TECHETHOS

FUTURE ○ TECHNOLOGY ○ ETHICS

Results of media analysis

D3.3

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D3.6 Results of media analysis			
Work Package	Societal awareness and attitudes of various stakeholder groups towards the ethical implications of the selected technologies		
Lead Partner	Trilateral Research (TRI)		
Author(s)	Anais Resseguier (TRI), Ilaria Bonavita (TRI)		
Contributor(s)	TRI: Rowena Rodrigues, Hayley Watson, Kehinde Owoeye, Nicole Santiago, David Wright Contributing partners: AIT: Eva Buchinger, Wenzel Mehnert, and Michael Bernstein; AIRI: Andrea Porcari and Gustavo Gonzalez; DMU: Laurence Brookes and Nitika Bhalla; Ecsite: Andrew Whittington-Davis and Critina Paca; EUREC: Lisa Tambornino and Philipp Hoevel; TUD: Pieter Vermaas Contributing Linked Third Parties: SCN: Irene Besenbaeck and Mira Yordanova; IQL: Ondřej Votruba; BSF: Toma Patrascu; CPN: Djordje Petrovic, Bogdan Djordjevic, Ivan Umeljić, Petar Lausevic; PdlC: Ana Crespo Blanc and Lourdes López; VA: Gustav Bohlin and Helen Garrison		
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The TechEthos Project

Short project summary

TechEthos is an EU-funded project that deals with the ethics of the new and emerging technologies anticipated to have high socio-economic impact. The project involves ten scientific partners and six science engagement organisations and runs from January 2021 to the end of 2023.
TechEthos aims to facilitate “ethics by design”, namely, to bring ethical and societal values into the design and development of new and emerging technologies from the very beginning of the process. The project will produce operational ethics guidelines for three to four technologies for users such as researchers, research ethics committees and policy makers. To reconcile the needs of research and innovation and the concerns of society, the project will explore the awareness, acceptance and aspirations of academia, industry, and the public alike and reflect them in the guidelines.
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Definitions and abbreviations

Table 1: List of Definitions

Term	Explanation
API (Application Programming Interface)	A software intermediary between two computers or computer programmes (applications) so that they can transfer data between each other
Bigram	A pair of words frequently occuring together
Climate engineering	Climate engineering is a family of technologies that enables the modification of natural processes and human activities looking to detect, mitigate and respond to global threats due to climate change crisis locally and globally (TechEthos definition, Factsheet).
Digital extended reality	Digital Extended Reality refers to AI-powered digital technologies (hardware and software) capable of perceiving and processing human sensorial outputs, e.g.,

	voice, gestures, language, movement, emotions, and other elements of human communication). By processing such human-related data, extended or mixed virtual scenarios (e.g., visual, audio, linguistic or haptic) can be tailor-made or "customized" based on the user interest and behaviour. These technologies can be used to profile, model, predict, discriminate, and influence the user's behaviour or nudge their choices. (TechEthos definition, Factsheet).
JSON (JavaScript Object Notation)	Open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of attribute-value pairs and arrays.
Media analysis	An analysis of the media. The present study explores how the media represents the three technologies of interest to TechEthos.
Media discourse	A mediated form of discourse. The present study focuses on discourses in online news outlets.
Metadata	Data that describes other data, not the content of the data itself. For instance, metadata of an image will give the type of data it is (an image), its size, when it was filed, but won't indicate what it represents.
Neurotechnology	Health technologies that aim at affecting and emulating human-brain capabilities and functions through artificial replacements or add-ons in a two-way interaction between the brain and the external environment or systems. (TechEthos definition, Factsheet).
REST (Representational State Transfer) API	An API that conforms to the constraints of REST architectural style, first defined by computer scientist Dr. Roy Fielding (Fielding, R.T., 2000)
String	In computer programming, a string is a data type consisting of an ordered sequence of characters; a query string denotes a string used to request specific content from a server, usually including keywords of interest connected by logical operators or other syntax operators and additional parameters.
Web crawler	Also known as web spider, is a programme that systematically scans and categorises content on the internet.
Web scraper	Programme that is used to extract specific content from a webpage.

Table 2: List of Abbreviations

Term	Explanation
Airi	Associazione Italiana per la Ricerca Industriale
AIT	Austrian Institute of Technology
ALLEA	All European Academies
API	Application Programming Interface

BSF/ASUR	Asociația Secular-Umanistă din România
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CPN	Center for the Promotion of Science
CZ	Czech
D	Deliverable
DE	German
DMP	Data Management Plan
DMU	De Montfort University
DoA	Description of Action
EC	European Commission
Ecsite	Association européenne des expositions scientifiques techniques et industrielles
EN	English
ELSI	Ethical, Legal, and Social Issues
EUREC	European Network of Research Ethics Committees
FR	French
GA	Grant Agreement
GDPR	General Data Protection Regulation
IT	Italian
IQL	iQLANDIA
JSON	JavaScript Object Notation
LTP	Linked Third Party
NER	Named Entity Recognition
PC	Project Coordinator
PdlC	Parque de las Ciencias
PoPD	Protection of Personal Data
REST	Representational State Transfer
RO	Romanian

SCN	The Science Center Network
T	Task
TRI	Trilateral Research
TUD	Technische Universiteit Delft
URL	Uniform Resource Locator
UT	Universiteit Twente
VA	Vetenskap & Allmänhet
VR	Virtual Reality
WP	Work Package
XML	Extensible Markup Language
XR	Extended Reality

Executive Summary

This report presents the results of the media scan and analysis task (T3.6) of the TechEthos project. This study was carried out between November 2021 and May 2022. It sought to gain insights on the media discourse on TechEthos' three families of technologies: geoengineering, neurotechnology and digital extended reality. The media both reflect and shape public perceptions on technologies and, as such, give important indications of these perceptions.

Study details
This study contributes to TechEthos' analysis of public awareness and acceptance of the three families of technology (the focus of TechEthos WP3), through an exploration of media discourse. This task was led by Trilateral Research and carried out with the support of TechEthos' partners and the science centers and museums associated with the project. The task explored the media discourse in 13 countries - it looked at online news outlets (excluding social media). This included ten EU countries: Austria, Czech Republic, France, Germany, Ireland, Italy, Netherlands, Romania, Spain, and Sweden and three non-EU countries: Serbia, UK, and USA. The study covered news stories published in 2020 and 2021.
To scan and analyse the massive amount of data of interest to this analysis, we used state-of-the art computational tools to collect, clean and analyse the data. This made it possible to collect and analyse a large set of news stories which would not have been possible with traditional and manual techniques. However, it also presented some challenges, especially in relation to data access. For various reasons, it appeared that some key media outlets were missing from the datasets and that we were sometimes missing data for a few months in 2020 and 2021. It is thus difficult to assess the representativeness of the results of this study. That said, we believe that this study provides interesting snapshots on the media discourse in these countries. In addition, it contributes to methods for the analysis of media discourses through computational methods. This report presents the method used in the study in detail.

Report structure
Following the introduction (Section 1), Section 2 presents the overall research task design, highlights the task objectives, general method used, breakdown of responsibilities, timeline of work progress and the collaborative work that went into this task. Section 3 details the approach and tools used for the data collection, the data cleaning and the data analysis and includes considerations on the limitations of this study. Section 4 presents the results across countries and Section 5 presents the results per country. Despite its limitations, the study provides some interesting snapshots on the media representation of TechEthos' three families of technologies. We present a few noteworthy ones below.

Key observations
We observe that digital extended reality is by far the family of technologies for which most of the news stories were collected (accounting for more than 62% of all data collected), suggesting that this family of technologies is more prevalent in the media discourse than the other two. For neurotechnology, less news stories were collected for all countries (on average a bit more than 5% of share). This was the case for all countries, except for Germany and Austria where climate technologies were the most discussed.

In the news stories collected for digital extended reality, 'virtual reality' is the most frequently mentioned keyword (in almost 42% of the stories collected). This suggests that this family of technology is mainly discussed through this notion. Natural language processing (NLP) is rarely mentioned. Keywords related to Ethical, Legal, and Social Issues (ELSI) were mentioned in 35% of the overall news stories collected for digital extended reality, with 'society', 'security', and 'privacy' being the most frequently mentioned topics.

The analysis related to climate engineering also includes some interesting findings. To begin with, we observe that 'green hydrogen' is the most frequently mentioned keyword in stories collected for this family of technology, appearing in almost 31% of the stories collected for climate engineering. Green hydrogen was part of the overall horizon scanning exercise conducted in TechEthos within the technologies that aim at tackling climate change; however, it was then excluded from the narrower definition of climate engineering technologies as it does not specifically "act on the Earth's climate

system".[1] We can therefore observe that discussions on technologies to tackle issues of climate change are not dominated by climate engineering in the narrow sense of the term as defined by TechEthos. Furthermore, we can observe that solar engineering techniques are rather rarely discussed in new stories discussing "climate engineering" topics as defined for the purpose of this study through the list of keywords established. Techniques such as sun shield, solar radiation management or cloud modification or whitening are rarely discussed. On the contrary, afforestation, reforestation, carbon capture, sequestration and storage are among the most discussed topics.

Regarding the third family of technology under study in TechEthos, neurotechnology, we observe that the most frequent keyword is "cyborg" which was mentioned in over 21% of the stories collected for this technology, suggesting that the media representation of this technology is highly shaped by this notion. Another interesting finding on the media representation of neurotechnology related to the frequent appearance of Elon Musk and/or Neuralink, i.e., the neurotechnology company that Musk co-founded: they appear in almost 35% of the stories collected. This suggests that discussions on this technology are highly dominated by Musk and his activities in the area or, to put it differently, that neurotechnology is often discussed in the media in relation to what Musk does in the area, and therefore framed by him.

[1] https://www.techethos.eu/climate-engineering/

1 Introduction

This report presents the results of the media scan and analysis (Task 3.6) conducted between November 2021 and May 2022. This task was led by Trilateral Research (TRI) and carried out with the support of TechEthos partners and Linked Third Parties (see the list of contributing partners on page 1 of this report).
This task sought to gain insights on the *media discourse* on the three TechEthos technologies: neurotechnology, climate engineering, and digital extended reality.[2] It was therefore interested in the *representation* in the media of these technologies, not these technologies in and of themselves. This task contributes to TechEthos' study of public awareness and acceptance of the three technologies, by focusing on the media discourse. Indeed, this discourse is of particular interest in that it both represents public perceptions and shapes them. The scan and analysis in this task were carried out using state-of-the-art computational tools that are outlined in this report. As such, this task is also a methodological contribution to media discourse analysis, pointing to the value of carrying out such study, detailing the method we used, including the access challenges and limitations we faced while conducting this research.
Section 2 presents the research task design, including the task objectives, the overall method used, the breakdown of responsibilities per partner, the timeline and the collaborative process in this task. Section 3 then provides details on the data collection (including the design and implementation), the data cleaning process, the data analysis and software implementation. It also highlights some key limitations of this study, in particular the challenges we faced with data access. Section 4 then presents some key highlights of the results across all countries. Section 5 presents the results of the data analysis per country. It includes one subsection per country, each providing a description of the cleaned dataset, and presenting the country results for each technology. Finally, Section 6 provides a conclusion. This report also includes a bibliography and two annexes with lists of keywords used in this study in each language.

2 Research task design

2.1 Task objectives

The TechEthos media scan and analysis (Task 3.6) aimed at getting insights on how the three TechEthos technology families – geoengineering, digital extended reality, and neurotechnology – are *represented* in the media, i.e., the *media discourse* on these technologies. This task was interested in the representation of these technologies in the media as media discourse both reflects and shapes public perception, awareness, and acceptance of technologies. It focused on the media in 13 different countries. This included ten EU countries: Austria, Czech Republic, France, Germany, Ireland, Italy, Netherlands, Romania, Spain, and Sweden and three non-EU countries: Serbia, UK, and USA. These countries were selected as we had representatives from each of these countries in the project. Since we needed to draw from some contextual knowledge of the country media landscape, including knowledge of the national language, it was essential to have representatives from these countries.
The analysis of the media discourse focused on identifying:

- If the technologies of interest are discussed in the media?
- If they are discussed:
    - How are they discussed?
    - How much are they discussed?
    - When are they discussed?

[2] The project TechEthos has developed Factsheets providing a brief description of each of the three families of technologies. Neurotechnologies: https://www.techethos.eu/in-short-neurotechnologies/; digital Extended Reality: https://www.techethos.eu/in-short-digital-extended-reality/; climate engineering: https://www.techethos.eu/in-short-climate-engineering/

- In relation to what topic or to which entity (individual, organisation, etc.), or to which location are they discussed?
- What differences and similarities can be identified across countries?
- Whether any ethical, legal, and social issues raised by these technologies are discussed? If so, what are the most prominent issues being discussed?

2.2 Overview of the study approach

The media landscape today is strongly digitized. As Karlsson and Strömbäck have noted: "Since the introduction of the World Wide Web in the mid-19902, the media environment and the conditions that journalism operates under have changed dramatically" (2010, p. 2) The Reuters Institute Digital News Report for 2021 indicates, there is a "longer term shift toward digital sources", in spite of the "temporary bumb in TV consumption" caused by the lock-down due to the Coronavirus pandemic from the start of 2020 (Newman et al., 2021, p. 10). Hence, for this task, we decided to focus on online news sources as opposed to TV or printed media.

The changing landscape of the media due to its increasing digitisation led media, communication and journalism scholars to adapt their research methods (see in particular: Karlsson, Strömbäck, 2010; Sjøvaag and Stavelin, 2012; Lewis, Zamith, Hermida, 2013; Rodrigo, Lewis, 2015; Sjøvaag and Karlsson, 2016; Rodrigo, 2018; Tromble, 2021). The media analysis reported here draws from progress in this field since the 2010s.

The research study approach for this task was changed from what was initially planned in the project's Description of Action (DoA). As lead of this task, Trilateral Research identified state-of-the-art computational tools that would make it possible to collect and analyse a much larger set of news stories than originally anticipated through the qualitative research method defined in the DoA (see the tools defined in Section 3). While the initial task design had to limit the number of news outlets (anticipated to be three per country) and the number of news stories to be analysed (anticipated to about 20 per outlet), this limitation could be removed in the quantitative research method task design. This convinced us of the value of this new approach.

In that sense, this task draws from recent methodological advances in the field of content analysis which increasingly evolves toward a hybrid approach bringing together computational and manual methods. As Lewis, Zamith, and Hermida put it, since 2010 approximately, "at the intersection of computer science and social science, communication scholars have incorporated computational techniques to study massive databases of media texts" Lewis, Zamith, and Hermida, 2013, p. 35). As the communication scholars highlight, this makes it possible to "best leverage the systematic rigor and contextual awareness of traditional content analysis while taking advantage of the efficiencies of computational methods and the novel cases offered by the Big Data phenomenon?" (Lewis, Zamith, and Hermida, 2013, p. 35).

As such, this approach not only provides insights on the media representation in the 13 countries selected, but it would also make it possible to contribute to the field of media analysis by sharpening the computational approach. The potential methodological innovation could be of great value to future research projects exploring public perceptions on technologies, and beyond.

Method for data collection, cleaning, and analysis is described in more details in Section 3.

2.3 Breakdown of responsibilities

The task was led by TRI who carried out the data collection and the data analysis, with the support of the following TechEthos partners EUREC, AIRI, TUD, Ecsite, and AIT and Linked Third parties: SCN, iQlandia, BSF, CPN, PdlC, VA. Partners' support was particularly important for the translation of the keywords into national languages and for help with understanding better the national media context in each country, including the type of outlets whose new stories we collected.

Below is the list of countries and partners' responsibilities:

Country	Language	Responsible partners
Austria	German	SCN and AIT

Czech Republic	Czech	iQlandia
France	French	TRI
Germany	German	EUREC
Ireland	English	TRI
Italy	Italian	AIRI
Netherland	Dutch	TUD
Romania	Romanian	BSF
Serbia	Serbian	CPN
Spain	Spanish	PdlC
Sweden	Swedish	VA
UK	English	DMU
USA	English	TRI

Ecsite contributed to this task by coordinating activities with the six LTPs and CEA and ALLEA reviewed the draft report before submission.

2.4 Timeline

The task progressed according to the following timeline:

MONTHS	ACTIVITIES
Nov-Dec 2021	**Preparation of data collection** ➢ Elaboration of method ➢ Identification of the news provider ➢ Development of list of keywords ➢ Translation of keywords in the 10 languages relevant to the search
Jan 2021-April 2022	**Data collection, cleaning, processing and analysis** ➢ With automated tools developed and used by TRI
April 2022	**Reporting on the results** ➢ Bilateral discussion with each partner on results for each country ➢ Report writing
May 2022	**Review and finalisation of D3.3**
31 May 2022	**Submission of D3.3 to the EC**[3]

2.5 Collaboration

In addition to support with translation and labelling of news outlets, TRI sought the input of TechEthos partners and LTPs during the progress of this task, through a series of team and bilateral meetings, as summarised below.

Date	Meeting	Participants	Purpose
14 Oct 2021	Meeting with LTPs	All partners and LTPs	Initial presentation of media analysis task
11 Nov	Bi-Weekly WP3 meeting	WP3 contributors	Presentation and discussion on task design and method

[3] Due to some data access challenges and internal capacity, TRI had to delay the submission of the report by one month (from end of April to end of May 2022) to ensure good quality results.

7-8 Dec	Consortium meeting	All partners	Presentation and discussion on task progress
18 Jan 2022	M13 Jour Fixe	All partners	Presentation and discussion on task progress
15 March	M15 Jour Fixe	All partners	Presentation and discussion on task progress and initial results
5 April	Media analysis progress update meeting	T3.6 contributors	Presentation and discussion on task progress
End of April-start of May 2022	Bilateral on country results (10 meetings)	Partner representative of each country	Presentation and discussion on result from each country

3 Data collection, cleaning, and analysis

This section describes the methodology adopted for collecting and cleaning the data and processing them to produce analytics, including summaries, descriptive statistics, and visualisations.

3.1 Data collection design

For each country and technology combination, we wanted to collect news stories, published between January 2019 and December 2021[4] by an online news outlet in one of the targeted countries, which contained at least one keyword related to the technology.

3.1.1 Choice of technology keywords

The search for relevant news stories was carried out using a set list of keywords, translated in the ten languages of the countries of interest. In this report, the term "keyword" means both a search term made of one word and multi-word search term (sometime referred to as key-phrase). The list of keywords was drawn from the work in TechEthos WP1, especially "D1.2: TechEthos technology portfolio: assessment and final selection of economically and ethically high impact technologies", specifically, the factsheets developed for each of the three technologies. Below is the list of English keywords used for each technology to search for relevant news stories.

Climate engineering:
Afforestation / albedo modification / artificial photosynthesis / artificial upwelling / atmospheric / radiation reflection / Carbon capture / Carbon usage / Carbon sequestration / Carbon storage / Climate engineering / cloud modification / cloud seeding / cloud whitening / Direct Air Capturing / Geoengineering / Green hydrogen / Greenhouse gas removal / Land-based radiation reflection / Negative emission technology / Ocean fertilisation/fertilization / solar radiation management / Splitting carbon dioxide / sulfate aerosol injection / sun shield / Wastewater nutrient recovery / Water splitting.

Digital extended reality:
augmented reality / Digital avatar / Extended reality / metaverse / mixed reality / Natural Language Processing / NLP / smart glasses / digital twin / virtual avatar / virtual environment / Virtual reality / virtual world / VR / XR.

Neurotechnology:
Artificial brain / Artificial eye / artificial human / Artificial organ / Artificial uterus / artificial synapse / brain boosting device / brain chip / brain computer interface / brain enhancement / brain implant / brain machine interface / brain machine interaction / brain to brain / cyborg / cognitive enhancement / mind

[4] This is the time period indicated in the DoA as we estimated this period to be sufficiently long to help identify some trends, and not too long which would have made it challenging for the analysis.

reading machine / neural control / neural interface / neural prostheses / neuromorphic computing / neuromorphic engineering / neuroprosthetic / neurotech / neurotechnology / transcranial electrical stimulation / thought control / Wearable organ.

Annex 1 provides the list of keywords translated in the languages required to cover the targeted countries: Czech, Dutch, French, German, Italian, Romanian, Serbian, Spanish, and Swedish. Regarding translations, some keywords had several translations, sometimes including terms in English. This was especially the case for digital extended reality-related terms that are often used in English even in other languages. For instance, in Dutch 'mixed reality' is often referred to using the English term 'mixed reality', although 'gemengde realiteit' sometimes occurs. In such cases, we used both the English and the Dutch terms in the search.

3.1.2 Relevance of the news stories collected

A common challenge when retrieving information using keywords is that a portion of irrelevant documents is often returned (i.e., false positive); similarly, a portion of relevant documents could be missed (i.e., false negative). This is because words can have different meanings when used in different contexts, and a single idea can be expressed by several different words or synonyms. Modern information retrieval systems (e.g., those used by Google and news providers) implement semantic search strategies, i.e., the system searches for documents that, besides matching the keywords provided by the user, contain terms and expressions that the system considers to be semantically similar to the provided keywords. While this usually results in a higher recall of the system (i.e., retrieval of a larger portion of relevant document, including those where the searched keywords are not matched exactly), irrelevant documents can still be returned as the system might not accurately interpret the user search intentions. To be able to discern relevant documents from irrelevant ones it is essential to agree on a definition of relevance. Among other factors, this definition depends on the user needs, on the specificities of the study, and on the methods that will be used to remove irrelevant documents.
In the context of this study, we define as 'relevant', **a news story published by an outlet in which at least one of the search keywords (or closely related words and inflections of the word) is found in the news title or body and the word is used with the meaning commonly adopted in the context of the given technology.**
Based on this definition, all the news published by a country outlet that meet the relevance criteria are considered relevant for that country, including stories that were originally published in another language and were translated and republished in a different language in another country.

3.2 Data collection implementation

Automatised collection of news published online can be done in different ways. Some outlets provide developers access to their databases via an API.[5] This is the case for a minority of outlets and is a viable approach if we are interested in gathering news from these specific outlets only. However, a researcher interested in programmatically collecting data from multiple outlets – as we were – has two options:

1. **Relying on a news API provided as a service by a company.** These services allow to programmatically request news specifying different filters of interest and they deliver content which has been usually reviewed and curated.
2. **Building custom web scrapers to the web pages of interest.** Web scrapers can gather content from any web page. A page of interest in the context of news crawling is any webpage of an outlet as well as the web pages resulting from a Google search or from a search on Google News.

News APIs are easier to use than web scrapers. They are usually more computationally and time efficient and return cleaner and correctly formatted content. As such, they require less post-processing efforts. However, they are often paid services, and they might not provide content covering all the years,

[5] This is the case for the New York Times for instance: https://developer.nytimes.com/

geographies and outlets required. In this task, we were interested in maximising the quality of the data retrieved, we adopted the first option and we relied on web scraping only in those cases where content from the news API was not available. We discuss the details of the two approaches followed below.
This report refers to both web scraping and web crawling. The two words are often used interchangeably; however, they refer to different, though closely related, actions. Web crawlers can scan the entire content of a web page and are usually used to discover URLs from the page. Web scrapers are used to retrieve specific content from a URL (e.g., specific sections of a web page).

3.2.1 Requesting data from news API

Companies providing news API generally scrape relevant text from news websites, blogs and articles. They then tag each news with relevant metadata, ranging from standard labels such as time, publisher, country, language, to more advanced ones which are inferred by Machine Learning models, like sentiments, topics, or persons mentioned. They store the news in databases which they make programmatically accessible to developers via an API. A wide plethora of news API solutions are available in the market. Many provide free access to limited content of their databases (only the title and summary of the news) and different subscription plans to access wider sets of data. The volume, quality, variety, coverage of the data provided by these APIs depend on the company and the type of subscription. To choose the data provider most suitable for the task we used the following criteria (in no particular order of priority):

- Time coverage of news: at least 2020 and 2021
- Geographic coverage: at least 80% of the required countries
- Availability of full content, i.e., not only summary of the news story
- Indexing of data: allowing filtering by keyword, country, and year
- Comprehensiveness of metadata
- Transparency on data sources used by the provider
- Quality of documentation and resources for developers
- Computational efficiency, i.e., number of news returned per second per call to the data provider API
- API access cost

The table below presents the different solutions we evaluated.

Solution	Cost	Time coverage	Geo coverage	Full content
NewEdge OPENS API	Up to 60K GPB/year; no monthly subscription available	past 6 months	Worldwide, limited content for AT, CZ, RO, RS	For some outlets only
News API - developers	Free	past 1 month	Worldwide, limited contend for RO, missing content for CZ, RS	Summary only
News API - business	Starting from 449USD/month	past 5 years	Worldwide, limited contend for RO, missing content for CZ, RS	yes
GNews - developers	Free	Past 2 years or before	Worldwide, AT, CZ, RS missing	Summary only
Gnews - paid	from 50USD/month	Past 2 years or before	Worldwide, AT, CZ, RS missing	Yes
ALYEN News API	Starting from 40K USD/year; no monthly subscription available	Past 6 years	Worldwide; unclear if countries of interest are covered	Yes
Bing News Search API	Pay-as-you-go service (free 1000 news/month then starting from 4 USD per 1000 news)	not clear but possibility to select time range	Worldwide; unclear if countries of interest are covered	Unclear

Table 3 Comparison of the news API services evaluated

After evaluating different alternatives, we purchased access to GNews API for one month, during which the data collection was carried out. We purchased the Business Plan for EUR 99.99/month. A free subscription plan is available, but it was not suitable for our case as it did not provide the full text of the news. GNews API is a REST (Representational State Transfer) API that allows requesting news articles matching a user-defined query and returns the result in JSON (JavaScript Object Notation) format. The API allows to filter the results by language of the news, country of publication, time range and by keywords and key-phrases as specified by the query string used to request the data. In computer programming, a string is a data type consisting of an ordered sequence of characters; a query string denotes a string used to request specific content from a server, usually including keywords of interest connected by logical operators or other syntax operators and additional parameters.
The approach with news API was used for France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, UK and US. For each country and for each technology, i.e., for each country-technology pair, we searched for any news from that country that contained at least one of the keywords assigned to that technology. The table below indicates the search parameters used.

Parameter	Value	Description
q	“keyword 1” OR “keyword 2” …OR “keyword N”	Query string where all the keywords are connected by the OR operator
lang	Iso2 language code (of the official main language of the country)	Language of the returned article
country	Iso2 country code	Country of the returned article, among the ones available
in	Title, description, content	Attributes of the articles in which the query will be searched
from	2020-01-01T00:00:00Z	Keep articles with a publication date greater than or equal to the given date. ISO 8601 format
to	2021-12-31T23:59:59Z	Keep articles with a publication date less or equal to the given date. ISO 8601 format
expand	content	Retrieve the full content of the article (instead of the summary only).

Table 4 GNews API query parameters

3.2.2 Custom web crawlers and scrapers

Three countries (Austria, Czech Republic and Serbia) were not included in the list of countries GNews collects data from. All the other news API we evaluated presented this limitation. Hence, for these countries, we developed alternative strategies to collect the relevant news stories. For Czech Republic and Serbia, we built custom web crawlers and scrapers to the Google News results. For these countries, we first developed web crawlers to the HTML page of a Google News result page to retrieve the news URLs. Then, we developed web scrapers to gather the content of interest (news title, text, publishing date) from the news URL. As in the GNews case, the query string used for the search was designed to retrieve results containing at least one of the keywords for that topic and country, in the country language, published between 2020 and 2021. For Austria, a similar approach was adopted but as Austrian outlets could not be found on Google News, the web scrapers collected results from the HTML pages of a Google Search result pages. The parameters that can be fed to a Google Search are only search strings. Since searching on Google for the Austrian keywords only would return any type of web page matching the searching criteria, i.e., not necessarily news outlets, we designed the search strings to include, besides the technology-keywords, the names of some relevant Austrian news outlets. These were identified using the "Reuters Institute Digital News Report 2021", 10th edition (Newman et al., 2021). This implied a slight change in the experiment design for the Austria compared with the other countries where the results were not pre-filtered by specific outlets.

3.2.3 Note on web scraping/crawling and content availability

Scraping by custom scrapers the news outlets content was done in compliance with the outlet website directives, as specified by their robot exclusion protocol implemented by robot.txt file[6]. This file specifies to crawlers which parts of the website can be accessed. The same consideration applies to the crawlers to GNews API. Though GNews does not make available the list of outlets they gather content from, it is reasonable to assume they collect content in compliance with the abovementioned regulations. Therefore, our dataset includes only news stories from outlets that allow automatised gathering of their content or of parts thereof. If a news outlet is completely missing from our dataset, it cannot be inferred a true lack of news stories around the three selected technologies on the outlet website; the missing data could reflect the restrictions to crawling imposed by the outlet website.
The impact of these restrictions on our data collection is that media discourse from relevant outlets (e.g., widely read news journals, magazines that are specialised in one of the selected technologies) might be missing from the dataset and with different degrees of severity, depending on the country. We recognise this as a serious limitation of the present study and its research design

3.2.4 Data Storage and Access

News stories, including content and metadata, were retrieved from GNews in JSON format and in XML (Extensible Markup Language) by the crawlers and scrapers. We then formatted them into tables and saved as Excel files. The files were securely stored in TRI's internal repository. Access to this drive is password protected and only TRI personnel have access to the content of this Drive. Files resulting from the different stages of data processing (from raw data to clean data used for the final analysis) were stored for allowing traceability. Some partners expressed interest in reviewing the data collected from their country. Relevant files with clean data were therefore shared with them. Making the research data open access was not possible in the context of this study as GNews' Terms and Conditions of Use do not allow the use of their material for "public display".[7]

3.3 Data Cleaning

To ensure relevance and correctness of the content collected we followed the cleaning pipeline described below. This pipeline was applied to all the data. However, since different languages present

[6] http://www.robotstxt.org/
[7] https://gnews.io/terms

different characteristics which might require specific handling, each country data underwent an additional language-specific curation. The cleaned data consists in one table for each country where each instance (i.e., row) is a news story and each column indicate: topic of news, news URL, title, body text, date of publishing, domain (i.e., name of the outlet), section (i.e., denomination of the section of the outlet where the news was published).

3.3.1 Standard cleaning and formatting

As we collected data with a mixed approach, we homogenised the data headers and date formats to consistent values. We screened the data for missing values and incorrectly formatted rows. No missing values were found in the news metadata. A small portion of data (<1%) had missing or corrupted text in one or both of the "title" and "body" fields. We removed all the news for which both fields were missing or corrupted. If only one of the two fields was affected by the problem, we kept only the field with correct text. Further, we removed duplicated news stories if they were gathered for the same technology topic. By duplicated stories we mean news with identical URL (hence published by the same outlet, in the same section). If the text of a news story was published in different outlets, we considered the news as two separate instances.
Furthermore, we realised that the data we collected for 2019 were significantly fewer than for 2020 and 2021 and completely missing for some countries. When questioned on this, the data provider did not provide a clear explanation though they mentioned that older news stories are store in different servers which made data retrieval more challenging. Considering this limitation, we decided to remove news from 2019 from the final dataset used in the analysis.

3.3.2 Removal of irrelevant outlets

For each country, we asked partners to review the publishing outlets of the news we collected. Partners were asked to annotate the type and main topic of the outlet, choosing the most suitable label from a provided list, as indicated in *Table 5* and Table 6.

Label	Description
GENERAL_NEWS	General news
FREESHEET	freesheet (free newspapers)
LOCAL	local/regional news
MAGAZINE	magazine
NEWS_AGENCY	news agency
NEWS_AGGREGATOR	news aggregator
TV_RADIO	radio/TV
TABLOID	tabloid (sensational news: crime, celebrity gossip, etc.)
Unsure	Unsure
Other	Other
Mislabelled	Outlet to be removed, e.g., because it is not from the correct country, etc.

Table 5 Labels for type of news outlets.

Label	Description
GENERAL	outlets covering politics, cultures, daily news etc.
TECH	tech, gaming, tech products reviews, etc.
CULTURE	culture, entertainment, fashion, etc
ECONOMY	economy, finance, business

SCIENCE	science, medicine, etc.
Other	other topcis e.g., car, sport, food
Unsure	When it is not clear what the topic is and it's not either general.

Table 6 Labels for main theme of an outlet.

To reduce the annotation work to a manageable effort, we asked partners to annotate only outlets for which less than five news stories were found. To ensure a dataset of higher quality, we kept in the country datasets only stories from annotated outlets. News from outlets that were marked as mislabelled were also removed.

3.3.3 Removal of irrelevant news stories

We manually reviewed a small subset of news in the languages in which members of the data collection team are fluent (i.e., English, Italian, French and Spanish) to identify potential issues with respect to relevance of the news. We realised that some keywords with ambiguous meaning were likely to return irrelevant content and this problem seemed consistent across countries. This was the case of the words *cyborg*, *virtual world*, *thought control*, *VR* and *XR*. To remove irrelevant news related to these topics, the following steps were taken (using automatic translation tools where required):

- The word "Cyborg" was found in news about some movies and videogames as part of the name of one of the characters. We removed all the news where, among the neurotechnology keywords, only "cyborg" was found together with the name of one of these movie or videogames.
- Some news mentioning "thought control" were about telepathy or the terms was loosely used (i.e., not in relation with neurotechnology). Since this keyword generated low return of news, we identified all the news where "thought control" was the only keyword found and manually reviewed their pertinence to the neurotechnology topic.
- All the news where the only digital extended reality keyword found was "XR" were removed as we found it was part of the name of some products (e.g., iPhone-XR) or referring to Extinction Rebellion movement. When "XR" was used as acronym for extended reality, the full term was usually also found.
- In the case of "VR" we found that it was sometimes used as acronym for something different than "Virtual Reality" (e.g., city codes). However, technical outlets often use it without specifying the full word ("Vr", "vr" and "VR" were indistinguishably used). Removing all the instances of news mentioning only "VR" would result in the loss of a significant portion of relevant data. For this reason, we identified all the news where "VR" was the only keyword found, among the digital extended reality ones, and we manually removed the irrelevant ones.

3.4 Data analysis

This section presents the descriptive statistics and text analytics we carried out on the data. Since the volume of news collected, the type, focus, popularity of the outlets as well as the availability of outlets on the news APIs vary across countries, we have only performed few analytics across countries (see section 4) and avoided comparative studies between countries. Instead, we focused the analysis each country and interpreted the outcomes within the context of the country's media landscape, accounting for the characteristics, biases and potential limitations and weaknesses of the news set gathered for that country.

We carried out four types of analysis:

- Descriptive statistic on metadata
- Keywords extraction from text
- Identification of ethical, legal, and social issues (ELSI)-related keywords
- Word clouds, bigrams and named entities

We initially considered performing sentiment analysis on the text of the news body as a means to identify the general positive or negative polarity in the discussions around the selected technologies. However, building accurate sentiment analysis models usually requires manual labelling effort (i.e., labelling a portion of the dataset you want to predict sentiment of) which was out of scope for this task. Although off-the-shelf models (i.e., models that have been trained of previously collected text and can be used to predict sentiment of new unseen text) exist, they were not available for all the languages in our dataset. Furthermore, models for languages different than English tend to have poorer performances than those for English, which would not allow us to gain reliable insights on the sentiment of the news for all studied countries.

Each type of analysis is presented below in more detail.

3.4.1 Descriptive statistics on metadata

We computed different aggregated views of the data to provide summaries and for quality checking. More precisely, we produced visualisations and tables for:

- The counts of news returned per year-month, broken down by technology
- The counts of news returned by each outlet, broken down by technology
- The counts of news returned by outlets of each theme (GENERAL, TECH, etc.), for each technology
- The counts of news divided by section of the outlet where they appear, for each technology.

3.4.2 Keywords extraction from text

Since the data collection was not carried out separately for each keyword and the way the news APIs assess relevance of the returned news with respect to the search criteria does not always transparently map to the keywords, we processed the text content of the news to retrieve mentions of the initial keywords. The primary purpose of this analysis was to gain insights on which of the concepts underlined by the keywords are more frequently mentioned in the news. Furthermore, this keyword extraction can also serve to highlight which wording, among the ones provided in the list of keywords, are more often used. For instance, the concept of virtual reality in several countries is referred to with the original English word, with the country language exact translation of the word and with the acronym of the English word, though with different frequencies.

Before searching for matches of each keyword in the news text content and in order to minimise missing matches because of words inflections (e.g., plurals, tense, gender, number, mood, person) or punctuation (e.g., hyphenation) we performed the following steps:

1. We combined title and text of the news in a single string
2. We removed the punctuation
3. We lower-cased the string and the keywords (for languages in which the casing of a word does not change its meaning)
4. We removed stop words (i.e., set of commonly used words in a language normally including prepositions, particles, interjections, unions, adverbs, pronouns, introductory words, numbers from 0 to 9, symbols, punctuation).
5. We lemmatised all the words in the string and all the keywords (if lemmatisation tools were available for a language). See more details on this step below.

Keyword matching was then performed on the lemmatised text and keywords. In computational linguistics, lemmatisation is the process of determining the non-inflected form (called lemma or base form) of a word based on its intended meaning. Building algorithms for lemmatisation is a challenging task, it is highly language dependent and an active area of research (Lagus et al., 2021). We relied on automatic lemmatisers provided by Python spaCy library (Van Rossum, Drake, 1995; Honnibal, Montani, 2017) which assign a base form to a word using rules based on part-of-speech tags or lookup tables. The performances of these lemmatisation models vary with the languages and, though the output is not perfect, and some manual adjustment is often necessary, they allowed us to increase the number of relevant matches. At the time of writing this report, the library implements lemmatisers only for a subset of the languages we are interested in, namely: English, Dutch, French, German, Italian, Romanian,

Spanish, Swedish. For Serbian and Czech, steps 1 to 4 were followed, and step 5 was replaced by exact keyword matching.

3.4.3 Identification of ethical, legal and social issues related keywords

Another focus of analysis was the identification of ethical, legal, or social issues (ELSI) in relation to the selected technologies. This analysis aimed at contributing to TechEthos' main objective to study ethical and legal aspects of the three technologies considering their high socio-economic impact. To this aim, we developed a list of ELSI keywords, taking into account the work carried in WP1.[8] We then used the same approach described in the previous section to retrieve matches of the words in the news text.

ELSI keywords in English:
Ethics / privacy / fairness / discrimination / bias / human rights / negative impact / vulnerable group / accountability / integrity / physical integrity / security / justice / dignity / society / well-being / fundamental rights / sustainability / law / responsibility

The translations are reported in the Annex 2. We used automatic translation (provided by DeepL Translator[9]) to translate them in the other languages and asked partners to review the translation during the bilateral calls held with each of them in April and May 2022. To be able to analyse more closely the subset of news set potentially addressing ELSI, we marked all the news where at least one ELSI keyword was found.

3.4.4 Word clouds, bigrams and named entities

Finally, we applied algorithms for producing word clouds and extracting bigrams (i.e., pair of words frequently occurring together) from the cleaned text. We also used pre-trained Named Entity Recogniser (NER) models to extract named entities from the text. A named entity is a real-world object that can be denoted with a proper name – for example a person, a product, an organisation. Currently, spaCy library provides NER models only for some languages; the types of named entities and the performances of the entities' extraction models vary across languages and entity types. For languages where NER models were available, we extracted mentions of one or more of these entities: persons, organisations and geo-political entities.

3.5 Software implementation

All the software we built for data collection, cleaning and analysis were developed in Python code, using several open-source Python libraries. The code is securely stored on TRI's server, on a Git-based source code repository (Chacon, Straub, 2014) which allows version control (version control is the act of tracking and managing changes to software code developed by a team over time and Git is a version control system software).
We relied on standard libraries to develop the functions to get the API results from GNews and for the data cleaning and processing. For the custom web scrapers and crawlers, we leveraged specific libraries used to parse content from HTML pages, extract news URLs and parse and correctly format content from the news page. For the processing and analysis of text we largely relied on spaCy library, which provides models and pipelines for advanced natural language processing in multiple languages. Where language support was available, we used spaCy to perform the lemmatisation, named entity recognition, keyword matching, and stop words removal. The python code developed for analysing and describing the dataset will be made accessible via GitHub[10] by July 2022.

[8] Due to task timing, we did not have the full list of ELSI keywords from WP2 (ethical analysis) ready in time for this task. However, the list we used does cover a majority of the main ELSI keywords identified in WP2.
[9] https://www.deepl.com/en/whydeepl
[10] https://github.com/

3.6 Limitations

Now that we have presented the method, processes, and tools used for the data collection and cleaning and for the analysis of data, and before we move on with the presentation of results per country, we need to highlight a few limitations of this study. It is essential to account for these in the discussion of the results (presented in Section 4 and Section 5).

3.6.1 Limitations due to challenges with data collection

The main challenges relate to the data collection phase in which we encountered the following difficulties:

- Some relevant outlets were missing for most of the countries (e.g., the *Daily Mail* in the UK or *Kronen Zeitung* in Austria). The news providers did not disclose transparently the reasons for this gap. For this reason, if any news from known relevant outlets are not present in our collection, we cannot be sure that this reflects a genuine lack of news stories in the outlet. However, since some of the keywords used for the data collection are very common in the media discussions, we can reasonably infer that that the data gap is due to the fact that news from this outlet were not available on the news provider databases.
- The time coverage presented some gaps of unclear origin, such as some months missing at the start of 2020 for Germany. These might be due to errors with the connection to news API servers and storage of the news in the news provider databases. As for the previous point, we could not obtain a clear answer on the issue from the news provider.
- Due to the high volume of news stories matching the digital extended reality search strings, in some cases we hit the rate limit of news stories over time imposed by the news API. In spite of the mechanisms we implemented in the code to account for the rate limits constraints, this was an issue in the cases of France, Italy and US, resulting in data gaps spanning several months. Since we had limited time access to the API we could not repeat the search to amend for this gap.
- News stories published close to the time of collection are more easily accessible and available in larger amount. This produces a data bias towards more recent events and discussions, which gain more visibility in our analysis. This is due to challenges related with data storage and access made available by the news providers.

This means that *it is difficult to assess the representativeness of the data collected*. In other words, we *cannot* claim that our results are representative of the media discourse in general in this or that particular context. Rather they present the media discourse in the news stories that were collected, using the rigorous cleaning and analytics tools highlighted in this section, and for the purpose we set out to pursue, i.e., giving a snapshot on the way the media represent the three technologies. In that sense, they give a method and systematic an *indication* of the media discourse in a particular geographical context. Further analysis could be conducted to enhance the representativeness of the results obtained in the present study. This means that we need to show extreme prudence when presenting the results. Other limitations that need to be highlighted include limits of using keyword matching as method to retrieve content of interest due to languages idiosyncrasies.

3.6.2 Limitations due to challenges with data analysis

The data analysis phase also brought a number of challenges. Firstly, performances and quality of tools for automatic text processing vary across languages, with generally poorer performances for languages other than English. Furthermore, words can have multiple meanings and therefore be retrieved even though it did have the intended meaning. This challenge was more critical in the case of the search for ELSI keywords. Indeed, as opposed to the list of technical keywords used to collect news stories related to the three families of technologies, the ELSI keywords are more general. For instance, 'society' in some languages is a synonym for 'company'; 'Würde' in German can mean 'dignity' or 'would' if the verb appears at the beginning of a sentence; 'legge' in Italian can refer to 'law' or to the third person singular of the verb 'to read'. However, given the high number of languages included in our analysis, accounting for the specificity of each language in the data processing would have increased significantly the time and complexity of the task. To limit this effort, we decided to standardise as much as possible the data

processing, though this might have resulted in the identification of some irrelevant ELSI-keyword matches. In particular, we noticed some irrelevant matches of the word 'privacy': the text of some news, as provided by the API, contained pieces of text extracted from the section of the news webpage referencing newsletter subscription and 'privacy notice'.
Further data analysis could be done to confirm the results obtained in this study. For a more in-depth picture of the media discourse, a qualitative analysis could also be conducted (such as: Barnard-Wills, 2011).

4 Results across countries

This section presents some key results of the analysis across all countries, while Section 5 presents detailed reports of the results for each country. The set of news stories retrieved for each country varies significantly in terms of volume, quality (i.e., relevance), time and outlets coverage (this was due to challenges with data access and retrieval, as we discuss in more details in Section 3.6). While the high data variability across countries motivated our choice of performing a per-country analysis rather than a comparative analysis across countries, we were able to identify some general patterns and noteworthy findings from the data collected across all countries.

4.1 Collected data

For most countries studied, digital extended reality was the technology for which more news stories were collected. On average, it accounted for 62.1% of the news stories in a country. Germany and Austria are an exception in this regard as the highest number of stories relates to climate engineering topics. Neurotechnology was the topic for which less news stories were collected for all countries (on average, 5.4% of share). Figure 1 presents the percentage of news stories collected per technology, for each country.

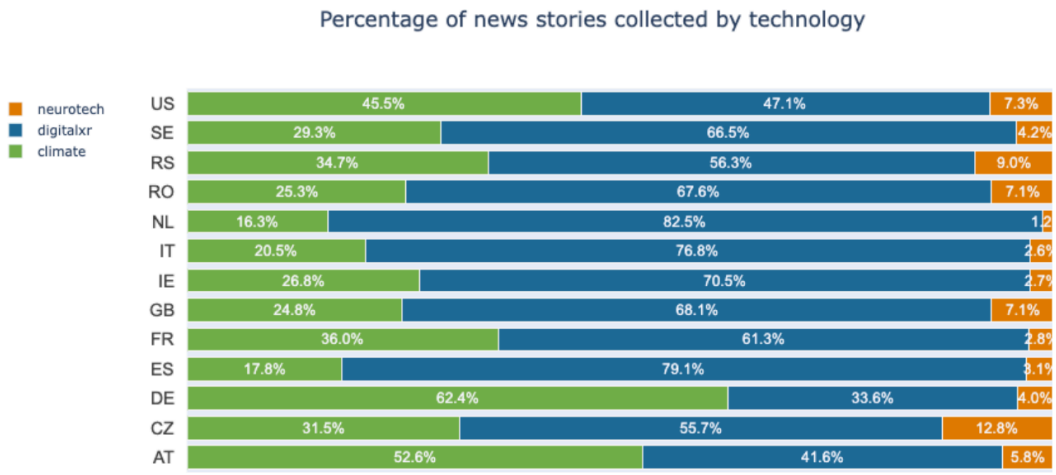


Figure 1 Percentage of news stories collected, for each country, for each technology category (over the total news stories collected for that country).

Figure 2 shows the raw counts of news collected overall.

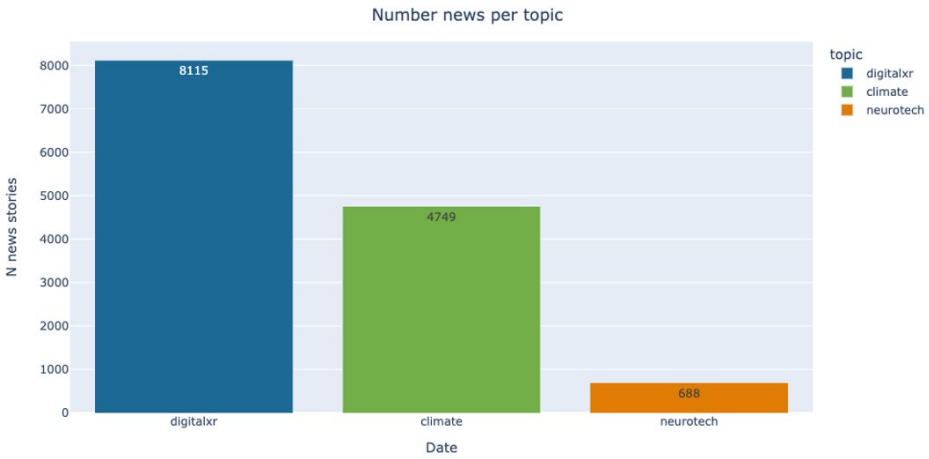


Figure 2 Total count of news stories collected for the three selected technologies.

