics, really, alternative, bites, uses]	[different, new, ineffective, pandemic, antibiotic]

Note. Top terms by STM(SAGE) on open-item survey responses, stopwords have been dropped, plural and singular representation into one, loosely translated terms, FREX = Marginal frequency and exclusivity measure, Prob = Marginal probability, Score = Marginal conditional log probability with smoothing. From the SAGE specification, Topic kappa = and Kappa with baseline. FREX is the weighted harmonic mean of the word's rank in terms of exclusivity and frequency (Airoldi & Bischof, 2016; Bischof & Airoldi, 2012). Loose translation from Swedish to English.

6.1.7 Baseline considerations, Public Health attribute

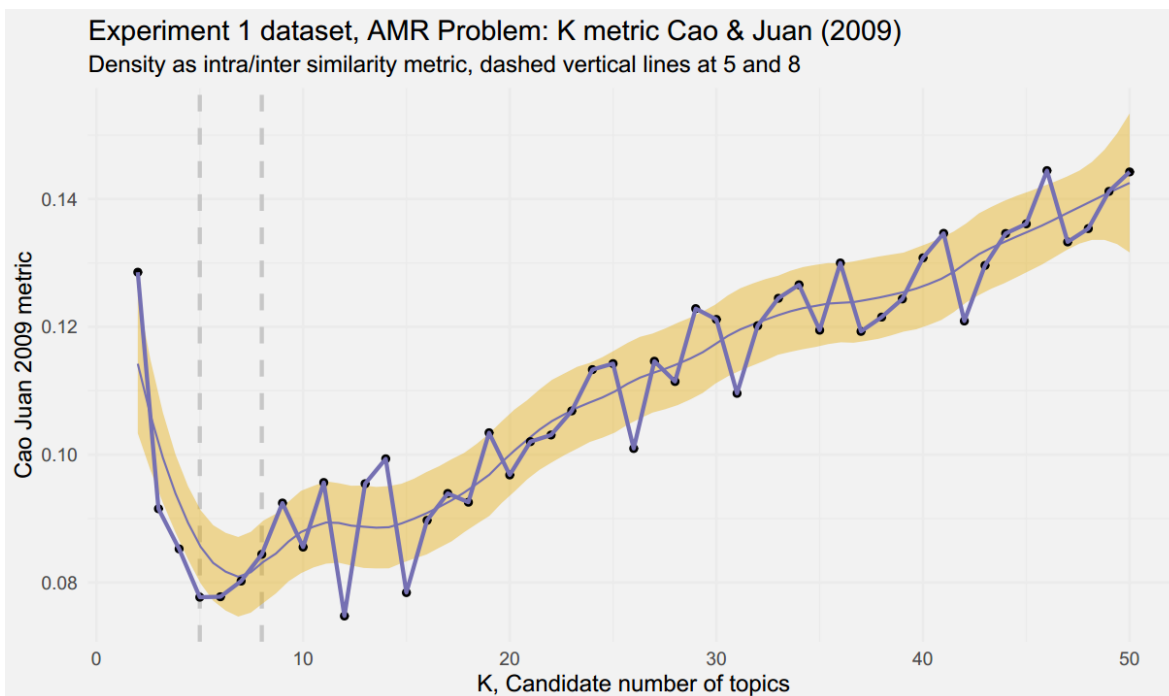
Figure 9:



Note. PH=Public Health, EC=Economic Consideration baseline and all treatment conditions collapsed, PH and EC at baseline measure wave 1, here the PH as baseline influence potential treatment effect making it significant on one option in wave 2 and another option on both wave 2 and 3 from baseline wave