In total, stories were retrieved from 727 different outlets: digital extended reality news stories were collected from 311 outlets; climate engineering stories from 238 and neurotechnology stories from 178 outlets. Figure 3 shows the counts of unique outlets and the counts of news stories collected for each country. We can observe that US stands out from the set of countries for the higher volume of news stories collected from a larger set of unique outlets. We can also observe that for countries for which between 1000 and 25000 news stories were collected (Germany, UK, Italy, and France), the number of unique outlets ranges from 20 to 35. From countries for which less than 100 news stories were collected, the number of unique outlets is, in general, lower than 20, such as Austria, Netherlands, Sweden, Spain, Romania, Ireland. Czech Republish and Serbia are exceptions to this with a high number of outlets (between 35 and 40) but a low number of news stories (less than 500). This might be explained by the different method used for the data collection for these two countries (as detailed in Section 3.2.2).

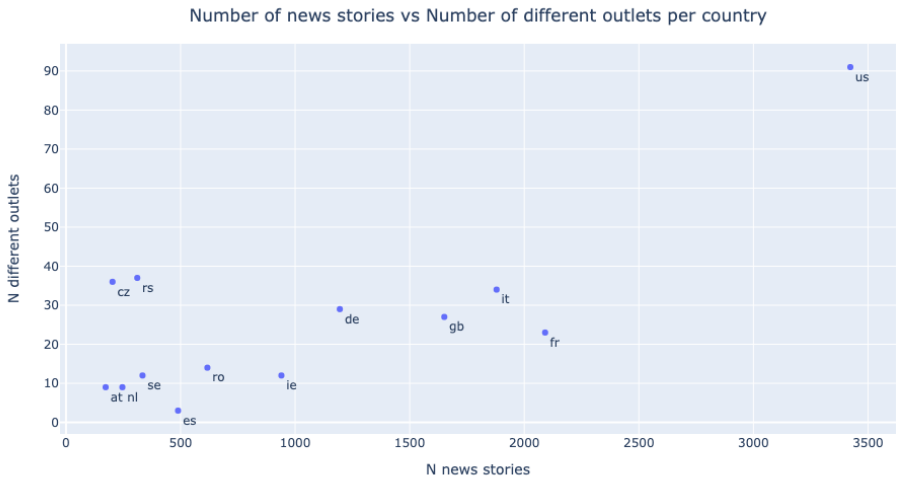


Figure 3 Number of news stories collected for a country as a function of the number of unique outlets where the news stories were published.

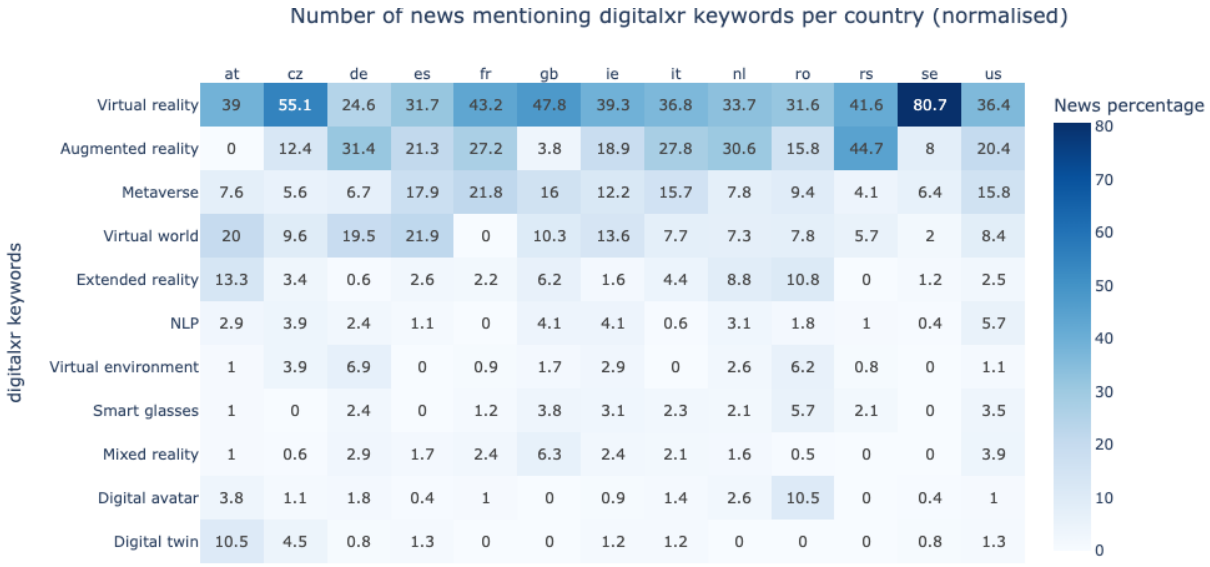
Due to the high variance of the number of news stories collected for each country, comparing the raw numbers will bias the insights towards countries for which a larger set could be gathered. For this reason, for each of the technology keyword we computed the number of news stories where the

keyword appears and scaled between 0 and 1. The results are visualised as heatmaps in the figures below.

4.2 Digital extended reality

'Virtual reality' was the topic most frequently mentioned in the news stories for digital extended reality, appearing, on average, in 41.7% of the news stories of a country collected for this technology. 'Augmented reality', 'Metaverse' and 'virtual world' appear, on average, 20.2%, 11.3% and 10.3% respectively. 'Virtual reality' was the top keyword for all countries except in Germany and Serbia, where the most frequent item is 'augmented reality' (Figure 4). Most of the news stories collected for this technology were published in outlets covering general topics or tech topics (41.9% and 40.5% respectively). As for the type of outlets with most stories, 20.0% of the news stories were found in general outlets (national newspapers covering general topics) and 11.6% on freesheets.

Figure 4 Heatmap showing the percentage of news stories in which the digital extended reality keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news sets sizes.



Mentions of big technology companies have been found consistently across all countries. 'Facebook', 'Apple' and 'Google' are mentioned in 9.3%, 5.8% and 2.5% of the news stories collected for digital extended reality. We can observe in the figure below (Figure 5) a peak in titles mentioning 'Facebook' or 'Meta' in October 2021, period in which 'Facebook' announced the change of name to 'Meta'. We also found that 28.8% and 16.8% of this set of news, address issues around 'privacy' and 'security' respectively.

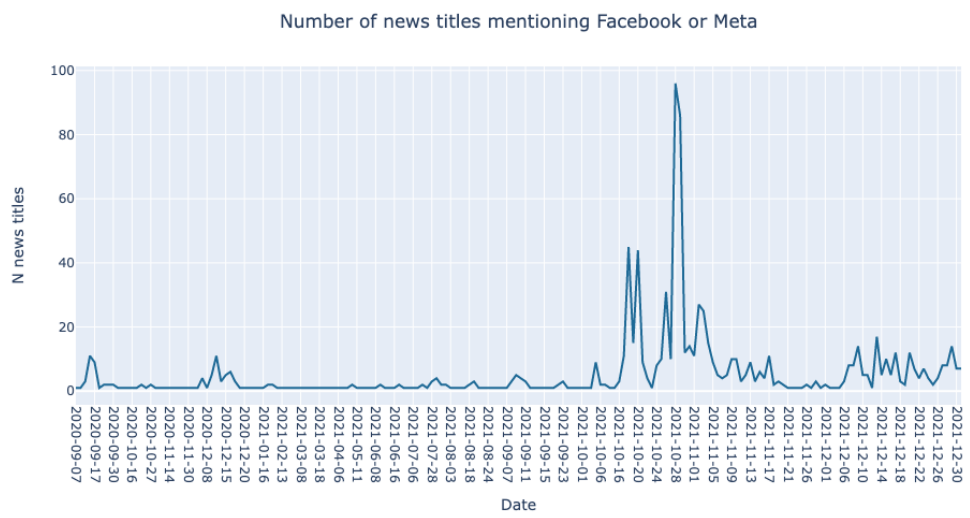


Figure 5 Daily number of news mentioning 'Facebook' or 'Meta' in the title (sum of counts of all the countries).

ELSI-keywords were mentioned in 35% of the overall news stories collected for digital extended reality. The breakdown by keyword is shown in the figure below (Figure 6) where the values on the y-axis indicate the average percentage with which ELSI keyword appeared in the digital extended reality news stories across all countries.

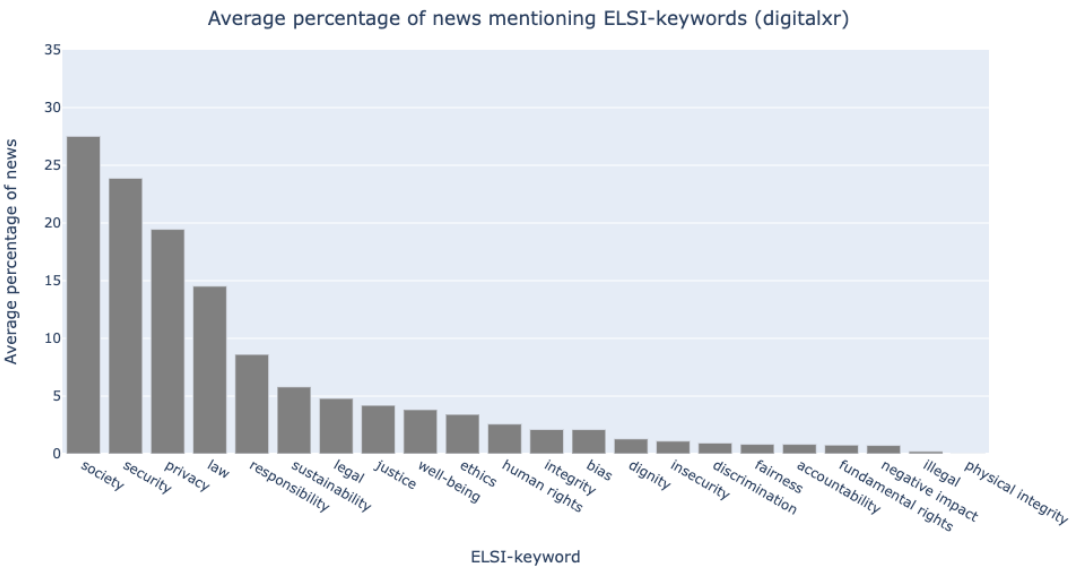
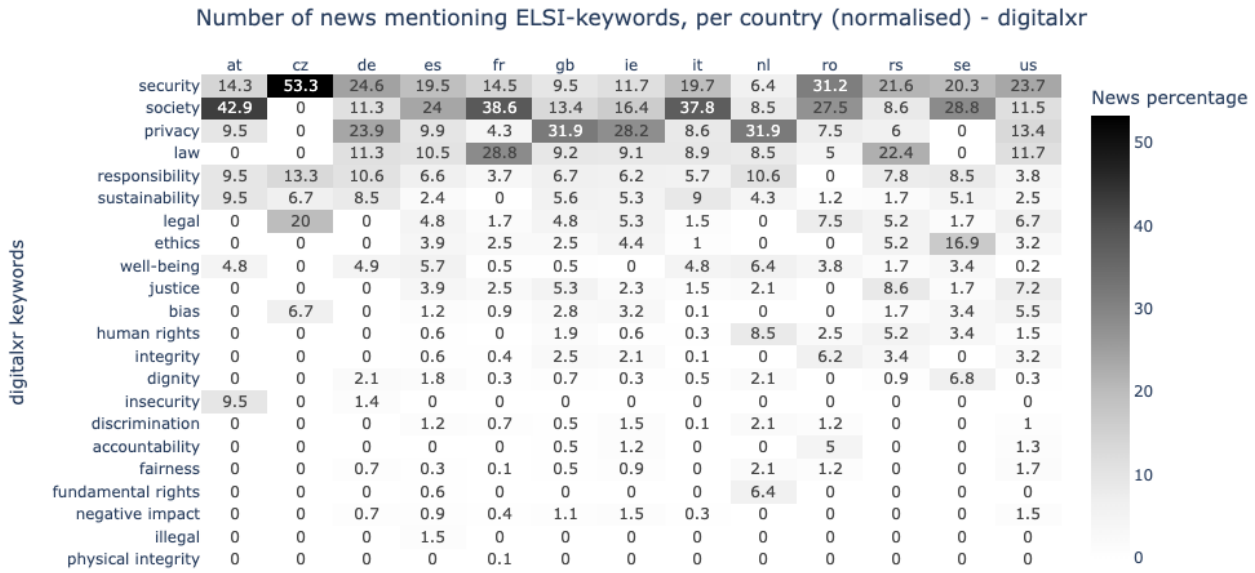


Figure 6 Average percentage of news in which the ELSI-keywords on the x-axis are mentioned in the set of news stories collected, for a country, for digital extended reality.

Figure 7 shows, for each country, the number of news mentioning each keyword, divided by the total mentions of ELSI-keywords in the digital extended reality stories for that country.



	at	cz	de	es	fr	gb	ie	it	nl	ro	rs	se	us
security	14.3	53.3	24.6	19.5	14.5	9.5	11.7	19.7	6.4	31.2	21.6	20.3	23.7
society	42.9	0	11.3	24	38.6	13.4	16.4	37.8	8.5	27.5	8.6	28.8	11.5
privacy	9.5	0	23.9	9.9	4.3	31.9	28.2	8.6	31.9	7.5	6	0	13.4
law	0	0	11.3	10.5	28.8	9.2	9.1	8.9	8.5	5	22.4	0	11.7
responsibility	9.5	13.3	10.6	6.6	3.7	6.7	6.2	5.7	10.6	0	7.8	8.5	3.8
sustainability	9.5	6.7	8.5	2.4	0	5.6	5.3	9	4.3	1.2	1.7	5.1	2.5
legal	0	20	0	4.8	1.7	4.8	5.3	1.5	0	7.5	5.2	1.7	6.7
ethics	0	0	0	3.9	2.5	2.5	4.4	1	0	0	5.2	16.9	3.2
well-being	4.8	0	4.9	5.7	0.5	0.5	0	4.8	6.4	3.8	1.7	3.4	0.2
justice	0	0	0	3.9	2.5	5.3	2.3	1.5	2.1	0	8.6	1.7	7.2
bias	0	6.7	0	1.2	0.9	2.8	3.2	0.1	0	0	1.7	3.4	5.5
human rights	0	0	0	0.6	0	1.9	0.6	0.3	8.5	2.5	5.2	3.4	1.5
integrity	0	0	0	0.6	0.4	2.5	2.1	0.1	0	6.2	3.4	0	3.2
dignity	0	0	2.1	1.8	0.3	0.7	0.3	0.5	2.1	0	0.9	6.8	0.3
insecurity	9.5	0	1.4	0	0	0	0	0	0	0	0	0	0
discrimination	0	0	0	1.2	0.7	0.5	1.5	0.1	2.1	1.2	0	0	1
accountability	0	0	0	0	0	0.5	1.2	0	0	5	0	0	1.3
fairness	0	0	0.7	0.3	0.1	0.5	0.9	0	2.1	1.2	0	0	1.7
fundamental rights	0	0	0	0.6	0	0	0	0	6.4	0	0	0	0
negative impact	0	0	0.7	0.9	0.4	1.1	1.5	0.3	0	0	0	0	1.5
illegal	0	0	0	1.5	0	0	0	0	0	0	0	0	0
physical integrity	0	0	0	0	0.1	0	0	0	0	0	0	0	0

Figure 7 Heatmap showing the percentage of digital extended reality news stories in which the ELSI keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news stories set sizes.

We can observe that the terms 'society', 'security', 'privacy', 'law' are the most frequently mentioned ELSI terms on average across all countries.

4.3 Climate engineering

Regarding climate engineering, we can observe that 'green hydrogen' is the most prevalent item of discussion across countries (on average, this keyword accounts for 30.7% of the mentions of climate engineering keywords in the news stories collected for a country), followed by 'afforestation' (22.4%), 'carbon storage' (14.0%), 'carbon capture' (13.0%), and 'reforestation' (7.5%). The other keywords appear on average in less than 5% of the stories collected. 'Afforestation' was the most frequent topic in the Austrian, German, Spanish, Romanian and Serbian news stories. 'Green hydrogen' shared the highest portion of news stories in Czech Republic, France, Italy and the Netherlands. In the UK, Ireland and US 'carbon capture' was mentioned in most news stories and 'carbon storage' in Sweden (Figure 8).

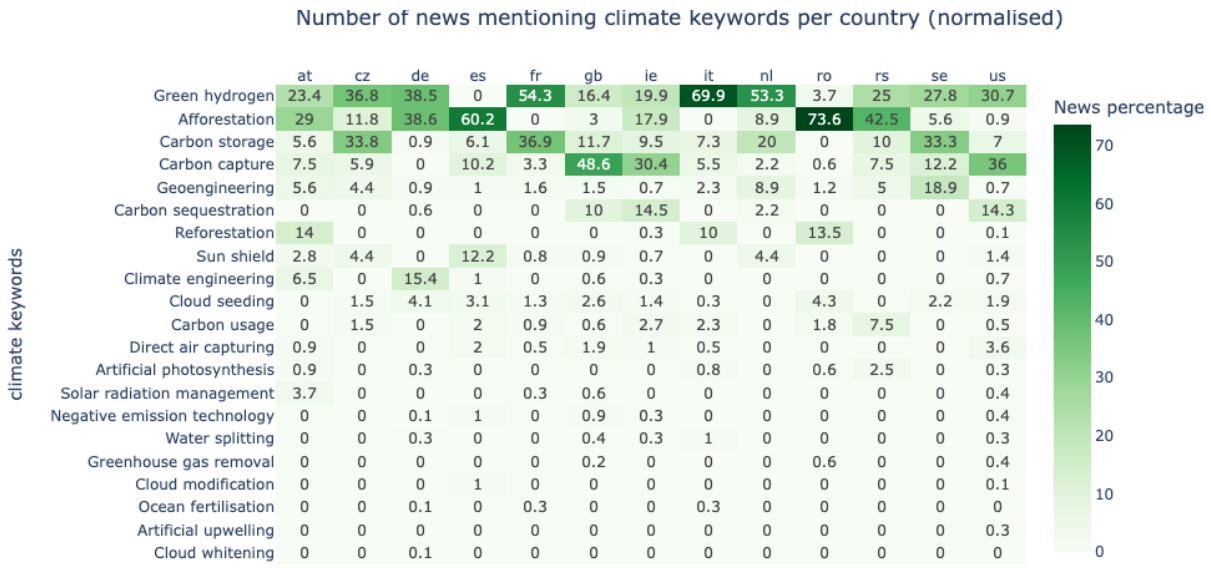


Figure 8 Heatmap showing the percentage of news stories in which the climate engineering keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news sets sizes.

The fact that green hydrogen is the most frequently mentioned keywords in stories collected for climate engineering is an interesting finding. Indeed, green hydrogen does not strictly belong to the category of climate engineering as this family of technology has been defined in the TechEthos project. It was part of the overall horizon scanning exercise, with the technologies that aim at tackling climate change; however, it was then excluded from the definition of this family of technologies as it does not specifically "act on the Earth's climate system".[11] We can therefore observe that discussions on technologies to tackle issues of climate change are not dominated by climate engineering (in the narrow sense of the term as defined by TechEthos).
Furthermore, we can observe that solar engineering techniques are rather rarely discussed in new stories discussing "climate engineering" topics (as defined for the purpose of this study through the list of keywords established. Indeed, afforestation, reforestation, carbon capture, sequestration and storage are among the most discussed topics (see Figure 8). On the contrary, technologies such as sun shield, solar radiation management or cloud modification or whitening are rarely discussed.

We found that generalist country outlets (as opposed to technical for instance) published a large share of the news stories for this technology. 69.9% of the climate engineering news stories were published in outlets covering general topics; 17.3% in outlets with an economic focus and 4.7% on technical outlets. 29.3% of the climate engineering news were collected from general outlets (national online newspapers without a specific focus); 14.4% of the news were published on local outlets and 11.3% on TV or radio broadcasters' websites.
On average, for each country, ELSI-keywords were found in 44.6% of the news stories collected for climate engineering for all countries. The breakdown by keyword is shown in the figure below (Figure 9) where the values on the y-axis indicate the average percentage with which ELSI keyword appeared in the climate engineering news stories of all countries.

[11] https://www.techethos.eu/climate-engineering/

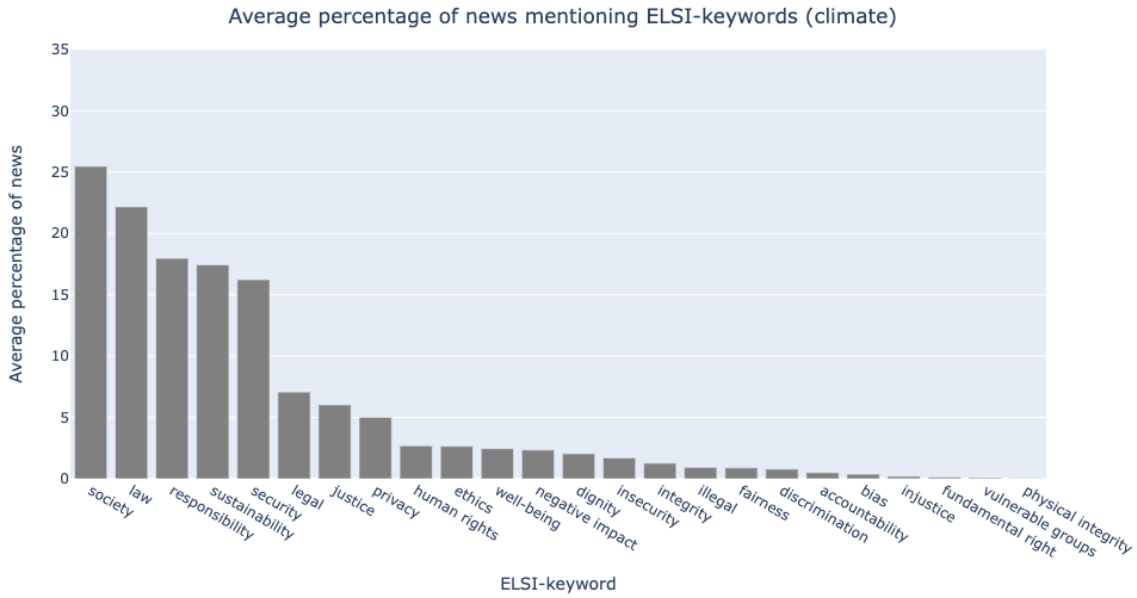
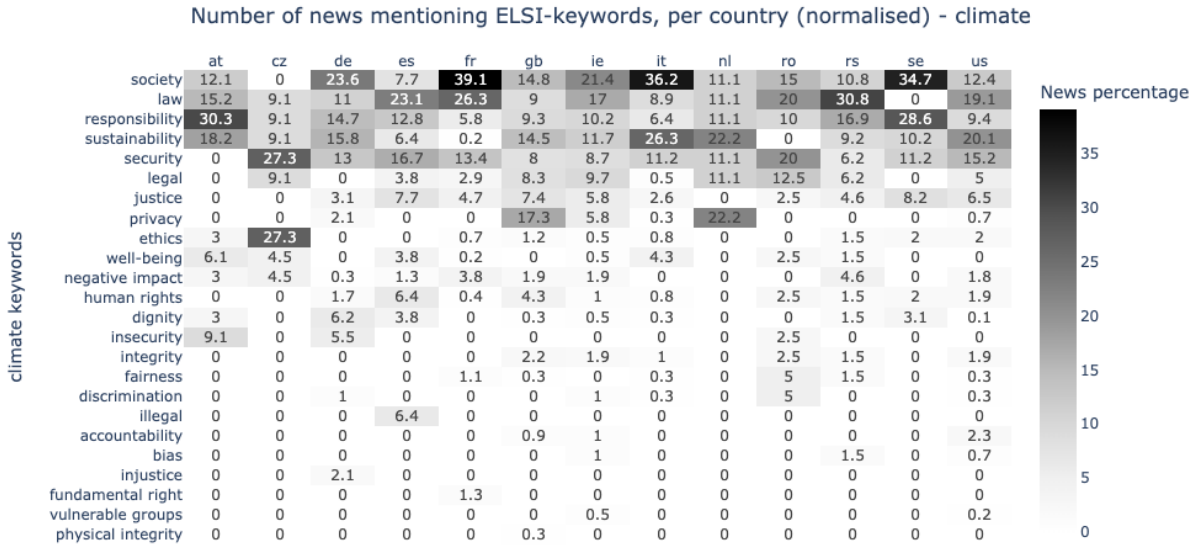


Figure 9 Average percentage of news in which the ELSI-keywords on the x-axis are mentioned in the set of news stories collected in all countries, for climate engineering.

Figure 10 below shows, for each country, the number of news mentioning each keyword, divided by the total mentions of ELSI-keywords in the climate engineering stories for that country



	at	cz	de	es	fr	gb	ie	it	nl	ro	rs	se	us
society	12.1	0	23.6	7.7	39.1	14.8	21.4	36.2	11.1	15	10.8	34.7	12.4
law	15.2	9.1	11	23.1	26.3	9	17	8.9	11.1	20	30.8	0	19.1
responsibility	30.3	9.1	14.7	12.8	5.8	9.3	10.2	6.4	11.1	10	16.9	28.6	9.4
sustainability	18.2	9.1	15.8	6.4	0.2	14.5	11.7	26.3	22.2	0	9.2	10.2	20.1
security	0	27.3	13	16.7	13.4	8	8.7	11.2	11.1	20	6.2	11.2	15.2
legal	0	9.1	0	3.8	2.9	8.3	9.7	0.5	11.1	12.5	6.2	0	5
justice	0	0	3.1	7.7	4.7	7.4	5.8	2.6	0	2.5	4.6	8.2	6.5
privacy	0	0	2.1	0	0	17.3	5.8	0.3	22.2	0	0	0	0.7
ethics	3	27.3	0	0	0.7	1.2	0.5	0.8	0	0	1.5	2	2
well-being	6.1	4.5	0	3.8	0.2	0	0.5	4.3	0	2.5	1.5	0	0
negative impact	3	4.5	0.3	1.3	3.8	1.9	1.9	0	0	0	4.6	0	1.8
human rights	0	0	1.7	6.4	0.4	4.3	1	0.8	0	2.5	1.5	2	1.9
dignity	3	0	6.2	3.8	0	0.3	0.5	0.3	0	0	1.5	3.1	0.1
insecurity	9.1	0	5.5	0	0	0	0	0	0	2.5	0	0	0
integrity	0	0	0	0	0	2.2	1.9	1	0	2.5	1.5	0	1.9
fairness	0	0	0	0	1.1	0.3	0	0.3	0	5	1.5	0	0.3
discrimination	0	0	1	0	0	0	1	0.3	0	5	0	0	0.3
illegal	0	0	0	6.4	0	0	0	0	0	0	0	0	0
accountability	0	0	0	0	0	0.9	1	0	0	0	0	0	2.3
bias	0	0	0	0	0	0	1	0	0	0	1.5	0	0.7
injustice	0	0	2.1	0	0	0	0	0	0	0	0	0	0
fundamental right	0	0	0	0	1.3	0	0	0	0	0	0	0	0
vulnerable groups	0	0	0	0	0	0	0.5	0	0	0	0	0	0.2
physical integrity	0	0	0	0	0	0.3	0	0	0	0	0	0	0

Figure 10 Heatmap showing the percentage of climate engineering news stories in which the ELSI keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news sets sizes.

4.4 Neurotechnology

The most frequently mentioned keywords in the news stories for neurotechnology were 'cyborg' (found on average in 21.3% of the news stories collected across all countries for this technology), 'brain implant' (13.5%), 'neurotechnology' (11.55%), 'brain chip' (10.4%) and 'brain computer interface' (9.6%). 'Cyborg' was the top keyword for Italy, Netherlands, Romania, and Sweden. In France, the UK, and the US, 'brain computer interface' was most frequently mentioned. 'Neurotechnology' was the most frequently mentioned keyword in Germany and Spain. Finally, 'thought control', 'brain to brain', 'brain implant' and 'brain chip' where the top keywords in Austria, Serbia, 'Czech Republic' and 'Ireland' respectively (see Figure 11Figure 11.
Neurotechnology news stories were mainly published in general outlets - national newspapers with no specific thematic focus (17.3%) and TV and radio broadcasters' websites (8.3%). 44.0% of the news stories appeared in outlets covering general topics, 25.7% in tech specific outlets and 17.7% in outlets with science focus.
Neuralink or Elon Musk are mentioned in news stories collected in all countries and, in total, occur in 34.4% of the neurotechnology new stories collected.

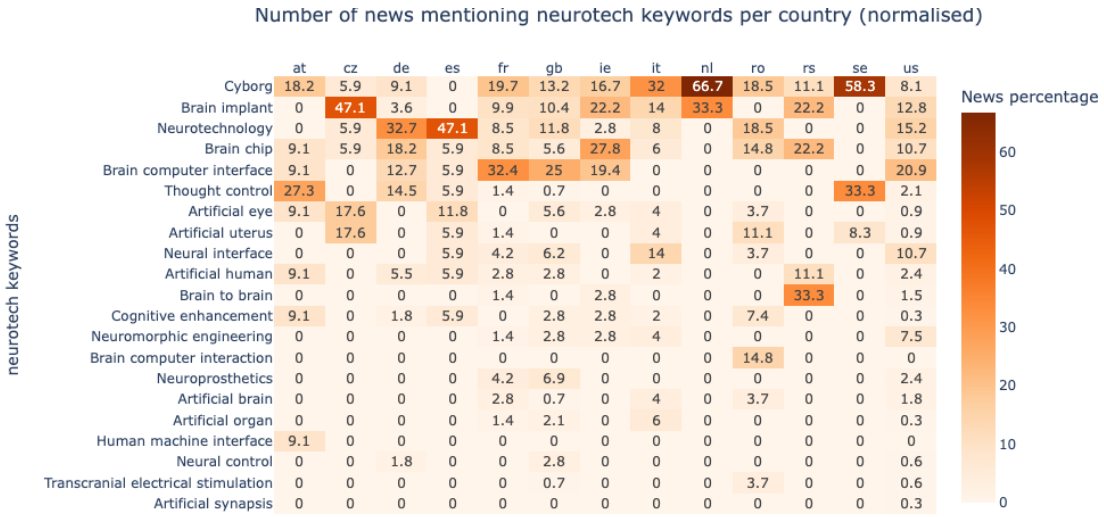


Figure 11 Heatmap showing the percentage of news stories in which the neurotechnology keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news sets sizes.

On average, for each country, ELSI-keywords were found in 41.8% of the news stories collected for neurotechnology for a country. The breakdown by keyword is shown in the figure below (Figure 12) where the values on the y-axis indicate the average percentage with which ELSI keyword appeared in the neurotech news stories collected for all countries.

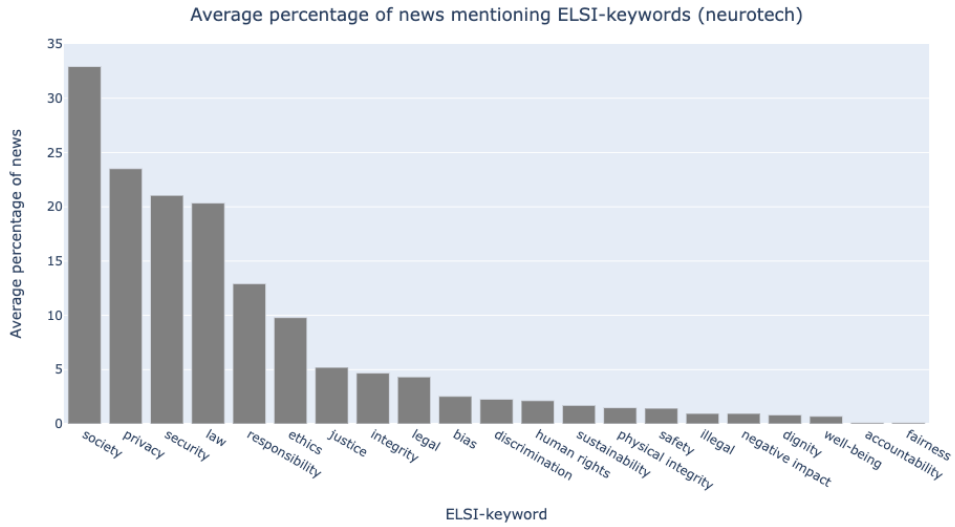
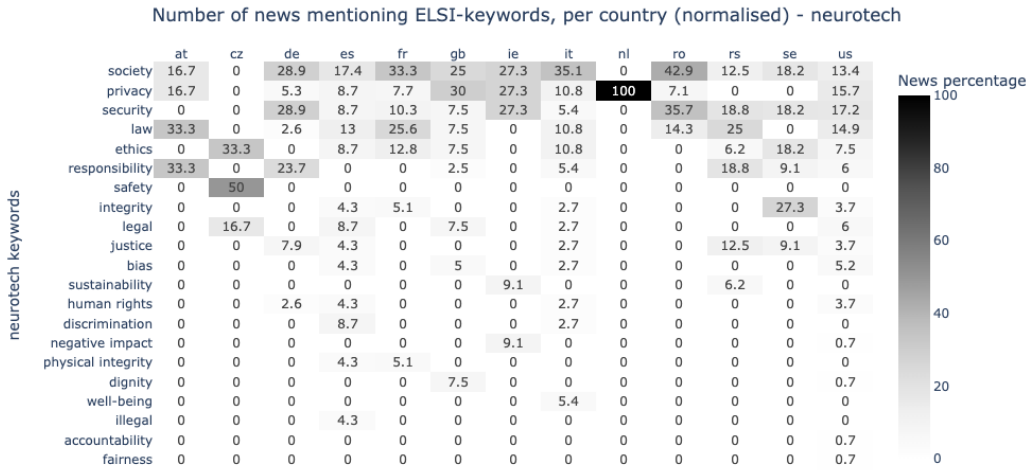


Figure 12 Average percentage of news in which the ELSI-keywords on the x-axis are mentioned in the set of news stories collected, for a country, for neurotechnology

The heatmap below shows, for each country, the number of news mentioning each keyword, divided by the total mentions of ELSI-keywords in the neurotechnology stories for that country (Figure 13).



	at	cz	de	es	fr	gb	ie	it	nl	ro	rs	se	us
society	16.7	0	28.9	17.4	33.3	25	27.3	35.1	0	42.9	12.5	18.2	13.4
privacy	16.7	0	5.3	8.7	7.7	30	27.3	10.8	100	7.1	0	0	15.7
security	0	0	28.9	8.7	10.3	7.5	27.3	5.4	0	35.7	18.8	18.2	17.2
law	33.3	0	2.6	13	25.6	7.5	0	10.8	0	14.3	25	0	14.9
ethics	0	33.3	0	8.7	12.8	7.5	0	10.8	0	0	6.2	18.2	7.5
responsibility	33.3	0	23.7	0	0	2.5	0	5.4	0	0	18.8	9.1	6
safety	0	50	0	0	0	0	0	0	0	0	0	0	0
integrity	0	0	0	4.3	5.1	0	0	2.7	0	0	0	27.3	3.7
legal	0	16.7	0	8.7	0	7.5	0	2.7	0	0	0	0	6
justice	0	0	7.9	4.3	0	0	0	2.7	0	0	12.5	9.1	3.7
bias	0	0	0	4.3	0	5	0	2.7	0	0	0	0	5.2
sustainability	0	0	0	0	0	0	9.1	0	0	0	6.2	0	0
human rights	0	0	2.6	4.3	0	0	0	2.7	0	0	0	0	3.7
discrimination	0	0	0	8.7	0	0	0	2.7	0	0	0	0	0
negative impact	0	0	0	0	0	0	9.1	0	0	0	0	0	0.7
physical integrity	0	0	0	4.3	5.1	0	0	0	0	0	0	0	0
dignity	0	0	0	0	0	7.5	0	0	0	0	0	0	0.7
well-being	0	0	0	0	0	0	0	5.4	0	0	0	0	0
illegal	0	0	0	4.3	0	0	0	0	0	0	0	0	0
accountability	0	0	0	0	0	0	0	0	0	0	0	0	0.7
fairness	0	0	0	0	0	0	0	0	0	0	0	0	0.7

Figure 13 Heatmap showing the percentage of neurotechnology news stories in which the ELSI keyword on the y-axis was mentioned in the news set of the corresponding country on the x-axis. The values in each column (i.e., country) have been divided by the total number of mentions of keywords (i.e., the sum of the column values) to make the results comparable across countries, due to the large differences in the news sets sizes.

5 Results per country

In this section we present and discuss the results of the analysis for each country separately. The insights presented below are the result of the different analytics activities detailed in Section 3. We visually interpreted the tables, plots and text analytics resulting from the analysis, which provide different summaries of the news set under examination. We also manually scanned some titles and news text based on what appeared as more relevant or interesting from the summaries (e.g., news where more ELSI-keywords were found, news about the most mentioned technology keyword, news where a certain keyword was mentioned with unexpected high/low frequency).[12] Additionally, we drew on the comments, feedback and insights provided by partners during the bilateral calls we held with them in April-May 2022.
Most country reports follow the same structure: 1. Dataset description; 2. Climate engineering; 3. Digital extended reality; 4. Neurotechnology. Due to some specificities of the data collected for particular countries and some differences in the methods that could be applied for the analysis, each report might present a slightly different focus.

5.1 Austria

5.1.1 Dataset description

Austria was the only country for which the data collection was carried out by scraping Google results (explanation provided in Section 3.2.2). We found that this approach returned a higher portion of irrelevant news compared to the others. As emerged by applying the data cleaning pipeline described before, several news collected did not mention any of our keywords and were probably returned by the Google results because containing some words synthetically but not semantically similar to the keywords. Figure 14 reports the counts of news stories gathered for each month-year, broken down by technology.
After cleaning and processing the data, the final news set comprised 173 news stories: 91 for climate, 72 for digital extended reality, 10 for the neurotechnology.

[12] For the manual review of titles and news bodies we relied, when necessary, on automatic translation (we used DeepL translator for short text and Google translate browser extension for translation of entire news web pages).

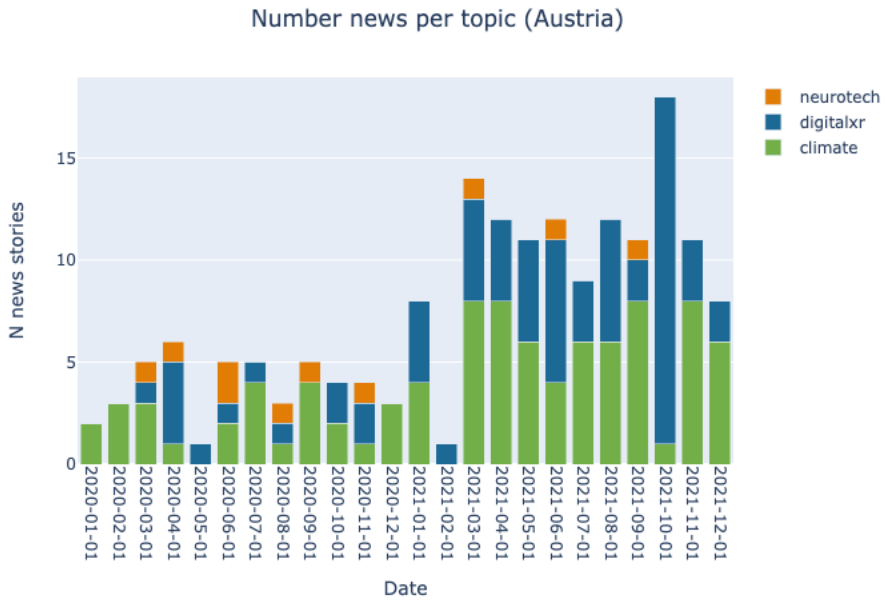


Figure 14 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Austria

The table below (Table 7) shows the breakdown count by technology and outlet together with the annotation of the type and the main theme/topic of the outlet as provided by the LTP SCN.
As indicated above (Section 3.2.2) the Austrian data collection is the only one in which we specified the outlet publishing the news by using a ranked list of popular outlets. This could explain why the outlets have a "General" theme and are mostly "General News" type of outlets. However, two key Austrian outlets, *Krone* and *Der Standard*, which were present in the outlet list we used and were referred by the Austrian partners (SCN) as relevant, are missing from our collection. This is because these outlets do not allow crawling of their content. This constituted a limitation of the study and means that we need to interpret the results shown below by clearly accounting for this data access limitation.

Outlet	Climate	Digital XR	Neurotechnology	Outlet type	Outlet theme
Die Presse	2	9	0	GENERAL_NEWS	GENERAL
GMX	1	0	1	NEWS_AGGREGATOR	GENERAL
Kleine Zeitung	11	10	1	LOCAL	GENERAL
Mein Bezirk	32	14	2	GENERAL_NEWS	GENERAL
OÖNachrichten	13	5	0	GENERAL_NEWS	GENERAL
Oe24	8	22	5	GENERAL_NEWS	GENERAL
ORF	13	5	1	GENERAL_NEWS	GENERAL
Puls24	8	5	0	TV_RADIO	GENERAL
Salzburg24	3	2	0	LOCAL	GENERAL

Table 7 Counts of news stories collected from each outlet, broken down by technology, for Austria. The annotation for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.1.2 Climate engineering

The bar plot below (Figure 15) shows, for each keyword, the number of news stories where the keyword was mentioned. We can observe that most of the news gathered for the climate engineering topic mention 'afforestation', 'green hydrogen' and 'reforestation'. 'CO2 capture', 'geoengineering' and 'climate engineering' are also found in a few news stories collected. Several of the other keywords were found though they are mentioned in less than five news stories.

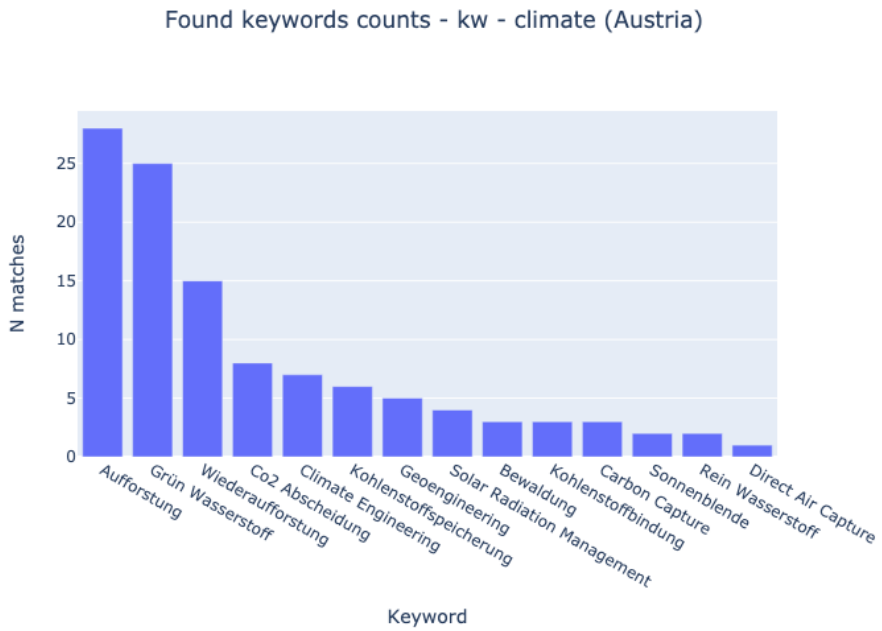


Figure 15 Counts of news stories mentioning the climate engineering keyword on the x-axis for Austria. The English translation of the words is, from left to right: afforestation, green hydrogen, reforestation, CO2 capture, climate engineering, carbon storage, geoengineering, solar radiation management, forestation, carbon sequestration, carbon capture, sun shields, pure hydrogen, direct air capture.

The bigrams helped us identify pair of words that are often mentioned in the news and can provide further insights on topics, issues, expressions that are discussed in the outlets. We ranked them by frequency and selected the most interesting. The selection is reported in the table below (Table 8).

Frequent bigrams (DE)	***Frequent bigram (EN)***
Million Euro	*Million euro*
Grad Celsius	*Degree Celsius*
Kampf Klimawandel	*Fight climate change*
Gigatonnen CO2	*Gigatons of co2*
Klimaziele erreichen	*Achieve climate goals*
Gas Zukunft	*Gas future*
Baum pflanzen	*Tree planting*
Wasserstoff erzeugen	*Generate hydrogen*
Ausstoß Treibhausgasen	*Greenhouse gas emissions*

Table 8 A selection of the most frequent bigrams from the climate engineering news stories for Austria

The following analytics were generated considering only the subset of the news where at least one of the ELSI keywords was found. This subset comprises 28 news stories, corresponding to 31% of the total climate news. The bar plot below shows that 'responsibility', 'law', 'sustainability', 'unsafety' and 'society' are found more often.

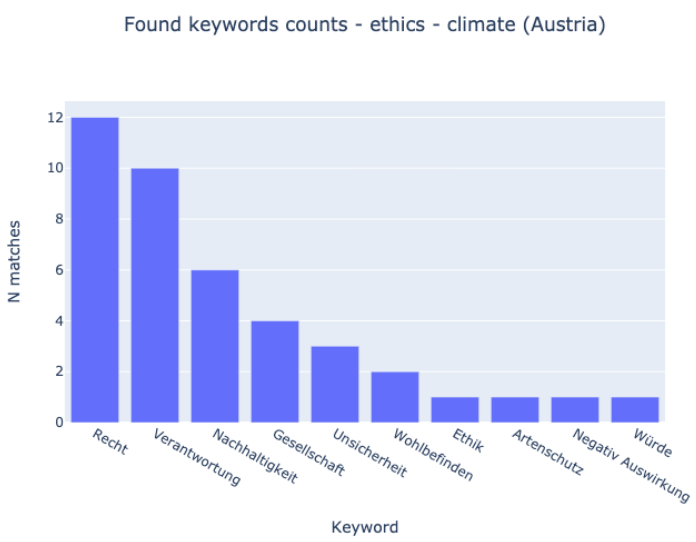


Figure 16 Counts of news stories mentioning the ELSI-keyword on the x-axis for Austria. The English translation of the words is, from left to right: law, responsibility, sustainability, society, insecurity, well-being, ethics, conservation, negative impact, dignity.

The word cloud highlights the words most often occurring in the news. Before generating the word cloud, we removed the German stop words using a list provided by spaCy library and manually removed other brief informative words (e.g., verbs such as 'say', 'do', 'come', and time expression such as 'year' or 'day') that were missing from the list but considered irrelevant to our analysis.

Figure 17 Word cloud on news stories mentioning ELSI-keywords for Austria. The top words in the cloud are: CO2, Wald (forest), Österreich (Austria), Energie (energy), Unternehmen (company).

The NER analysis showed that organisations such as Microsoft, WWF, EU, ETH, Infineon were mentioned in the news. Places mentioned often were Austria, South-Austria, Germany, China, Africa, Villach, Norway, Switzerland, Tirol, Gabersdorf, Europe, Vienna, Ruanda, North-Austria. By retrieving some news mentioning these entities, we found, for instance, news about Microsoft's plan to reach CO2 neutrality by 2030, news announcing the climate focus of the Dürnstein Symposium 2022, titled "Climate - Seismograph for Nature and Society" and news on the sustainability of solutions such as the green hydrogen plant that Infineon (a German semiconductor manufacturer) is piloting in Villach.
We found most of the news containing ELSI keywords were in relation to afforestation (followed by carbon capture, geo-engineering and green hydrogen) and mentioned 'responsibility'. Some titles refer to the tree planting action by the Lebenshilfe NGO, the afforestation project in Haringsee and the political stance of Austrian Chancellor Sebastian Kurz on the fight against climate change.

5.1.3 Digital extended reality

In the news stories collected for the digital extended reality technology, as can be observed in the bar plot below, about half of the stories mentioned the word virtual reality (Figure 18). One fourth of the stories mentioned virtual world and digital twins; extended reality, metaverse and virtual environment were discussed in ten and eight stories respectively while the other keywords generated less volume of discussion.