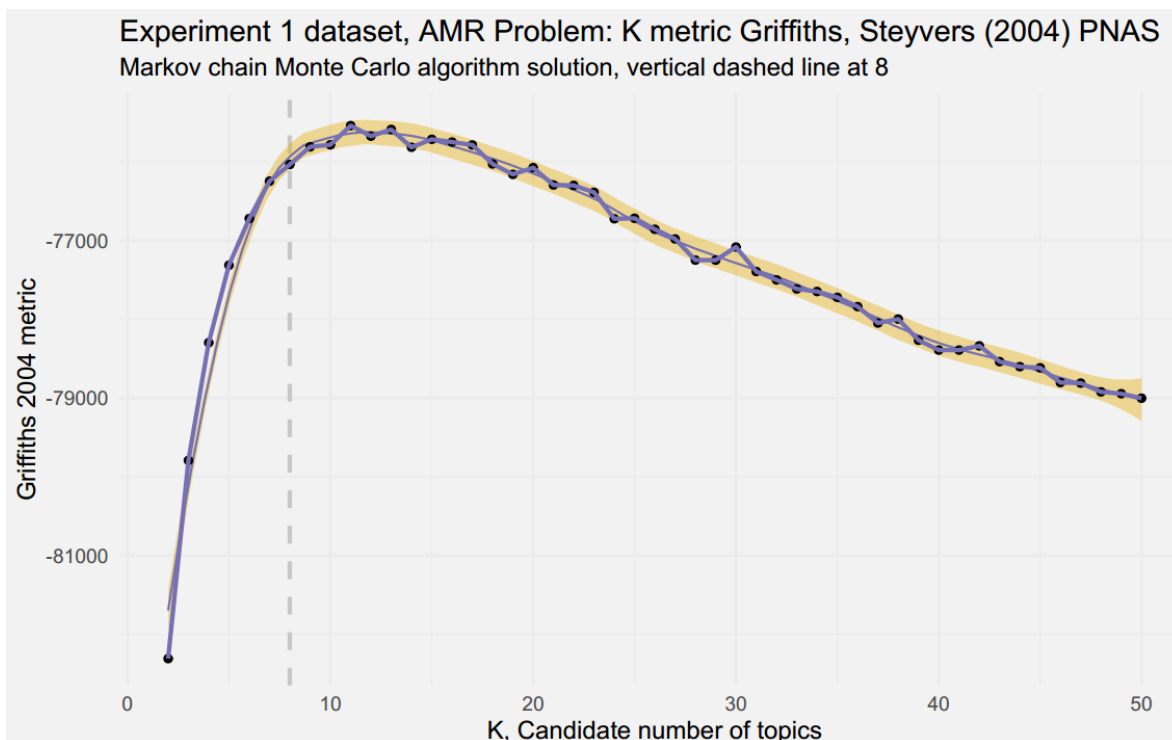
6.1.8 Model setup

Figure 10:



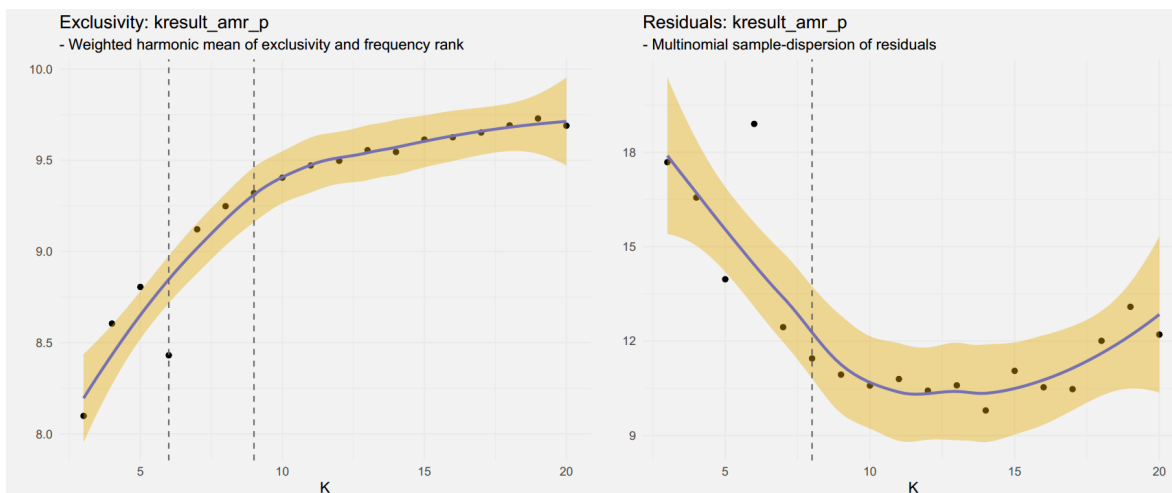
Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 11:



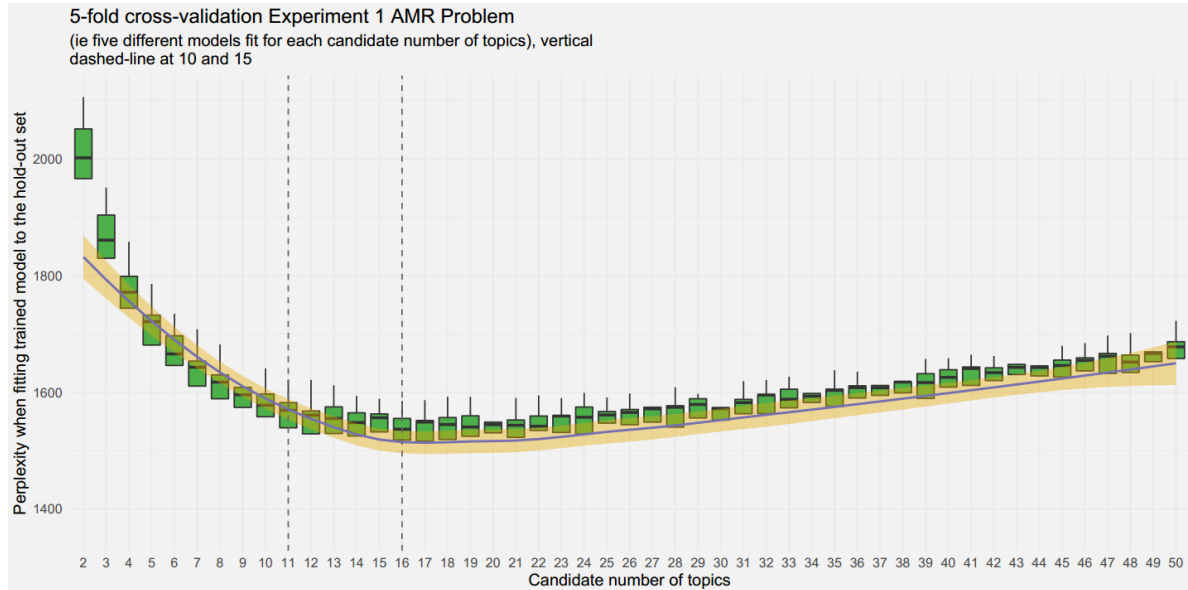
Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 12:



Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 13:



Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

6.2 Experiment 2

6.2.1 Summary statistics

Table 6: Summary Statistics for Experiment 2 DFM by Wave

Corpus	N	Mean Terms/Document	Trimmed Mean	Std. Dev.	Min	Max
Total	5973	7.776904	6.143694	9.249758	1	237
Wave 1	2086	7.607092	6.041293	8.572678	1	112
Wave 2	2077	8.126564	6.337740	10.697074	1	237
Wave 3	1810	7.571271	6.047652	8.136661	1	68

Note. Data is presented post minor preprocessing stages. Trimmed means are robust estimators of central tendency dropping top and bottom 10 percent, excluding systematic outliers.

6.2.2 Stimulus article 1, wave 2 Positive

Swedish Students' Reading Ability Ranks Among the Best Internationally

[Photo]

Swedish students in grade four demonstrate reading skills that are significantly above the average of EU and OECD countries, according to the international assessment, PIRLS.

"These are positive results. Historically, Swedish students have exhibited strong reading skills," says Cecilia Stenman, project manager for PIRLS at the Swedish National Agency for Education.

PIRLS measures the reading abilities of Swedish students in grade four. This international survey is conducted every five years. The latest results indicate a general decline in reading skills across most countries, a trend that can partly be attributed to the COVID-19 pandemic during which the study was conducted in 2021.

While it is not new that Swedish students excel in reading, Sweden has consistently performed above the average of EU and OECD countries in all five assessments since 2001. Among Nordic countries, only Finland has shown better results in the latest survey.

"We have a strong foundation in the Swedish school system, including well-trained staff, adequate resources, and teachers who employ various strategies to stimulate and enhance students' reading," says Cecilia Stenman.

Despite the high international performance, PIRLS indicates a significant decline in reading ability since 2016, a trend also observed in many other countries. Additionally, the gap between low- and high-achieving students is widening. The results further reveal that girls outperform boys in reading, and both home resources and the language spoken at home play crucial roles in reading proficiency.

The survey was conducted in the spring of 2021, involving approximately 5,000 students from 146 schools in Sweden. The next assessment is scheduled for 2026, which will reveal whether Swedish ten-year-olds continue to demonstrate high reading abilities compared to their peers in other countries.

Note. Loosely translated from Swedish

6.2.3 Stimulus article 2, wave 2 Negative

Swedish Students Experience Significant Decline in Reading Ability

[Photo]

Students in grade four are reading significantly worse than in 2016, according to the international assessment PIRLS. "The most concerning aspect is the increasing number of low performers," says Cecilia Stenman, project manager for PIRLS at the National Education Agency.