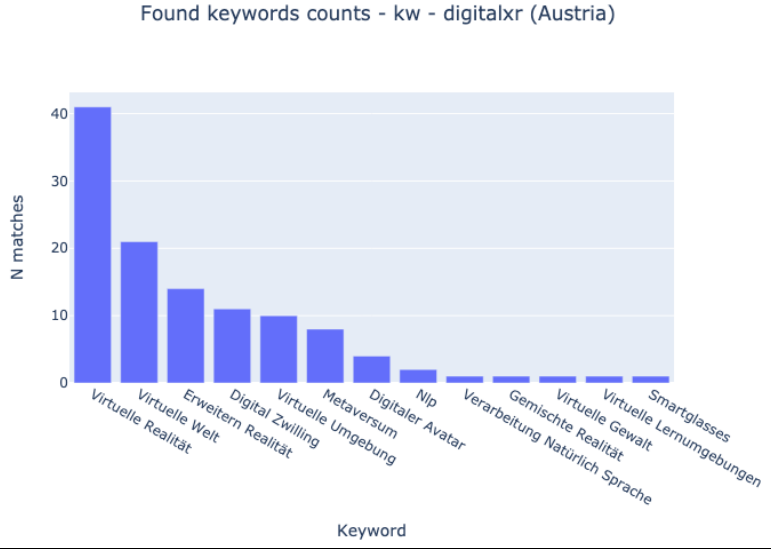


Figure 18 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for Austria. The English translation of the words is, from left to right: virtual reality, virtual world, augmented reality, digital twin, virtual environment, metaverse, digital avatar, NLP, natural language processing, mixed reality, virtual violence, virtual learning environments, smartglasses.[13]

Table 1 presents terms that frequently co-occurred in the news stories.

Frequent bigrams (DE)	Frequent bigram (EN)
Million Dollar	*million dollar*
Alltag gehören	*everyday life*
Gefühl Ort	*feeling place*
Social Media	*social media*
Metaverse lenken	*metaverse steering*
Mensch verbinden	*human connect*
Profit Nutzer	*profit user*
Nutzer stellen	*place user*
Firmennamen ändern	*change company name*
Fahrerlosen Auto	*driverless car*
Spezialbrillen Kopf	*special glasses head*

Table 9 A selection of the most frequent bigrams from the digital and extended reality news stories, for Austria.

ELSI-related keywords were mentioned in 17 news stories gathered for digital XR technology (corresponding to 24% of the total stories for the topic). The word 'society' was found in most of the news; 'law', 'safety', 'sustainability', 'privacy', were also mentioned.

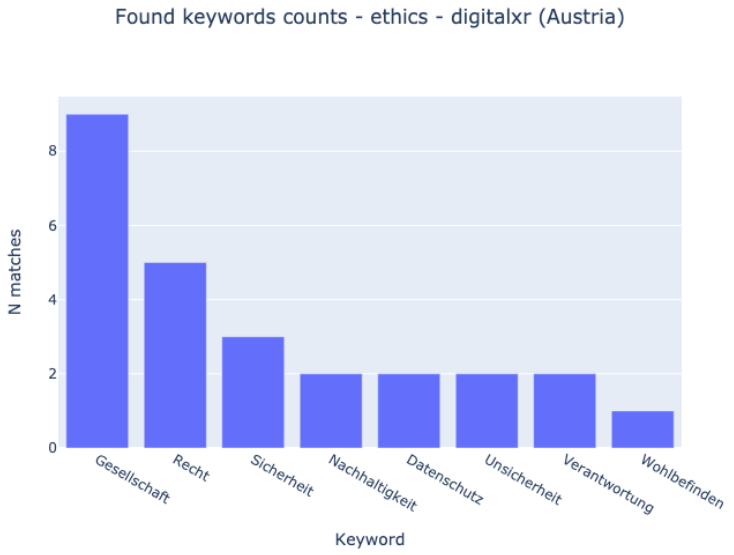


Figure 19 Counts of news stories for the digital extended reality, mentioning the ELSI-keyword on the x-axis, for Austria. The English translation of the words is, from left to right: society, law, security, sustainability, privacy, insecurity, responsibility, well-being.

The word cloud and the named entities extracted from this news stories set give us some insights on the topics discussed. The NER models found that organisations such as Meta, Apple, ÖBB, AIT, Facebook, Pool3, Microsoft were mentioned. Places most frequently mentioned are Austria and Europe. By

[13] Some of the keywords in the figures with keyword counts include words which are not present in the original list of keywords for this technology. The reason why they appear in the plot is that we did not do search for exact keyword matching therefore some words that are related or similar to the original list of keywords are also matched.

reviewing some news stories titles, we found a story discussing sustainability and societal benefits that VR solutions (e.g., virtual meetings) could bring as well as news expressing concerns for the increasing presence of virtual realities in our life. News mentioned 'privacy' and 'law' often in relation to the Metaverse and to controversies faced by Facebook around these topics.

Figure 20 Word cloud on news mentioning ELSI-keywords in digital extended reality news stories, for Austria. The top 5 words in the cloud are Facebook, Meta, Konzern (corporation), Zuckerberg and Unternehmen (company).

5.1.4 Neurotechnology

Since only ten news were gathered for neurotechnology the outcomes are highly biased by the specific topics discussed by each news. We found mention of 'mind control' in three news and of 'cyborgs' in two. Words related to brain implants were mentioned in one news item.

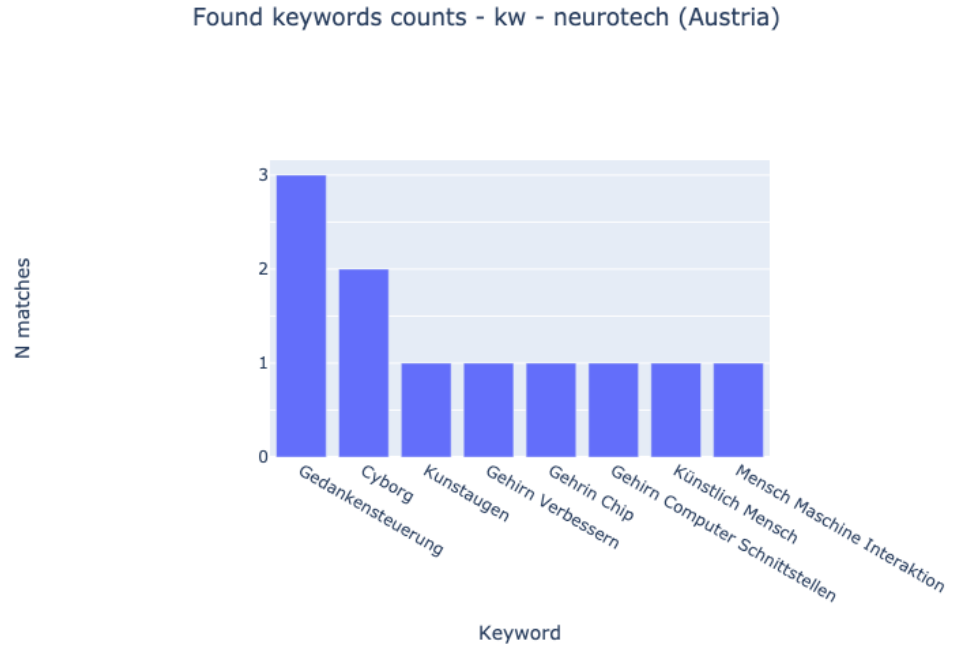


Figure 21 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Austria. The English translation of the words is, from left to right: mind control, cyborg, artificial eyes, brain enhancement, brain chip, brain computer interfaces, artificial human, human machine interaction.

Table 1 presents terms that frequently co-occurred in the news stories, giving an indication of the dominant themes in the news stories.

Frequent bigrams (DE)	**Frequent bigram (EN)**
Mensch Maschine	man machine
Fähigkeit verbessern	enhance capability
Humanoiden Roboter	humanoid robot
Interaktion Mensch	human interaction
Armband Gedankensteuerung	bracelet mind control
Gehirn Funkverbindung	brain radio link
Implantation Fehirn	brain implantation
Computerspiel Behandlung	computer game treatment

Table 10 A selection of the most frequent bigrams from the neurotechnology news, for Austria.

As some of the bigrams highlight, we found news about Facebook's plans to develop a wristband to control computers with the mind, Elon Musk Neuralinks' brain chip experiments and a news story about a US-produced game, EndeavorRX, which aims to improve cognitive skills through digital therapy in children. Interestingly, an article reported the results of a survey conducted in Austria where half of the participants responded that they would be willing to improve their body with the help of technology. Only two stories featured at least one of the ELSI-related keywords. The news about the survey, published on the *ORF*, discusses issues around responsibility, regulations, data protection and self-determination associated with practices of human enhancement. Another news on the *ORF* discusses humanoid robots and the dangers or robotics research.

5.2 Czech Republic

5.2.1 Dataset description

The Czech Republic data collection was carried out crawling Google News. We found that this approach returned a higher volume of news (and coming from more outlets) compared to GNews but that it was much noisier (i.e., containing a large number of irrelevant news items). Automatic models for handling the Czech language were not available in spaCy library. To ensure the highest relevance of the dataset, we retained only news where exact matching between keywords and text was found. The final dataset consisted of 203 news stories: 64 for climate, 113 for digital extended reality, 26 for the neurotechnology topic. As observed consistently across countries, a higher number of stories from 2021 were returned (see Figure 22**Error! Reference source not found.**).

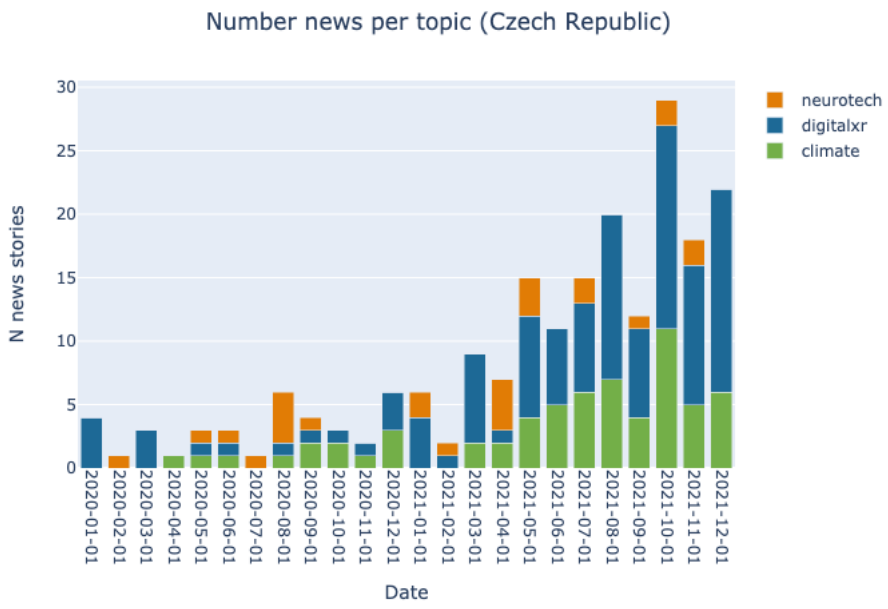


Figure 22 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Czech Republic.

Table 11 presents the outlets from which stories were collected. Most of the stories found on digital extended reality were published on *iDNES* (one of the main national outlets) and *Indian-TV* (a freesheet web outlet focussed mainly on video games). Most of the news on the climate engineering topic in our dataset were published in two outlets covering scientific topics: *Oenergetice*, a website publishing up-to-date information on the Czech, European and world energy sector, and *Ekolist*, an online newspaper focused on nature and environment. Stories about neurotechnology were present in different Tech and General outlets.
Most of the stories were published in the main and news section of the outlets.

Outlet	Climate	Digital XR	Neurotechnology	Outlet Theme	Outlet Type
chip	0	7	1	TECH	Other
ctidoma	0	0	1	Other	TABLOID
czechsight	2	1	0	SCIENCE	Other
dotyk	0	1	0	SCIENCE	Other

doupe	0	3	0	TECH	Other
e15	1	1	1	ECONOMY	Other
ekolist	11	0	0	SCIENCE	Other
enviweb	6	0	0	SCIENCE	Other
epochaplus	0	1	1	SCIENCE	MAGAZINE
euro	0	7	3	TECH	Other
forbes	1	8	2	ECONOMY	MAGAZINE
hrnews	0	1	0	Other	Other
idnes	1	15	3	GENERAL	GENERAL_NEWS
indian-tv	0	16	0	TECH	Other
irozhlas	4	1	2	GENERAL	TV_RADIO
kurzy	2	1	1	TECH	Other
letemsvetemapplem	0	5	1	TECH	Other
lidovky	2	1	3	GENERAL	GENERAL_NEWS
lupa	0	2	0	TECH	Other
m	1	3	0	Unsure	Unsure
nedd	0	2	2	SCIENCE	Other
neviditelnypes	2	0	0	GENERAL	GENERAL_NEWS
novinky	0	3	1	GENERAL	GENERAL_NEWS
oenergetice	16	0	0	SCIENCE	Other
plus	4	0	0	TECH	Other
radiozurnal	0	2	0	GENERAL	TV_RADIO
seznamzpravy	4	2	1	GENERAL	GENERAL_NEWS
smartmania	0	2	1	TECH	Other
startupjobs	0	6	0	Other	Other
svethardware	0	3	0	TECH	Other
vedavyzkum	1	1	0	SCIENCE	Other
vortex	0	5	0	TECH	Other
vseoprumyslu	0	6	0	TECH	Other
vtm	1	1	2	SCIENCE	Other
zive	0	4	0	TECH	Other
zpravy	5	2	0	GENERAL	GENERAL_NEWS

Table 11 Counts of news stories collected from each outlet, broken down by technology, for Czech Republic. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.2.2 Climate engineering

Most of the stories for this technology were published by outlets specialised in topics related to the technology (energy, nature, environment) therefore the data are likely to reflect this focus. We found that most of the news discuss green hydrogen and carbon storage, as indicated in Figure 23.

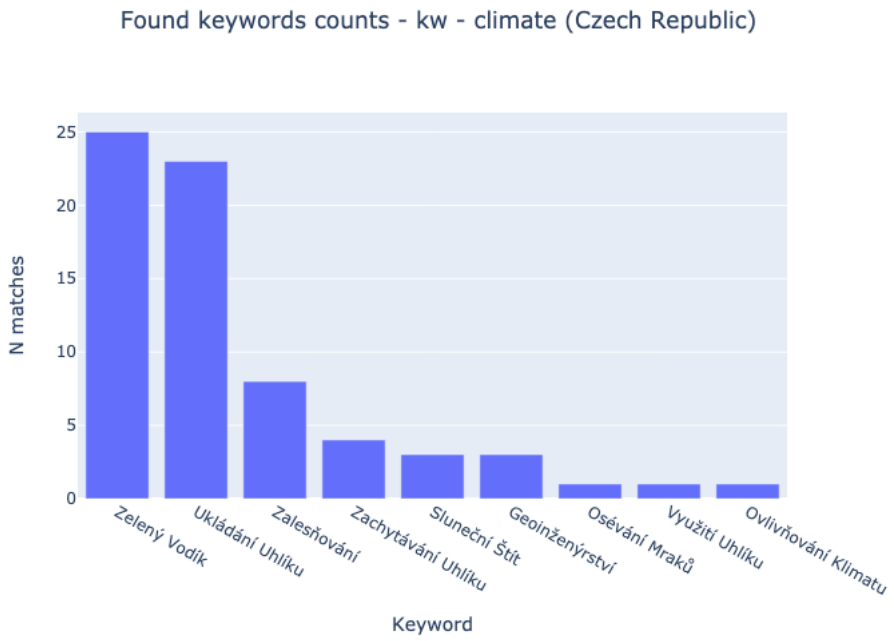


Figure 23 - Counts of news stories mentioning the climate engineering keyword on the x-axis, for Czech Republic. The English translation of the words is, from left to right: green hydrogen, carbon storage, reforestation, carbon capture, solar shield, geoengineering, cloud seeding, carbon utilisation, climate influence.

ELSI keywords were mentioned in 15 news stories (23% of the total for this technology). Some of the stories in this selection had a national focus discussing, for instance, the plan for 30 hydrogen filling stations, coal exit strategies for Czech, and importance of climate strategy in the political elections. Other news stories were more technical and dived into climate change impacts; others questioned the impact of hydrogen-based solutions and the involved interests of fossil fuel giants.

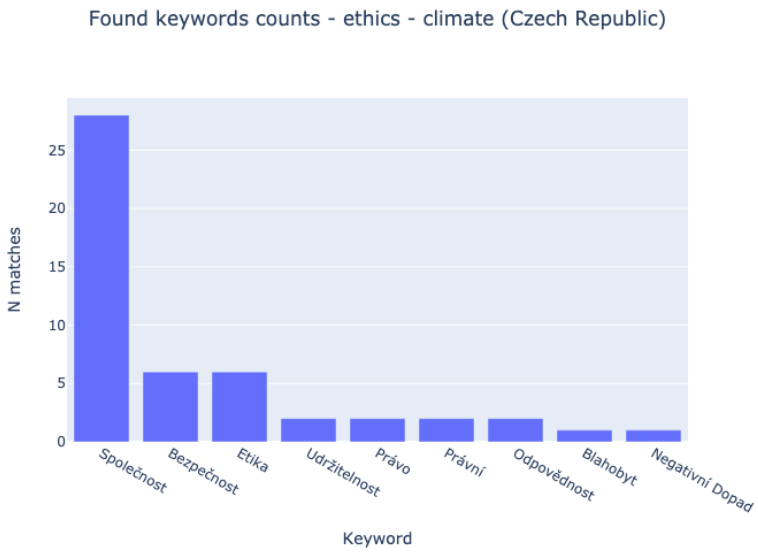


Figure 24 Counts of climate engineering news stories mentioning the ELSI-keyword on the x-axis, for Czech Republic. The English translation of the words is, from left to right: society, security, ethics, sustainability, law, legal, responsibility, welfare, negative impact.

The word cloud below (Figure 25) presents the words most widely mentioned on stories mentioning ELSI-keywords.

Figure 25 Word cloud on news mentioning ELSI-keywords. The top words in the cloud are CO2, energie (energy), uhlíku (carbon), klimatu (climate), uhlí (coal), vodíku (hydorgen).

5.2.3 Digital extended reality

In the news set collected for this technology, the discussion appears to be dominated by the virtual reality topic. We found that news from *Indian-TV*, the outlet returning the most news, were mostly about games which use VR solutions with a few mentions of companies' investment in VR solutions (Microsoft, Netflix, Panasonic).

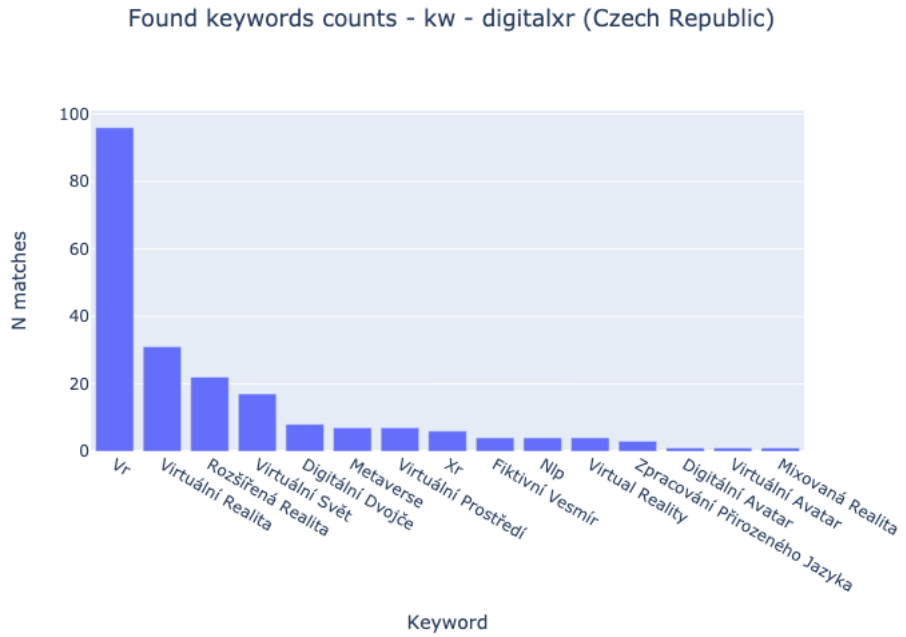


Figure 26 Counts of news mentioning each digital XR keyword. The English translation of the words is, from left to right: VR, virtual reality, augmented reality, virtual world, digital twin, metaverse, virtual environment, XR, fictional universe, NLP, virtual reality (kept in English), natural language processing, digital avatar, virtual avatar, mixed reality.

In stories from *iDNES*, the second outlet from which most news items were collected, VR was also mentioned in relation to gaming, movies, flight simulators, VR sets and glasses, and the metaverse.
We found 15 stories (13% of the total for the technology) mentioning ELSI-keywords. This selection of news discusses issues related with the metaverse, safety and prejudice. Safety is also discussed in relation to the use of digital solutions (digital twins, VR glasses, metaverse) in the manufacturing and military industries. Some news stories discuss issues of safety and responsibility around the use of AI in healthcare, such as providing "virtual personas" (virtual humans based around a specific person, referred also as digital twins) for mental health support. Some articles discuss more broadly the opportunities and risks of virtual reality.

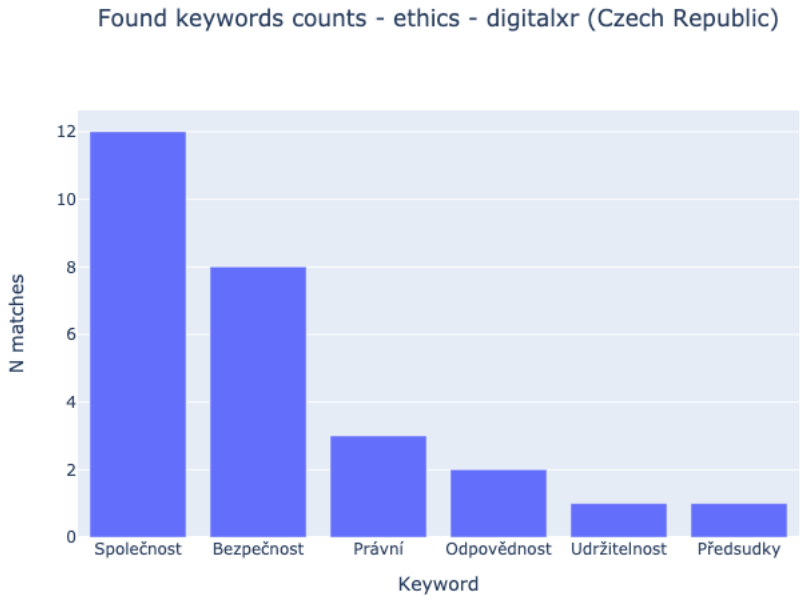


Figure 27 Counts of digital extended reality news stories mentioning the ELSI-keyword on the x-axis, for Czech Republic. The English translation of the words is, from left to right: company, safety, legal responsibility, sustainability, prejudice.

Figure 28 Word cloud on news mentioning ELSI-keywords. The top words in the cloud are VR, prostředí, (environment), metaverse, technologie (technology), reality, brýle (glasses).

5.2.4 Neurotechnology

Most of the news collected for this technology mentioned Neuralink and the brain implant experiments on monkeys and guinea pigs designed by Elon Musk. The second most mentioned topics were artificial uterus and artificial eye.

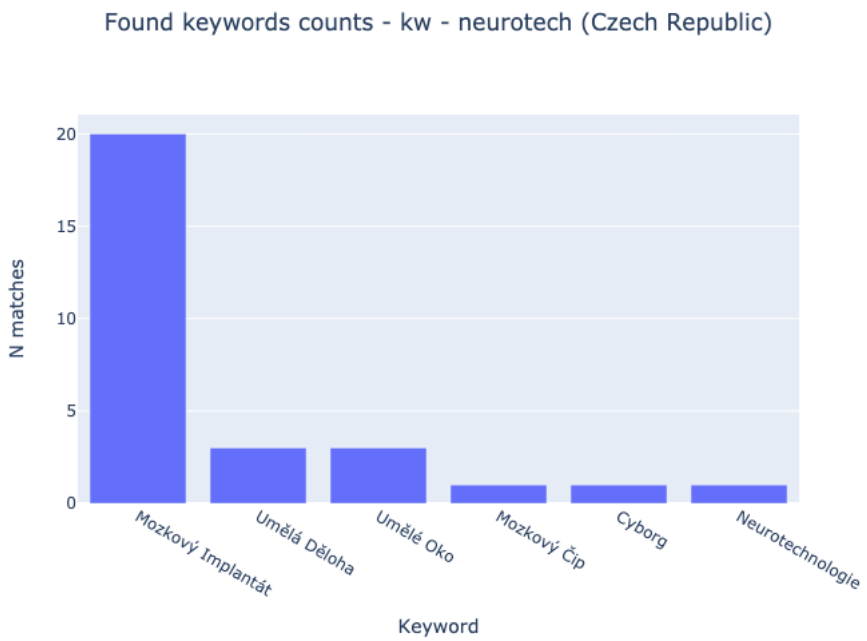


Figure 29 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Czech Republic. The English translation of the words is, from left to right: brain implant, artificial uterus, artificial eye, brain chip, cyborg, neurotechnology.

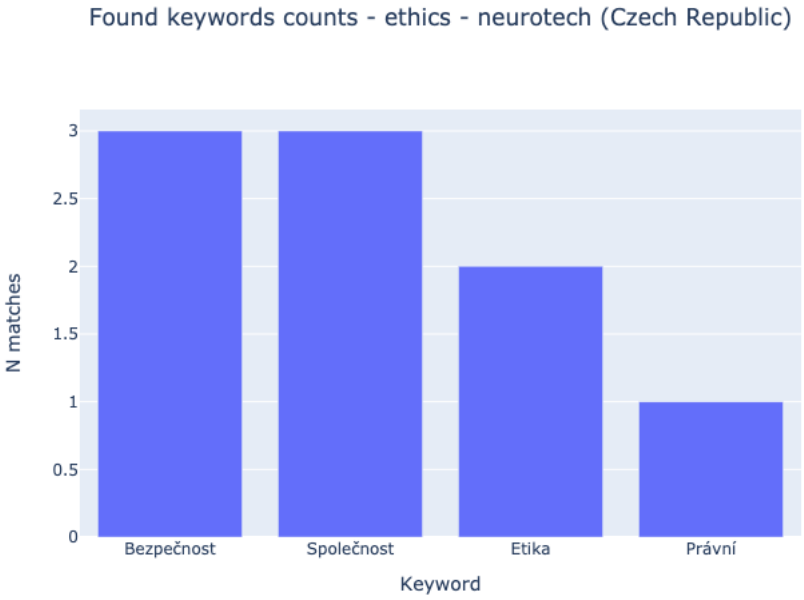


Figure 30 Counts of neurotechnology news stories mentioning the ELSI-keyword on the x-axis, for Czech Republic. The English translation of the words is, from left to right: security, company, ethics, legal.

We found 6 news (23% of the total for this technology) contained ELSI-keywords. They discuss the ethics of use of neurotechnology in the medical field (such as artificial uteruses to prevent pre-natal deaths or

brain chips to cure depression), the safety of Neuralink's proposed solutions and broader critique of the implications of brain implants for humans and society.

Figure 31 Word cloud on neurotechnoogy news stories mentioning ELSI-keywords, for Czech Republic. The 5 top words in the cloud are mozku implantát (brain implant), lidé (peole), vědci (scientists), bolesti (pain), signály (signal).

5.3 France

5.3.1 Dataset description

The clean dataset for France consisted of 2091 news stories, 1281 for digital extended reality, 752 for climate and 58 for neurotechnology. The distribution of stories over time is show in figure (Figure 32). We found a data gap in the months preceding September 2021 and, for the digital extended reality category only, in the months between January and September 2021. These gaps are likely due to errors in the connection to the news API in the data collection phase (see explanatory note in Section 3.6).

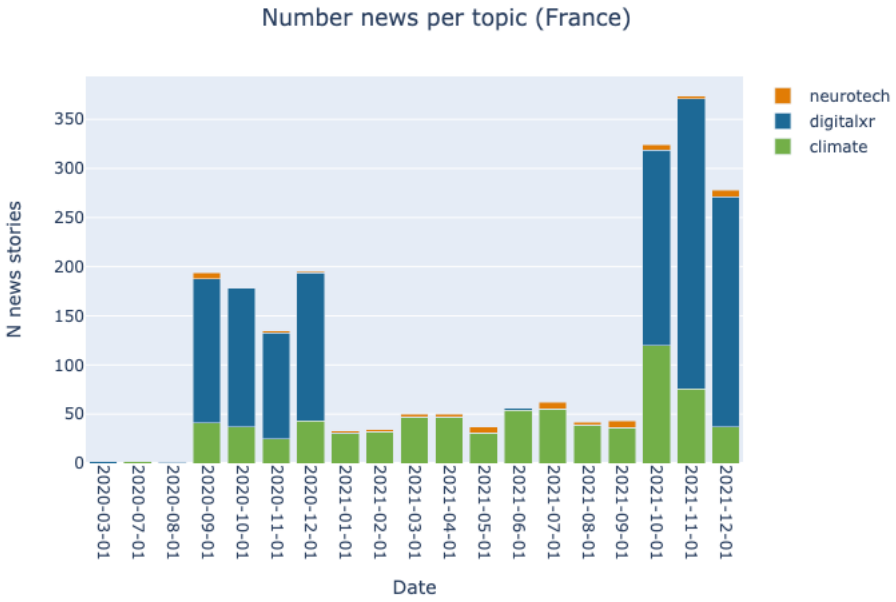


Figure 32 The bar plot shows the count of news stories published for each year-month, broken down by technology, for France.

Table 12 shows a breakdown of news count by technology category and output. While some major French news outlets, such as *FranceTVInfo* and *Le Monde* were included in the outlets, some appear to be missing, such as *Le Figaro* or *Liberation*.

Outlet	Climate	Digital XR	Neurotech	Outlet type	Outlet theme
actu	41	56	4	Unsure	GENERAL
boursorama	82	69	4	Unsure	ECONOMY
caradisiac	4	7	0	Unsure	Other
closermag	0	3	0	MAGAZINE	CULTURE
france24	39	52	6	TV_RADIO	GENERAL
france3-regions	50	45	0	TV_RADIO	GENERAL
francetvinfo	62	55	4	TV_RADIO	GENERAL
frandroid	1	129	3	Unsure	TECH
generation-nt	3	73	0	Unsure	TECH
huffingtonpost	13	32	0	Unsure	GENERAL
igen	0	23	0	Unsure	TECH
journaldugeek	10	136	13	Unsure	TECH
ladepeche	87	121	2	LOCAL	GENERAL
lci	14	19	0	TV_RADIO	GENERAL
lemonde	69	60	5	GENERAL_NEWS	GENERAL
lesechos	148	108	2	GENERAL_NEWS	ECONOMY
letelegramme	39	27	0	LOCAL	GENERAL
linternaute	0	57	0	Unsure	GENERAL
melty	0	69	1	Unsure	CULTURE

numerama	8	60	6	Unsure	TECH
presse-citron	2	116	8	Unsure	TECH
tradingsat	59	26	0	Unsure	ECONOMY
varmatin	21	22	0	LOCAL	GENERAL

Table 12 Counts of news stories collected from each outlet, broken down by technology, for France. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

The largest share of stories was retrieved from outlets covering general topics. A relevant portion of climate engineering news (38%) was published on outlets with a focus on economy while 38% of digital extended reality news was found on technical outlets (Figure 33).

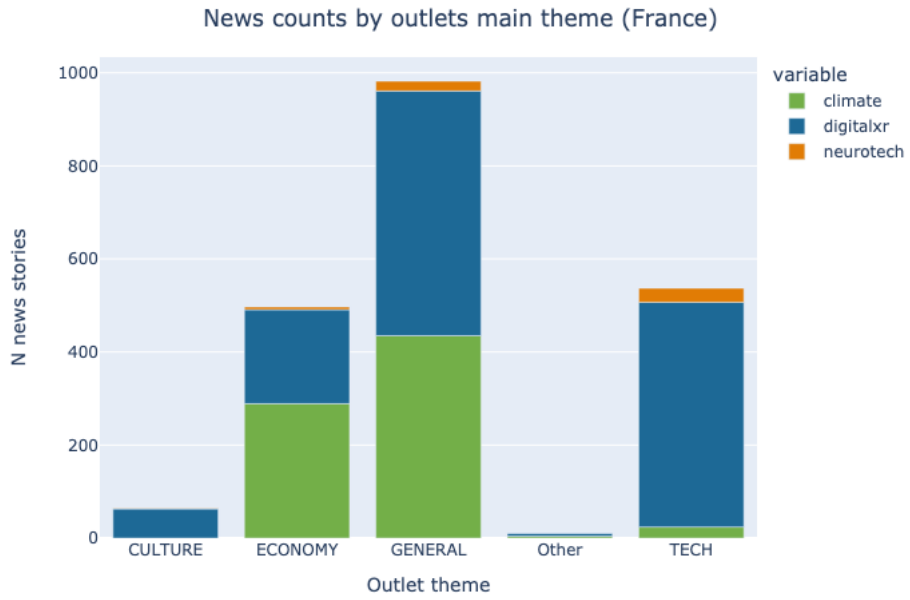


Figure 33 Counts of news stories by theme of outlets where they were published, broken down by technology, for France.

5.3.2 Climate engineering

'Green hydrogen' is the most prevalent topic of discussion in the news collected for climate engineering, being mentioned in 53% of the stories collected. The second most frequently mentioned keyword was 'carbon storage' (found in 39% of the stories) (see Figure 34).

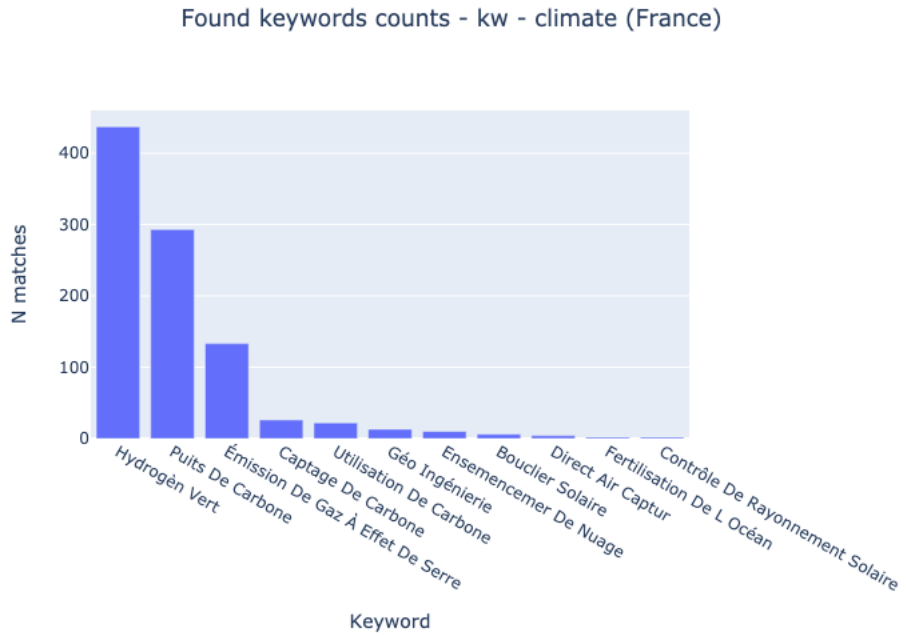


Figure 34 Counts of news stories mentioning the climate engineering keyword on the x-axis, for France. The English translation of the words is, from left to right: 'green hydrogen', 'carbon storage', 'greenhouse gas emission', 'carbon capture', 'carbon use', 'geoengineering', 'cloud seeding', 'sun shield', 'direct air capture', 'ocean fertilization', 'solar radiation management'.

The extraction of the most frequently co-occurring words suggests some dominant topics of discussion in these news stories: investment and recovery plans, objective of climate neutrality and CO2 emissions reduction, energy production and consumption (
Table 13).

Frequent bigrams (FR)	**Frequent bigram (EN)**
Million/milliard d'euro	million/billion euro
neutralité carbone	carbon neutrality
plan relance	recovery plan
réduire émission	reduce emission
plan d'investissement	investment plan
atteindre neutralité	achieve neutrality
production d'énergie	energy production
limiter réchauffemer	limit warming
technologie d'avenir	future technology
loi climat	climate law

Table 13 A selection of the most frequent bigrams from climate engineering news stories, for France.

Mentions of ELSI-keywords were found in 46% of the news collected for this technology category. 'Society', 'law' and 'security' were the most often mentioned terms (Figure 35).

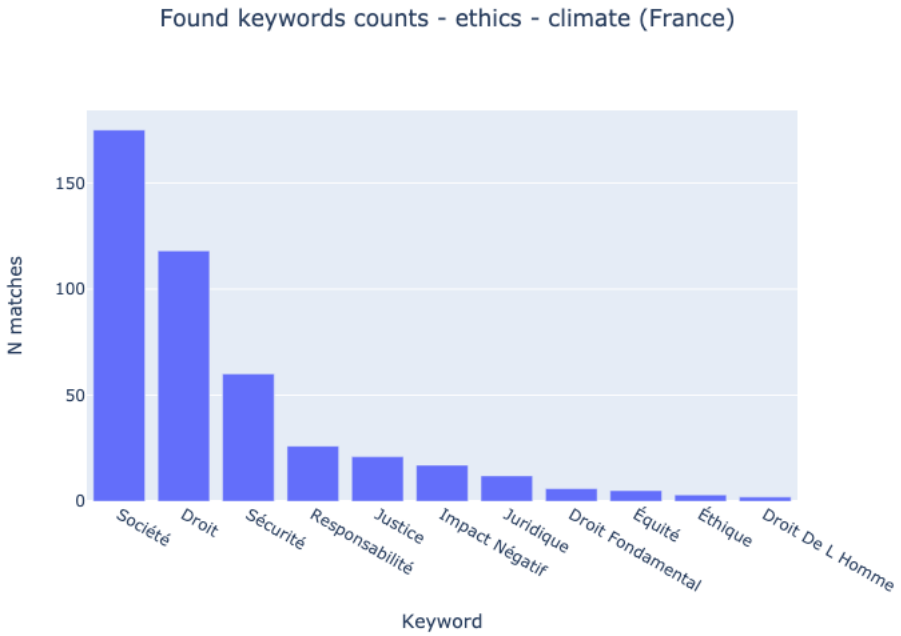


Figure 35 Counts of climate engineering news stories mentioning the ELSI-keyword on the x-axis, for France. The English translation of the words is, from left to right: society', 'law', 'security', 'responsibility', 'justice', 'negative impact', 'legal', 'fundamental right', 'fairness', 'ethics', 'human right'.

From the named entities analysis, we found frequent mentions of international organisations (e.g., EU, EU Commission, EU Parliament, Greenpeace), French political entities (e.g., the parliament, the senate, PS – French socialist party, CEA - The French Alternative Energies and Atomic Energy Commission) and private organisations associated with energy production (e.g., McPhy – a hydrogen equipment manufacturer, EDF – the French electricity utility company, Air Liquide – French industrial gases supplier) (see Figure 36).

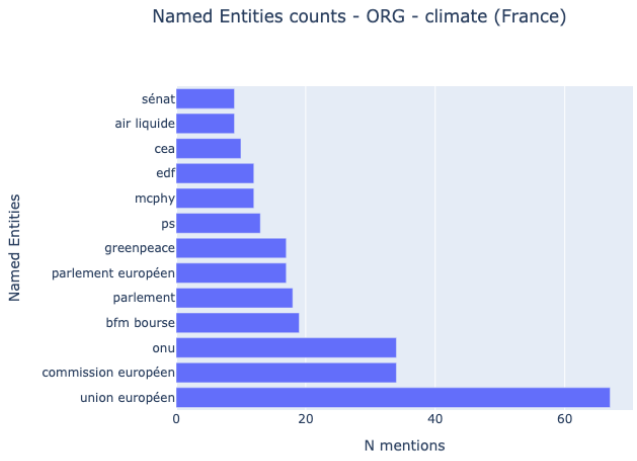


Figure 36 Mention of named entities labelled as 'organisations' (ORG) by Spacy NER model, for France. Values on the x-axis indicate the number of climate engineering, ELSI-relevant, news stories in which the entity on the y-axis appear.

The counts of extracted locations suggests that the discussion is focussed, as expected, on France and the European landscape (see Figure 37). 'Glasgow' is mentioned in 25 stories, in relation to the COP26 and in 22 stories we found mentions of the Amazon rainforest in news discussing deforestation and impact of climate change on tropical forests.

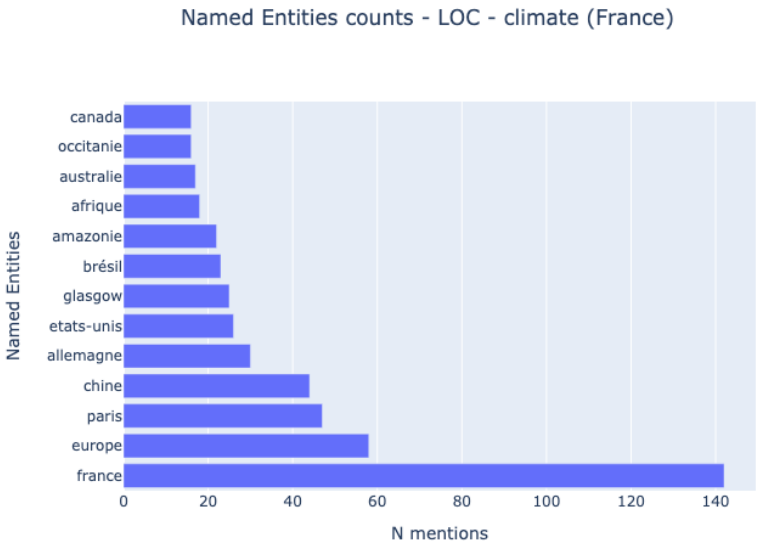


Figure 37 Mentions of named entities labelled as 'locations' (LOC) by Spacy NER model, for France. Values on the x-axis indicate the number of climate engineering, ELSI-relevant, news stories in which the entity on the y-axis appear.

5.3.3 Digital extended reality

In the news set collected for digital extended reality, 'virtual reality' was the most prevalent topic, mentioned in 55% of the news stories. 'Augmented reality', 'Metaverse', 'virtual world' were mentioned in 35%, 28% and 15% of the news stories, respectively. The other keywords were found in less that 5% of the set (Figure 38). The largest share of news stories for this category was published in *Journal du geek* (an outlet specialised in news on high-tech, pop culture, videogames, space, and mobility) as 10% of news stories on digital extended reality were found there. 9% of the stories were also found on *La Dépêche du Midi* (a daily regional newspaper covering the Occitania region) and on *Frandroid* (a website providing technology products reviews and news). 8% of the stories were found on another technical outlet, *Presse-citron*, which focuses on digital news, tech innovations and social media world and on *Les Echos*. We found that relevant portion of these news stories (23%) discussed the digital extended reality topics in relation to video games.

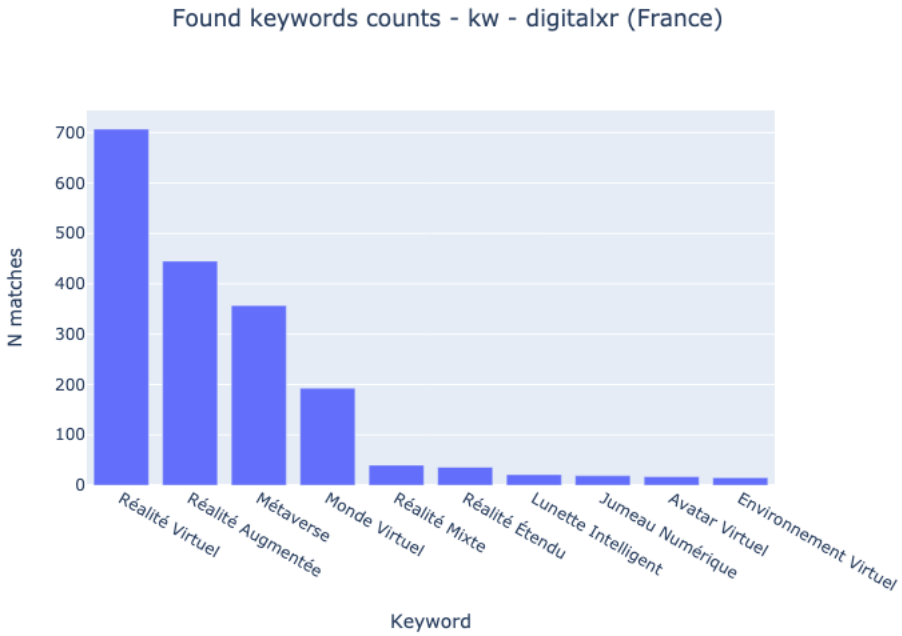


Figure 38 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for France. The English translation of the words is, from left to right: 'virtual reality', 'augmented reality', 'metaverse', 'virtual world', 'mixed reality', 'extended reality', 'smart glasses', 'digital twin', 'virtual avatar', 'virtual environment'.

Mentions of ELSI-keywords was found in 45% of the news stories (see Figure 39) and *Les Echos* published the larger portion of these stories (9%). 'Society', 'law' and 'security' were the three most mentioned keywords (Figure 39).
Consistently with the other countries, the set of organisation mentions extracted from these news features big tech companies (e.g., Meta, Google), video games companies (e.g., Nintendo, Atari) and IT companies (e.g., IBM, Sony) - Figure 40.

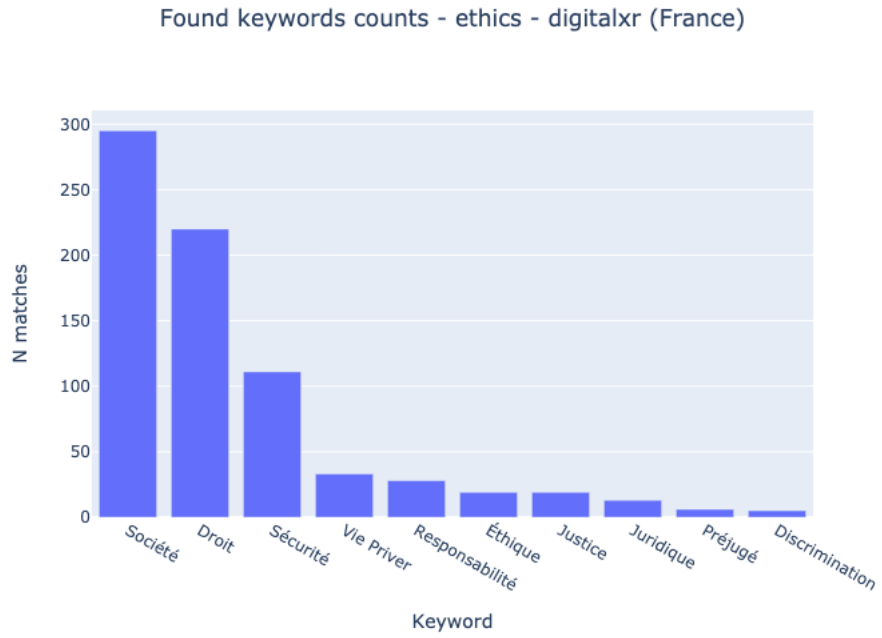


Figure 39 Counts of digital extended reality news stories mentioning the ELSI-keyword on the x-axis, for France. The English translation of the words is, from left to right: 'society', 'law', 'security', 'privacy', 'responsibility', 'ethics', 'justice', 'legal', 'bias', 'discrimination'.

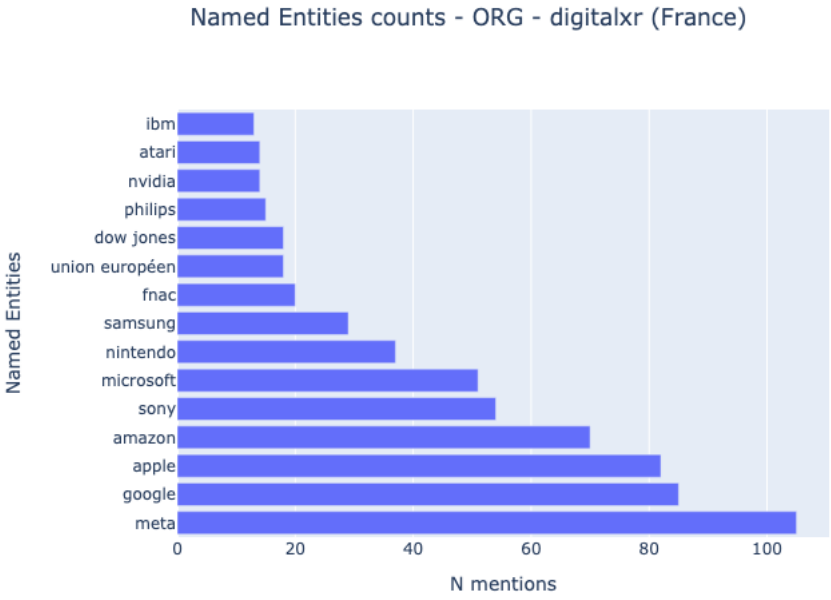


Figure 40 Figure 36 Mention of named entities labelled as 'organisations' (ORG) by Spacy NER model, for France. Values on the x-axis indicate the number of digital extended reality, ELSI-relevant, news stories in which the entity on the y-axis appear.

5.3.4 Neurotechnology

The most prevalent keyword found in the neurotechnology news set was 'brain-machine interface' which was mentioned in 40% of the news stories. 'Cyborg' was mentioned in 14% of the stories, 'brain implant' and 'brain chip' in 12% and 10% respectively. *Journal du geek* was the main publisher for these news stories and more than half of the stories (52%) were published on outlets covering technical topics.

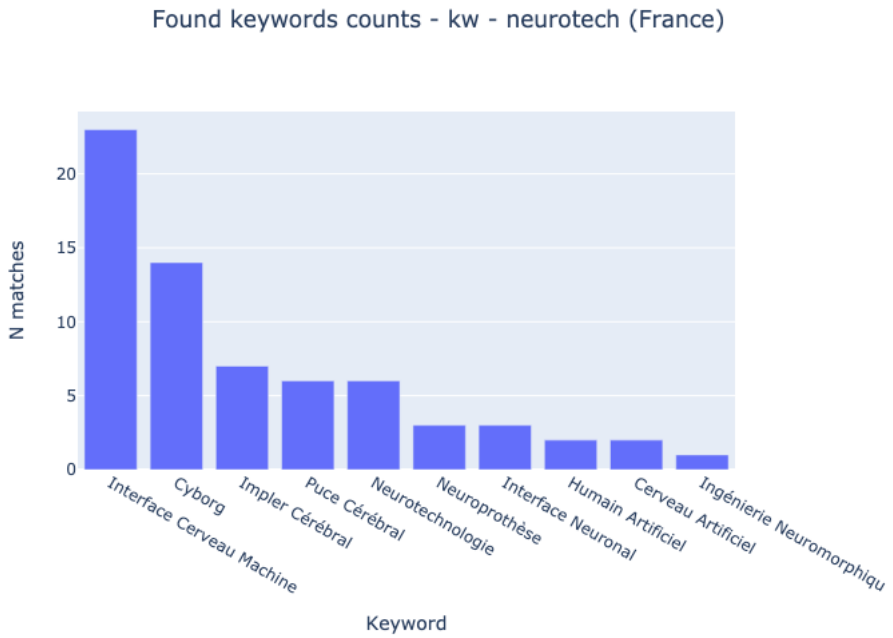


Figure 41 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for France. The English translation of the words is, from left to right: 'brain machine interface', 'cyborg', 'brain implant', 'brain chip', 'neurotechnology', 'neuro-prosthesis', 'neural interface', 'artificial human', 'artificial brain', 'neuromorphic engineering'.

Mentions of ELSI-keywords were found in 50% of the stories collected for this technology category. 'Society', 'law' and 'ethics' were the words more frequently mentioned while other words were mentioned in less than 5 stories. 41% of the stories mentioned 'Neuralink' or 'Elon Musk' and discussed potential impact on society on brain experimentation. The other stories discuss different neurotech applications such as creation of brain chips to ease pain, robotics arm, neuro-prosthesis to repair the spinal cord, artificial heart made in France as well as mentions of Chile's vote to introduce 'neuro-rights' (mentions of this news were also found in stories collected for UK, US and Spain).

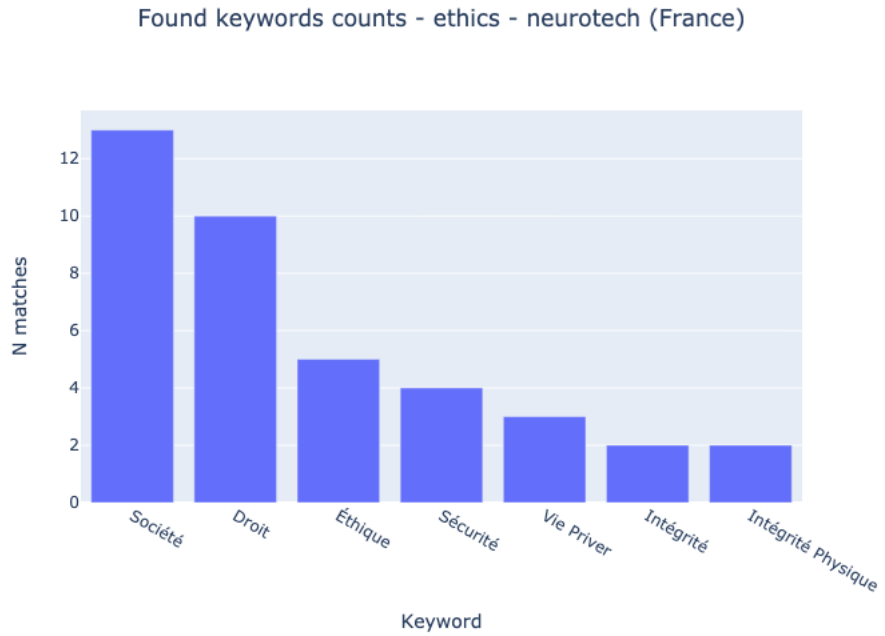


Figure 42 Counts of neurotechnology news stories mentioning the ELSI-keyword on the x-axis, for France. The English translation of the words is, from left to right: 'society', 'law', 'ethics', 'security', 'privacy', 'integrity', 'physical integrity'

5.4 Germany

5.4.1 Dataset description

The clean dataset for Germany consisted of 1195 news stories: 746 for climate engineering, 401 for digital extended reality and 48 for neurotechnology (see Figure 43). As opposed to most of the other countries, climate engineering was the family of technologies for which a higher number of news stories was retrieved.

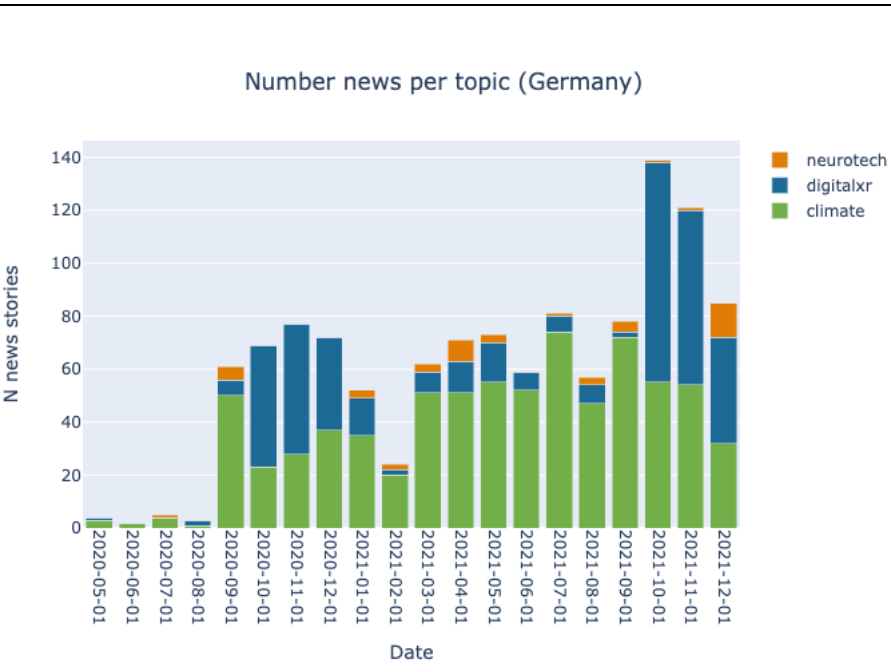


Figure 43 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Germany.

For the three technology categories, most of the news stories (over 85%) were published in outlets covering general, i.e., non-technical topics (Table 14). Overall, we found that the stories were published primarily in the main section of the outlet. Stories related to digital extended reality also appeared in sections 'economy' and 'digital' while those related to climate engineering were found also on sections 'regional' and 'politics'. A relevant portion (32%) of the outlets is made of local news sources.

Outlet	Climate	Digital XR	Neurotechnology	Outlet Theme	Outlet Type
berliner-zeitung	3	4	0	LOCAL	GENERAL
bild	13	12	2	TABLOID	GENERAL
br	13	9	0	TV_RADIO	GENERAL
chip	1	18	2	Other	TECH
digitalfernsehen	1	3	1	Unsure	Unsure
express	4	4	0	TABLOID	CULTURE
fr	54	10	0	GENERAL_NEWS	GENERAL
heilpraxisnet	0	0	1	Other	Other
hessenschau	7	3	0	TV_RADIO	GENERAL
ksta	48	26	1	LOCAL	GENERAL
merkur	46	24	8	LOCAL	GENERAL
n-tv	107	29	2	TV_RADIO	GENERAL
netzwelt	2	16	1	Other	TECH
noz	9	5	0	LOCAL	GENERAL
playfront	0	2	2	Other	TECH
rp-online	33	30	1	LOCAL	GENERAL
solinger-tageblatt	24	13	1	LOCAL	GENERAL
stern	60	39	4	MAGAZINE	GENERAL
sueddeutsche	51	39	3	GENERAL_NEWS	GENERAL
swp	9	4	0	LOCAL	GENERAL
t-online	17	25	5	NEWS_AGGREGATOR	GENERAL
tag24	6	8	1	NEWS_AGGREGATOR	GENERAL
tagesspiegel	68	19	2	LOCAL	GENERAL
web	19	11	1	Other	GENERAL
welt	145	45	10	GENERAL_NEWS	GENERAL

Table 14 Counts of news stories collected from each outlet, broken down by technology, for Germany. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.4.2 Climate engineering

The main sources of climate engineering stories in our collection were *Die Welt* (19% of the collected stories were published there) and the TV-broadcaster *N-TV* (14%).
'Afforestation' and 'green hydrogen' appear as the main topics of discussion in this set of news stories retrieved (both are mentioned in 63% of the stories). 'Climate engineering' is mentioned in 25% of the news stories, 'cloud seeding' in 7%, and some of the other keywords have been found in less than 2% of the stories (Figure 44 *Counts of news stories mentioning the climate engineering keyword on the x-axis, for Germany. The English translation of the words is, from left to right: afforestation, green hydrogen,*

climate engineering, cloud seeding, geoengineering, carbon storage, carbon sequestration, water splitting, negative emission technologies, ocean fertilisation, cloud brightening, artificial photosynthesis.).

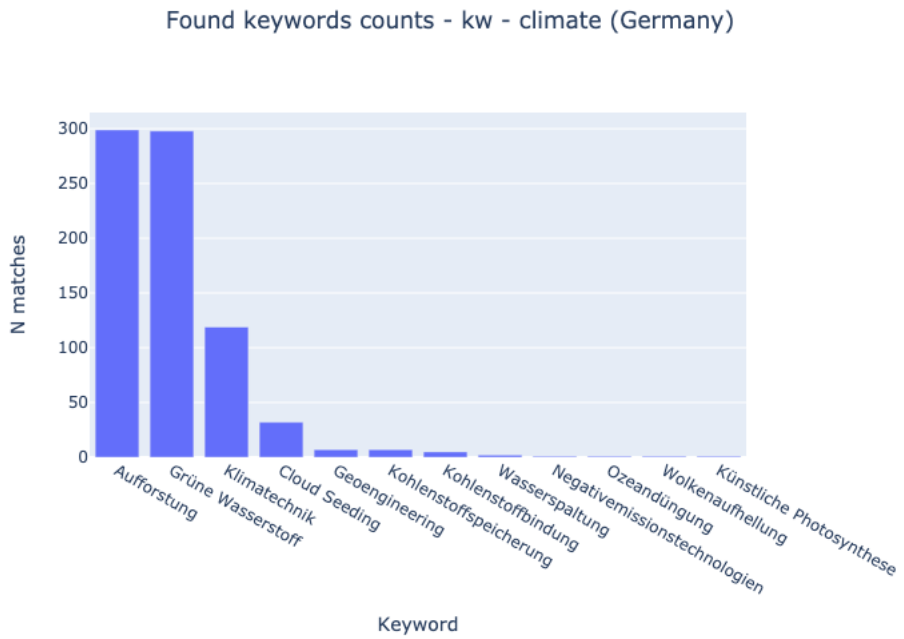


Figure 44 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Germany. The English translation of the words is, from left to right: afforestation, green hydrogen, climate engineering, cloud seeding, geoengineering, carbon storage, carbon sequestration, water splitting, negative emission technologies, ocean fertilisation, cloud brightening, artificial photosynthesis.

The most frequent bigrams extracted from the news texts, suggest some of the topics of the discussion such as fighting climate change, renewable energies, and actions in the transportation industry (Table 15).

Frequent bigrams (DE)	**Frequent bigram (EN)**
Million/Milliarde Euro	million/billion euro
Kampf Klimawandel	fight climate change
Industrie Verkehr	industry transport
Wirtschaft Politik	economy politics
Erneuerbaren Energie	renewable energy
Ziel Klimaneutralität	goal of climate neutrality
Erdgas ablösen	replace natural gas
Aufbau Wasserstoffwirtschaft	building hydrogen economy
Beitrag Klimaschutz	contribution to climate protection

Table 15 A selection of the most frequent bigrams from climate engineering news stories, for Germany.

ELSI-keywords were mentioned in 30% of the climate engineering news stories. 'Society', 'sustainability', 'responsibility', 'security' and 'law' are the terms most frequently mentioned in the collected stories (Figure 45).[14]

[14] For the German ELSI-keywords, the search accounted for upper case so as to avoid retrieving irrelevant terms, such as the verb "werden" which becomes "würde" in the subjective mood, and could be confused with "Würde" which means "dignity". Content was also manually checked to avoid such issues of terms with multiple meanings.

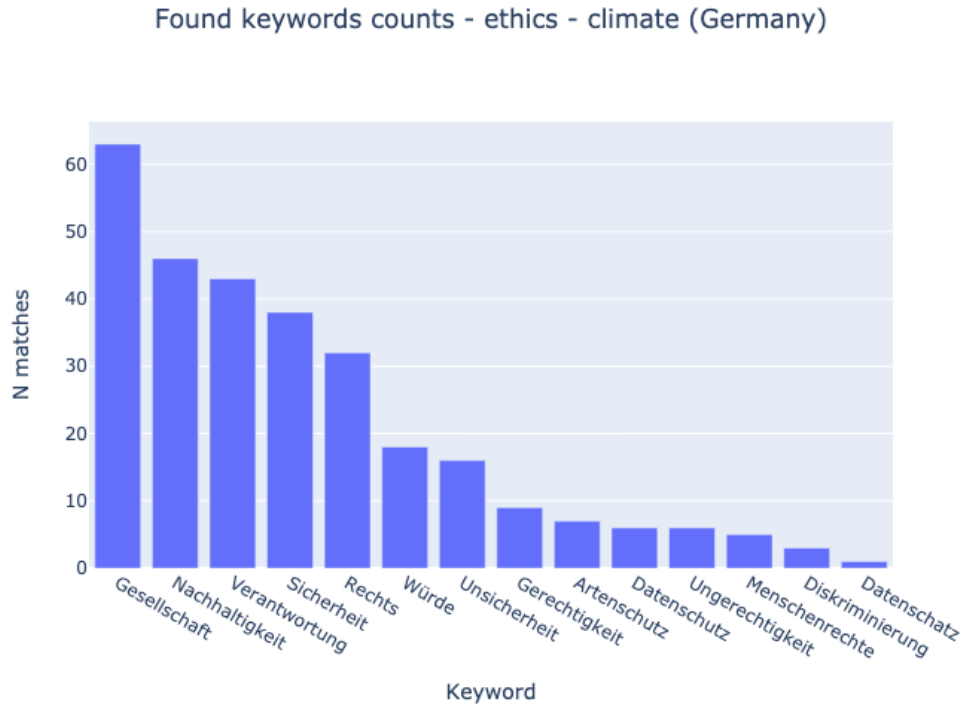


Figure 45 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for Germany. The English translation of the words is, from left to right: 'society, 'sustainability', 'responsibility', 'security', 'law', 'dignity', 'insecurity', 'justice', 'wildlife protection', 'privacy', 'injustice', 'human rights', 'discrimination', 'data protection'.

The extraction of named entities highlighted the frequent mentions of supranational political organization (EU, EU-Commission) and German political parties (SPD, CDU, FDP) (see Figure 46).

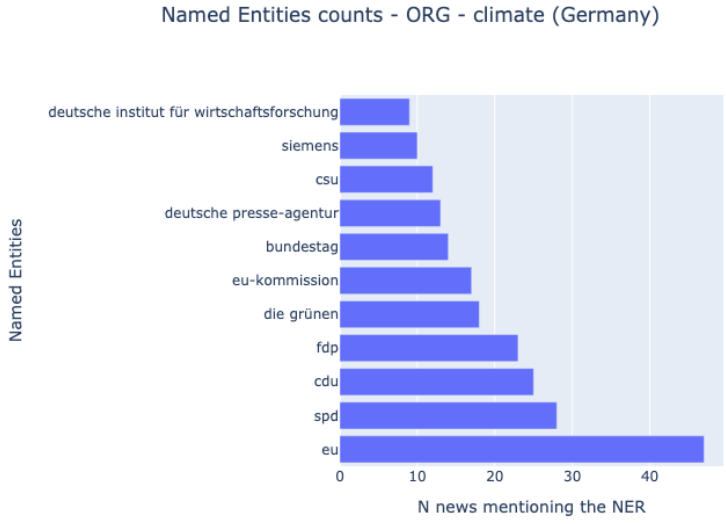


Figure 46 Mention of named entities labelled as 'organisations' (ORG) by Spacy NER model, for Germany. Values on the x-axis indicate the number of climate engineering, ELSI-relevant, news stories in which the entity on the y-axis appear.

5.4.3 Digital extended reality

'Augmented reality' was the most prevalent topic in the news collected for digital extended reality, mentioned in 49% of the news stories. 'Virtual reality' was mentioned in 38% of the news stories, followed by 'virtual world' (30%), 'virtual environment' (10%) and 'metaverse' (10%). Other keywords were mentioned in less than 5% of the stories.

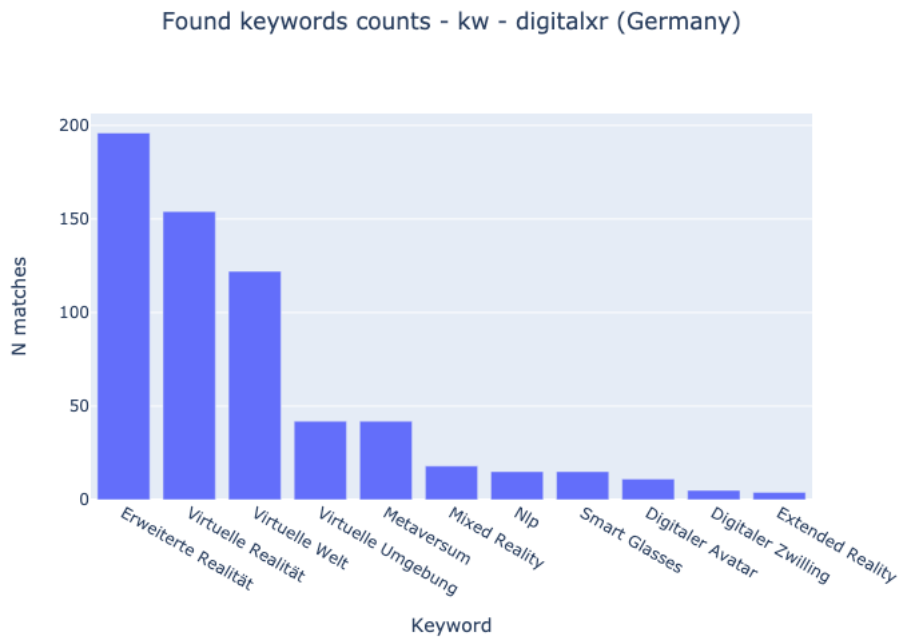


Figure 47 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for Germany. The English translation of the words is, from left to right: 'augmented reality','virtual reality','virtual world','virtual environment','metaverse','mixed reality','Nlp','smart glasses','digital avatar','digital twin','extended reality'.

In the most frequently co-occurring terms in the news stories, we found, among other, discussions around Facebook and the company's turn toward the metaverse, and discussions around driverless cars and technology that could allow to 'implement human presence' and 'connect humans' (Table 16).

Frequent bigrams (DE)	Frequent bigram (EN)
Million/Billion Euro/Dollar	million/billion euro
Präsenzeffekt umsetzen	implement presence effect
Mensch verbinden	connect humans
Fahrerlosen Auto	driverless auto
Performances veranstaltung	event performances
Facebookgründer Mark	Facebook founder Mark (Zuckerberg)
Facebookkonzern Name	Facebook company name
Merkmal Metaverse	Metaverse feature
Metaverse betonen	Metaverse emphasise

Table 16 A selection of the most frequent bigrams from the digital extended reality news stories, for Germany.

28% of the news stories retrieved for digital extended reality contained at least one ELSI-keyword. ‘Security’ and ‘privacy’ were the most frequently mentioned terms (appearing in 9% and 8% of the news stories respectively) (see Figure 48).

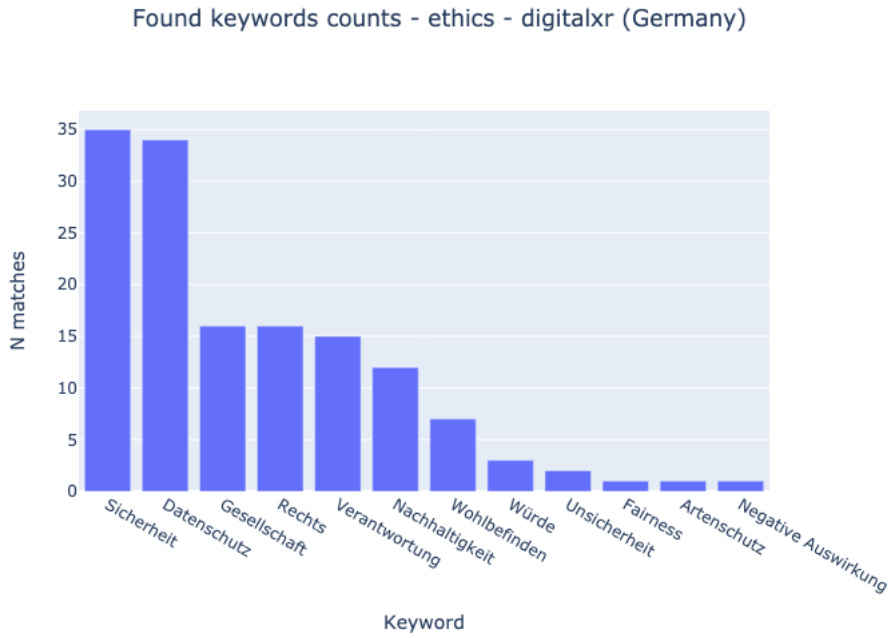


Figure 48 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for Germany. The English translation of the words is, from left to right: 'security', 'privacy', 'society', 'law ,'responsibility' ,'sustainability', 'wellbeing', 'dignity', 'insecurity', 'fairness', 'wildlife protection , 'negative impact'.

Mentions of entities labelled as ‘organisation’ show that ‘Apple’ and ‘Facebook’ are mentioned in several news stories (34 and 18). Mentions of other tech companies (‘Microsoft’, ‘Google Street View’, ‘Sony’ and a general ‘VR-company’) and other companies (McKinsey, VW) have been found in few news stories. Mentions of political entities (EU, CSU, US Securities and Exchange Commissions) have been also found (Figure 49).

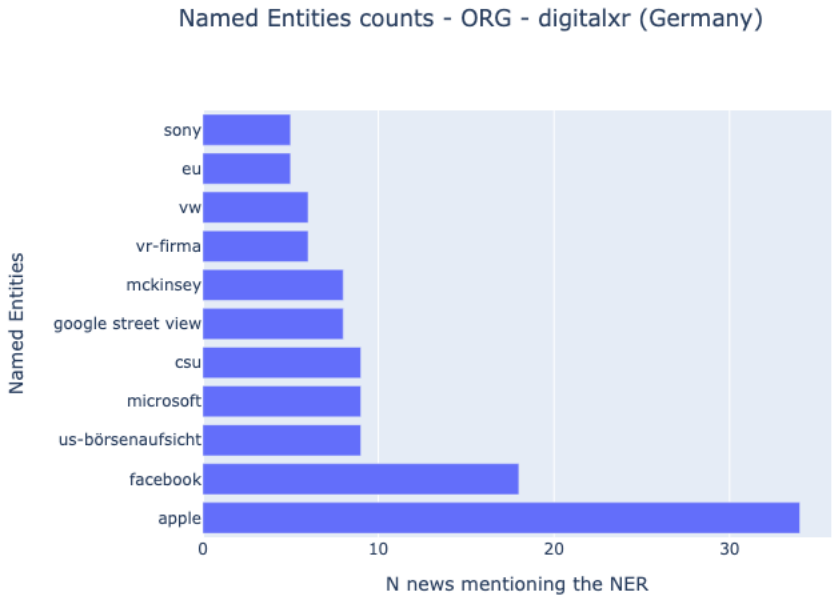


Figure 49 Mention of named entities labelled as 'organisations' (ORG) by Spacy NER model, for Germany. Values on the x-axis indicate the number of digital extended reality, ELSI-relevant, news stories in which the entity on the y-axis appears.

5.4.4 Neurotechnology

The most frequently mentioned keywords in the neurotechnology news collection were 'neurotechnology' and 'brain chip', appearing in 38% and 21% of the news stories, respectively (Figure 50).

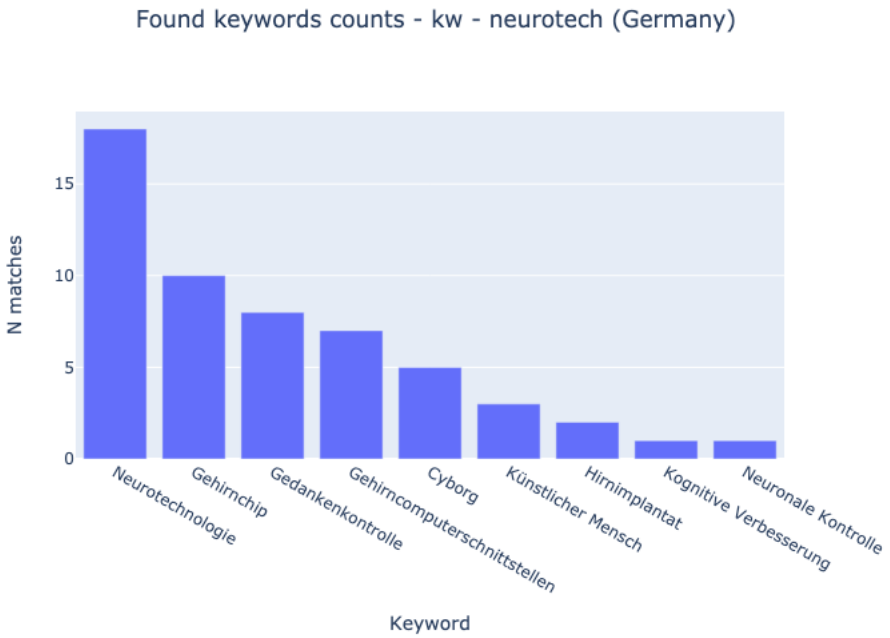


Figure 50 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Germany. The English translation of the words is, from left to right: 'neurotechnology', 'brain chip', 'thought control', 'brain computer interfaces', 'cyborg', 'artificial human', 'brain implant', 'cognitive enhancement', 'neural control'.

Extraction of the most frequently co-occurring terms suggest that Neuralink (and the experiments which taught a monkey to play a videogame) are discussed in the news. The neurotechnology news stories also appear to be discussed in relation to 'human diseases', 'Alzheimer', 'human functioning' (Table 17).

Frequent bigrams (DE)	Frequent bigram (EN)
Unternehmen Neuralink	Company Neuralink
Wandel Gesellschaft	Change society
schließen Alzheimer	close Alzheimer
Krankheit Mensch	human disease
funktionieren Mensch	human functioning
Wissenschaftler Kritik	scientist criticism
Affe steuern	monkey control
steuern Videospiel	control video game

Table 17 A selection of the most frequent bigrams from the digital extended reality news stories, for Germany.

Mentions of ELSI-keywords were found in 25 news stories, corresponding to 52% of the stories collected for this technology category. 'Security', 'society' and 'responsibility' were the terms mentioned in more news stories. We found that a high portion of the news stories (60%) were about Elon Musk and Neuralink.

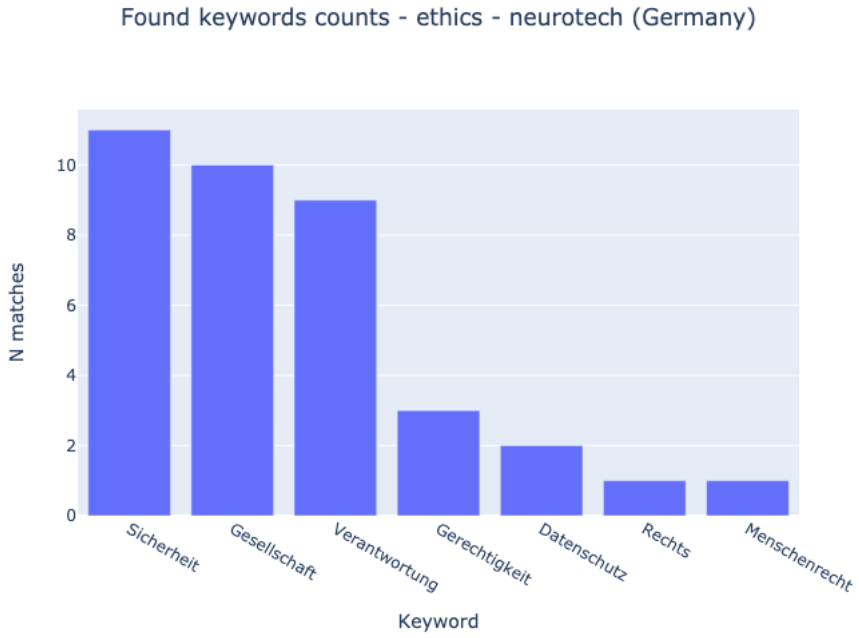


Figure 51 Counts of neurotechnology news stories mentioning the ELSI- keyword on the x-axis, for Germany. The English translation of the words is, from left to right: 'security', 'society', 'responsibility', 'justice', 'privacy', 'law', 'human rights'.

5.5 Ireland

5.5.1 Dataset description

The final dataset for Ireland included 930 news stories: 252 for climate, 663 for digital extended reality, and 25 for neurotechnology. The counts of the news stories over time are represented in the bar plot below (Figure 52).

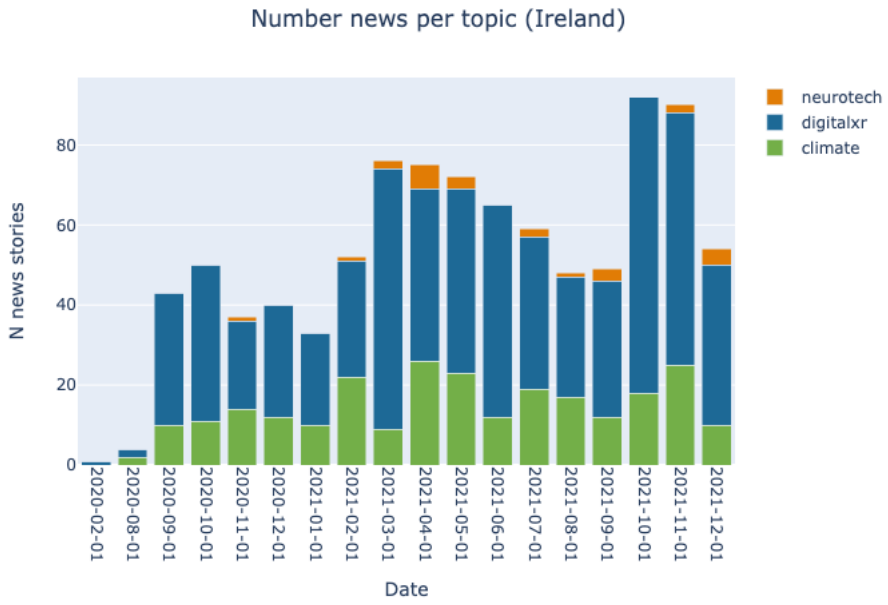


Figure 52 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Ireland.

Most of the news stories collected (82%) were retrieved from outlets covering general topics (17% of the stories were found on technical outlets, mainly for the digital extended reality news) - Figure 53 .

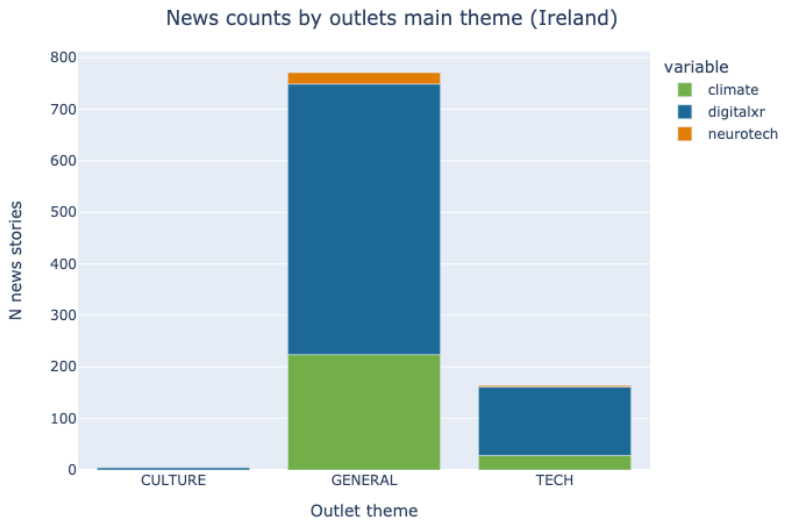


Figure 53 Counts of news stories by theme of outlets where they were published, broken down by technology, for Ireland.

The majority of the stories in the collection were published on the *Irish Times* (19%), *The Independent* (18%), *Silicon Republic* (17%), and *The Sun* (17%) - Table 18 .

Outlet	Climate	Digital XR	Neurotechnology	Outlet Theme	Outlet Type
breakingnews	18	45	1	GENERAL_NEWS	GENERAL
buzz	11	23	0	GENERAL_NEWS	GENERAL
fm104	0	6	0	TV_RADIO	GENERAL
independent	68	96	1	GENERAL_NEWS	GENERAL
irishmirror	4	48	1	GENERAL_NEWS	GENERAL
irishtimes	66	109	1	GENERAL_NEWS	GENERAL
lmfm	1	5	0	TV_RADIO	GENERAL
rsvplive	0	5	0	MAGAZINE	CULTURE
rte	27	47	4	GENERAL_NEWS	GENERAL
siliconrepublic	28	133	3	Unsure	TECH
thejournal	17	14	2	GENERAL_NEWS	GENERAL
thesun	12	132	12	TABLOID	GENERAL

Table 18 Counts of news stories by theme of outlets where they were published, broken down by technology, for Ireland.

The news stories were published primarily in the main sections of the outlets for the three categories. The second most frequent sections were 'tech' for digital extended reality and neurotechnology news and 'environment' for climate engineering.

5.5.2 Climate engineering

The most frequently mentioned topic in the news stories collected for climate engineering was 'carbon capture', present in 36% of the stories. The related 'carbon sequestration', 'carbon storage', 'carbon

usage' were mentioned in 18%, 11% and 3% of the stories, respectively. 'Green hydrogen' and 'afforestation' were also found in a relevant portion of news stories (23% and 21%) (see Figure 54).

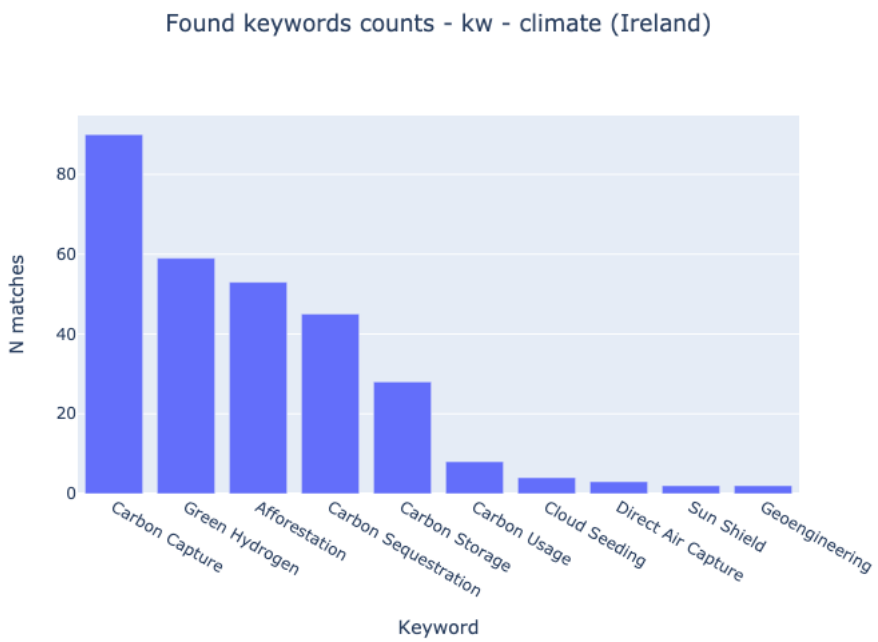


Figure 54 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Ireland.

The most frequently co-occurring bigrams suggest a preoccupation with climate change, climate crisis, carbon footprint, and the need of take actions to reduce carbon emissions and achieve 'climate targets' (Figure 55).

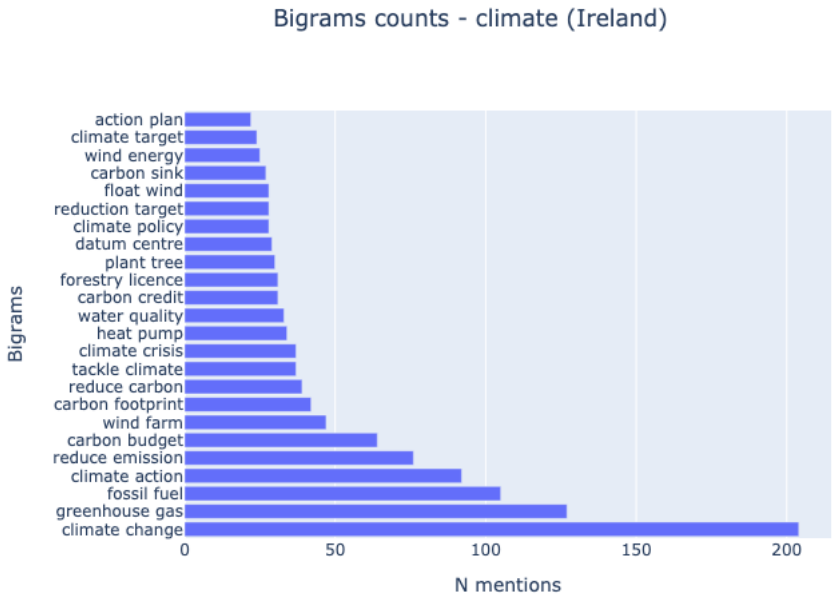


Figure 55 A selection of the most frequently co-occurring terms (bigrams) in the climate engineering news stories, for Ireland.

Mentions of ELSI-keywords were found in 51% of the news stories collected for this category, with 'society', 'law' and 'sustainability' being the most common terms in the news (Figure 56).

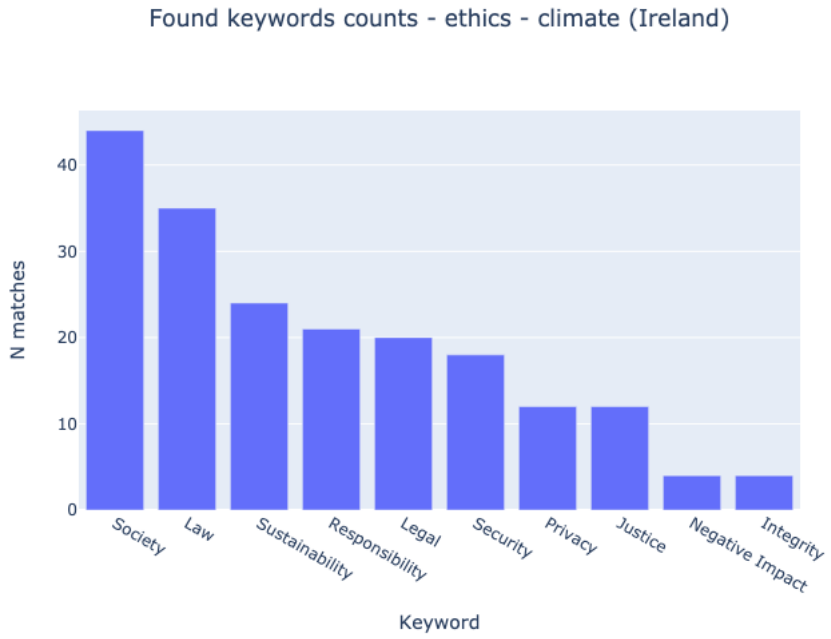


Figure 56 Counts of climate engineering news stories mentioning the ELSI-keyword on the x-axis, for Ireland.

Through extraction of named entities (Figure 57), we found that in this subset of news stories, several stories mention international political organisations (e.g., EU, UN, the European Commission) and national ones (e.g., The Climate Change Advisory Council, the Department of Agriculture, EPA – Environmental Protection Agency) as well as national companies: Teagasc (a state agency providing research, advisory and education in agriculture, horticulture, food and rural development in Ireland), ESB (the main state-owned electricity company), Bord na Móna (a semi-state company working in the renewable energy, recycling , wasteland and peatland restoration).

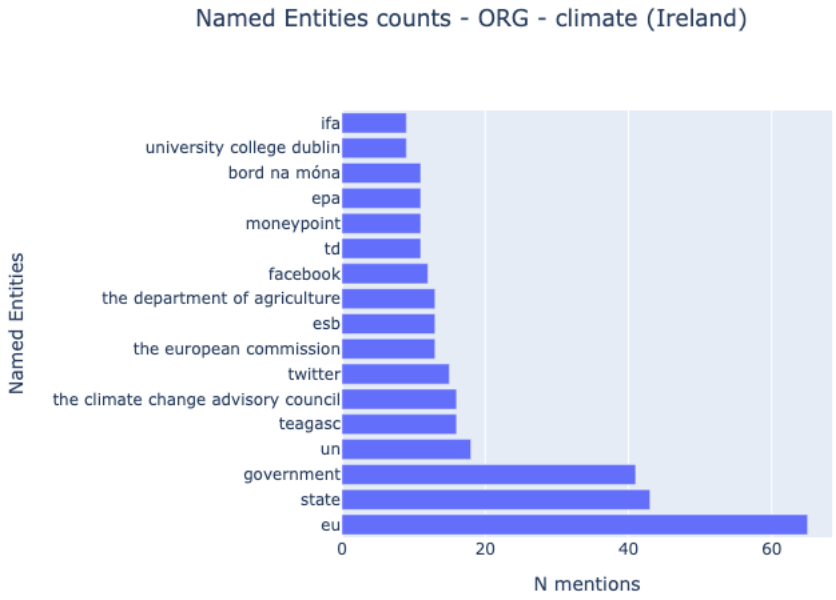


Figure 57 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for Ireland. The number on the x-axis indicate the number of climate engineering news, mentioning ELSI-keywords, where the entity on the y-axis was mentioned.

Extraction of named entities of type 'person' revealed mentions of Irish political figures in several news stories, in particular Eamon Ryan, leader of the Irish Green Party since 2011 and has held/is holding roles in the government, including as Minister from the Environment, Climate and Communications. He is mentioned in 15% of the news stories that include ELSI keywords (Figure 58).

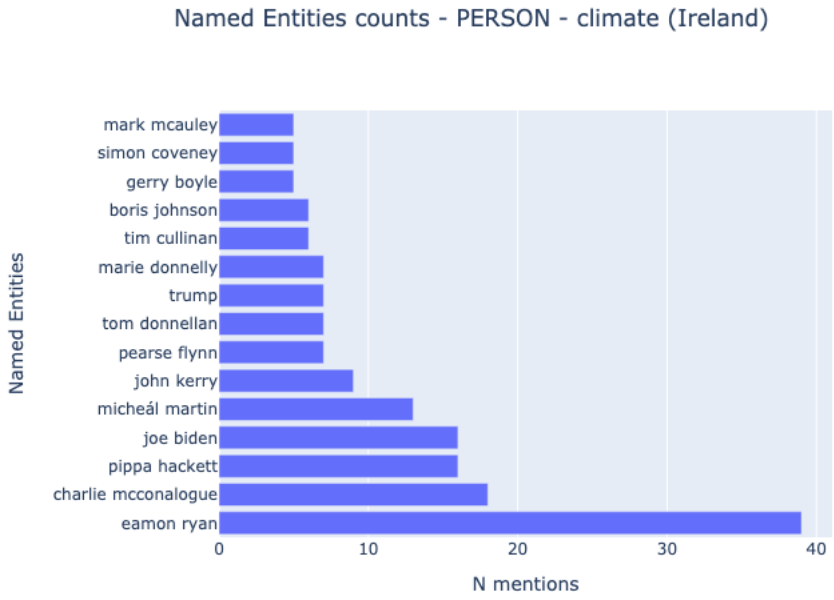


Figure 58 Selection of most frequently mentioned named entities classified under the category 'PERSON' by Spacy NER models, for Ireland. The number on the x-axis indicate the number of climate engineering news, mentioning ELSI-keywords, where the entity on the y-axis was mentioned.

5.5.3 Digital extended reality

As it is the case for most of the other countries, 'virtual reality' was the most prevalent keyword in the news stories collected for digital extended reality (Figure 59). It is mentioned in 54% in the stories. 'Augmented reality', 'virtual world' and 'Metaverse' were mentioned, respectively, in 26%, 19% and 17% of the stories (other keywords are mentioned in less than 5% of the stories). *Silicon Republic* (a news website specialised in technology, science and start-up news) was the outlet in which the largest share of news stories were found (20%; 81% of all the news collected from this outlet belong to this technology category), followed by *The Sun* (19.9%), *The Irish Times* (16%) and *The Independent* (14%). Through extraction of most frequently co-occurring terms we found that a relevant portion of the news stories (24%) discussed 'virtual reality' in relation to video games and consoles.

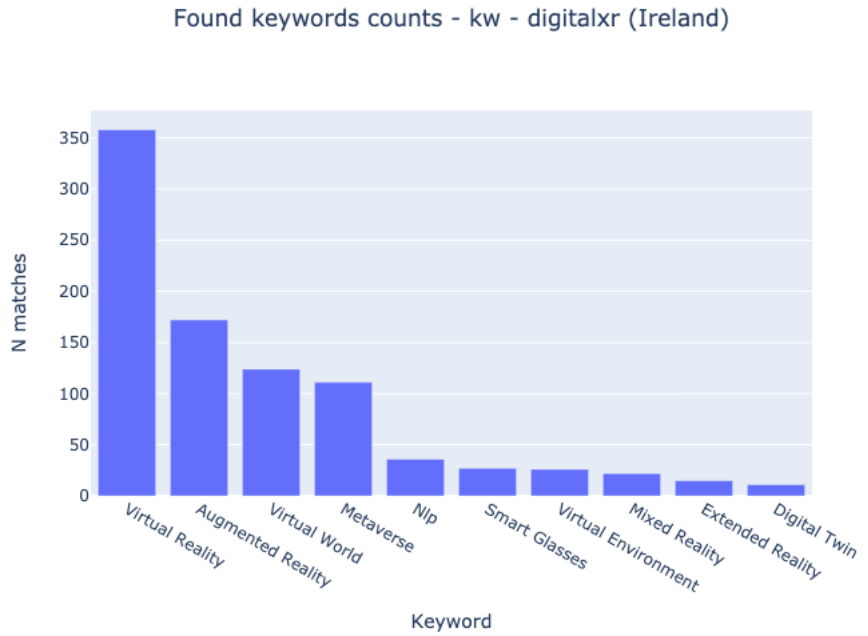


Figure 59 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for Ireland.