PIRLS measures the reading abilities of Swedish students in grade four. This international survey is conducted every five years. The latest results reveal a general decline in reading skills across most countries, a trend that can partly be attributed to the COVID-19 pandemic during which the study was conducted in 2021.

In addition to the overall decline in reading ability, the results highlight increasing disparities between different student groups and schools. In Sweden, the proportion of students failing to meet the minimum knowledge level has more than doubled since 2016, and the gap between the highest and lowest performers has widened. "Reading is fundamental for learning in other subjects. In grade four, it is crucial to have reading skills to avoid falling behind in school. In the worst-case scenario, students risk entering a negative spiral with serious consequences," explains Cecilia Stenman.

Despite the decline in reading ability, PIRLS shows that Sweden still outperforms the average of EU and OECD countries. Among Nordic countries, only Finland has better results. The assessment also indicates that girls read better than boys and that both home resources and the language spoken at home significantly influence reading proficiency. The survey was conducted in the spring of 2021, with a total of 65 countries participating. In Sweden, approximately 5,000 students from 146 schools took part. The next assessment is scheduled for 2026, which will further investigate the reading abilities of Swedish ten-year-olds.

Note. Loosely translated from Swedish

6.2.4 Stimulus article 3, wave 3 Positive

Students Show Significant Improvement in Mathematics and Science

[Photo]

Swedish students have shown notable improvements in mathematics and science over the past ten years, according to the international assessment TIMSS. "There has been a clear improvement since 2011, confirming that the increase in results observed last year was not coincidental," says Maria Axelsson, project manager for TIMSS at the Swedish National Agency for Education.

TIMSS measures Swedish students' knowledge in mathematics and science, conducting assessments every four years for students in grades 4 and 8. Currently, the Swedish National Agency for Education is working on compiling the next TIMSS results, which will determine if the upward trend noted in the 2019 report continues.

The recent improvement in mathematics and science marks a significant shift that began in 2015, breaking a long-standing negative trend. Since 2015, results have remained stable; however, the proportion of high-achieving students has increased. "All the investments made in schools over the years seem to have had a positive impact. This means that students are gaining more knowledge and receiving the education they deserve," explains Maria Axelsson. Despite the overall improvements, TIMSS highlights significant disparities in educational equity among different student groups. The gap between low- and high-achieving students continues to widen, and home resources play a crucial role in influencing school performance.

The survey was conducted in 2019, with a total of 64 countries participating. In Sweden, approximately 8,000 students from grades 4 and 8 were involved. The next TIMSS study is expected to be published at the end of next year and will reveal whether the positive results in mathematics and science are sustained.

Note. Loosely translated from Swedish

6.2.5 Stimulus article 4, wave 3 Negative

Growing Gaps in Students' Knowledge of Mathematics and Science

[Photo]

The lack of equity in education is impacting Swedish students' results in mathematics and science, as highlighted by the international assessment TIMSS. "The Swedish school system is not reaching all students, and unfortunately, students' backgrounds appear to have an increasingly significant influence on their academic performance," says Maria Axelsson, project manager for TIMSS at the Swedish National Agency for Education.

TIMSS assesses the knowledge of Swedish students in mathematics and science every four years, targeting students in grades 4 and 8. Currently, the Swedish National Agency for Education is compiling the next set of TIMSS results, which will reveal whether the trends identified in the 2019 report continue.

One of the key findings from TIMSS 2019 is that the Swedish school system faces significant challenges regarding equity. The gap between low- and high-achieving students is widening, and resources available at home play a crucial role in determining educational outcomes. "It is concerning for both individuals and society that the school is struggling to fulfill its compensatory role. This failure affects students' futures, democracy, and Sweden's overall competitiveness," notes Maria Axelsson.