Mention of ELSI-keywords was found in 35% of the news stories collected for digital extended reality. 'Privacy' was the most prevalent keyword, found in 41% of the stories that included ELSI-keywords (Figure 60).

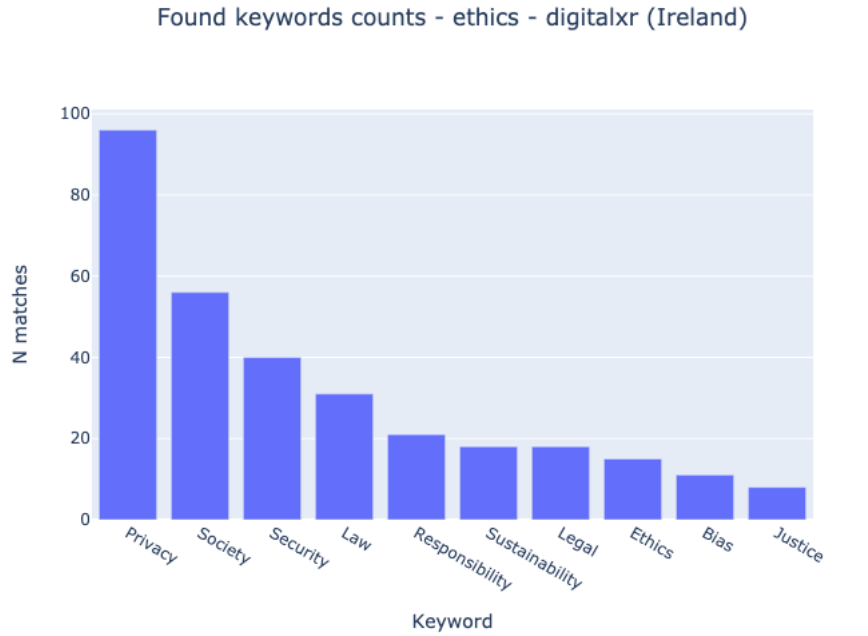


Figure 60 *Counts of digital extended reality news stories mentioning the ELSI-keyword on the x-axis, for Ireland.*

Extraction of the organisation entities reveals frequent mentions of known big technology and social media companies. Facebook is mentioned in 30% of the ELSI-relevant news stories, Instagram and WhatsApp in 20% and 11% respectively (Figure 61).

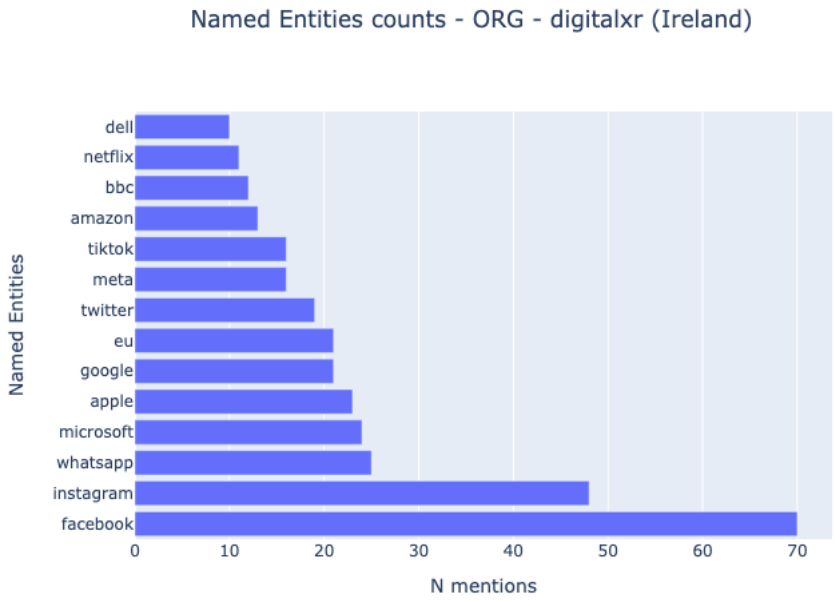


Figure 61 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for Ireland. The number on the x axis indicate the number of digital extended reality news, mentioning ELSI-keywords, where the entity on the y axis was mentioned.

The two most frequently mentioned person, identified by the named entities extraction models, were Mark Zuckerberg (mentioned in 12% of the stories) and Frances Haugen (7%). With respect to geo-political entities, Ireland is the most prevalent one (mentioned in 42% of the stories; US and UK' are found in 22% and 20% of the stories respectively).

5.5.4 Neurotechnology

For the neurotechnology category only 25 news could be retrieved. The results of the analysis are therefore biased by the specific news that are reported in this collection. We found that brain implant technologies were the most prevalent topic discussed ('brain chip' is mentioned in 40% of the stories, 'brain implant' in 36% and 'brain computer interface' in 28%) - Figure 62.

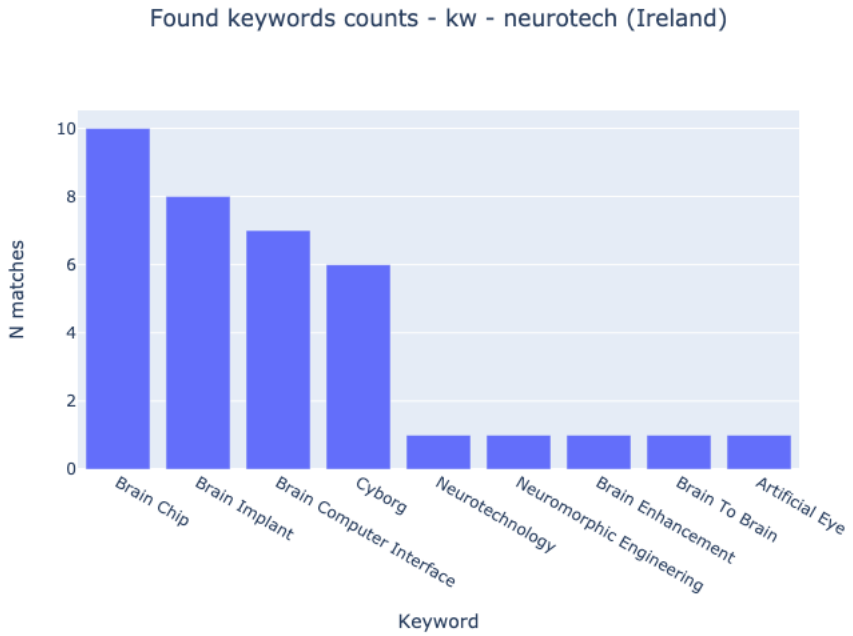


Figure 62 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Ireland.

The Sun was the main source of news stories in this collection (48% of the stories were published there). We found that 52% of the stories discuss Elon Musk and Neuralink experiments. Two stories report about the Dr Phil Kennedy, an Irish neuroscientist presented as 'father of the cyborgs'.
ELSI-keywords were found in 9 news stories, corresponding to 36% of the total collected for this category (Figure 62). Stories included news about potential impact on brain experiments on privacy ('mental privacy') and titles about Elon Musk.

5.6 Italy

5.6.1 Dataset description

The final dataset for Italy consisted of 1883 news stories: 386 for climate engineering, 1448 for digital extended reality, 49 for neurotechnology. The distribution of the news over time can be observed in the figure below. We noticed a data gap for the digital extended reality news (data for this technology were missing in the months between January 2021 and August 2021). This gap is likely due to errors in the connection to the news API in the data collection phase (see explanatory note in Section 3.6). We acknowledge this data artifact, but we do not consider it invalidating for the analysis to follow as we focussed on time-independent analysis of the news content. However, due to this data gap, if relevant events associated with the digital extended reality technology happened in the months for which data are missing, the discussion around them will not be reflected in our data.

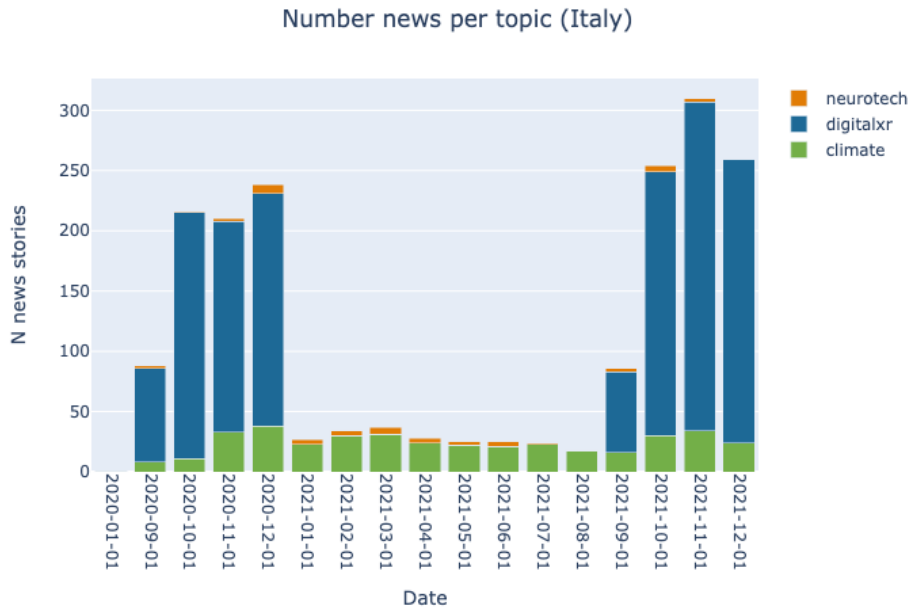


Figure 63 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Italy.

The table below shows the breakdown counts by technology and outlet together with the annotation of the type and the main theme/topic of the outlet (provided by TRI). The outlets include widely read national newspapers (*La Stampa*, *Repubblica*, *Il Sole 24 Ore*), local outlets, and outlets specialised in technology reviews, economy, or other topics.

Outlet	Climate	Digital XR	Neurotechnology	Outlet Type	Outlet Theme
adnkronos	1	10	0	NEWS_AGENCY	GENERAL
affaritaliani	87	68	3	GENERAL_NEWS	GENERAL
androidworld	0	6	0	FREESHEET	TECH
ansa	30	57	5	NEWS_AGENCY	GENERAL
dilei	0	1	1	MAGAZINE	Other
dissapore	0	1	0	MAGAZINE	Other
fanpage	1	8	0	TABLOID	GENERAL
gazzetta	13	25	0	GENERAL_NEWS	Other
genova24	8	22	1	LOCAL	GENERAL
giornaledibrescia	17	11	0	LOCAL	GENERAL
ilgiornaledivicenza	13	18	2	LOCAL	GENERAL
ilpost	14	22	0	FREESHEET	GENERAL
ilsecoloxix	5	8	0	LOCAL	GENERAL
ilsole24ore	14	39	1	GENERAL_NEWS	ECONOMY
lastampa	5	26	1	GENERAL_NEWS	GENERAL
money	36	98	1	MAGAZINE	ECONOMY
multiplayer	0	258	3	FREESHEET	TECH

napoli	0	7	0	LOCAL	GENERAL
palermo	1	5	0	LOCAL	GENERAL
proiezionidiborsa	5	12	1	FREESHEET	ECONOMY
rainews	8	13	2	TV_RADIO	GENERAL
repubblica	23	24	4	GENERAL_NEWS	GENERAL
smartworld	0	72	1	FREESHEET	TECH
sport	1	14	0	GENERAL_NEWS	Other
techprincess	4	199	6	FREESHEET	TECH
tg24	4	71	5	TV_RADIO	GENERAL
tgcom24	8	53	3	TV_RADIO	GENERAL
tomshw	20	258	9	FREESHEET	TECH
trend-online	67	31	0	FREESHEET	ECONOMY

Table 7 Counts of news collected from each outlet, broken down by technology, for Italy. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

As can be observed in Figure 64, for the digital extended reality technology, more news items were found in technical outlets compared to non-technical ones. We note that several technical outlets are present in the data (*tomshw*, *androidworld*, *multiplayers*, *techprincess*) which can explain the high volume of news returned for the digital extended reality topic. These outlets focus on reviews of IT products, technological devices and videogames. For the climate topic, a significant portion of news stories was found in outlets with an economic focus. Neurotechnology news stories are discussed in technical or general outlets.

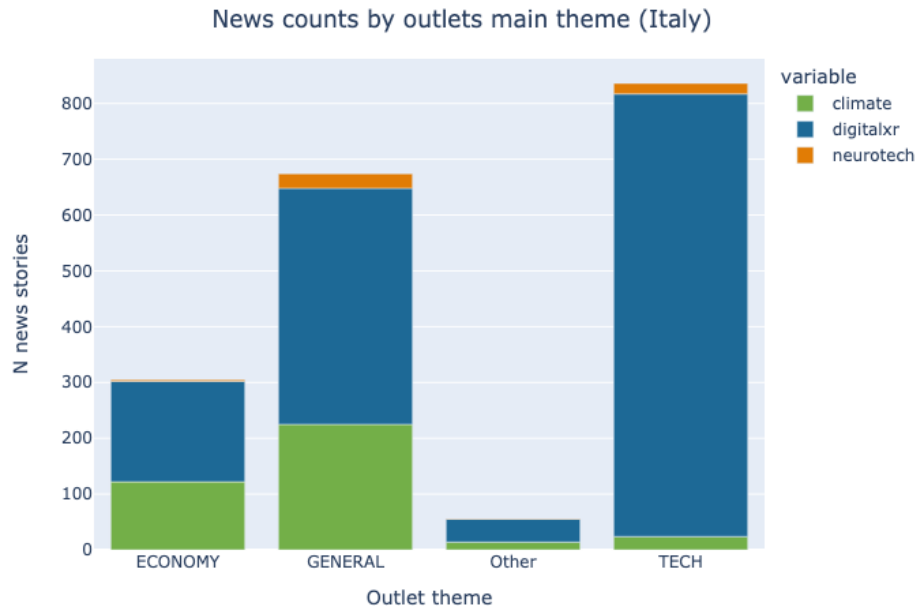


Figure 64 Counts of news stories by theme of outlets where they were published, broken down by technology, for Italy.

5.6.2 Climate engineering

From the analysis of the keywords' mentions in the news, 'green hydrogen' is by far the dominant topic (mentioned in over 70% of the news for this technology). 'Afforestation' and 'reforestation', 'carbon storage' and 'carbon capture' are mentioned in less than 50 news stories while the other keywords are less frequently mentioned (Figure 65).

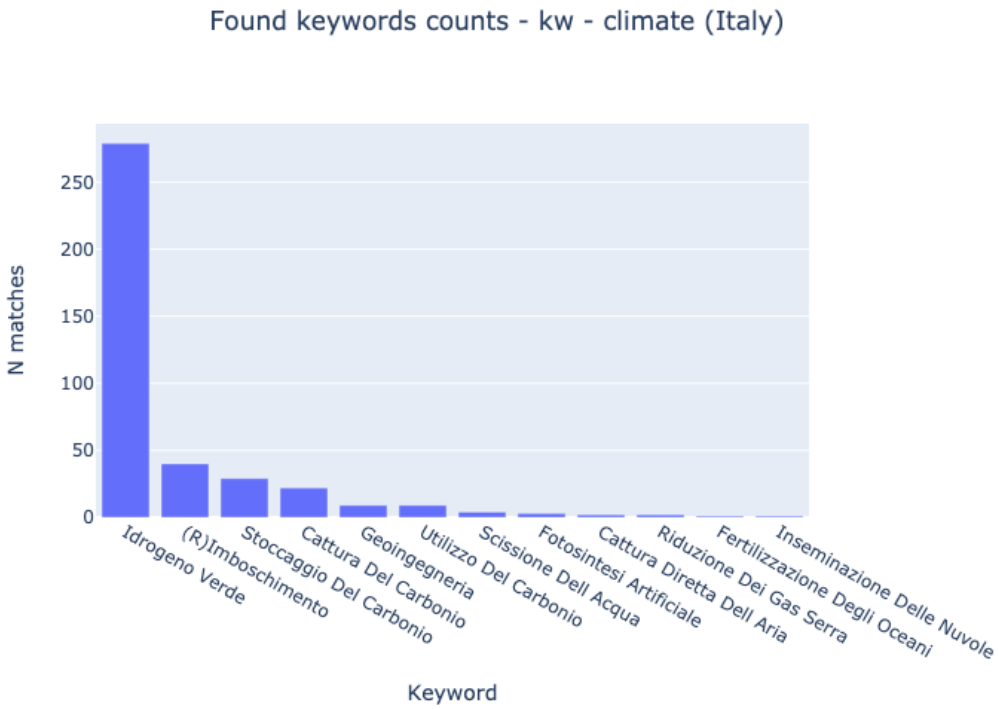


Figure 65 Counts of news stories mentioning the climate technology keywords on the x-axis, for Italy. The English translation of the words, from left to right, are: green hydrogen, afforestation/reforestation, carbon storage, carbon capture, geo-engineering, carbon usage, water splitting, artificial photosynthesis, direct air capturing, greenhouse gas emissions reduction, oceans fertilisation, cloud seeding.

During the bilateral call, partners from Italy (AIRI) found this finding consistent with their knowledge of the Italian discussion around the climate topic. Investments in green hydrogen solutions to reduce carbon emissions are considered high priority and are often central in political discussions, as the frequent mentions of expressions like 'reach objective', 'decarbonise sector', 'accelerate transition' suggest (Table 19).

Frequent bigrams (IT)	**Frequent bigram (EN)**
Raggiungere obiettivo	*Reach objective*
Ridurre emissione	*Reduce emissions*
Target price	*Target price*
Decarbonizzazione settore	*Decarbonise sector*
Accelerare transizione	*Accelerate transition*
Firmare accordo	*Sign agreement*
soluzione mobilità	*Mobility solution*

Table 19 A selection of the most frequent bigrams from the climate engineering news, for Italy.

About 50% of the news contained at least one ELSI-keyword. The discussion in these news items revolves mostly around investments for renewable energy.

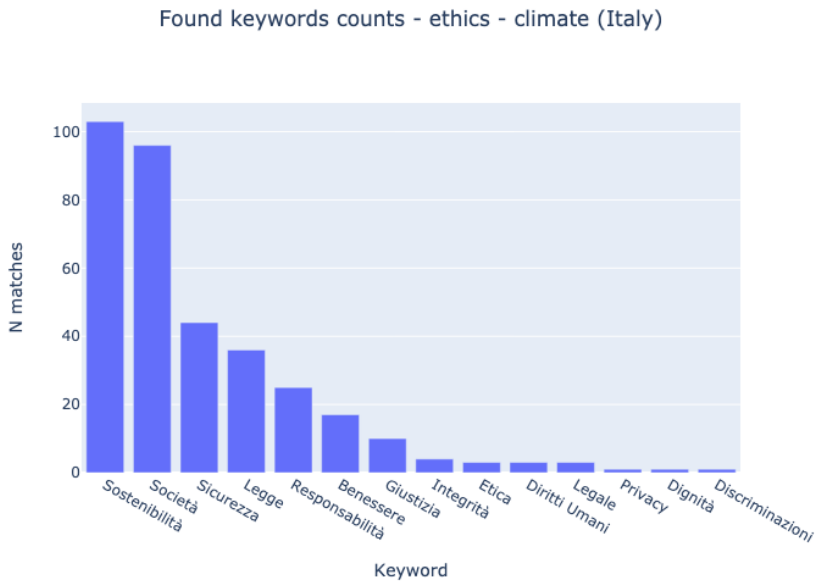


Figure 66 Counts of climate engineering news stories where the ELSI-keyword on the x-axis was found, for Italy. The English translations of the words, from left to right, is: sustainability, society safety, law, responsibility, well-being, justice, integrity, ethics, human rights, legal, privacy, dignity, discriminations.

Several news stories discuss the Recovery Plan, i.e., a plan of reforms and investments to support Italy's green and digital transition. We found mentions of various major Italian companies operating in the energy and petroleum fields ('Snam', 'Eni', 'Saipem') in relation to their green strategies. Several news items mentioning safety, responsibility and laws provides reports on the fires which affected particularly the South of the country.

Figure 67 Word cloud generated from the text of ELSI-relevant climate engineering news, for Italy. The biggest 5 words are sviluppo (development), euro, produzione (production), Snam (Snam S.p.A., an Italian energy infrastructure company), società (society).

5.6.3 Digital extended reality

The main topics of discussion in the news stories we collected for digital extended reality were 'virtual reality', 'augmented reality' and 'metaverse'. As observed for the other countries, we found that 'virtual

reality' was often mentioned in news from technical outlets, in relation to products (movies, videogames, smart glasses, headsets) making use of VR solutions.

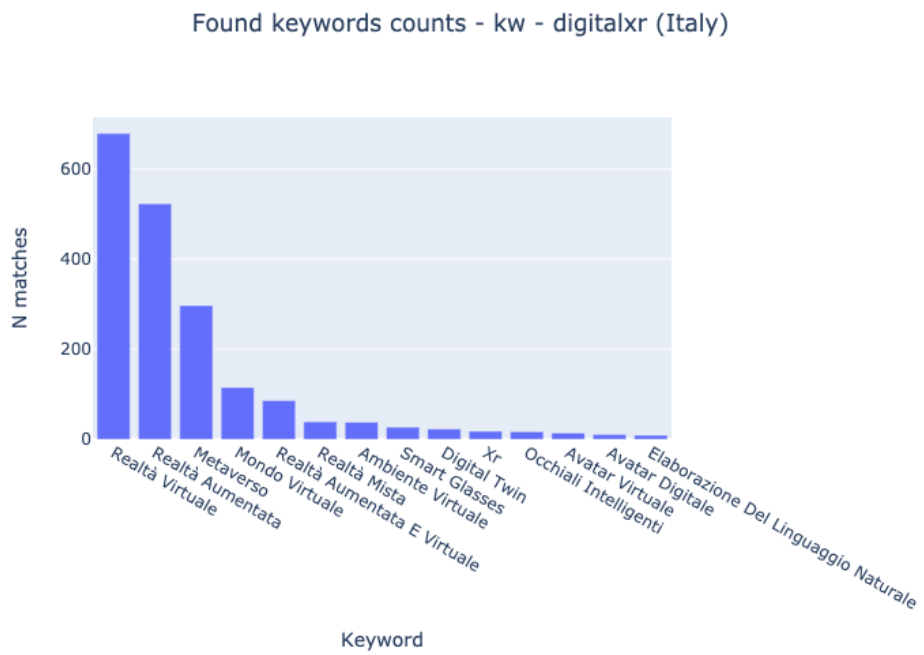


Figure 68 Counts of news stories where the digital extended reality keyword on the x-axis was found, for Italy. The English translations of the words, from left to right, are: virtual reality, augmented reality, metaverse, virtual world, augmented and virtual reality, virtual environment, smart glasses, digital twin, XR, smart glasses, virtual avatar, digital avatar, natural language processing

As some of the bigrams suggest, the stories often discuss the potential of digital extended reality solutions to 'create', 'live' and 'share' experiences (see Table 20). 'Art market' is mentioned in several stories, suggesting the application of these technologies in the creative sector. Curiosity and expectations toward the metaverse are subject of several news.

Frequent bigrams (IT)	Frequent bigram (EN)
Mercato dell'arte	Art market
Ricerca e sviluppo	Research & development
Machine learning	Machine learning
Costruire piattaforma	Build platform
Sistema assistenza	System assistence
Replicare comportamento	Replicate behaviour
Customer experience	Customer experience
Vivere esperienza	Live experience
Creare esperienza	Create experience
Condividere esperienza	Share experience

Table 20 A selection of the most frequent bigrams from the digital extended reality news stories, for Italy.

Less than 30% of the news stories found mentioned ELSI-keywords (Figure 69). The NER models extracted, in these stories, mention organisations like Apple, Facebook, Nvidia, Intel, Lenovo and the European Commission. As it is the case for other countries, a large portion of news discusses Facebook controversies around user privacy and concerns toward the metaverse.

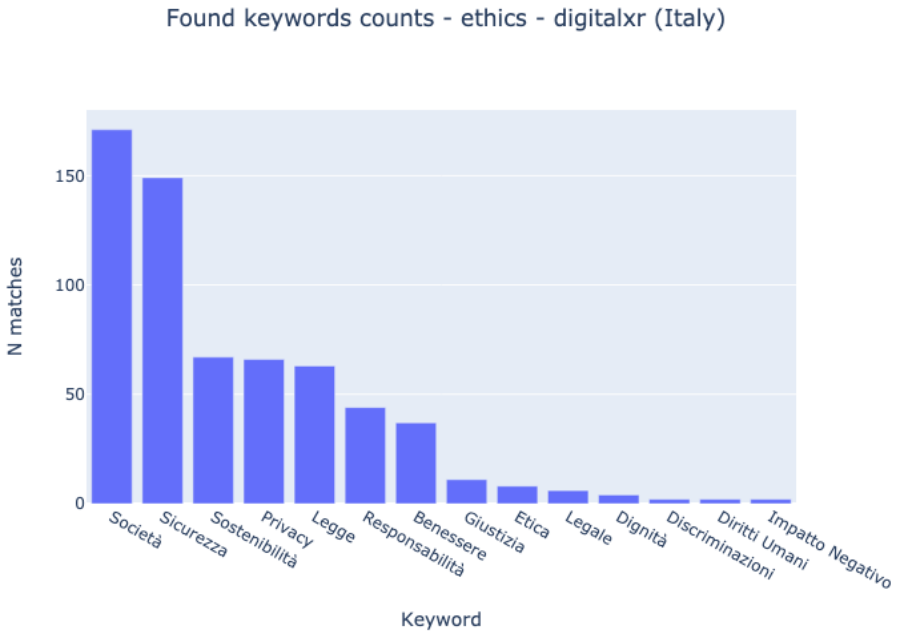


Figure 69 Counts of digital extended reality news where the ELSI-keyword on the x-axis was found, for Italy. The English translations of the words, from left to right, is: society, safety, sustainability, privacy, law, responsibility, well-being, justice, ethics, legal, dignity, discriminations, human rights, negative impact.

There is also mention of the case of groping in the metaverse. Several news stories refer to the sustainability of digital and extended reality solutions and their role in the transition towards a greener economy.

The word cloud below presents the most frequently occurring terms in the news stories collected for digital extended reality that included ELSI-keywords (see Figure 70 Word cloud generated from the text

Figure 70 Word cloud generated from the text of ELSI-relevant digital extended reality news stories, for Italy. The biggest 5 words, besides Facebook, are: società (society), gioco (game), possono (they can), sicurezza (safety), metaverso (metaverse).

of ELSI-relevant digital extended reality news stories, for Italy. The biggest 5 words, besides Facebook, are: società (society), gioco (game), possono (they can), sicurezza (safety), metaverso (metaverse).

5.6.4 Neurotechnology

Neurotechnologies have generated a considerably lower volume of discussion in the Italian news outlets available in our dataset. One third of the news stories mention the word ‘cyborg’, 7 mention

'neural interface' and 'brain implants' while some of the other keywords were found in less than four news stories (Figure 71). Among other topics, these stories discuss 'Cybathon', the cyborg's Olympics held in Zurich in 2020.

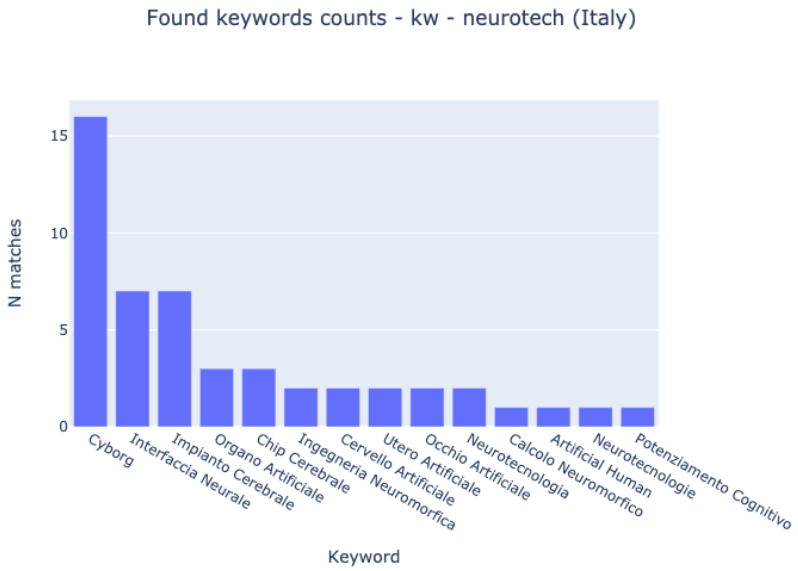


Figure 71 Counts of news stories where the neurotechnology-keyword on the x-axis was found, for Italy. The English translations of the words, from left to right, are: cyborg, neural interface, brain implant, artificial organ, brain chip, neuromorphic engineering, artificial brain, artificial uterus, artificial eye, neurotechnology, neuromorphic computation, artificial human, neurotechnology, cognitive enhancement.

Other news stories, as the bigrams (Table 21) suggest, question whether the increasing adoption of wearables ('wearing technology') and the practices like eggs freezing ('obstetric gynecology') will "turn humans into cyborgs".

Frequent bigrams (IT)	**Frequent bigram (EN)**
Tecnologia indossare	Wearing technology
Continuare ricerca	Continuing research
Ostetricia ginecologia	Obstetric gynecology
Gruppo di ricerca	Research group
Film fantascienza	Sci-fi movie
Interpretare segnale	Interpret signal
Trasmettere computer	Transmit computer

Table 21 A selection of the most frequent bigrams from the neurotechnology news stories, for Italy.

In the set of ELSI-relevant news set, beyond 'society' (which in Italian can be used as synonym for 'company' and hence not necessarily reflect relevance to ELSI-topics), 'privacy', 'ethics' and 'law' were mostly mentioned (Figure 72). 'Law' is mentioned in relation to bioethics in stories about artificial uteruses. Privacy concerns are mentioned in relation to digital technology such as the smart wristband announced by Facebook (where 'neuronal interface' is mentioned) and Google's smart glasses (where the word 'cyborg' is also found).

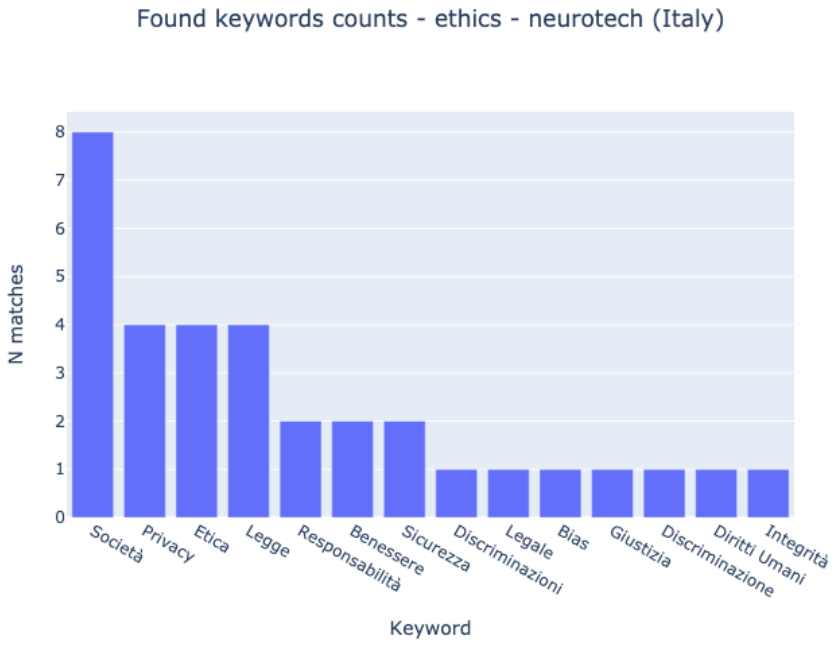


Figure 72 Counts of neurotechnology news stories where the ELSI-keyword on the x-axis was found. The English translations of the words, from left to right, is: society, privacy, ethics, law, responsibility, well-being, safety, discrimination, legal, bias, justice, discrimination, human rights, integrity.

The word cloud (Figure 73) suggests that these neurotechnologies are object of research (indeed news mention research studies or experiments).

Figure 73 Word cloud generated from the text of ELSI-relevant neurotechnology news, for Italy. The biggest 5 words are: possible (they can), dati (data), ricerca (research), società (society), sistema (system).

5.7Netherland

5.7.1 Dataset description

The clean dataset for the Netherlands consisted of 245 news stories. Most of the stories were retrieved for the digital extended reality technology (203), followed by climate engineering (40) and neurotechnology for which only 2 news stories were kept (one story about subcutaneous chips used to make card payments and discussing biohacking and one about Neuralink's monkey experiment). The low number of neurotechnology news stories might be due to error in the connection with the news API

while collecting the data for this category but might also reflect a low interest in the discussion in the outlets that were available or a choice of keywords which does not reflect the terminology with which these topics are discussed in the news (Figure 74). Due to the limited sample size of neurotechnology news, we discarded this category from the analysis.

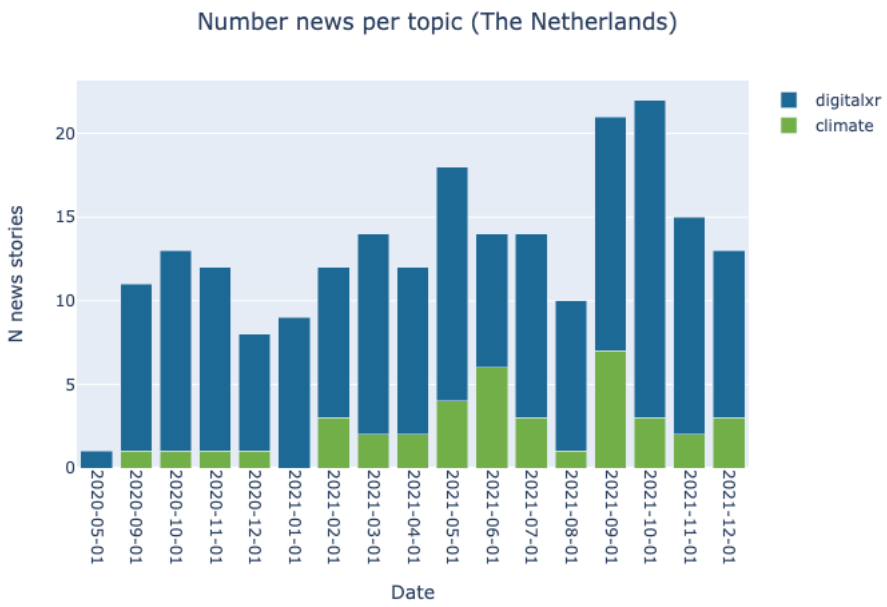


Figure 74 The bar plot shows the count of news stories published for each year-month, broken down by technology, for the Netherlands.

For each technology category, the largest portion of news stories was published on outlets covering general topics (98% of the total climate engineering news and 55% of the digital extended reality ones). 36% of the digital extended reality news stories were published on technical outlets and 8% on outlets with focus on culture (Table 22).

Outlet	Climate	Digital XR	Neurotechnology	Outlet Type	Outlet Theme
androidworld	1	54	0	MAGAZINE	TECH
omroepbrabant	3	17	1	TV_RADIO	GENERAL
onemorething	0	28	0	MAGAZINE	TECH
telegraaf	6	21	1	GENERAL_NEWS	GENERAL
televizier	0	15	0	MAGAZINE	CULTURE
tpo	1	15	0	FREESHEET	GENERAL
tweakers	0	5	0	MAGAZINE	TECH
welingelichtekringen	29	47	1	NEWS_AGGREGATOR	GENERAL

Table 22 Counts of news collected from each outlet, broken down by technology, for Netherlands. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.7.2 Climate engineering

73% of the climate engineering news stories were published on *Welingelichtekringen*, a news aggregator covering general topics. 6 stories (corresponding to 15% of the total for this category) were found on *De Telegraaf*, a widely read national newspaper.
The keyword most frequently mentioned was 'green hydrogen' (found in 58% of the stories); 'CO2-storage' was found in 23% of the stories and other topics (e.g., afforestation, sunshield) were mentioned in less than 3 news (Figure 75).

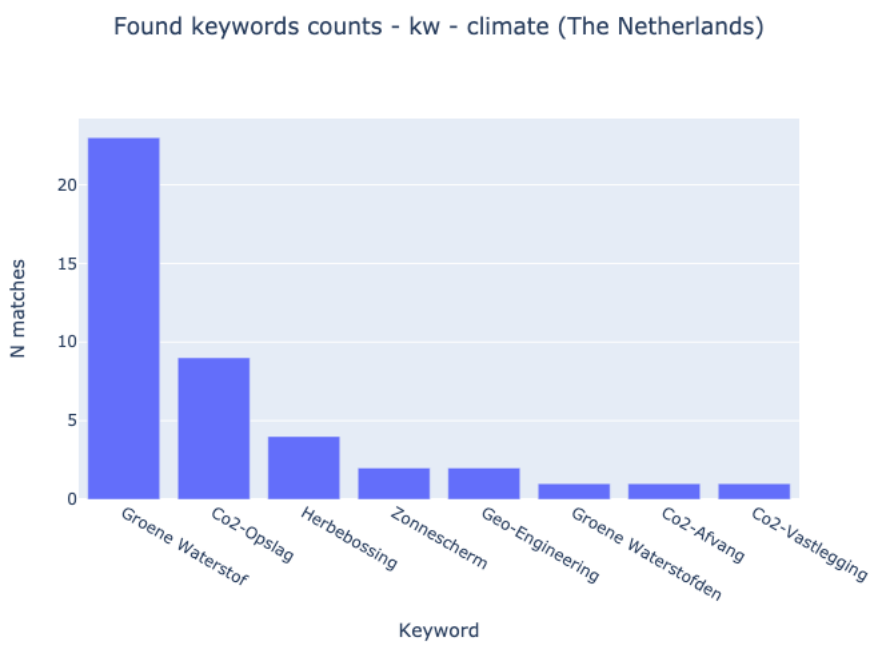


Figure 75 Counts of news stories mentioning the climate engineering keyword on the x-axis, for the Netherlands. The English translation of the words is, from left to right: 'green hydrogen', 'CO2 storage', 'reforestation', 'sunscreen', 'geo-engineering', 'CO2 capture', 'CO2 sequestration'.

The most frequent bigrams extracted from the news stories text suggests that the climate engineering keywords are mentioned in association with policy, funding and costs discussions (Table 23).

Frequent bigrams (NL)	**Frequent bigram (EN)**
Energie gebruiken	use energy
Beleid lukken	policy succeed
maatregel gaan	take measure
procent verlagen	decrease percent
waterstof verplichten	mandating hydrogen
verplichten stellen	make obligatory
oplopen kost	increase costs
fonds geven	give fund
'coördineren planning	coordinate planning

Table 23 A selection of the most frequent bigrams from the climate engineering news stories, for the Netherlands.

Mentions of ELSI-keywords were found in 8 stories, corresponding to 20% of the news stories collected for climate engineering (see Figure 76). These news stories included reporting on Bill Gates investments for clean energy development and 3 stories discussed Netherland's plan to switch to more sustainable energy production (2 stories reported the Tata Steel's plan to switch to natural gas and eventually hydrogen for steel production and one news commented the national plan to limit energy dependency from other countries).

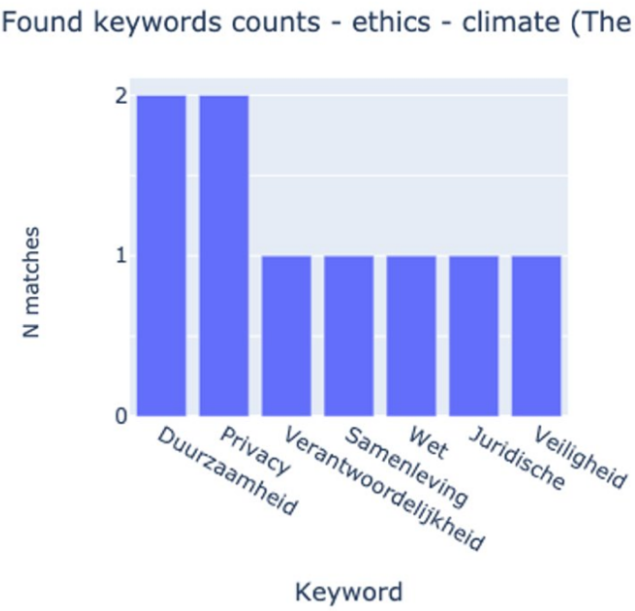


Figure 76 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for The Netherlands. The English translation of the words is, from left to right: 'sustainability', 'privacy', 'responsibility', 'society', 'law', 'legal', 'security'.

5.7.3 Digital extended reality

'Virtual reality' and 'augmented reality' were the most prevalent keywords in the news stories collected for digital extended reality, being mentioned in 35% and 30% of the stories, respectively. Other topics (e.g., 'metaverse', 'XR') received less attention and were found in less than 10% of the news stories (Figure 77).

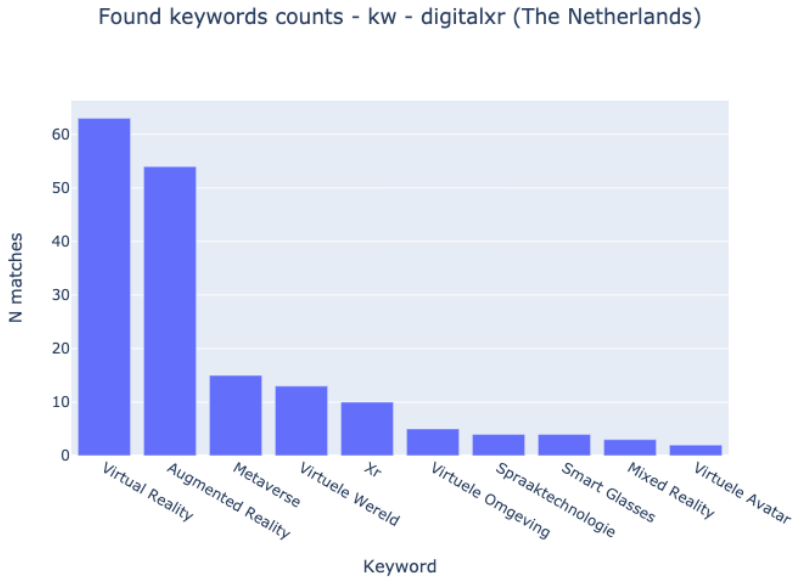


Figure 77 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for The Netherlands. The English translation of the words is, from left to right: 'virtual reality', 'augmented reality', 'metaverse', 'virtual world', 'xr', 'virtual environment', 'speech technology', 'smart glasses', 'mixed reality', 'virtual avatar'.

The larger portion of news stories for this category was published on *Welingelichte Kringen* (26%) and on *Adroidworld* (25%).
ELSI-keywords were found in 17% of the news stories and 'privacy' was the most prevalent term in these news (mentioned in 42% of the stories) (see Figure 78). 'Privacy' is mentioned mainly in relation to facial recognition technology and its use by companies like Meta and Instagram.

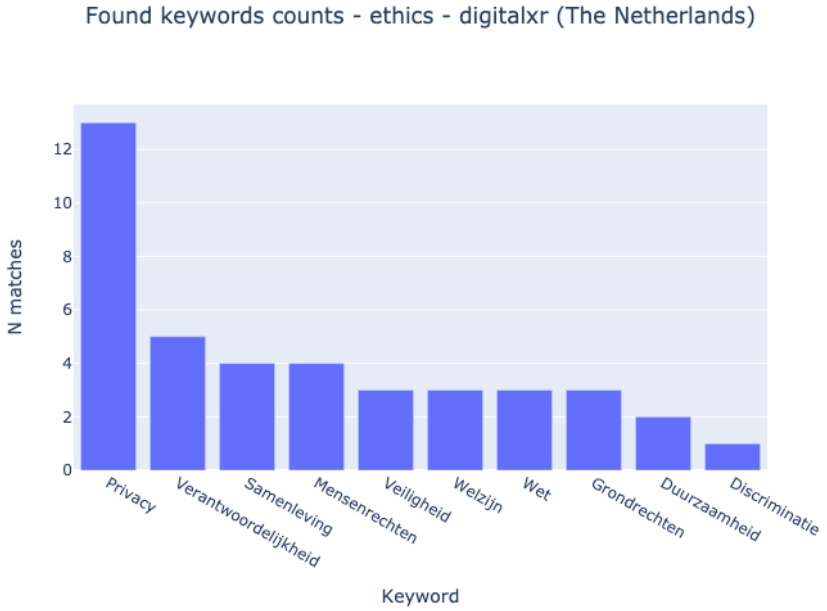


Figure 78 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for the Netherlands. The English translation of the words is, from left to right: 'privacy', 'responsibility', 'society', 'human rights', 'security', 'well-being', 'law', 'fundamental rights', 'sustainability', 'discrimination'.

5.8 Romania

5.8.1 Dataset description

The final news set for Romania comprised 617 news stories: 156 for climate engineering, 417 for digital extended reality, 44 for the neurotechnology. Figure 79 shows the distribution of frequencies over time. News stories published before September 2020 could not be retrieved.

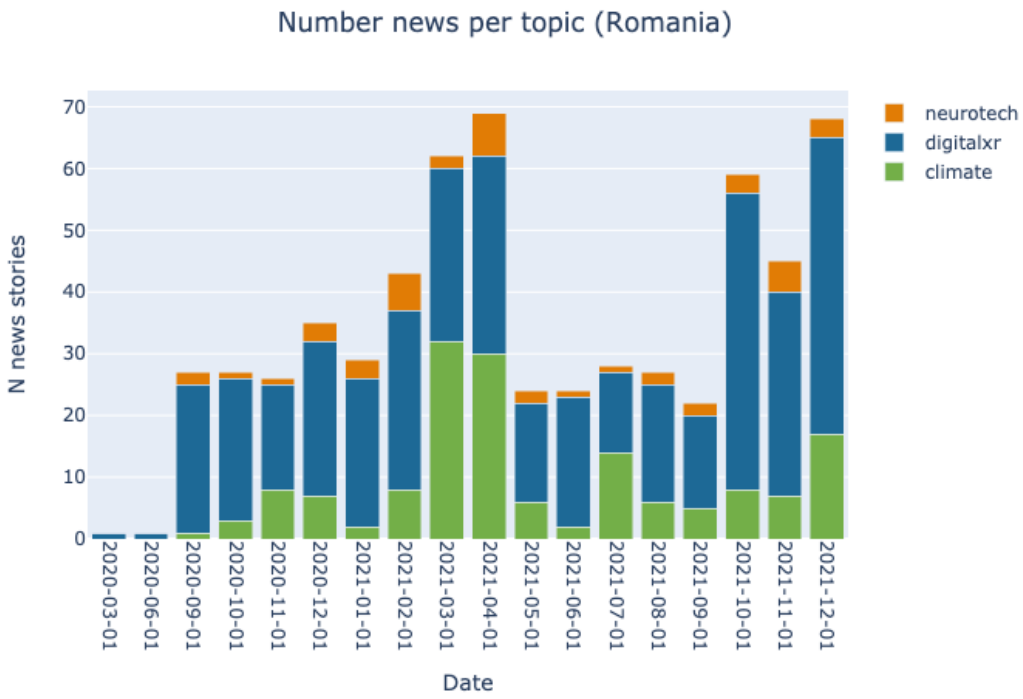


Figure 79 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Romania.

The news stories in the dataset come from different newspapers, magazines, tabloids and outlets specialised in specific topics, including technology (Table 24). During the bilateral call, partners from Romania (BSF) highlighted the presence in the list of rather reliable and widely consumed sources (*Stirileprovt*, *Libertatea*, *G4media*). Most of the news items (69% of the total) were published in non-technical outlets although for digital extended reality technology, a relevant share of news stories (40%) was published in technical outlets.