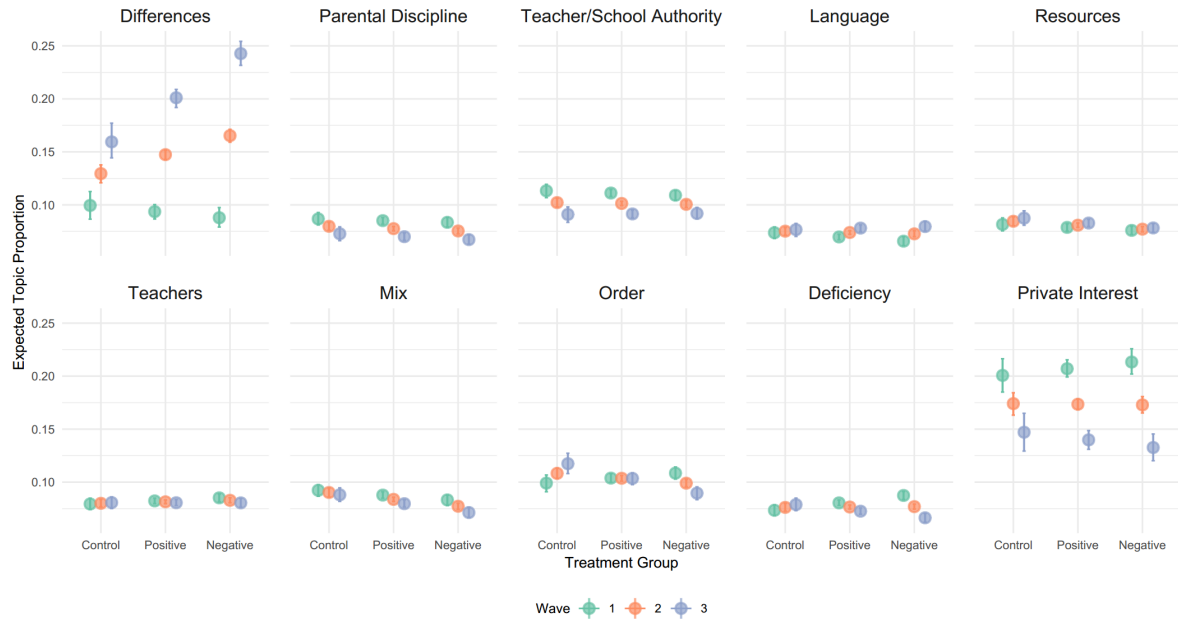
Despite the evident lack of equity, TIMSS also shows that Swedish students have been performing increasingly better in mathematics and science since 2011. A turning point occurred in 2015, marking the end of a long negative trend and the beginning of improved results.

The survey was conducted in 2019, including 64 participating countries. In Sweden, approximately 8,000 students from grades 4 and 8 took part. The next TIMSS study is expected to be published at the end of next year, providing insights into whether the growing disparities in mathematics and science continue.

Note. Loosely translated from Swedish

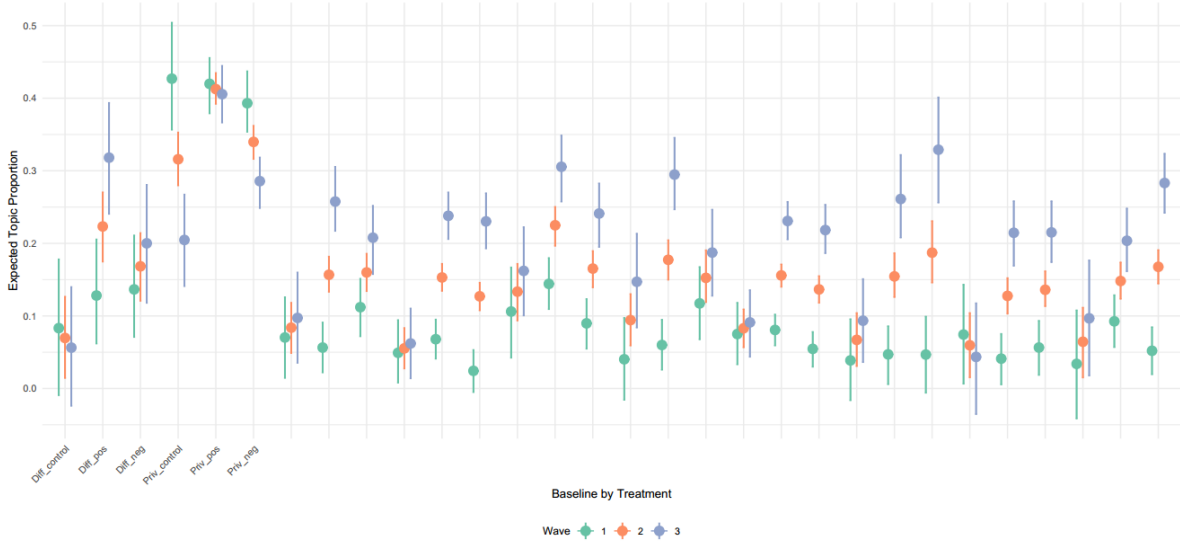
6.2.6 Full model effects

Figure 14: Experiment 2 School issue Pointestimate Wave by Treatment



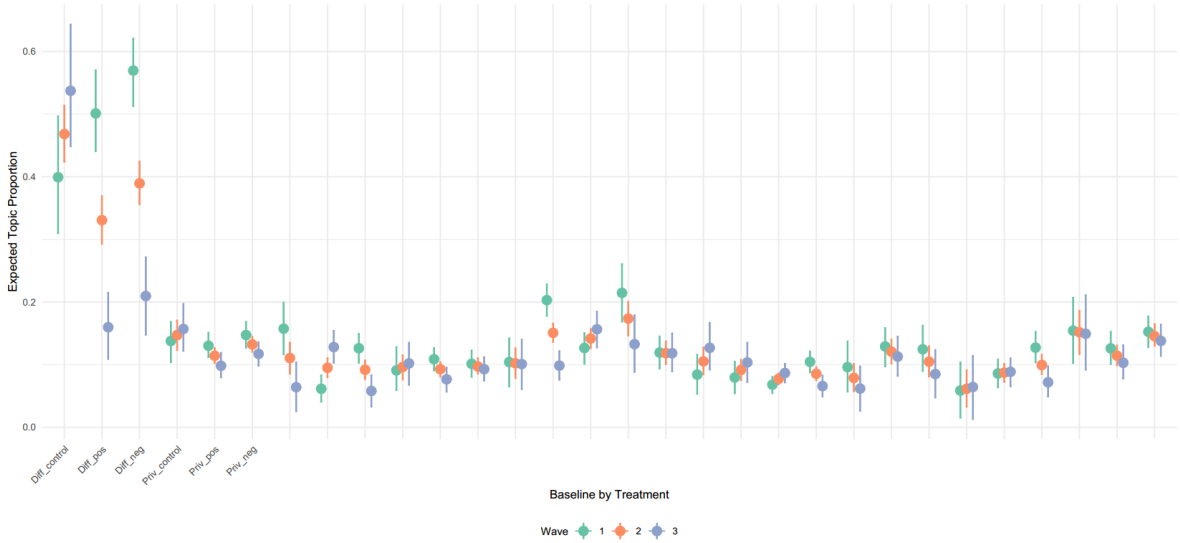
Note. Integrated Dirichlet regression on SAGE model, all topics, Confidence interval at 0.05.

Figure 15: Experiment 2 School issue Pointestimate Wave by Treatment, by baseline Differences & Conditions



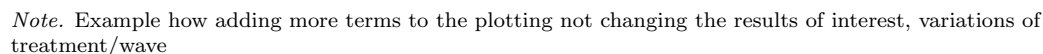
Note. Integrated Dirichlet regression on SAGE model, all topics, These results show, 'given baseline' and treatment condition, see x-axis, Diff-control no significant difference, Diff-positive significance from baseline (wave 1) to wave 3 f.i.. Confidence interval at 0.05.

Figure 16: Experiment 2 School issue Pointestimate Wave by Treatment, by baseline Private Interest & Resources



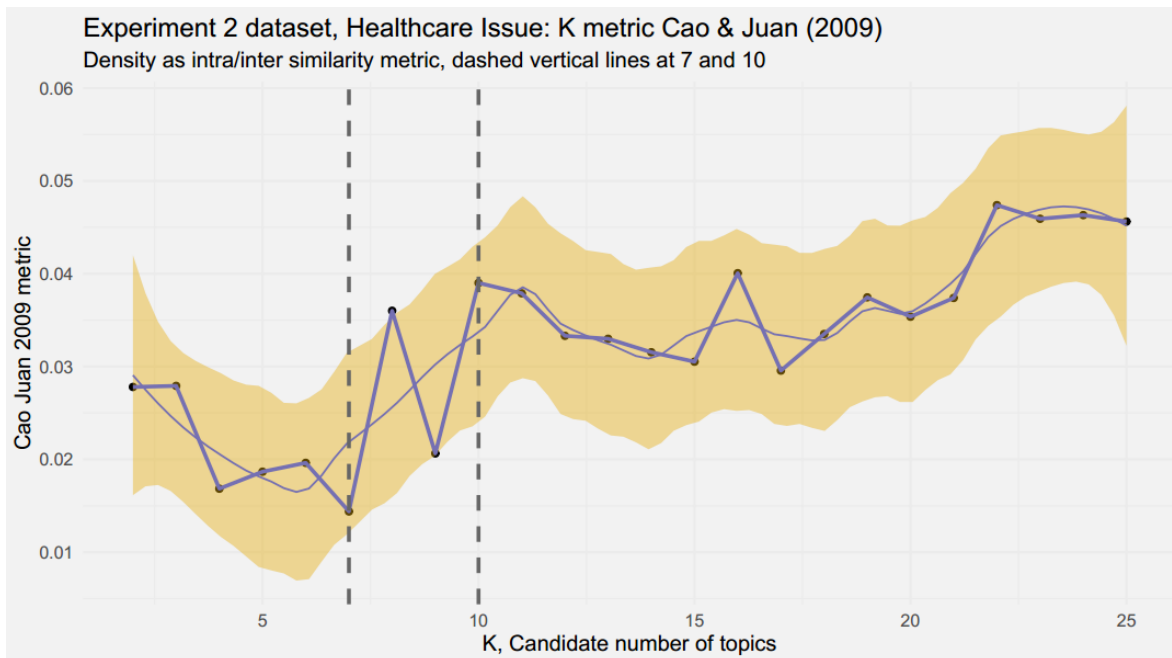
Note. Integrated Dirichlet regression on SAGE model, all topics, These results show, 'given baseline' and treatment condition, see x-axis, Diff-control no significant difference, Diff-positive significance from baseline (wave 1) to wave 2 and wave 3 f.i.. Confidence interval at 0.05.