Outlet	Climate engineering	Digital XR	Neurotechnology	Outlet type	Outlet theme
antena3	3	1	0	TV_RADIO	GENERAL
dcnews	21	27	4	TABLOID	GENERAL
evz	26	53	11	TABLOID	GENERAL
g4media	41	38	5	GENERAL_NEWS	GENERAL
idevice	0	6	0	Unsure	GENERAL
libertatea	32	34	7	GENERAL_NEWS	GENERAL
mobilissimo	0	147	0	MAGAZINE	TECH

promotor	1	23	2	MAGAZINE	TECH
prosport	2	2	0	MAGAZINE	Other
romaniatv	20	26	6	TV_RADIO	GENERAL
stirileprotv	3	26	6	TV_RADIO	GENERAL
stiripesurse	5	25	2	TABLOID	GENERAL
telekomsport	1	0	0	MAGAZINE	Other
viva	1	9	1	MAGAZINE	Other

Table 24 Counts of news stories collected from each outlet, broken down by technology, for Romania. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.8.2 Climate engineering

The topic most frequently occurring in the climate engineering news stories is 'afforestation': over 76% of the total news stories for this technology mention this keyword. 'Reforestation' was discussed in 14% of the news stories and other keywords were mentioned in less than 5% of the news (Figure 80).

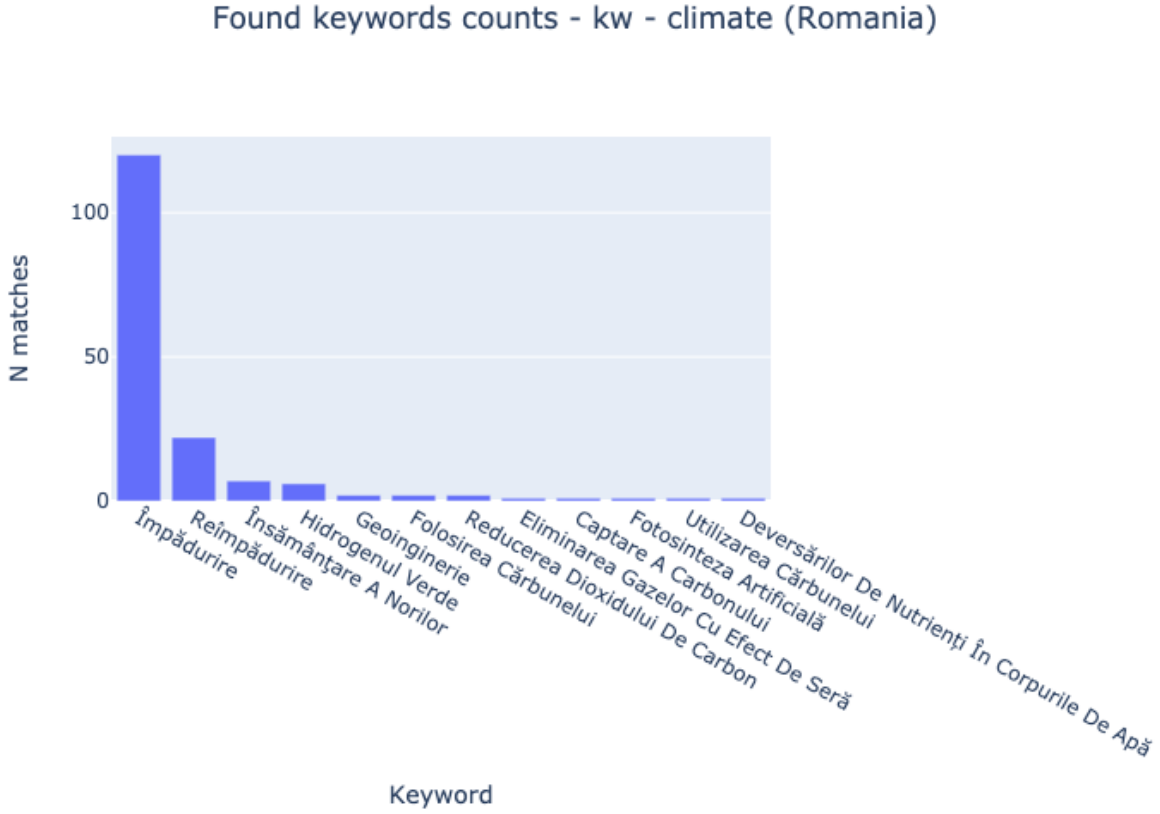


Figure 80 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Romania. The English translation of the words is, from left to right: afforestation, reforestation, cloud seeding, green hydrogen, geoengineering, coal use, carbon dioxide reduction, greenhouse gas removal, carbon sequestration, artificial photosynthesis, coal use, nutrient discharges to water bodies.

As illustrated by the bigrams, the news stories frequently mention political entities ('minister of labour', 'president of the council', 'ministry of the environment') suggesting a correlation, in our set of news, between the climate topics and the political landscape of Romania (

Table *25*).

Frequent bigrams (RO)	Frequent bigram (EN)
Ministrul Muncii	Minister of Labor
președinta Consiliului	President of the Council
Ministerul Mediului	Ministry of the Environment
holurile Parlamentului	Parliament halls
ministrul Investiţiilor	Minister of Investments
surse regenerabile	renewable sources
combaterea schimbărilor	combating change
protejarea mediului	environmental protection
alocarea fondurilor	allocation of funds
uciderea animalelor	killing animals
reducerea emisiilor	reducing emissions

Table 25 A selection of the most frequent bigrams from the climate engineering news stories, for Romania.

ELSI-keywords were mentioned in 20% of the news for the climate engineering technology. Figure 81 shows the breakdown of the counts by keyword.

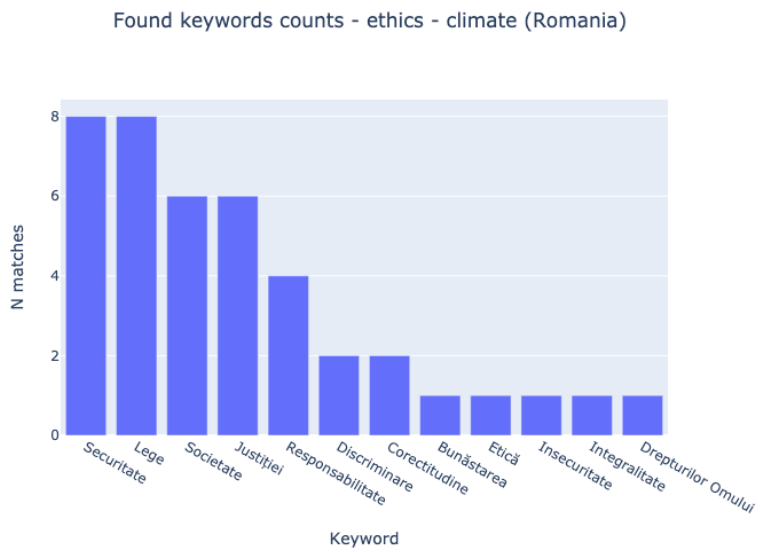


Figure 81 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for Romania. The English translation of the words is, from left to right: security, law, society, justice, accountability, discrimination, fairness, welfare, ethics, insecurity, integrity, human rights.

As the world cloud suggests, 'European Union' is mentioned often in these news stories together with 'PNRR' (National Recovery and Resilience Plan), which is discussed in almost 30% of the news stories (see Figure 82).

Figure 82 Word cloud on climate engineering news stories mentioning ELSI-keywords for Romania. The top words in the cloud are: Euro, pădure (forest), Uniunea Europeană (European Union), project, PNRR and Împădurire (afforestation).

5.8.3 Digital extended reality

'Virtual reality' is the topic most prevalent in the news stories collected for digital and extended reality, present in 52% of the news. 'Augmented reality', 'extended reality', 'avatar' and 'metaverse' were mentioned in between 22% to 10% of news stories while the other topics were found in less than 10% of the news (Figure 83).

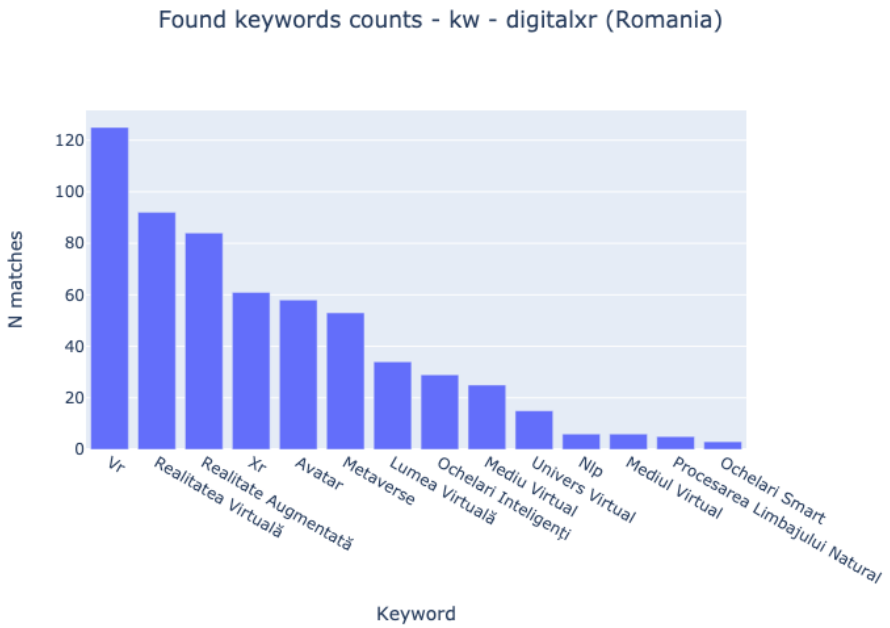


Figure 83 Counts of news stories mentioning the digital extended reality keyword on the x-axis. The English translation of the words is, from left to right: VR, virtual reality, augmented reality, XR, avatar, metaverse, virtual world, smart glasses, virtual environment, virtual universe, NLP, virtual environment, natural language processing, smart glasses.

ELSI-keywords were found in 16% of the news stories collected for digital and extended reality technologies (a breakdown of the counts is provided in Figure 84). The most frequently mentioned ELSI-keyword is 'security'. We found that this word is mentioned often in relation to security of an application or software product (e.g., TikTok, Apple Touch ID, iOS updates). The ELSI-keyword 'society' appears in news discussing digital innovations more broadly.

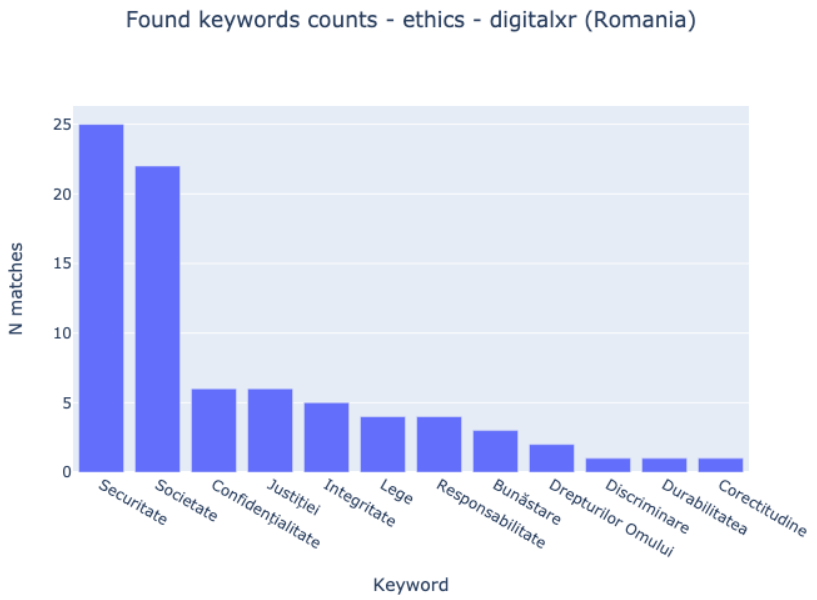


Figure 84 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for Romania. The English translation of the words is, from left to right: security, society, privacy, justice, integrity, law, accountability, welfare, human rights, discrimination, sustainability, fairness.

5.8.4 Neurotechnology

Most of the news stories collected for neurotechnology (61%) mention 'brain chip'. 'Cyborg' and 'neurotechnology' are mentioned in five news while the other keywords have been found less than 5 times (Figure 85).

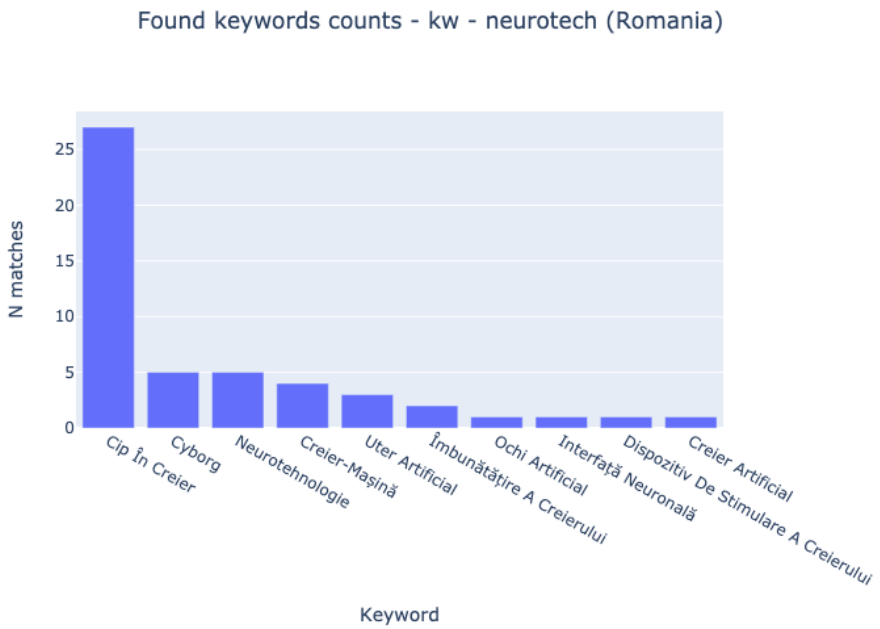


Figure 85 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Romania. The English translation of the words is, from left to right: brain chip, cyborg, neurotechnology, brain-machine, artificial womb, brain enhancement, artificial eye, neural interface, brain stimulation device, artificial brain.

Expressions like 'help of technology', 'improve intelligence', 'could treat', 'could help' are frequently occurring (Table 26), suggesting that the news discuss potential benefits of the use of neurotechnology.

Frequent bigrams (RO)	**Frequent bigram (EN)**
ajutorul tehnologiei	the help of technology
ajutorul minții	the help of the mind
calculator folosindu	using computer
puterea minții	the power of mind
putea ajuta	could help
putea permite	could afford
putea trata	could treat
conecta corpul	connect the body
îmbunătăți inteligența	improve intelligence

Table 26 Selection of the most frequent bigrams from the neurotechnology news stories, for Romania.

ELSI-keywords were mentioned in 20% of the news, corresponding to only nine news stories one third of which, mentioning 'society' and 'security', report the outcomes of survey questioning the acceptance of human augmentation in Romania.

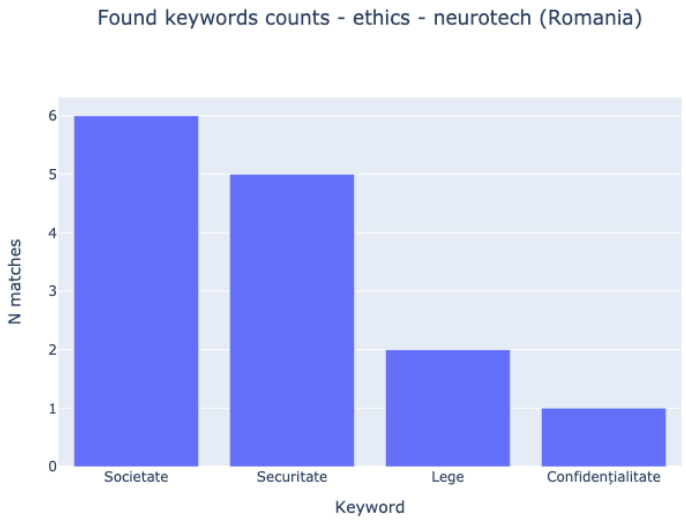


Figure 86 Counts of neurotechnology news stories mentioning the ELSI- keyword on the x-axis, for Romania. The English translation of the words is, from left to right: society, security, law, privacy.

5.9 Serbia

5.9.1 Dataset description

The clean dataset for Serbia comprised 311 news stories, 175 on digital extended reality, 108 on climate engineering and neurotechnology respectively.

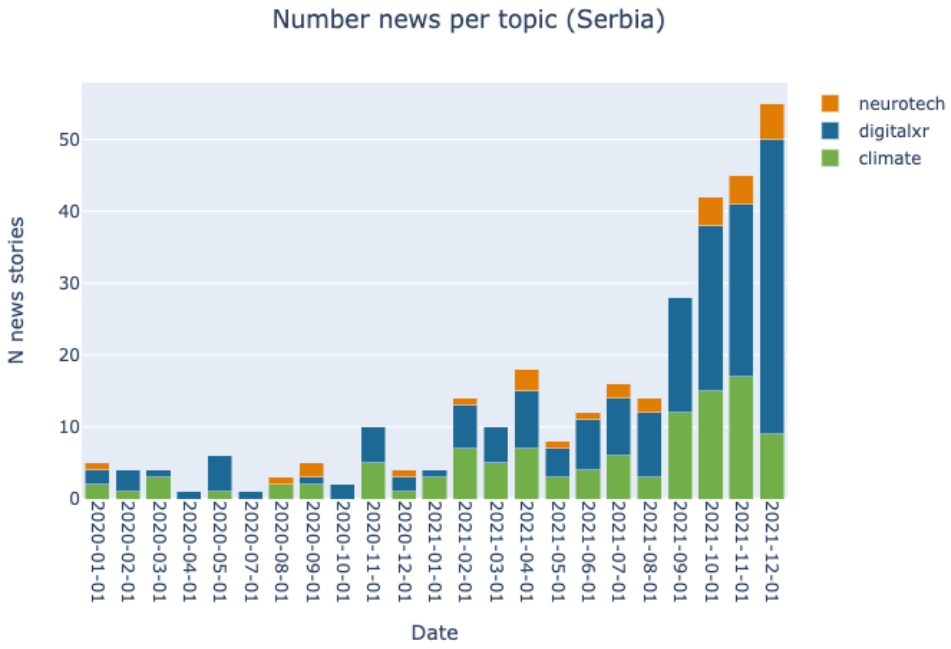


Figure 87 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Serbia.

For all technology, news stories were published mostly on general outlets (56%, 60% and 68% for climate engineering, digital extended reality and neurotechnology respectively). 23% of digital extended reality news stories and 28% of neurotechnology stories came from outlets covering technical topics (any news story on climate was published in outlets with this focus). We can observe that,

Outlet	Climate	Digitalxr	Neurotech	Outlet type	Outlet theme
021	0	8	0	LOCAL	GENERAL
alo	0	2	0	TABLOID	GENERAL
b92	2	5	2	TV_RADIO	GENERAL
balkangreenenergynews	29	0	0	Unsure	Other
bbc	24	34	8	GENERAL_NEWS	GENERAL
beta	2	1	0	NEWS_AGENCY	GENERAL
biznis	2	11	0	Other	Other
blic	2	10	2	TABLOID	GENERAL
danas	17	10	1	GENERAL_NEWS	GENERAL
dw	2	3	0	GENERAL_NEWS	GENERAL
edukacija	1	0	0	Other	Other
energetskiportal	7	1	0	Unsure	Other
glasamerike	2	1	0	GENERAL_NEWS	GENERAL
gradnja	5	1	0	Other	Other
informer	0	3	1	TABLOID	GENERAL
juznevesti	2	0	0	LOCAL	GENERAL
kurir	0	2	0	TABLOID	GENERAL
lepotaizdravlje	0	1	0	Other	Other
novosti	1	6	0	GENERAL_NEWS	GENERAL
pcpress	0	5	4	Other	TECH
republika	0	3	0	TABLOID	GENERAL
rs	3	4	0	Unsure	Unsure
rts	2	0	1	TV_RADIO	GENERAL
slobodnaevropa	4	5	2	TV_RADIO	GENERAL
smartlife	0	35	4	Other	TECH
srbijadanas	1	1	0	TABLOID	GENERAL
stil	0	3	0	Other	Other
subotica	0	1	0	LOCAL	Other
telegraf	0	10	2	TABLOID	GENERAL
vreme	0	2	0	Other	GENERAL

Table 27 Counts of news stories collected from each outlet, broken down by technology, for Serbia. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

compared to most of the other countries, news stories are spread across a large number of news outlets (30).

5.9.2 Climate engineering

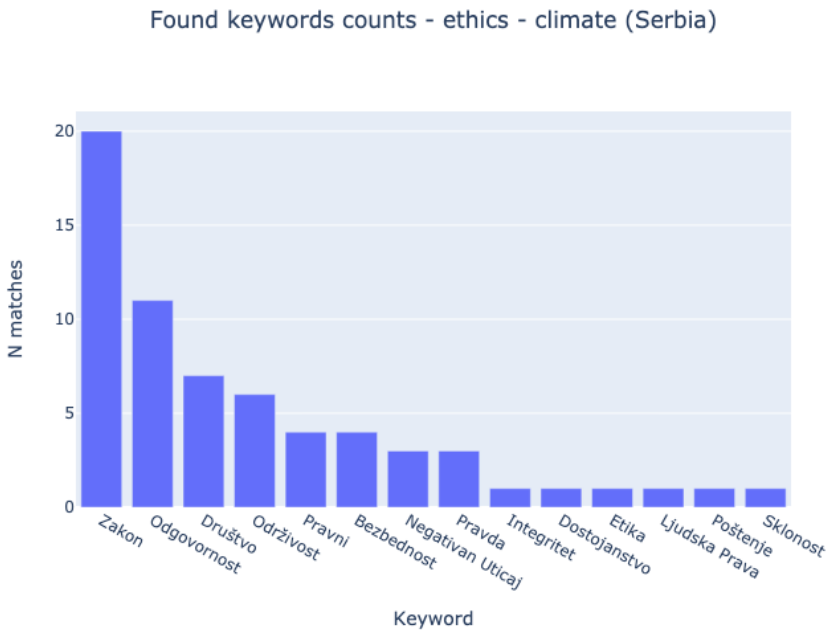


Figure 88 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for Serbia. The English translation of the words is, from left to right: 'law', 'responsibility', 'society', 'sustainability', 'legal', 'security', 'negative impact', 'justice', 'integrity', 'dignity', 'ethics', 'human rights', 'honesty', 'bias'.

As it can be observed in Figure 106, 'afforestation' is the topic most frequently mentioned in the climate news stories, followed by 'green hydrogen' and carbon-related keywords (carbon 'storage, 'capture' and 'usage'). The largest share of news stories (27%) in our collection were published on a specialised outlet, *Balkan Green Energy News*, a leading sustainable energy and green economy news provider in the Balkan region. 22% and 16% of the news stories were published on major national newspapers (*BBC Serbia* and *Danas*, respectively).

Mentions of ELSI-keywords (Figure 88) were found in 39% of the news stories for this technology category and over half of these stories were published in *Balkan Green Energy News*. 'Law' is ELSI word mentioned in most the news stories. We found that several of these news items discuss policies and incentives (from local bodies and EU) for supporting transition to production of renewable energy and green economy.

5.9.3 Digital extended reality

'Augmented reality' and 'virtual reality' were the topics most frequently occurring, almost always together, in the news set for digital extended reality (99% of the news stories mention the first keyword, 92% the second). 'Virtual world' (mentioned in 22% of the news stories), 'metaverse' (16%), were also found; 'smart glasses', 'virtual environment' and 'NLP' where the only other keywords found, mentioned in less than 10 news stories (Figure 89).

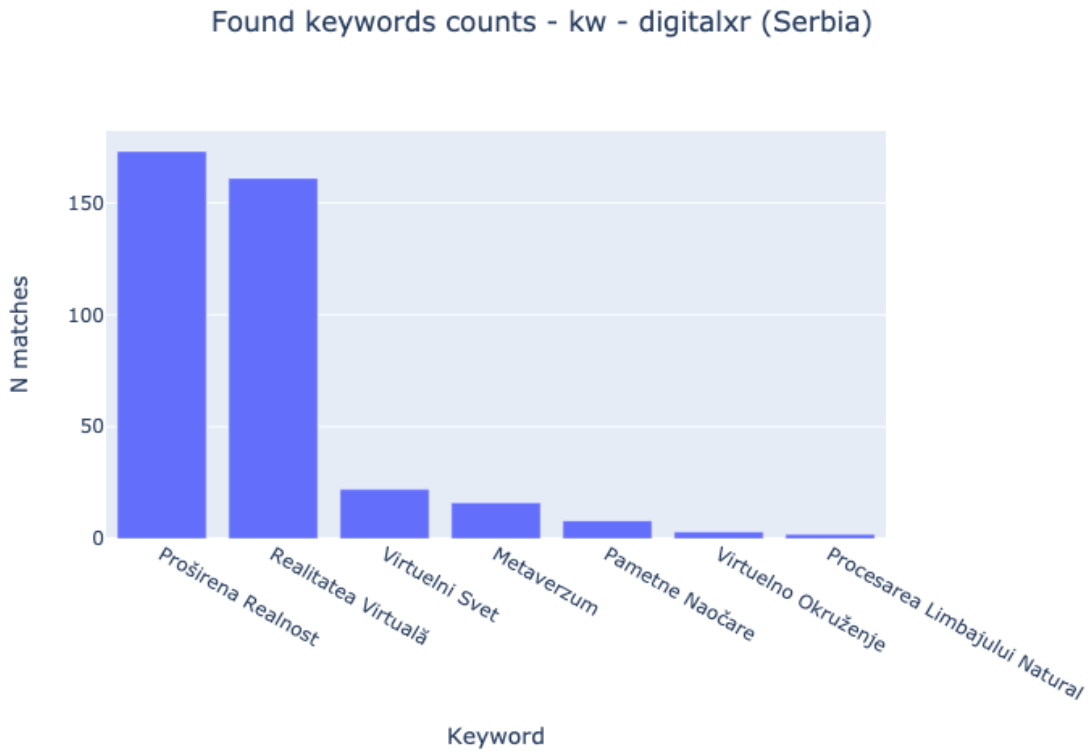


Figure 89 Counts of news stories mentioning the digital extended reality keyword on the x-axis. The English translation of the words is, from left to right: 'augmented reality', 'virtual reality', 'virtual world', 'metaverse', 'smart glasses', 'virtual environment', 'natural language processing'.

The main outlets where digital extended reality news stories in our collection were published were *Smartlife* (20%) a freesheet website specialised in news on a wide range of technologies including games, platforms, devices, smart hoses, mobility, eHealth, smart cities, business) and *BBC Serbia* (19%). Mentions of ELSI-keywords were found in 36% of the news stories. The biggest share of these stories (32%) was published on *BBC Serbia*. 'Law' and 'security' are the ELSI words mentioned more frequently in the news. The titles containing these words include news on the risks of specific technologies like Amazon Alexa, Facebook face recognition, and more general discussion on security on the internet (e.g., disinformation on the Net, protecting children from internet violence) or EU digital laws.

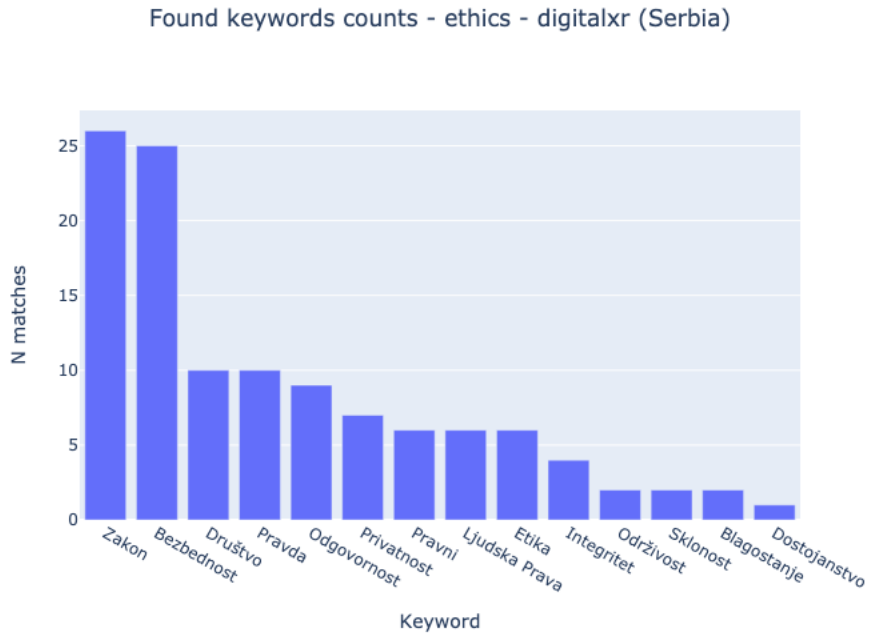


Figure 90 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis. The English translation of the words is, from left to right: 'law ',' security ',' society ',' justice ',' responsibility ',' privacy ',' legal ',' human rights', 'ethics',' integrity ',' sustainability ',' bias ',' welfare ', ' dignity '.

5.9.4 Neurotechnology

Our news collection includes only 28 news for neurotechnology. 3 of these news mention 'brain-to-brain', 2 mention 'brain implant' and 'brain chip', 'cyborg' and 'artificial man' were mentioned in 1 news. 39% of the news stories for this category where about Neuralink and/or Elon Musk. The remaining of the stories included reports on artificial heart transplants and general discussions on technologies for human enhancement.

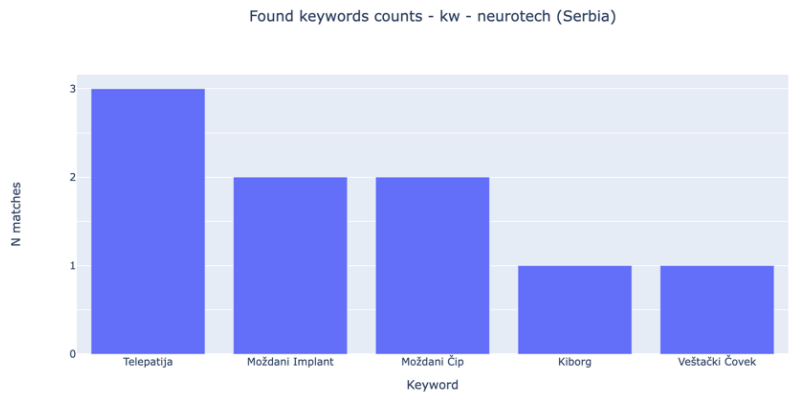


Figure 91 Counts of news stories mentioning the neurotechnology keyword on the x-axis. The English translation of the words is, from left to right: 'telepathy', 'brain implant', 'brain chip', 'cyborg', 'artificial man'

ELSI-keywords were found in 9 news stories which include discussion on the safety and risk on brain implants.

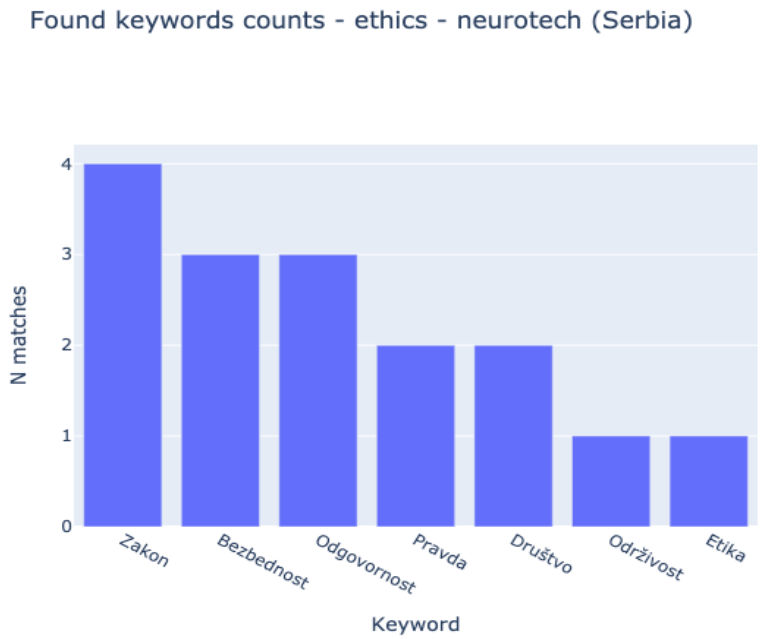


Figure 92 Counts of neurotechnology news stories mentioning the ELSI- keyword on the x-axis, for Serbia. The English translation of the words is, from left to right: 'law', ' security', ' responsibility', ' justice', 'society', 'sustainability', 'ethics'.

5.10 Spain

5.10.1 Dataset description

The final dataset for Spain consisted of 489 news stories, 387 for the digital extended reality, 87 for climate engineering and 15 for neurotechnology (Figure 93).

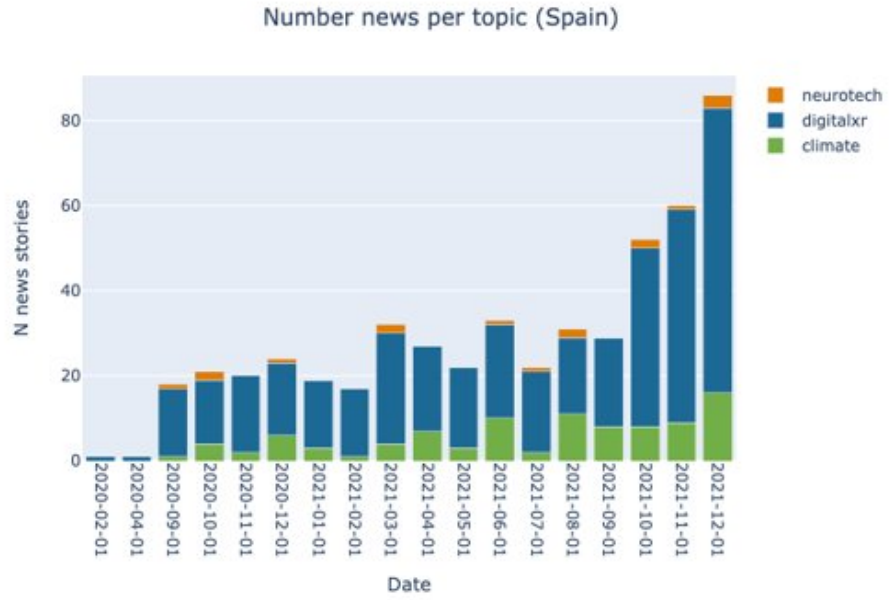


Figure 93 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Spain.

News could be retrieved from only 3 outlets: *20minutos*, *ABC* and *El País* (Table 28). These outlets are widely read news sources, covering general topics. The unavailability of news stories from other outlets might be due to the fact that Google shut down its Google News platform in Spain from 2014 to November 2021[15] (Google News is the main data source of news providers).

Outlet	Climate	Digitalxr	Neurotech	Outlet type	Outlet theme
20minutos	5	67	3	FREESHEET	GENERAL
abc	38	173	7	GENERAL_NEWS	GENERAL
elpais	44	147	5	GENERAL_NEWS	GENERAL

Table 28 Counts of news stories collected from each outlet, broken down by technology, for Spain. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

For the three technologies, news stories were published primarily in the main section of the outlets. Digital extended reality news stories were found also in the 'technology', 'network', 'opinion' sections; climate engineering news were also featured in the section 'society' and 'science'.

5.10.2 Climate engineering

'Reforestation/afforestation' (the two terms are often used interchangeably in Spanish) appear the most prevalent topic in the climate engineering news collection being mentioned in 67% of the news stories. 'Deforestation' is mentioned in 16% and the other topics in less than 12% of the news items (Figure 94).

[15] https://blog.google/around-the-globe/google-europe/google-news-in-spain/

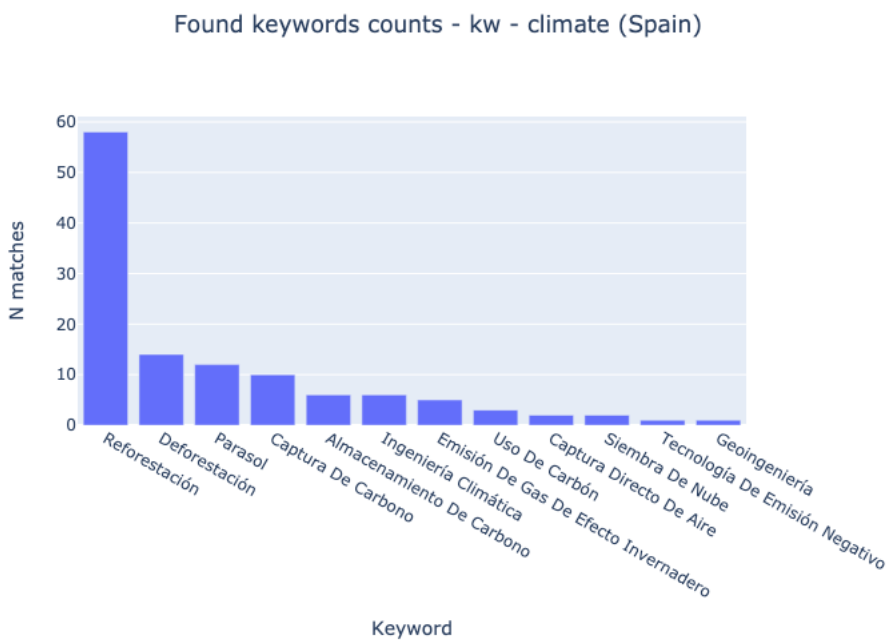


Figure 94 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Spain. The English translation of the words is, from left to right: 'reforestation/afforestation', 'deforestation', 'sun shield, 'carbon sequestration', 'carbon storage', 'climate engineering', 'greenhouse gas emissions', 'carbon usage', 'direct air capturing', 'cloud seeding', 'negative emission technology', 'geoengineering'.

Extraction of the most frequent bigrams suggests that 'greenhouse effect' is frequently discussed with these technologies (Table 29).

Frequent bigrams (ES)	**Frequent bigram (EN)**
efecto invernadero	Greenhouse effect
plantar árbol	Plant tree
derechos humanos	Human rights
planeta futuro	Future planet
tomar medida	Take measures

Table 29 A selection of the most frequent bigrams from the climate engineering news stories, for Spain.

We found mentions of ELSI-keywords in 47% of the climate engineering news stories. Through named entity extraction we identified frequent mentions of some specific organisations - like 'ONU', 'EU', 'European Commission' (each mentioned over 60 times) 'United Nation', (mentioned 20 times), 'International Union for Conservation of Nature', 'Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services', 'Vox' (Spanish political party), 'the government', 'the army'.

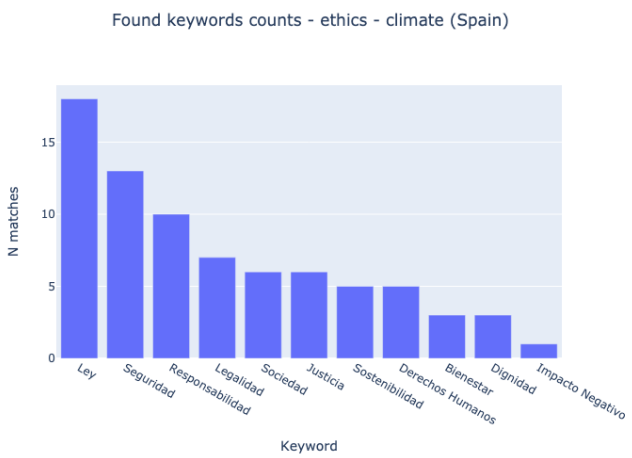


Figure 95 Counts of climate news stories mentioning the ELSI- keyword on the x-axis, for Spain. The English translation of the words is, from left to right: 'law',' security',' responsibility', 'legality', 'society', 'justice', 'sustainability', 'human rights', 'wellbeing'.

The word cloud also suggests an association between the ELSI-relevant climate engineering news and the political environment (see Figure 96).

Figure 96 Word cloud on climate engineering news stories mentioning ELSI-keywords, for Spain. The top words in the cloud are: país (country), proyecto (project), forest (bosque), government (gobierno), cambio climático (climate change), emisiones (emissions).

5.10.3 Digital extended reality

'Virtual reality' was the topic more frequently appearing in the news collected for digital extended reality being mentioned in 43% of the news stories. 'Virtual world', 'augmented reality' and 'metaverse' are also frequently mentioned (in 30%, 28% and 24% of the news stories respectively) while other topics appeared in less than 4% of the news (Figure 97).

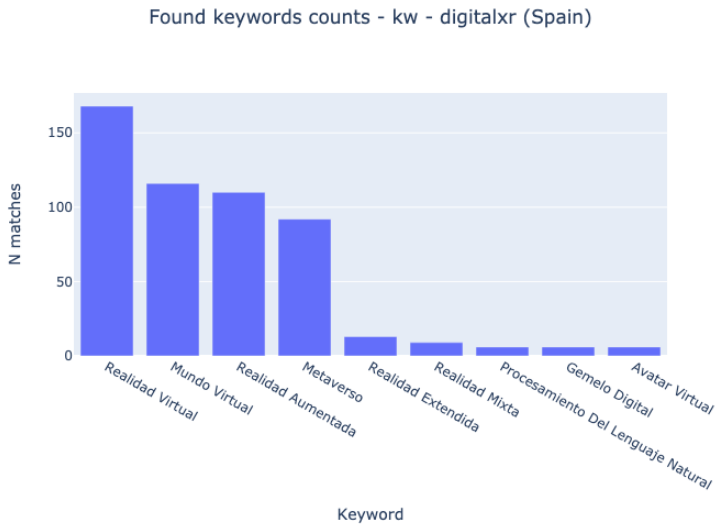


Figure 97 Counts of news stories mentioning digital extended reality keyword on the x-axis, for Spain. The English translation of the words is, from left to right: 'virtual reality', 'virtual world', 'augmented reality', 'metaverse', 'extended reality', 'mixed reality', 'natural language processing', 'digital twin', 'virtual avatar'.

Mentions of ELSI-keywords were found in 48% of the digital extended reality news stories. 'Society' and 'security' are the words most frequently mentioned (Figure 98).

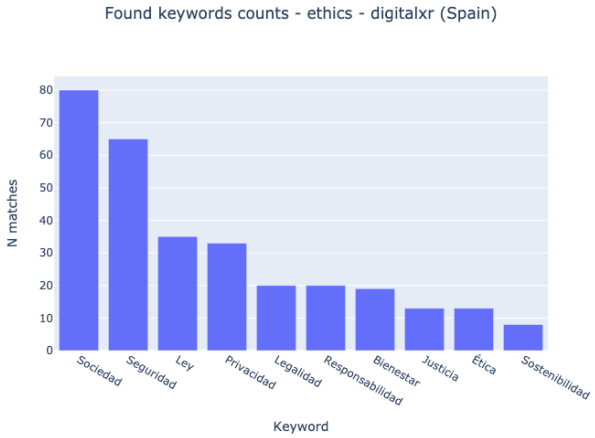


Figure 98 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for Spain. The English translation of the words is, from left to right: 'society', 'security', 'law', 'privacy', 'legality', 'responsibility', 'wellbeing', 'justice', 'ethics, 'sustainability'.

The word cloud (Figure 99) suggests some of topics discussed in this selection of news stories ('Facebook', 'company', 'internet', 'user', 'metaverse', 'future', 'technology' are some of the highlighted words). Interestingly, while in the climate related news 'country' was frequently mentioned, 'world' is a frequently occurring word in the news stories around digital extended reality technologies. Through extraction of named entities we found that Apple, Google, Microsoft, Instagram, Meta are the entities extracted in most news (17, 19, 15, 30, 23 respectively) and European Union is mentioned in 19 stories.

Figure 99 Word cloud on digital extended reality news stories mentioning ELSI-keywords, for Spain. The top words in the cloud are: Facebook, company (empresa), world (mundo), usuario (user), tecnología (technology).

5.10.4 Neurotechnology

The Spanish news set contains only 15 news on neurotechnology (7 published on *ABC*, 5 on *El País*, 3 on *20minutos*). The keyword 'neurotechnology' was mentioned in 8 of the news, 2 news were about 'artificial eyes' and other topics (including 'brain machine interface', 'brain chip', 'cognitive enhancement') were found in 1 news (Figure 100).

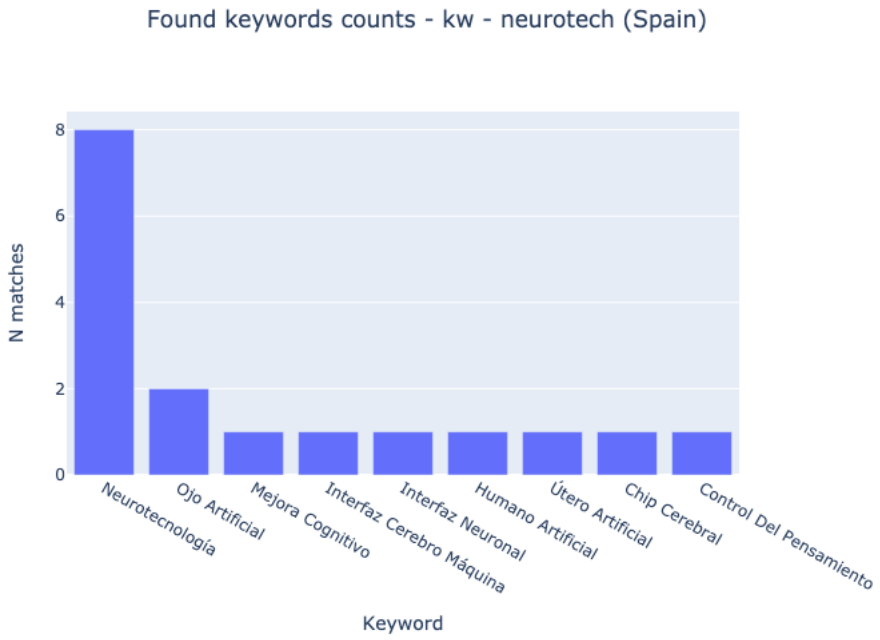


Figure 100 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for Spain. The English translation of the words is, from left to right: neurotechnology, artificial eye, cognitive enhancement, brain-machine interface, neural interface, artificial human, artificial uterus, brain chip, thought control.

We found 8 news stories containing mention of ELSI-keywords ('society' appears in 4 of the stories, 'law' in 3, Figure 101). These news stories include discussions on the security and effect on physical integrity

derived from potential increasing use of neural interface, human enhancement technology and other neurotechnologies and 3 of them refer to Elon Musk and Neuralink's experiments.

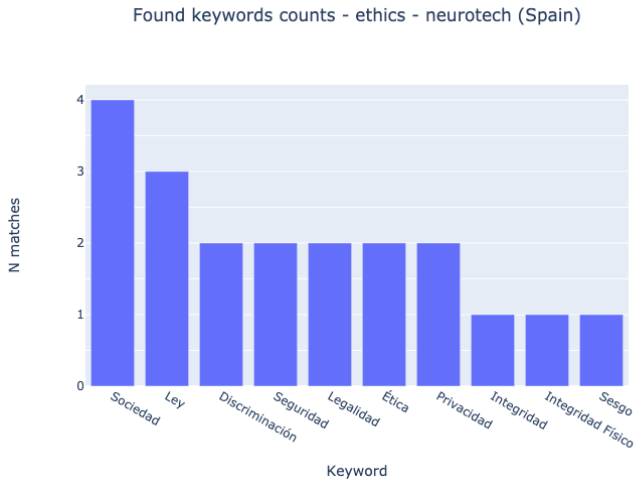


Figure 101 Counts of neurotechnology news stories mentioning the ELSI- keyword on the x-axis, for Spain. The English translation of the words is, from left to right: 'society', 'law', 'discrimination', 'security', 'legality', 'ethics', 'privacy', 'integrity', 'physical integrity', 'bias'.

5.11Sweden

5.11.1 Dataset description

The clean set of Swedish news consisted of 334 news stories (221 for digital extended reality, 97 for climate engineering and 12 for neurotechnology, Figure 102).
The news stories collected for climate engineering and neurotechnology were published in general outlets (national online newspapers covering general topics; Table 30). The biggest share of climate engineering news was published on *Dn* (*Dagens Nyheter*) and *ETC*. More than half (58%) of the digital extended reality news stories in our collection come from *fz,* a website specialised in reviews and news on games and everything around gaming. As a consequence, the analytics on the news stories for this technology category present a bias toward this type of topics.