Figure 17: Experiment 2 School issue PCA/PAM Wave by Treatment



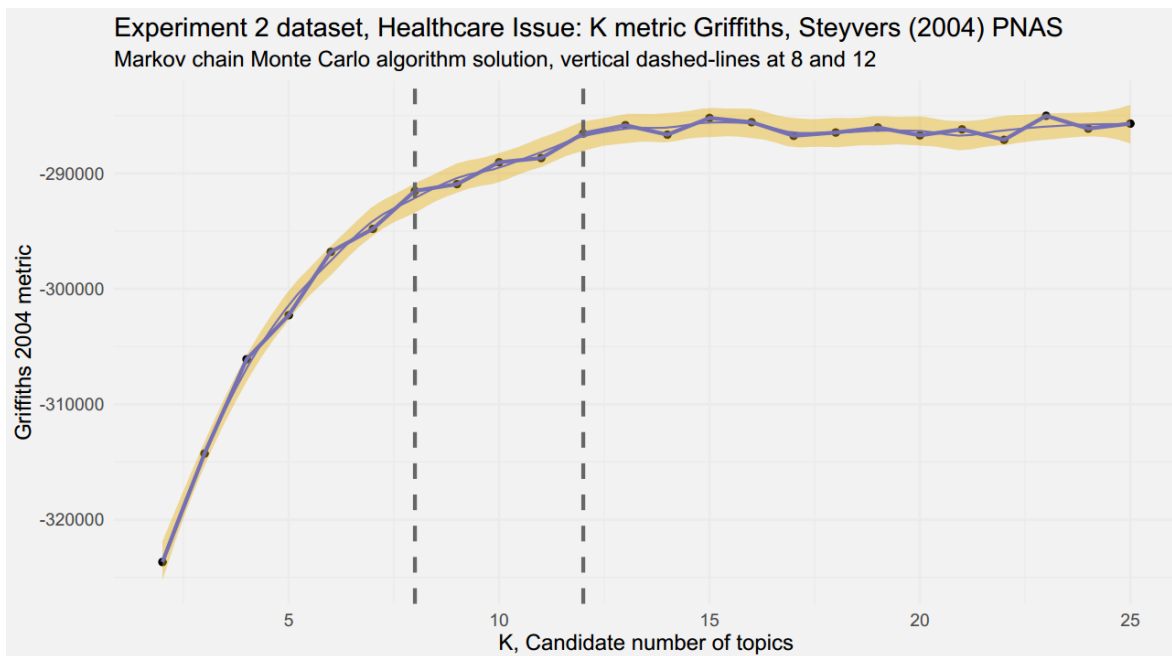
6.2.8 Model setup

Figure 18:



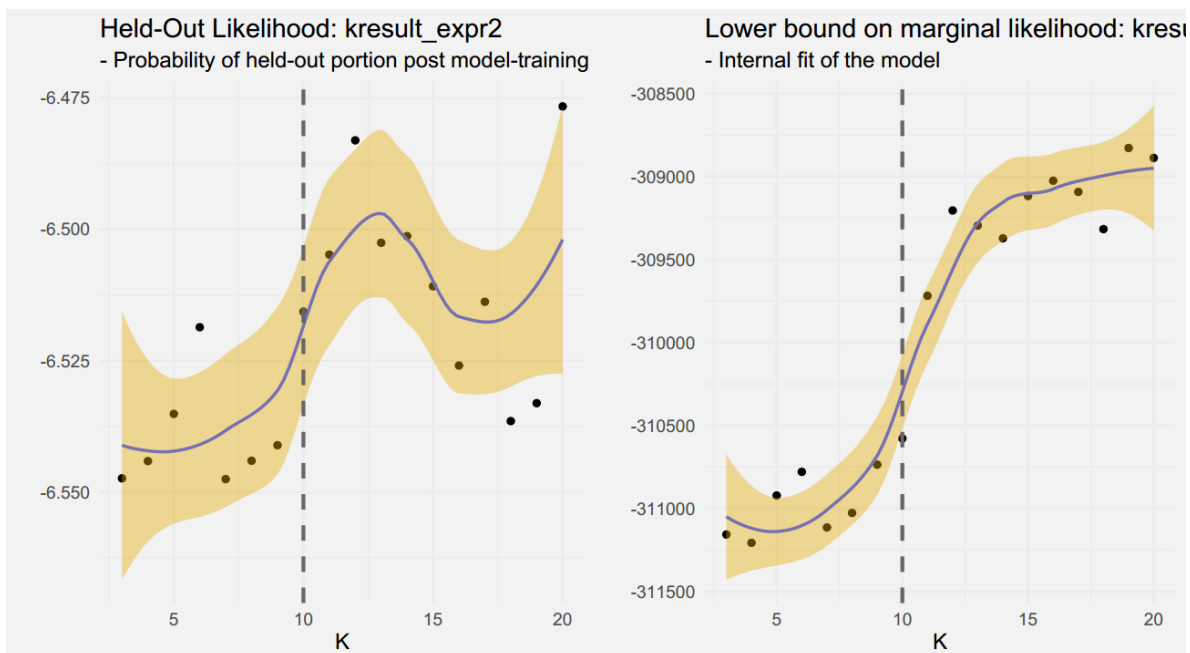
Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 19:



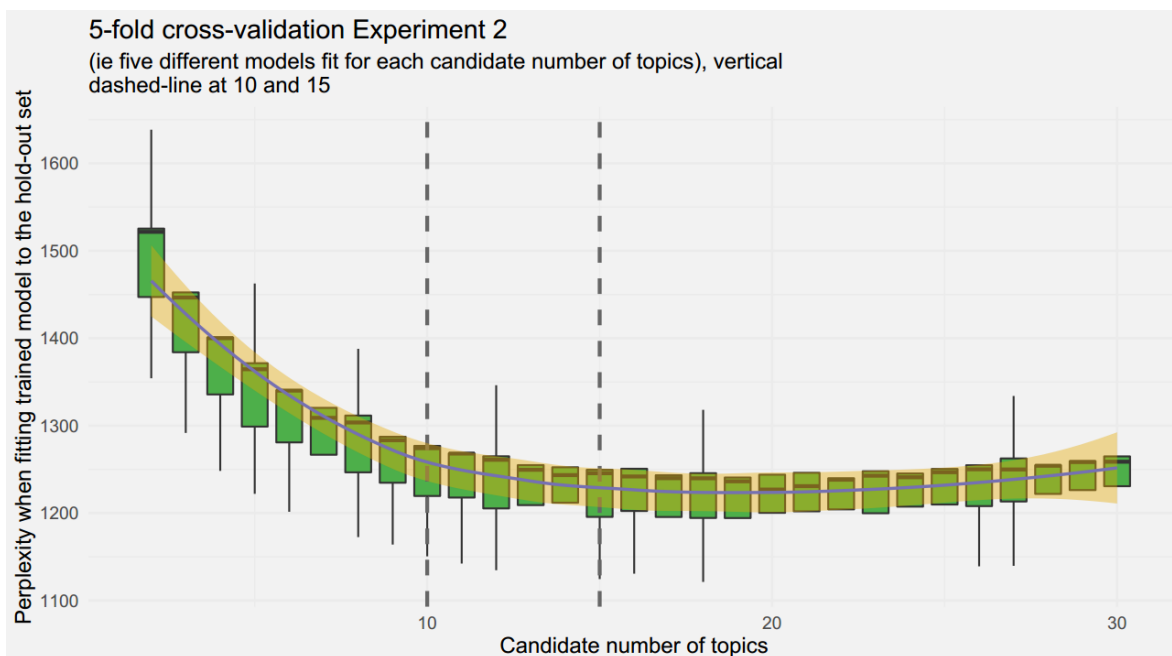
Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 20:



Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.

Figure 21:



Note. Measures to set the optimal k for the SAGE STM model, avoid researcher based validity issues.