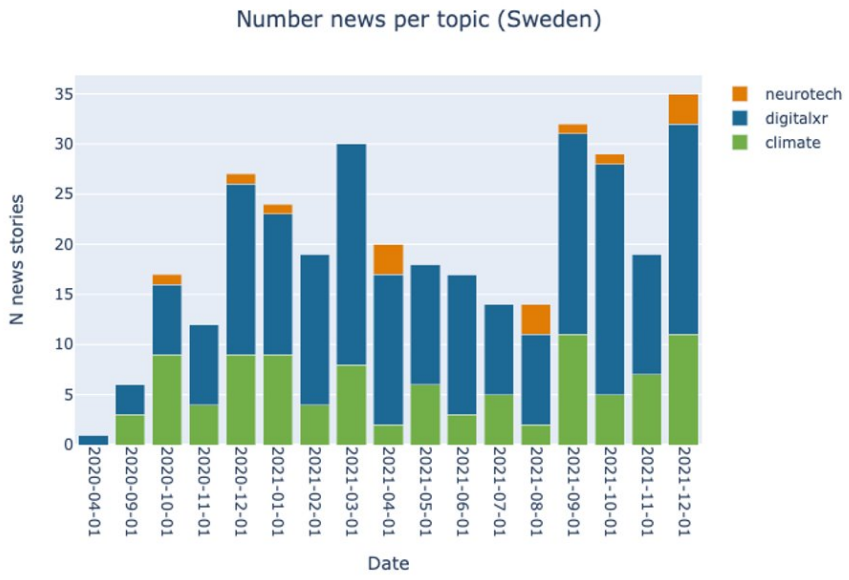


Figure 102 The bar plot shows the count of news stories published for each year-month, broken down by technology, for Sweden.

We found that the news stories were published primarily in the main section of the outlet; news for digital extended reality were also published in the sections 'economy' and 'culture' while climate engineering news stories were also found in section 'debate' and 'climate'.

Outlet	Climate	Digitalxr	Neurotech	Outlet type	Outlet theme
aftonbladet	5	4	3	TABLOID	GENERAL
allehanda	1	5	0	LOCAL	GENERAL
dn	38	44	5	GENERAL_NEWS	GENERAL
etc	20	10	0	GENERAL_NEWS	GENERAL
fz	0	129	2	OTHER	TECH
gp	11	8	1	LOCAL	GENERAL
hn	2	2	1	LOCAL	GENERAL
nwt	3	6	1	LOCAL	GENERAL
svd	6	6	0	GENERAL_NEWS	GENERAL
svt	4	6	0	TV_RADIO	GENERAL
sydostran	5	0	0	LOCAL	GENERAL
sydsvenskan	3	2	1	LOCAL	GENERAL

Table 30 Counts of news stories collected from each outlet, broken down by technology, for Sweden. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.11.2 Climate engineering

The main topics of discussion in our collection of news for climate engineering were ‘carbon storage’ and ‘green hydrogen’ (mentioned in 30% and 26% of the news story, respectively). ‘Geoengineering’ is mentioned in 17% of the news stories while other keywords (including ‘afforestation’, ‘sun shield’, ‘cloud seeding’) have been found in less than 5 news.

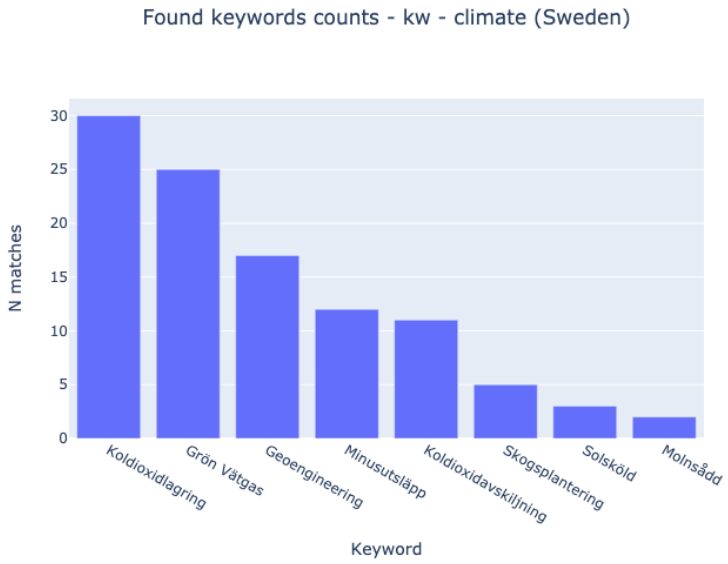


Figure 103 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Sweden. The English translation of the words is, from left to right: 'carbon storage', 'green hydrogen', 'geoengineering', 'minus emissions', 'carbon capture', 'afforestation', 'solar shield', 'cloud seeding.

95% of the news stories for this technology category mentioned at least one ELSI-keyword. The most frequently mentioned ELSI-keywords were ‘law’ (mentioned in 89% of the news), ‘society’ (35%) and ‘responsibility’ (29%); Figure 104.

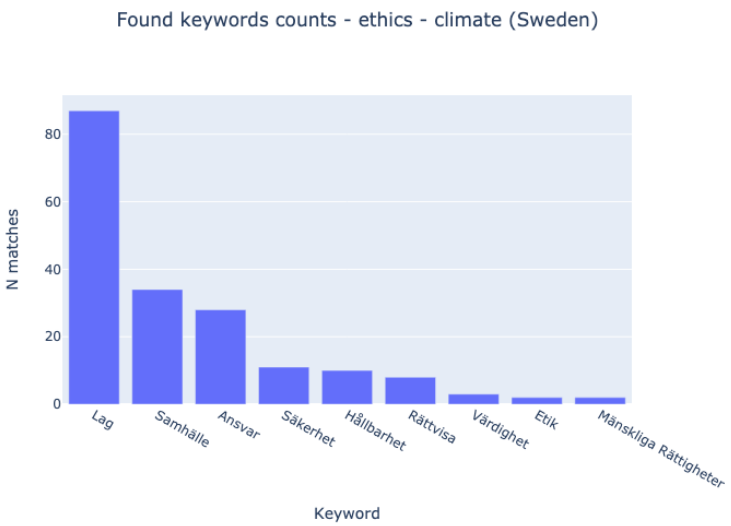


Figure 104 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for Sweden. The English translation of the words is, from left to right: 'law', 'society', 'responsibility', 'safety', 'sustainability', 'justice', 'dignity', 'ethics', 'human rights'.

The word cloud extracted from this subset of news (Figure 105) suggests that the news stories discuss 'green hydrogen' and technologies to reduce 'carbon emissions', with a focus on the EU context.

Figure 105 Word cloud on climate engineering news stories mentioning ELSI-keywords, for Sweden. The top words in the cloud are 'vätgas' (hyrdrogen), 'koldioxid' (carbon dioxide), 'EU', 'utsläpp' (emission), 'klimatkrisen' (climate crisis), 'minska' (reduce).

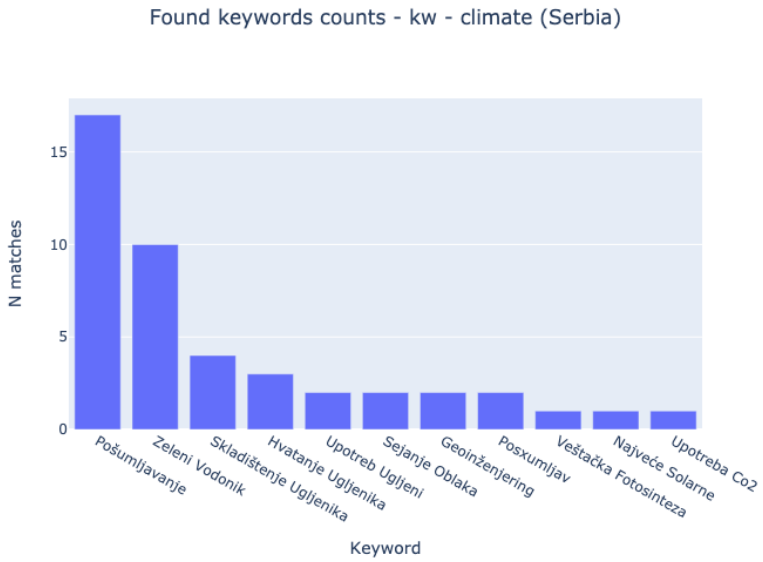


Figure 106 Counts of news stories mentioning the climate engineering keyword on the x-axis, for Serbia. The English translation of the words is, from left to right: 'afforestation', 'green hydrogen', 'carbon storage', 'carbon capture', 'carbon usage', 'cloud seeding', 'geoengineering', 'suspicious', 'artificial photosynthesis', 'Largest Solar'(panel), 'Co2 use'.

5.11.3 Digital extended reality

The vast majority (91%) of news stories collected for digital extended reality mentioned 'virtual reality'. 'Augmented reality' and 'metaverse' are mentioned in 9% and 7% while other topics like 'digital twin' and 'NLP' have been found in 5 news stories or less. The high number of mentions of virtual reality (generally reported with the acronym 'VR') is due to the presence in the data of news and reviews about games which make use of VR (Figure *107*).

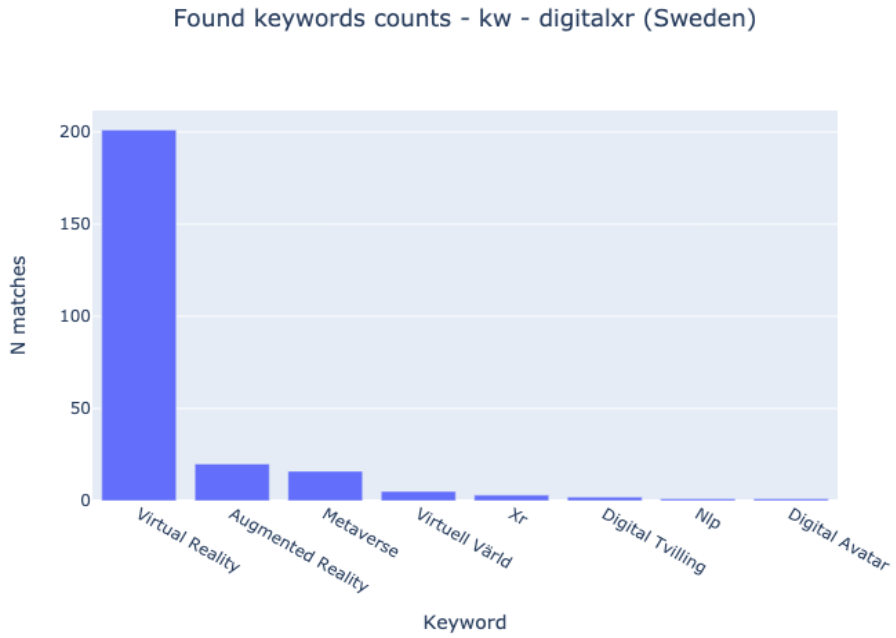


Figure 107 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for Sweden. The English translation of the words is, from left to right: 'virtual reality', 'augmented reality', 'virtual world', 'XR', 'digital twin', 'NLP', 'digital avatar' (note that the English term was used in the news in most of the cases).

ELSI-keywords were found in 19% of the news stories collected for this technology category. Most of them (47%) were published on *Dn*. 'Society', 'security' and 'ethics' were the most frequently mentioned keywords. Interestingly, we found that 40% of these news stories discussed digital extended reality technologies in the context of Art market mentioning, for instance, use of digital art in exhibitions and how cryptocurrency and NFT (non-fungible tokens) are revolutionising the art market.

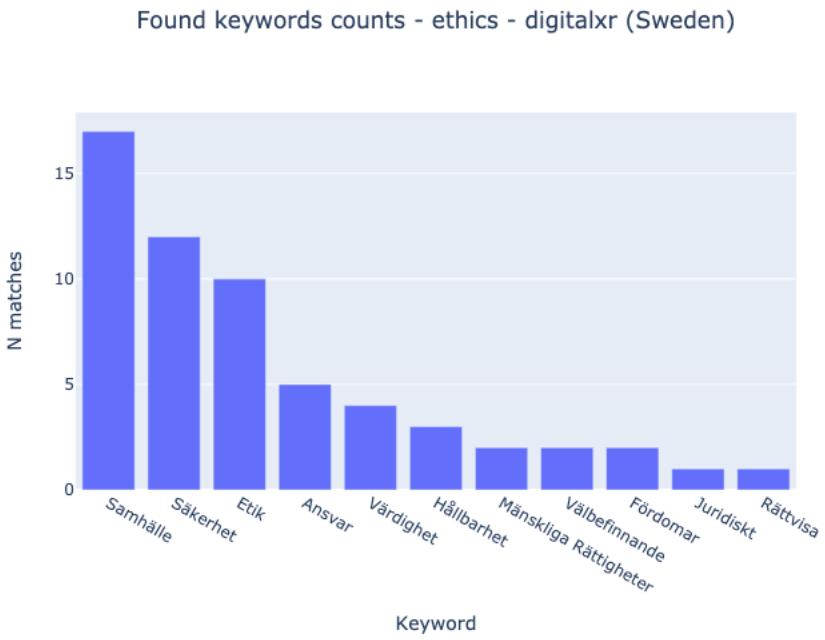


Figure 108 Counts of digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for Sweden. The English translation of the words is, from left to right: 'society', 'security', 'ethics', 'responsibility', 'dignity', 'sustainability', 'human rights', 'well-being', 'prejudice', 'legal', 'justice'.

5.11.4 Neurotechnology

We found only 14 news stories associated with neurotechnology. By manually reviewing them we found that some mentioned 'cyborg' or 'thought control' in broader sense, not strictly related with a technology. Relevant mentions of the word 'cyborg' were found in one news story about Elon Musk monkey experiment, a news discussing privacy implications in the use of biometrics locks in policing and a news story about a company planning to create an artificial uterus to recreate a living mammoth.

5.12 UK

5.12.1 Dataset description

After data cleaning, the dataset for UK consisted of 1651 news stories (1124 for digital extended reality, 410 for climate engineering and 117 for neurotechnology). We observed a lack of data (or unexpected lower volume of data) for the months between January and May 2021 (Figure 109). We believe this was due to technical issues in the collecting the data from the API (see explanation in Section 3.6.1).

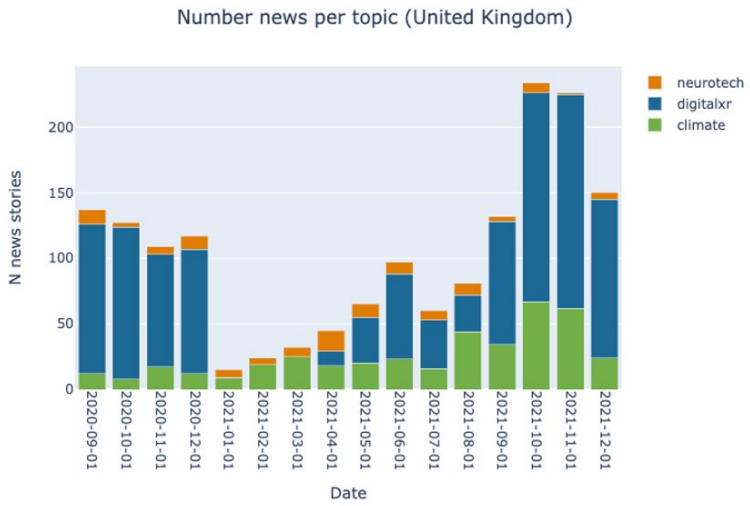


Figure 109 The bar plot shows the count of news stories published for each year-month, broken down by technology, for UK.

Most of the news stories collected for climate engineering category (90% over the total climate engineering stories) were published in outlets covering general topics; this percentage dropped to 47% for digital extended reality (where 39% of the stories were published in technical outlets and 9% of outlets with a focus on Science) and 27% for neurotechnology (where 72% of the stories were published on outlets with a focus on Science) (see Table 31).
The news stories were found mostly in the 'main' section of the outlet. The second most frequent sections were 'technology', 'environment' and 'brain' for digital extended reality, climate engineering and neurotechnology respectively.

Outlet	Climate	Digitalxr	Neurotech	Outlet type	Outlet theme
altchar	0	24	0	Unsure	TECH
androidcentral	1	203	0	Unsure	TECH
bbc	10	6	1	GENERAL_NEWS	GENERAL
belfasttelegraph	28	18	1	LOCAL	GENERAL
birminghammail	9	48	1	LOCAL	GENERAL
cornwalllive	10	9	0	LOCAL	GENERAL
coventrytelegraph	4	32	0	LOCAL	GENERAL
devonlive	14	12	2	LOCAL	GENERAL
digitalspy	0	12	1	Unsure	CULTURE
iflscience	19	21	17	Unsure	SCIENCE
imore	1	109	0	Unsure	TECH
indy100	5	21	3	Unsure	GENERAL
liverpoolecho	12	37	0	LOCAL	GENERAL
livescience	3	14	0	Unsure	SCIENCE
manchestereveningnews	11	34	0	LOCAL	GENERAL
motor1	1	28	0	Unsure	Other
Sky news	45	39	5	Unsure	GENERAL
news-medical	10	63	63	Unsure	SCIENCE
newstatesman	16	2	1	MAGAZINE	GENERAL
nottinghampost	19	37	3	LOCAL	GENERAL
plymouthherald	20	31	3	LOCAL	GENERAL
sciencefocus	4	5	4	MAGAZINE	SCIENCE
skysports	0	19	0	TV_RADIO	Other
standard	38	79	1	LOCAL	GENERAL
talksport	0	2	0	TV_RADIO	Other
theguardian	127	119	11	GENERAL_NEWS	GENERAL
windowscentral	3	100	0	Unsure	TECH

Table 31 Counts of news stories collected from each outlet, broken down by technology, for UK. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

5.12.2 Climate engineering

The most prevalent item of discussion in our collection of climate engineering news stories is ‘carbon capture’ (mentioned in 56% of the news). The related terms ‘carbon storage’ and ‘carbon sequestration’ are also among the most frequently mentioned keywords (13% and 11% respectively). ‘Green hydrogen’ is mentioned in 19% of the stories while other keywords are mentioned in less than 10% of the collection (Figure 110). As mentioned by our UK partner, DMU, during the discussion over the results for the UK media, it appears that among the geoengineering techniques, those related to carbon

management are much more present in the news than techniques related to management of solar radiation. As the data on all countries show, this is rather consistent across all countries studied (see discussion in Section 4.3).

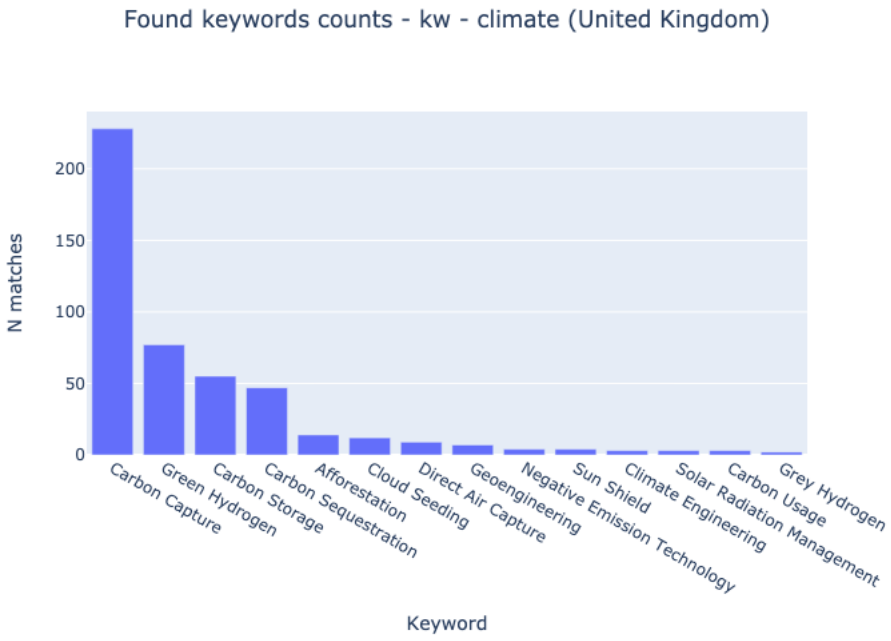


Figure 110 Counts of news stories mentioning the climate engineering keyword on the x-axis, for UK.

The most frequent bigrams (Figure 111) suggest that much of the discussion in the news stories revolves around fighting climate change, reduce/cut carbon emissions. 'Fuel company', 'oil company ', supply chain', 'world leaders' are also frequently mentioned. The biggest share of climate engineering news stories was published on the *Guardian* (30%), followed by *Sky news* (10%) and the *Evening Standard* (a London daily newspaper, 9%).

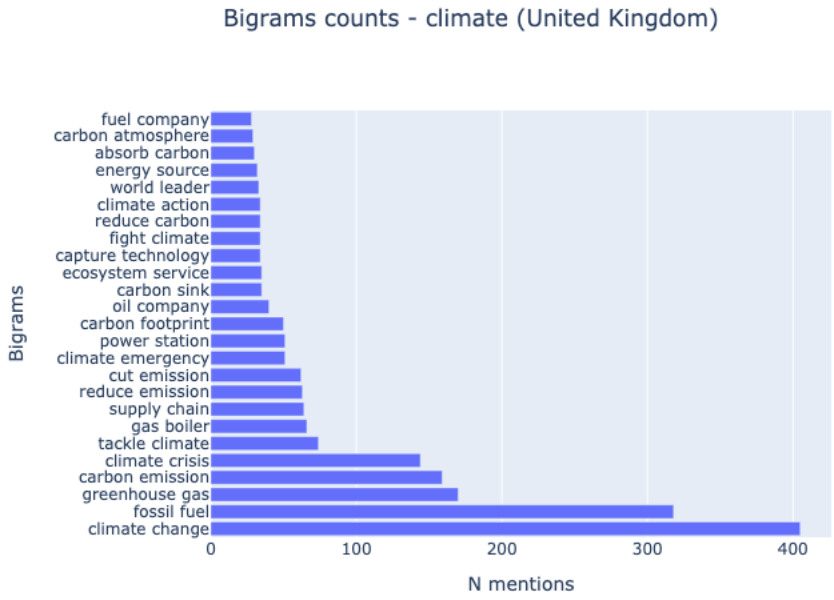


Figure 111 A selection of the most frequently occurring bigrams in the climate engineering news stories, for UK.

We found that 51% of the news stories in this collection mentioned at least one ELSI-keyword. The most frequently mentioned terms were 'privacy', 'society' and 'sustainability' (Figure 112). As we were surprised to see 'privacy' coming first as an ELSI for climate engineering, we manually checked the data and could observe that the text of some news, as provided by the API, contained pieces of text extracted from the section of the news webpage referencing newsletter subscription and 'privacy notice' (more details in Section 3.6.2).

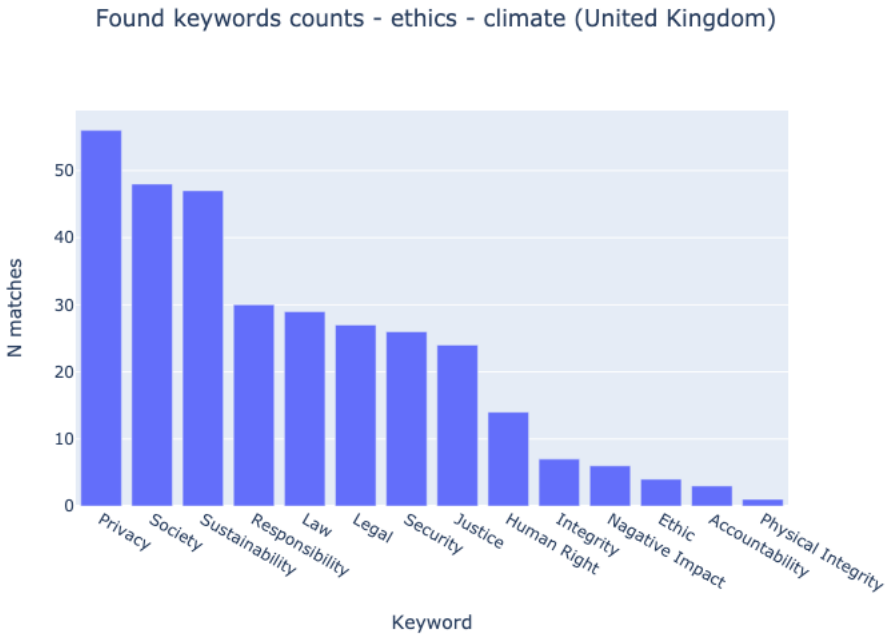


Figure 112 Counts of climate engineering news stories mentioning the ELSI- keyword on the x-axis, for UK.

The word cloud suggests again a focus on action to tackle climate change (Figure 113).

Figure 113 Word cloud on climate engineering news stories mentioning ELSI-keywords, for UK.

The named entity extraction applied on the ELSI-relevant news stories, highlighted frequent mentions of different political organisations (UN, EU, the Government, IPPC, the treasury, the National Farmers Union, Defra – Department for Environment, Food and Rural Affairs) as well as businesses (Shell, Amazon, Microsoft, Twitter, BP) (see Figure 114). Through extraction of GPE (geopolitical entities) we found that the Glasgow Climate Change Conference was mentioned in 16% of the stories and the Paris Agreement was mentioned in 13%.

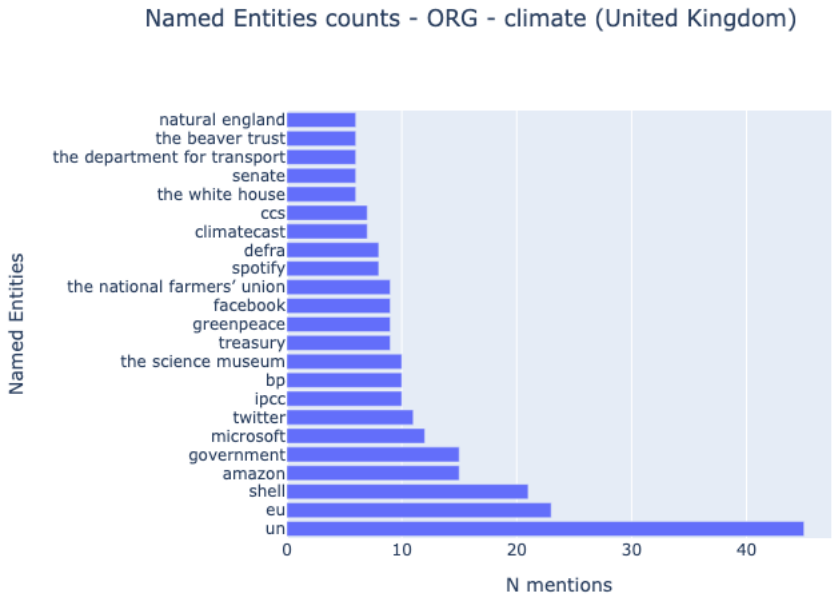


Figure 114 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for UK. The number on the x axis indicate the number of climate engineering news, mentioning ELSI-keywords, where the entity on the y axis was mentioned.

5.12.3 Digital extended reality

The largest share of news stories (18%) collected for the digital extended reality category were published on Android Central, a website specialised in software and products reviews and news on the technology trends, with a focus on Android products. 10% to 8% of the stories were found on *iMore* and

Windowscentral, two websites with similar format and content of Android Central but with a focus on Apple and Windows products respectively. 10% of the stories featured in The Guardian while the other outlets appear in lower percentages.
More than half of the news stories (51%) mentioned 'virtual reality' (similarly than for the other countries, this term is often found in reviews of software or digital products, like videogames, movies, smart glasses). Mentions of 'augmented reality' and 'metaverse' have been found in 29% and 17% of the stories respectively while the other digital extended reality keywords were found in less than 10% of the news items (Figure 115).

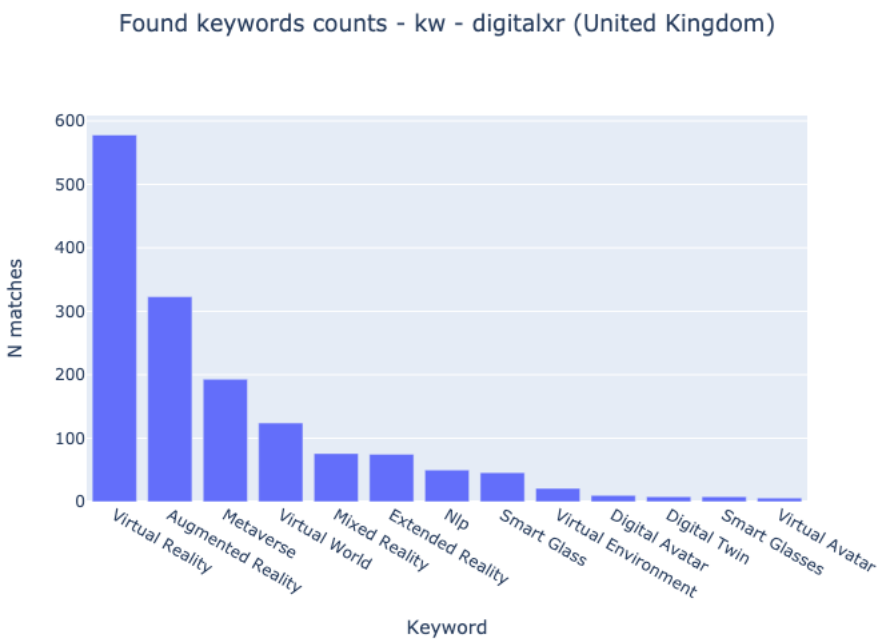


Figure 115 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for UK.

ELSI-keywords were found in 34% of the news stories. *The Guardian* was the main outlet where these news stories were published (20% of the ELSI-relevant news stories were found there), followed by the *Evening Standard* (9%) and the *Birmingham Mail* (a local tabloid newspaper, 7%). As in the climate engineering case, 'privacy' was the most mentioned words, found in 48% of the news stories (see Figure 116 Figure 117). 'Society', 'security' and 'law' were mentioned between 10 and 20% of the news stories and the other ELSI-keywords in less than 10%.

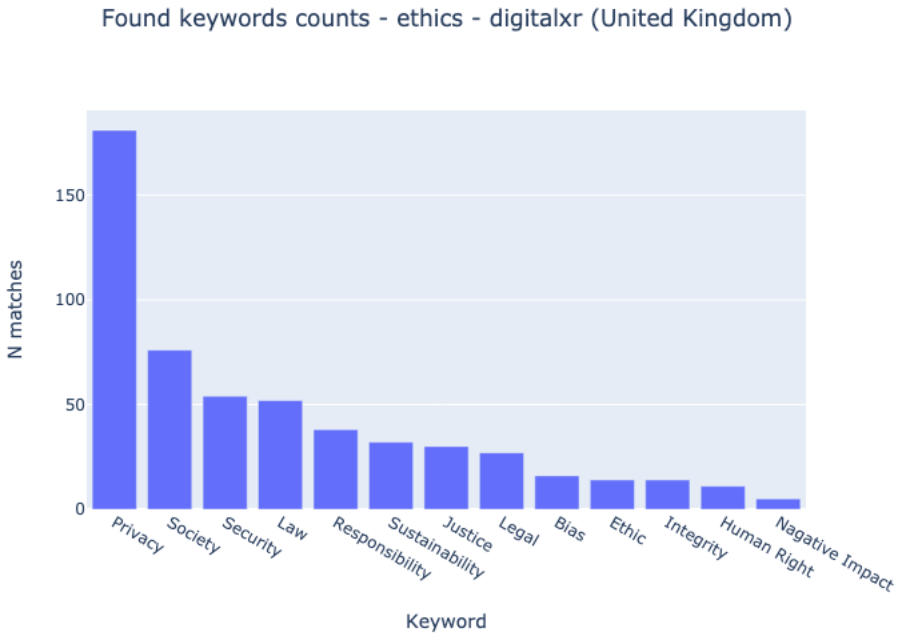


Figure 116 Counts of climate digital extended reality news stories mentioning the ELSI- keyword on the x-axis, for UK.

The word cloud obtained from this subset of news stories, highlights words of big tech ('Facebook', 'Apple') and terms like 'people', 'experience', 'work', 'future', 'help', 'technology', 'event' (see Figure 117).

Figure 117 Word cloud on digital extended reality news stories mentioning ELSI-keywords, for UK.

The bar chart of the named entities of type 'organization', reveals frequent mention of big technology companies (Figure 118).

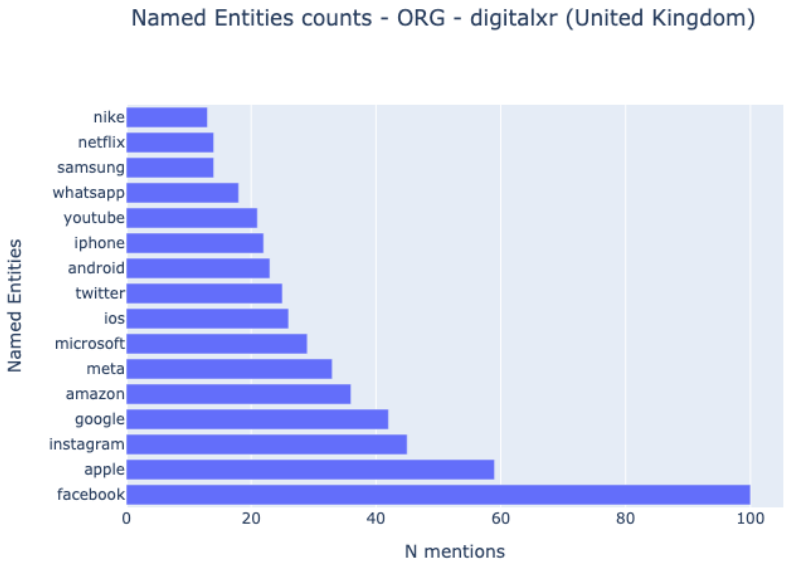


Figure 118 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for UK. The number on the x axis indicate the number of digital extended reality news, mentioning ELSI-keywords and where the entity on the y axis was mentioned.

Through extraction of person mentions (Mark Zuckerberg was in 44 news stories and Frances Haugen in 25), we found that several news items containing ELSI-keywords were about Facebook controversies and revelations on inner workings. Mentions of Donald Trump, Jeff Bezos and Boris Johnson were also found in 10 to 20 news stories. In general, we found that the mentions of 'privacy' (often together with 'security') were in relation to user privacy on social media platforms or on digital applications.

5.12.4 Neurotechnology

'Brain computer interface' appears as the most frequently discussed topic in the news retrieved for the neurotechnology category, appearing in 31% of the news stories. 16% of the stories mention 'cyborg', 15% 'neurotechnology' and 13% 'brain implant'. Other terms were found in less than 10% of the news (Figure 119). Most of the news stories (54%) were published on *News Medical*, a website focussed on sharing information on medicine and life science, including recent innovation in healthcare, research and technology. The second main outlet (14% of the news stories were published here) was *IFLScience*, a website divulgating scientific news for the general public, with a focus on entertaining and unconventional topics.

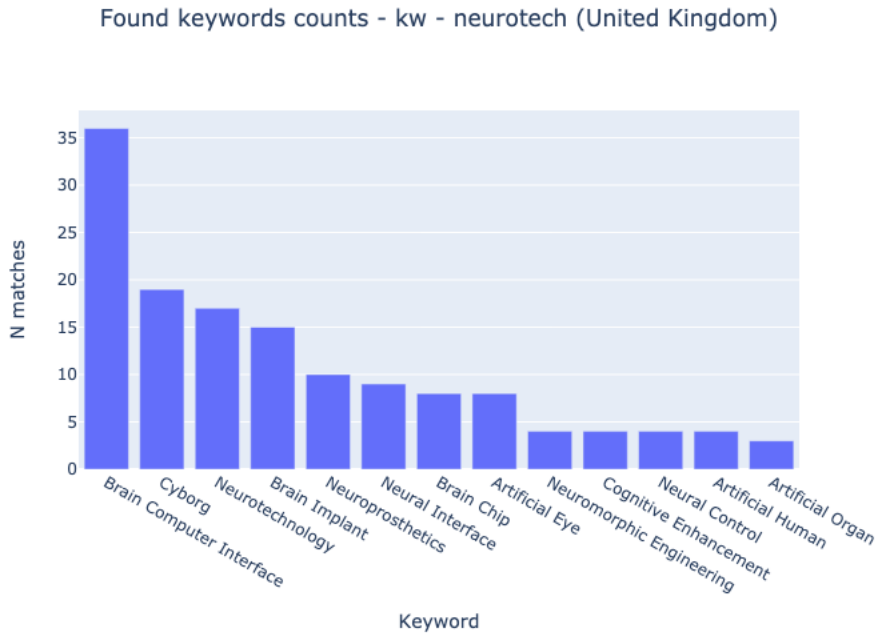


Figure 119 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for UK.

The bigrams extracted from the news stories indicate some of the techniques discussed in the news ('nerve stimulation', 'brain activity', 'brain stimulation') (see Figure 120). We can notice frequent mentions of expressions related with the reporting of scientific studies ('study publish', 'lead author', 'study/trial participants', 'publish journal'), suggesting that the news in this collection reference scientific literature (this might reflect the format and style of *News Medical* and *IFLScience*, the main news sources).

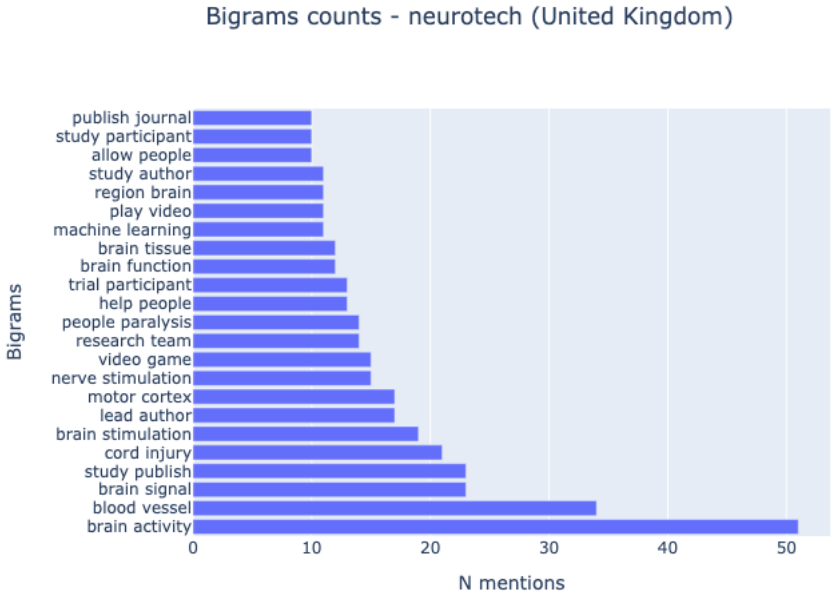


Figure 120 A selection of the most frequently occurring bigrams in the neurotechnology news stories, for UK.

ELSI-keywords were found in 32 news stories (corresponding to 27% of the total for this category). 'Privacy' and 'society' were mentioned in 38% and 17% of the news stories, respectively while other words (e.g., ethics, responsibility) were found in less than three stories. Some of the organisations mentioned in the subset of ELSI-relevant news stories were 'Neuralink', 'Massachusetts general Hospital', 'Southend University Hospital', 'the Childhood Eye Cancer Trust', 'Moorfield Eye hospital', 'the Royal London Hospital'. This is probably due to the fact that the news report specific neurotechnology experiments or studies carried out within these organisations/hospitals.

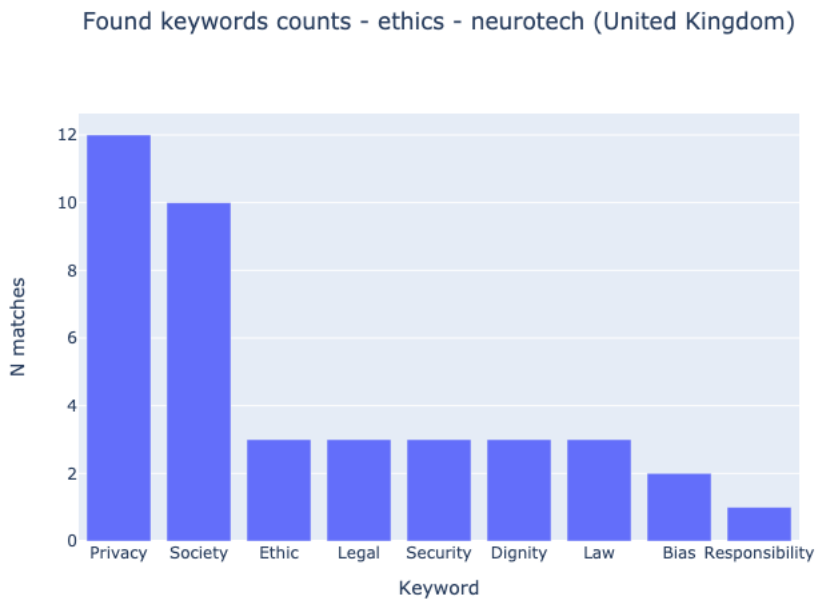


Figure 121 Counts of climate neurotechnology news stories mentioning the ELSI- keyword on the x-axis, for UK.

Extraction of named entities of type person also revealed mentions of 'doctors' and names of people who underwent some neurotechnology treatment. The word cloud shows frequent mentions of terms like 'patient', 'team', 'researchers', 'scientists' but also 'need', 'help', 'allow', 'better', suggesting discussions on the potential use and benefit of these technology (see Figure 122).

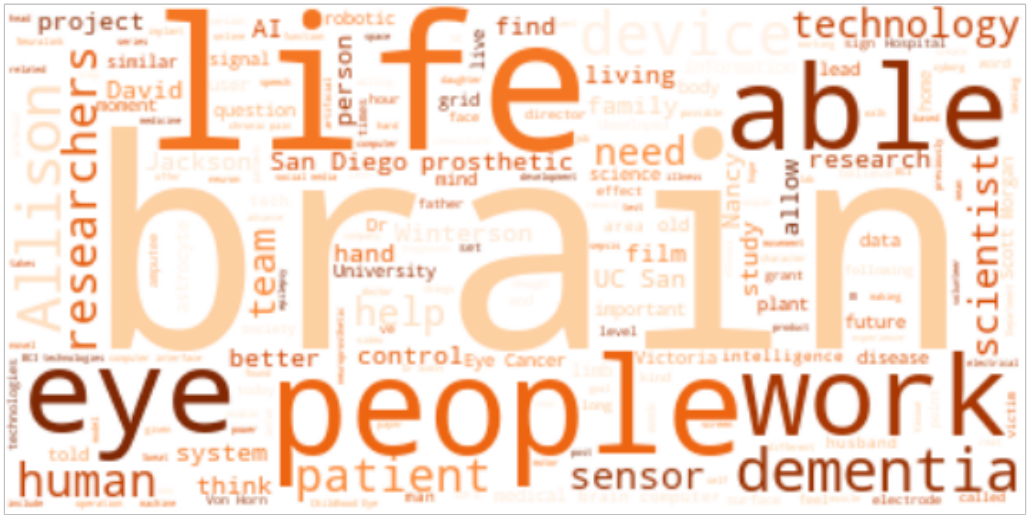


Figure 122 Word cloud on neurotechnology news stories mentioning ELSI-keywords, for UK.

5.13 USA

5.13.1 Dataset description

The final dataset collected for US consisted of 3423 news stories (1613 for digital extended reality, 1559 for climate engineering, 251 for neurotechnology). It can be noted that, news API returned a volume of data considerably larger than for the other countries (the US new set alone constitute 25% of the total news set). We noticed a data gap in the months preceding September 2020 for the three technologies and that the news stories for digital extended reality could only be retrieved for three months (November and December 2020 and December 2021) (see Figure 123). As for the other countries were this issue occurred (France and Italy), we believe that this was due to errors in the data collection step, when retrieving data for digital extended reality (see explanatory note in Section 3.6).

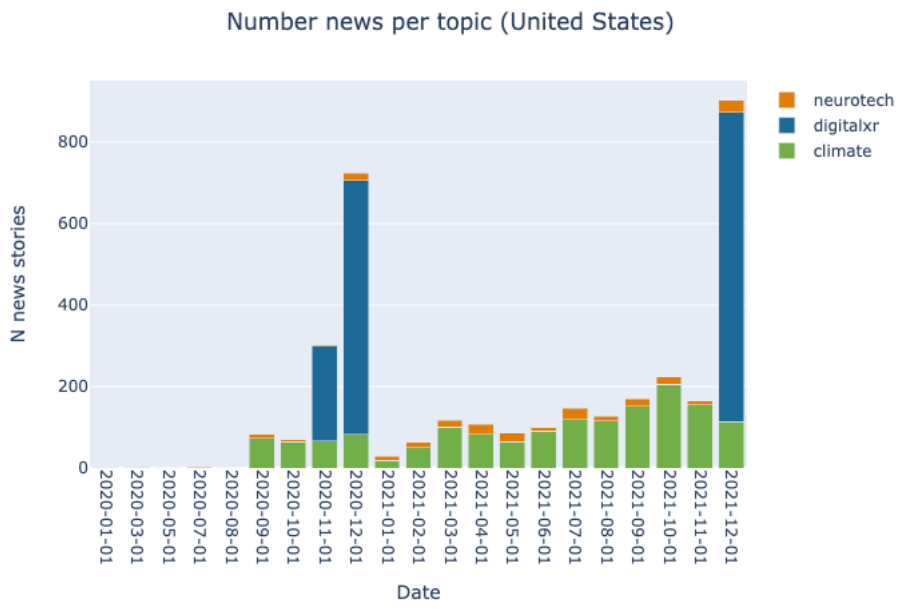


Figure 123 The bar plot shows the count of news stories published for each year-month, broken down by technology, for US.

The largest share of news stories (34%) was published on outlets specialised in technology topics. These were mainly stories on digital extended reality. Climate engineering stories are published predominantly in general outlets and in outlets with economic focus (Figure 124). Most of the news outlets present in our collection were outlets covering technical or general topics (32% and 29% respectively) (see Table 32).

Outlet	Climate	Digitalxr	Neurotech	Outlet type	Outlet theme
9to5google	0	16	1	Unsure	TECH
9to5mac	0	13	0	Unsure	TECH
abc4	1	3	1	TV_RADIO	GENERAL
abc7	9	3	0	LOCAL	GENERAL
Successful farming (agriculture)	103	1	0	Unsure	Other
al-monitor	7	0	0	Unsure	Other
androidauthority	0	7	0	Unsure	TECH
androidcommunity	0	6	0	Unsure	TECH
androidheadlines	0	10	2	Unsure	TECH
androidpolice	0	6	2	Unsure	TECH
apnews	25	9	0	NEWS_AGENCY	GENERAL
arstechnica	23	15	4	Unsure	Other
barrons	31	16	2	Unsure	ECONOMY
bgr	1	17	5	Unsure	TECH
bigrapidsnews	17	3	0	Unsure	GENERAL
billboard	0	9	1	MAGAZINE	CULTURE
boston	4	2	1	LOCAL	GENERAL
bostonglobe	15	18	3	GENERAL_NEWS	GENERAL
cbsnews	24	8	0	TV_RADIO	GENERAL
cheatsheet	0	5	0	Unsure	Other
cinemablend	0	3	0	Unsure	CULTURE
clickondetroit	16	13	3	TV_RADIO	GENERAL
cnbc	100	38	8	TV_RADIO	ECONOMY
cnet	8	157	24	Unsure	TECH
cultofmac	0	13	0	Unsure	TECH
dallasnews	7	7	4	LOCAL	GENERAL
deadline	0	22	3	Unsure	CULTURE
digitaltrends	2	13	0	Unsure	TECH
edition	11	6	1	TV_RADIO	GENERAL
espn	1	2	0	TV_RADIO	Other
essentiallysports	2	23	0	Unsure	Other
forbes	4	7	0	Unsure	Other
freightwaves	47	5	0	Unsure	Other
futurity	11	3	8	Unsure	SCIENCE
gamespot	0	57	1	Unsure	TECH

gamesradar	0	35	0	Unsure	CULTURE
givemesport	0	5	0	Unsure	Other
gizmodo	26	36	8	Unsure	TECH
hothardware	0	12	2	Unsure	TECH
hotnewhiphop	0	6	1	Unsure	CULTURE
insider	2	3	2	Unsure	GENERAL
interestingengineering	54	29	21	Unsure	SCIENCE
inverse	17	20	5	Unsure	TECH
investing	69	26	5	Unsure	ECONOMY
itproportal	1	21	1	Unsure	TECH
jimmyspost	3	36	1	Unsure	TECH
latimes	6	9	1	LOCAL	GENERAL
lifehacker	0	6	0	Unsure	Other
macrumors	1	20	0	Unsure	TECH
Markets insider	128	36	23	Unsure	ECONOMY
marketwatch	12	3	0	Unsure	ECONOMY
mercurynews	7	1	0	LOCAL	GENERAL
nbcboston	20	3	2	LOCAL	GENERAL
nbcnews	15	4	2	TV_RADIO	GENERAL
newsweek	26	15	1	MAGAZINE	GENERAL
nypost	12	14	11	TABLOID	GENERAL
nytimes	16	10	3	GENERAL_NEWS	GENERAL
phonearena	0	23	0	Unsure	TECH
polygon	0	25	1	Unsure	TECH
qz	33	16	0	Unsure	ECONOMY
reuters	334	31	6	NEWS_AGENCY	GENERAL
salon	6	3	3	Unsure	GENERAL
sciencemag	5	0	2	Unsure	SCIENCE
screenrant	0	51	1	Unsure	CULTURE
seekingalpha	7	0	0	Unsure	ECONOMY
slashfilm	0	2	0	Unsure	CULTURE
slashgear	13	30	12	Unsure	TECH
slate	13	5	3	MAGAZINE	GENERAL
socialmediatoday	0	11	1	Unsure	Other
space	10	4	2	Unsure	SCIENCE
sparkchronicles	13	35	6	Unsure	Other
techcrunch	43	81	9	Unsure	TECH
techspot	2	24	3	Unsure	TECH
techstartups	3	11	0	Unsure	TECH
theathletic	0	2	0	Unsure	Other
thehill	89	9	4	Unsure	Other
theintercept	5	1	0	GENERAL_NEWS	GENERAL
tomsguide	0	35	2	Unsure	TECH
upi	37	7	2	NEWS_AGENCY	GENERAL

uploadvr	0	28	1	Unsure	TECH
variety	0	49	2	Unsure	CULTURE
venturebeat	6	135	8	Unsure	TECH
vox	17	9	2	GENERAL_NEWS	GENERAL
vulture	0	5	0	Unsure	CULTURE
wccftech	2	39	4	Unsure	TECH
wcia	5	1	0	TV_RADIO	GENERAL
wdwnt	0	8	0	Unsure	CULTURE
westword	1	4	0	LOCAL	GENERAL
wsj	29	18	5	GENERAL_NEWS	ECONOMY
xda-developers	0	8	0	Unsure	TECH
zdnet	2	17	9	Unsure	TECH

Table 32 Counts of news stories collected from each outlet, broken down by technology, for US. The annotations for each outlet are provided in columns "Outlet Type" and "Outlet Theme" and have been assigned by TechEthos partners or LTP.

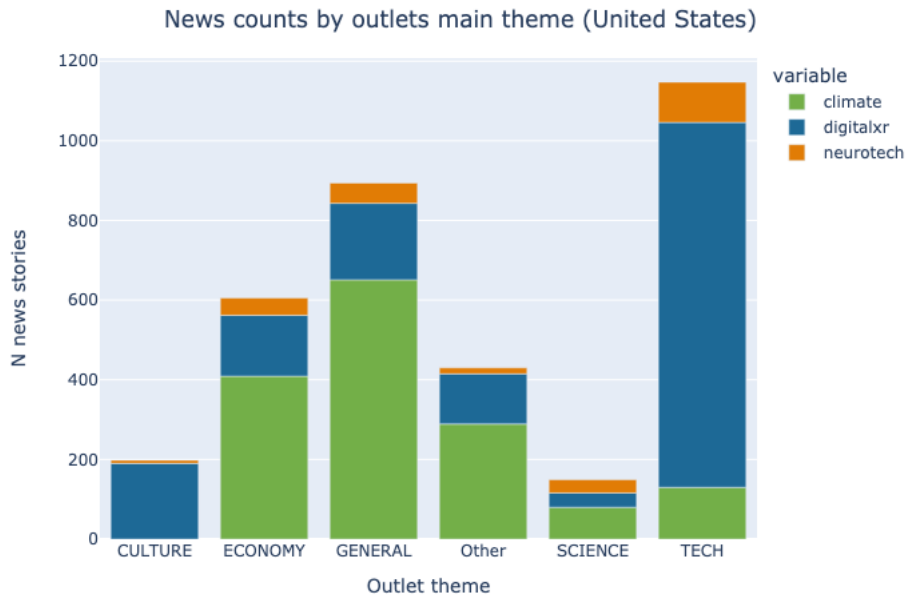


Figure 124 Counts of news stories by theme of outlets where they were published, broken down by technology, for US.

5.13.2 Climate engineering

The most prevalent keywords in the news stories collected for climate engineering was 'carbon capture', mentioned in 43% of the stories (see Figure 125). The related 'carbon sequestration', 'carbon storage' and 'carbon usage' were found in 21%, 8% and 1% of the stories respectively. 'Green hydrogen' also appears as a relevant topic of discussion, being mentioned in 38% of the news stories. The news agency *Reuters*, was the main publishing outlet of the climate engineering stories in our collection (21% of the stories were found there), followed by *Markets Insiders* (8%), *Successful farming* (7%), and *CNBC* (6%).

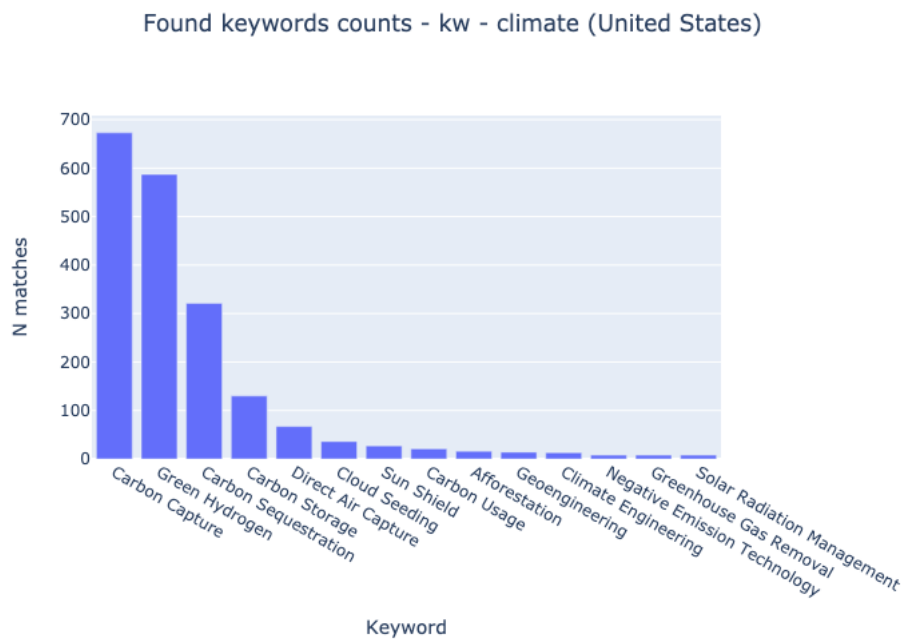


Figure 125 Counts of news stories mentioning the climate engineering keyword on the x-axis, for US.

Bigrams extracted from the news stories suggest that the climate engineering keywords are discussed in relation to 'climate change', 'climate policy', 'climate action', 'energy transition' and need to 'reduce/cut emissions' (Figure 126).

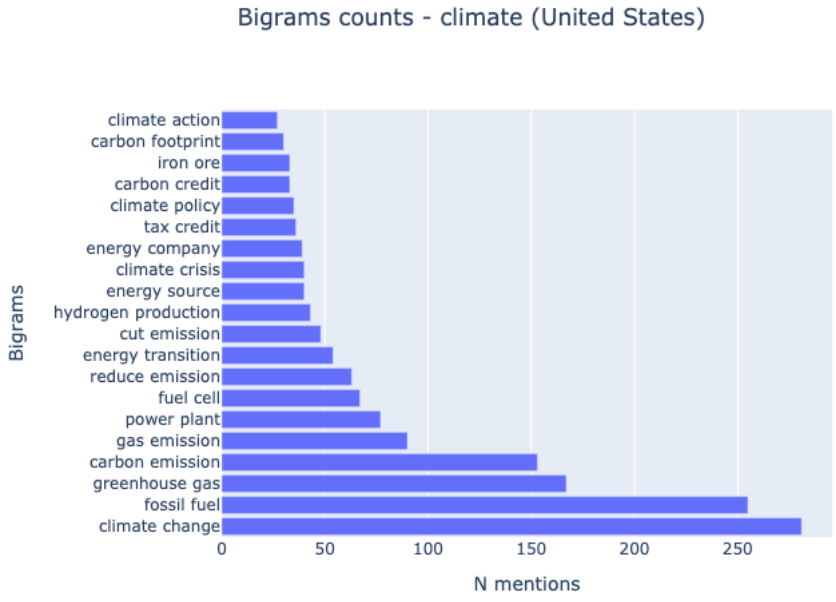


Figure 126 A selection of the most frequently occurring bigrams in the climate engineering news stories, for US.

Mentions of ELSI-keywords were found in 38% of the news stories and 'sustainability', 'law' and 'security' were the three most frequent terms, mentioned in 30%, 29% and 23% of the stories, respectively (Figure 127).

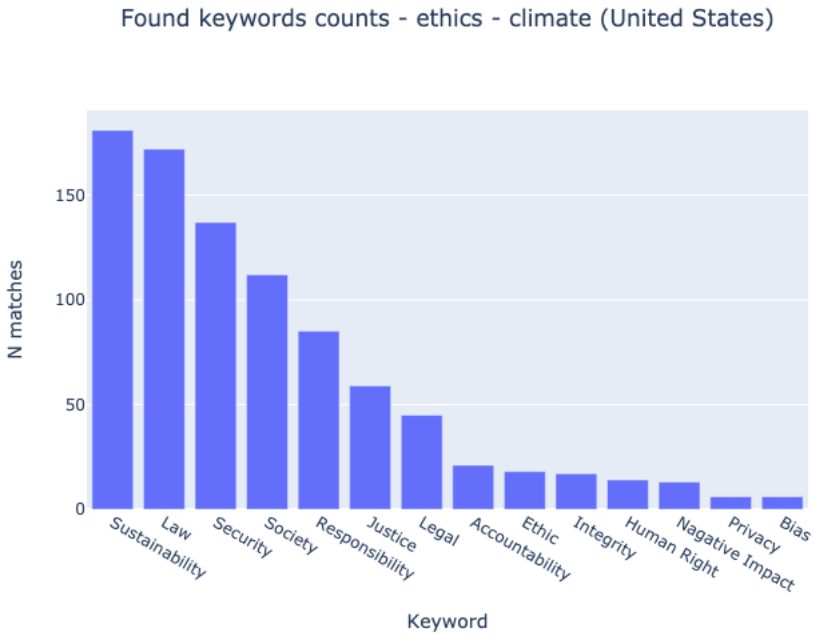


Figure 127 Counts of climate engineering news stories mentioning the ELSI-keyword on the x-axis, for US.

The ELSI-relevant stories featured several mentions of US political entities such as the Senate, the White House, SEC (US Security and Exchange Commission), GOP (the Republican party), USDA (United States Department of Agriculture), EPA (Environmental Protection Agency); international environmental or political entities, such as the United Nation, the European Union, the International Energy Agency, the Intergovernmental Panel on Climate Change (IPCC) together with gas companies (Royal Dutch Shell, BP, Exxon), energy company (Chevron) and other companies, such as Amazon, Facebook, Twitter, Microsoft, BMW (see Figure 128). Extraction of named entities of type 'person' highlights that 'Joe Biden' is mentioned in large portion of ELSI-relevant stories (29%), followed by 'Donald Trump' (11%), 'Barack Obama' (5%), 'Joe Manchin' (5%) and 'John Kerry' (3%). This suggests that the climate engineering stories are discussed often in relation to the political environment.

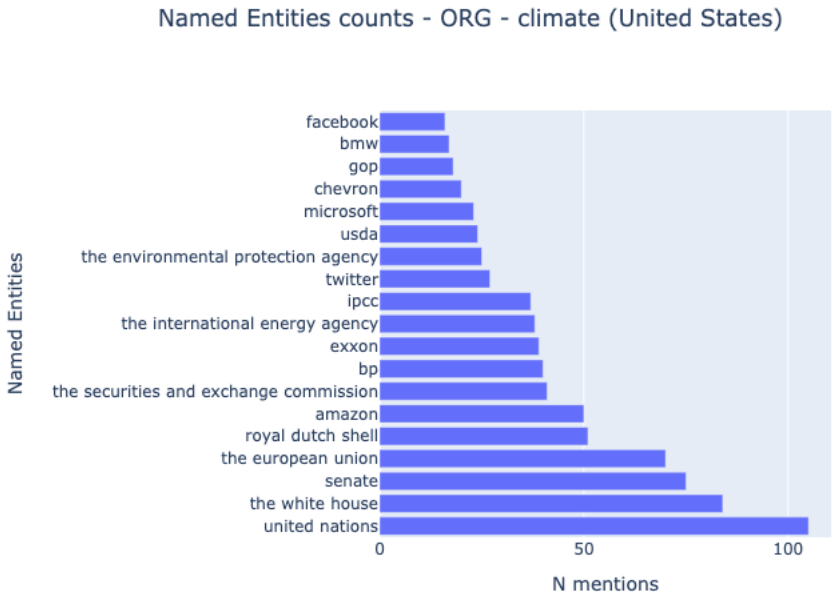


Figure 128 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for US. The number on the x axis indicate the number of climate engineering news, mentioning ELSI-keywords, where the entity on the y axis was mentioned.

5.13.3 Digital extended reality

We found that 50% of the news stories collected for digital extended reality mentioned 'virtual reality'. The second most mentioned keyword was 'augmented reality', found in 28% of the stories, followed by 'Metaverse', found in 22% news (Figure 129). Most of the news stories collected were published on outlets focusing on technology. The outlets publishing the largest shares of stories (10%, 8%, 5% and 4% respectively) were *CNET* (a media website that publishes reviews, news, articles, blogs, podcasts, and videos on technology and consumer electronics), *Venturebeat* (an outlet covering transformative technology), *Tech Crunch* (on online news site focussing on high tech and start-ups) and *Gamespot* (a website proving news, reviews, previews, downloads and other information on videogames).

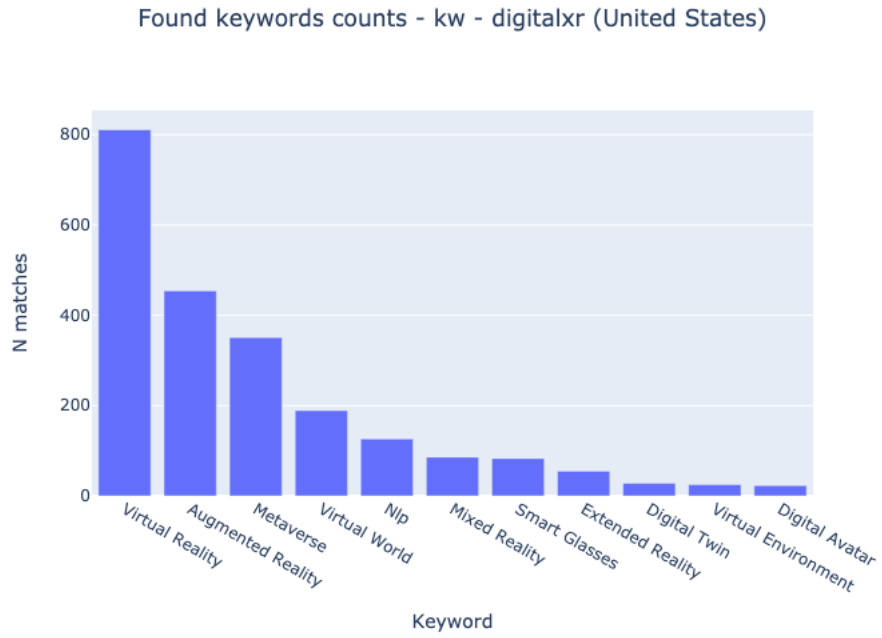


Figure 129 Counts of news stories mentioning the digital extended reality keyword on the x-axis, for US.

Bigrams extracted from news published on the top three outlets (*CNET*, *Venturebeat* and *Tech Crunch*) highlight frequent mentions of some technologies or fields of technologies (e.g., machine learning, computer vision, language model, language processing) related to digital extended reality; mentions of application of these technologies (e.g., video game, lidar sensor, 3D scan, 3D map) as well as terms related with industries (e.g., tech company, tech giant, game industry) (see Figure 130).

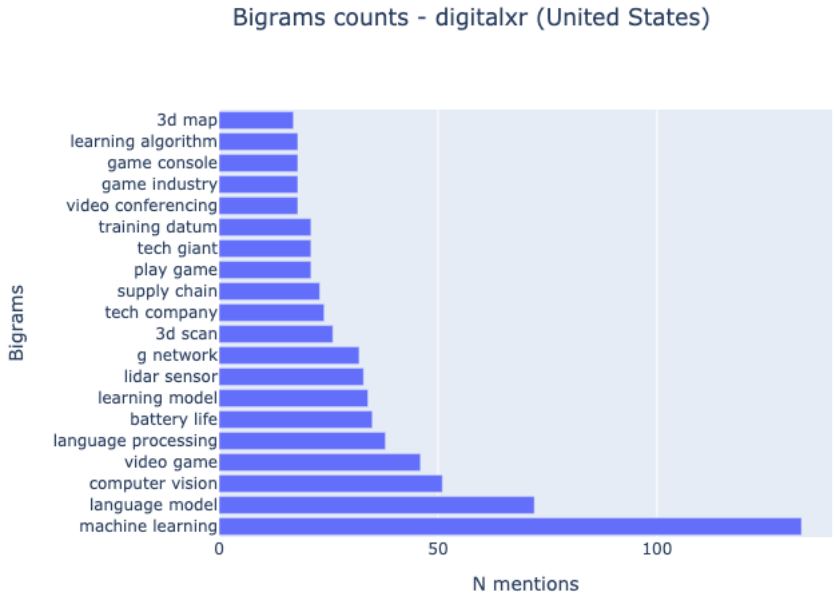


Figure 130 A selection of the most frequent bigrams from the digital extended reality news stories, for US. Bigrams have been extracted from a subset of news stories published on the outlets 'CNET', 'Venturebeat' and 'Tech Crunch'.

Bigrams extracted from national outlets covering general topics (Figure 131) suggest, as already observed before, that the digital extended reality topics are often discussed in relation to video games. Bigrams related to the marketplace ('stock price', 'stock market') suggest that some of these news stories present an economic focus. As observed in several other countries, 'coronavirus pandemic' (mentioned in news discussing the impact of Coronavirus on development of digital technologies) and 'climate change' (in opinion news discussing negative and positive impact of digital extended reality technologies on climate change) have been found in the set of news about digital extended reality.

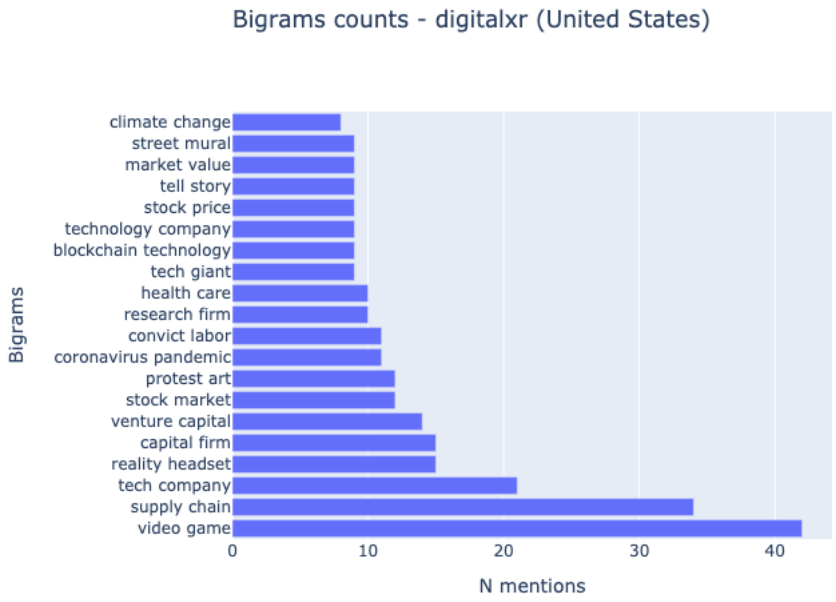


Figure 131 A selection of the most frequent bigrams from the digital extended reality news stories, for US. Bigrams have been extracted from a subset of news stories published on the outlets that have been marked as theme 'GENERAL' and not published on outlets of type 'LOCAL'.

Mentions of ELSI-keywords were found in 24% of the news stories collected for this technology category. The most prevalent keyword was 'security' (Figure 132), mentioned in 37% of the stories, followed by 'privacy' and 'law'.

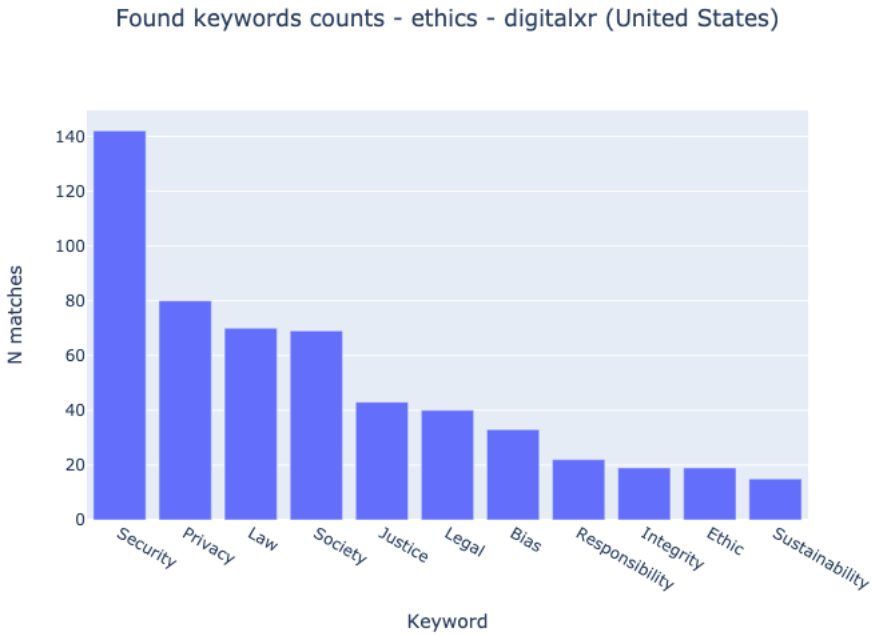


Figure 132 Counts of digital extended reality news stories mentioning the ELSI-keyword on the x-axis, for US.

Organisations mostly mentioned in these news stories (Figure 133) are big technology companies and social media (Facebook being the most mentioned one, present in 28% of the stories). Political entities are rarely discussed (e.g., the White House in mentioned in 5% of the stories, the Senate in 2%).

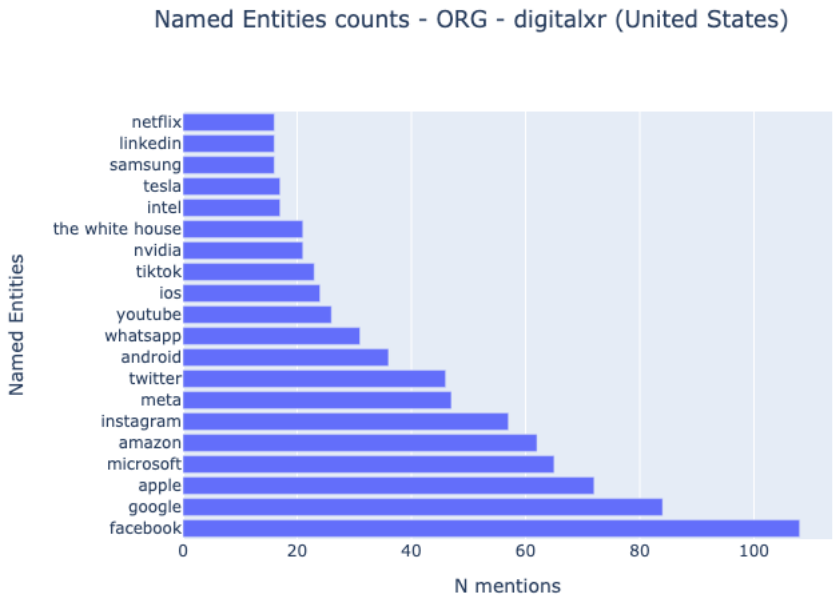


Figure 133 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for US. The number on the x axis indicate the number of digital extended reality news, mentioning ELSI-keywords, where the entity on the y axis was mentioned.

The most frequently mentioned person, as extracted by the Named Entity models, was 'Mark Zuckerberg' ('Frances Haugen' is often mentioned, suggesting the presence of news on the Facebook whistle blowing). 'Joe Biden' and 'Donal Trump' appear also in several news. Other persons entities extracted include known personalities in the world of technology (e.g., Elon Musk, Jeff Bezos, Tim Cook). George Floyd was also mentioned in news reporting the creation of augmented reality protest art created as a memorial for its death. Siri and Alexa were also mentioned, interestingly labelled as entities of type 'person' by the model. The voice assistants are discussed in news about privacy and security of products making use of them as well as in relation to potential biases of Natural Language Processing techniques used to develop them.

5.13.4 Neurotechnology

In the news collected for neurotechnology, 'brain computer interface' appears as the most prevalent topic, mentioned in 28% of the stories (Figure 134). 'Neurotechnology', 'brain chip', 'brain implant', 'neural interface' and 'cyborg' were mentioned in 20% to 10% of the stories while other keywords were found in less than 5% of the news. The largest portion of the neurotech news stories in our collection (10%, 9% and 7%) were retrieved from *CNET*, *Markets Insider*, and *InterestingEngineering* (a website covering engineering, technology and science breakthrough topics) respectively.

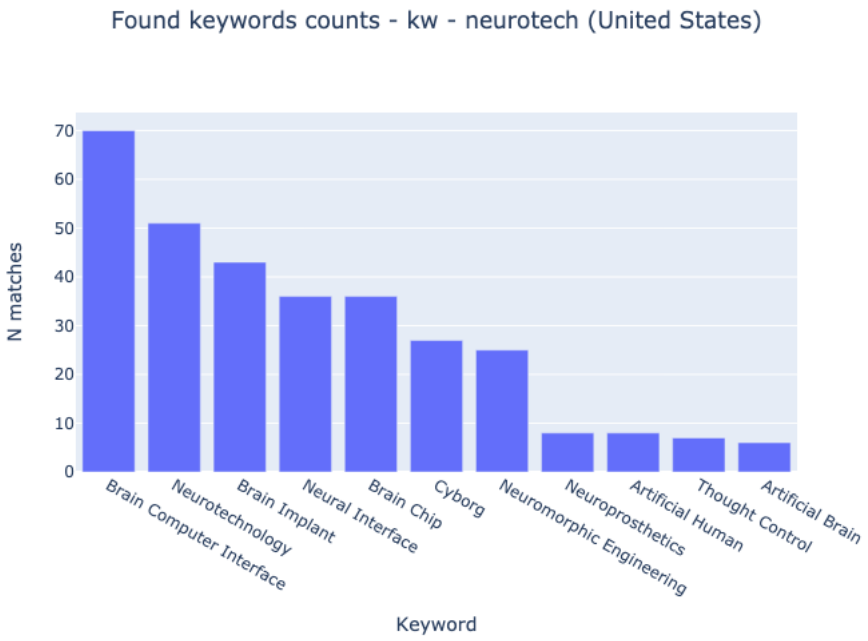


Figure 134 Counts of news stories mentioning the neurotechnology keyword on the x-axis, for US.

The most frequent bigrams extracted from these news stories (Figure 135) suggest the presence of news on Neuralink monkey experiment, references to science-fiction and application of neurotechnology to 'help people'.

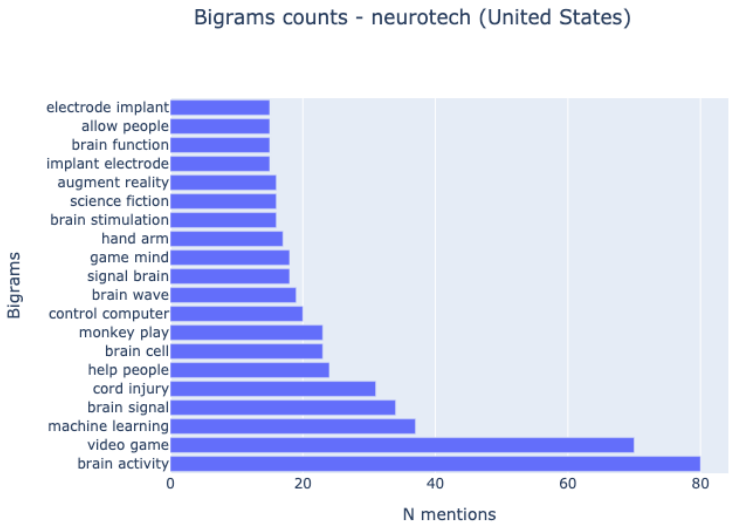


Figure 135 A selection of the most frequent bigrams from the neurotechnology news stories.

Mentions of ELSI-keywords were found in 28% of the news stories and 'security', 'privacy', 'law' and 'society' were the most prevalent terms (Figure 136).

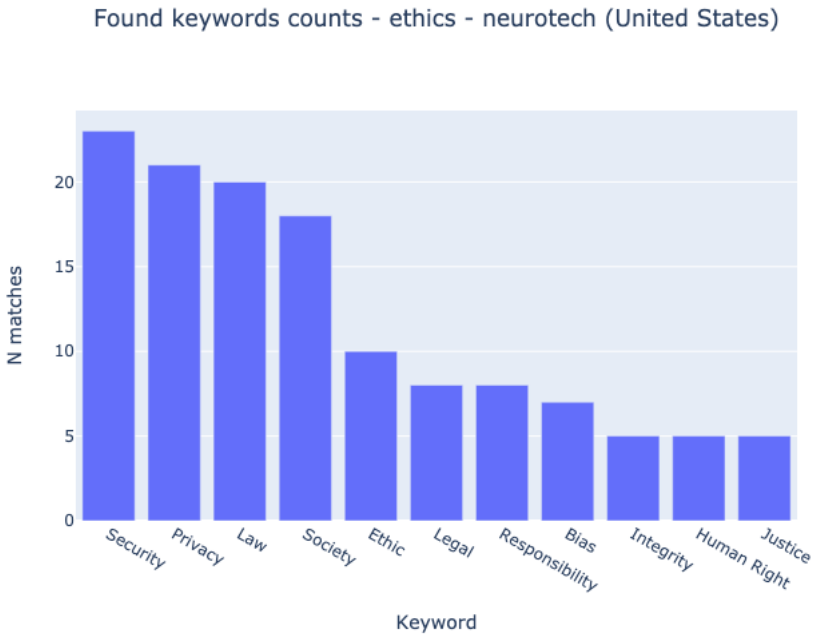


Figure 136 Counts of neurotechnology news stories mentioning the ELSI-keyword on the x-axis, for US.

'Neuralink' is the organisation most frequently mentioned (in 32%) of the news stories. Mentions of big technology companies and universities (mentioned in relation to studies and experiments developed in the neurotech field) have also been found (Figure 137). Elon Musk is the personality most frequently occurring in the stories (mentioned in 22% of them). Mentions of other personalities related with neurotechnology (e.g., Max Hodak, chief founder of Transcript, a company building brain machine interfaces) have also been found. The ELSI-relevant news stories include mentions of security issues in relation to, for instance, brain-machine interface development and risks of bio-hacks and concerns over

security risks posed by China's experimentation with brain-machine-interfaces with non-human primates. Other news concern impact on users' privacy related to the use of neurotechnology products, as well as discussions on neuromorphic computing advances in Artificial Intelligence.

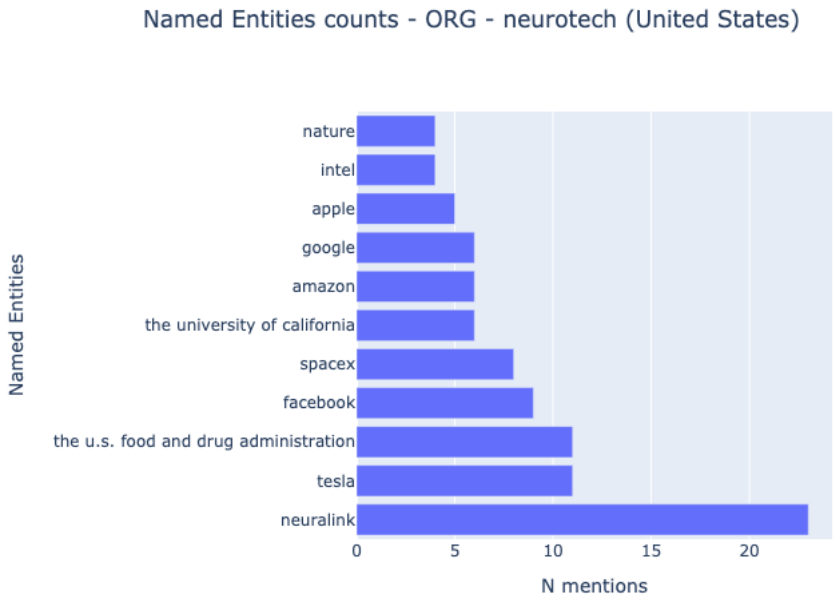


Figure 137 Selection of most frequently mentioned named entities classified under the category 'ORG' (organisation) by Spacy NER models, for US. The number on the x axis indicate the number of neurotechnology news, mentioning ELSI-keywords, where the entity on the y-axis was mentioned.

The word cloud in Figure 138 provides a snapshot of the topics discussed in the subset of ELSI-relevant news stories for this technology.

Figure 138 Word cloud on neurotechnology news stories mentioning ELSI-keywords, for US.

6 Conclusion

This report presented the results of the media scan and analysis carried out as part of TechEthos WP3 dedicated to the study of public awareness and acceptance of TechEthos' three families of technologies: climate engineering, digital extended reality, and neurotechnology. It explored the discourse in online media on the three families of technologies in order to get insights on the way the media *represents* them. Exploring this media representation aimed at better understanding public perceptions and awareness of these technologies. For instance, this study made it possible to get a view on what the dominant themes related to these technologies are; what entities (e.g., places, organisations, people) are frequently mentioned in relation to these technologies; and what ethical, legal, or social issues are highlighted in the news stories discussing these technologies.

This task was carried out between November 2021 and May 2022 and involved several TechEthos' partners and Linked Third Parties. It covered the media discourse in 13 different countries (ten EU and three non-EU countries), hence handling ten different languages. It was led by Trilateral Research that developed the study approach and carried out the data collection and data analysis using computational tools, completed with manual checks. Partners and LTPs contributed to the study with linguistic support and knowledge of the national context, in particular of the national media landscape. In spite of some limitations at the levels of the data collection and the data analysis, the study brought about numerous insights on the media discourse in the 13 countries studied and across all these countries.

Some key findings include the fact that digital extended reality is by far the family of technologies for which most of the news stories were collected (accounting for more than 62% of all data collected). This suggests that this family of technologies is more present in the media than the other two. This was the case in each country, except for Germany and Austria where climate technologies were the most discussed among the three technologies. Overall, neurotechnology was the topic for which less news stories were collected for all countries (only a bit more than 5% of total stories collected). This is a finding that the TechEthos project will need to have in mind for the public engagement activities: the public might be less familiar with neurotechnologies, a bit more with climate engineering, and much more with digital extended reality.

A noteworthy finding related to digital extended reality is that this family of technologies is primarily discussed with reference to virtual reality. Indeed, the term is mentioned in almost 42% of the stories collected for this family of technologies. On the contrary, natural language processing (NLP) is rarely mentioned. This suggests that the general public might have more awareness of virtual reality than with NLP techniques. This finding is also of interest to TechEthos public engagement activities, stressing the need for more effort to raise public awareness of NLP. Keywords related to Ethical, Legal, and Social Issues (ELSI) were mentioned in 35% of the overall news stories collected for digital extended reality, with terms 'society', 'security' and 'privacy' being the most frequently mentioned ELSI topics.

As for climate engineering, the media discussion is heavily dominated by green hydrogen, i.e., a technology aimed at tacking climate change, but which does not strictly fall within the climate engineering family of technologies as defined by TechEthos. This suggests that discussions on technologies to tackle issues of climate change are not dominated by climate engineering technologies in the narrow sense of the term as defined by TechEthos. Furthermore, we could observe that solar engineering techniques are rather rarely discussed in new stories collected for this family of technologies. Technologies such as solar radiation management or cloud modification or whitening appeared rarely in the media scanned, while afforestation, reforestation, carbon capture, sequestration and storage are among the most discussed topics. Hence, the media discourse as captured by this study indicates there might be less public awareness of solar radiation techniques, compared to other climate engineering techniques such as afforestation or carbon capture, usage, and storage techniques.

As for neurotechnologies, we could observe that the most frequently mentioned keyword is "cyborg", appearing in more than 21% of the stories collected for this family of technologies. This indicates that public awareness of this technology, as reflected in the media discourse, is highly dominated by this notion. Another interesting finding is the frequent appearance in the news stories related to neurotechnologies of Elon Musk and/or Neuralink, i.e., the neurotechnology company that Musk co-founded (they are mentioned in almost 35% of the stories collected). This suggests that discussions on this technology are highly dominated by Musk and his activities in the area or, to put it differently, that neurotechnology is often discussed in the media in relation to what Musk does in the area. Here as well,

such a strong presence in the media discourse indicates a great role of the businessman in the public awareness and perception of neurotechnologies.
The report presents many more findings from the media scan and analysis. Beyond these, this task also contributes to the scientific community and research on media representation of technologies with an innovative method to study media representation of technologies. The report provides great details on the method used for the data collection, cleaning, and analysis, so that it can be useful to researchers carrying out a similar analysis. By being transparent on the challenges that we faced carrying this study, and its related limitations, we aimed at providing resources for future research drawing from a similar method.
Finally, there would be great value in extending further this media scan and analysis, beyond what could be achieved within the limited time frame of this task. This could be done in several different ways. It could be interesting to explore in more depth specific outlets from which relevant news stories were retrieved, such as *The Guardian* for the UK, or *IlSole24Ore* for Italy. We could explore other APIs to get access to a broader set of news stories and, as such, work toward a better representativeness of the data. Another interesting method that could be implemented would be to complement the computational approach, using quantitative methods, with qualitative methods. This would make it possible to provide more in-depth insights on the way the media discuss the three technologies.

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Annexes

Annex 1: Keywords in all languages

6.1.1 Annex 1.1: Geoenginneering keywords

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
afforestation	zalesňování	herbebossing	boisement intensif	Aufforstung	Aufforstung / Wiederaufforstung / Bewaldung / Neuaufforstung	Rimboschimento	împădurire (reîmpădurire)	pošumljavanje	reforestación	skogsplantering
albedo modification	úprava odrazivosti	reflectie modificatie	modification de l'albédo	Albedomodifikation	Albedo-Modifikation / Albedo-Manipulation	/ Modifica dell'albedo	modificarea albedoului	albedo modifikacija	modificación del albedo	albedomodifiering
artificial photosynthesis	umělá fotosyntéza	kunstmatige fotosynthese	photosynthèse artificielle	künstliche Photosynthese	künstliche Photosynthese	Fotosintesi artificiale	fotosinteză artificială	veštačka fotosinteza	fotosíntesis artificial	artificiell fotosyntes
artificial upwelling	umělé vzlínání	kunstmatige zeeopwelling	remontée d'eau artificielle	künstlicher Auftrieb	künstlicher Auftrieb (Ozean) / Upwelling	Risalita artificiale delle acque profonde	ridicarea artificială a apelor de adâncime	-	Floración artificial	artificiell uppvällning
atmospheric radiation reflection	odraz atmosférického záření	amosferische	réflexion du rayonnement atmosphérique	Reflexion der atmosphärischen Strahlung	atmosphärische Rückstrahlung / Reflexion der Strahlung in der Atmosphäre	Riflessione della radiazione atmosferica	reflectarea atmosferică a radiației	refleksija atmosferskog zračenja / odraz atmosferskog zračenja	Reflexión de la radiación atmosférica	atmosfärisk reflektion av strålning
Carbon capture	zachytávání uhlíku	CO2/kooldioxide-afvang	Captage du carbone/CO2 / extraction du carbonne	Kohlenstoffbindung	CO2-Abscheidung / Carbon Capture / Kohlenstoffabscheidung	Cattura del carbonio	captarea carbonului	hvatanje ugljenika	Captura de carbono	Avskiljning av koldioxid
Carbon usage	využití uhlíku	CO2/kooldioxide - gebruik	Utilisation du carbone	Kohlenstoffnutzung	Kohlenstoffdioxidnutzung / Kohlenstoffverbrauch	Utilizzo del carbonio	folosirea / utilizarea carbonului	upotreba ugljenika	uso del carbono	Koldioxidanvändning
Carbon sequestration	sekvestrace uhlíku	CO2/kooldioxide - vastlegging	-	Kohlenstoffsequestrierung	Kohlenstoffbindung / Kohlenstoffsequestrierung	Sequestio del carbonio	stocarea durabilă a / sechestrarea carbonului	sekvestracija ugljenika	captura de carbono	Kolsekvestrering
Carbon storage	ukládání uhlíku	CO2/kooldioxide - opslag	Stockage du carbone / puits de carbonne	Kohlenstoffspeicherung	Kohlenstoffspeicherung	Stoccaggio del carbonio	stocarea carbonului	skladištenje ugljenika	almacenamiento de carbono	Koldioxidlagring
Climate engineering	Geoengineering / ovlivňování klimatu	klimaatengineering	Ingénierie climatique	Klimatechnik / English term	Klima-Engineering / English term	Ingegneria del clima	inginerie / modificare / manipulare / intervenție climatică / a climei	klimatski inženjering	Ingeniería climática	Geoengineering
cloud modification	úprava počasí	wolk modificatie	modification des nuages	Wolken-Modifizierung /	Wolkenmodifikation,	Modificazione delle nuvole	modificarea norilor	modifikacija oblaka	Modificación de las nubes	vädermodifikatiion

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
				Cloud-Modifizierung	Wolkenmanipulation / Wetterbeeinflussung					
cloud seeding	osévání mraků	wolkbezaaiing	ensemencement des nuages	Wolkenimpfen / Wolkenbildung / English term	Wolkenimpfung / Wolkenkondensation / Wolkenimpfen	Inseminazione delle nuvole	însămânțarea norilor	sejanje oblaka	Siembra de nubes	Molnsådd
cloud whitening	zozjasnění mořských mraků	bleken van wolken	blanchissement des nuages	Wolkenaufhellung / Wolkenweißung	Wolkenaufhellung, Wolkenbleichung / cloud whitening	Sbiancamento delle nuvole	albirea norilor	izbeljivanje oblaka	Blanqueamiento de nubes	-
Direct Air Capturing	přímé zachycování vzduchu	Direct Air Capturing	Direct Air Capturing	Direct Air Capturing	Direct Air Capturing (DAC)	Cattura diretta dell'aria (intrappolamento di CO2)	captarea directă din aer	direktno hvatanje vazduha	Captación directa de aire	direkt luftinfångning
Geoenginneering	geoinženýrství	geo-engineering	géo-ingénierie	Geoenginneering	Geo-Engineering	Geoingegneria	geoinginerie	geoinženjering	Geoingeniería	Geoengineering
Green hydrogen	zelený vodík	groene waterstof	Hydrogène vert	Grüner Wasserstoff	grüner Wasserstoff	Idrogeno verde	hidrogen verde	zeleni vodonik	Hidrógeno verde	Grön vätgas
Greenhouse gas removal	odstraňování skleníkových plynů	broeikasgas verwijdering	Élimination des gaz à effet de serre	Beseitigung von Treibhausgasen	Abbau von Treibhausgasen	Rimozione dei gas serra	îndepărtarea / eliminarea gazelor cu efect de seră	smanjanje gasova sa efektom staklene baste / uklanjanje gasova staklene bašte	Eliminación de gases de efecto invernadero	Växthusgasinfångning
Land-based radiation reflection	odraz záření od země	woestijn reflectie	Réflexion de rayonnement terrestre	Strahlungsreflexion an Land	Bodenabstrahlung / Erdoberflächenreflexion der Strahlung (meaning ground reflection radiation)	Riflessione della radiazione dalla terra	reflectarea radiației cu sisteme terestre / amplasate la sol	refleksija zračenja od zemljine površine	Reflexión de la radiación yerrestre	landbaserad reflektion av strålning
Negative emission technology	technologie odstraňující emise	negatieve emmissie technologie	Technologie d'émission négative	Negative Emissionstechnologie	Negative-Emission-Technologien, Negativemissionentechnologien	Tecnologia ad emissioni negative	tehnologie cu emisie negativă	tehnologije negativnih emisija	Tecnología de emisiones negativas	Minusutsläpp
Ocean fertilisation/fertilization	výživa oceánů	oceaanbemesting	Fertilisation de l'océan	Ozeandüngung	Ozeandüngung / Meeresdüngung	Fertilizzazione/fertilizzazione degli oceani	fertilizarea oceanelor	đubrenje okeana	Fertilización del océano	Havsgödning
solar radiation management	modifikace slunečního záření	Zonnestralingsbeheer / zonlichtmanagment	contrôle du rayonnement solaire	Solarstrahlungsmanagement	Management der Sonneneinstrahlung / Solar Radiation Management (SRM)	gestione della radiazione solare	managementul / gestionarea radiației solare	upravljanje solarnom radijacijom / pravljanje solarnim zračenjem	Gestión de la radiación solar	Solar radiation management
Splitting carbon dioxide	štěpení oxidu uhličitého	CO2/kooldioxide - splitsing	craquage du dioxyde de carbonne	Aufspaltung von Kohlendioxid	CO2-Spaltung / Kohlenstoffdioxid-Spaltung	Divisione del diossido di carbonio	disocierea dioxidului de carbon	razbijanje ugljen-dioksida / cepanje ugljen-dioksida	Dividir el dióxido de carbono	Spjälkning av koldioxid
sulfate aerosol injection	stratosférická aerosolová injekce	sulfaat earosol injectie	Injection stratosphérique d'aérosols	Sulfat-Aerosol-Injektion	Aerosolspritzung/-en, Sulfat-Aerosol-Injektion,	Iniezione di aerosol di solfato	injecția / injectarea de	injekcija sulfatnog aerosola /	Inyección de aerosol de sulfato	sulfataerosoltillförsel

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
					Schwefel-Aerosole / Aerosol-Injektion / English term		aerosoli (de sulfat)	razdvajanje ugljen-dioksida		
sun shield	sluneční štít	Zonnescherm / zonneschilde / zonnereflectoren	bouclier solaire / parasol spatial	Sonnenschutz	Sonnenschutzschild / Sonnenblende	Scudo Solare	ecran solar (umbrelă)	sunčani štit	Parasol	Solsköld
Wastewater nutrient recovery	obnova živin odpadních vod	afvalwater nutrient winning	récupération des nutriments des eaux usées	Rückgewinnung von Nährstoffen aus dem Abwasser	Nährstoffrückgewinnung aus Abwässern	Recupero dei nutrienti delle acque reflue	recuperarea nutrienților din apele uzate / reziduale	obnavljanja nutrijenata otpadnih voda	Recuperación de nutrientes de las aguas residuales	Näringsåtervinning från avloppsvatten
Water splitting	štěpení vody	water ontleding	craquage de l'eau	Wasserspaltung	Wasserspaltung / Spaltung von Wasser	Scissione dell'acqua	disocierea apei	razdvajanje vode	División del agua	Spjälkning av vatten

6.1.2 Annex 1.2: Digital Extended Reality keywords

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
augmented reality	rozšířená realita	augmented reality	réalité augmentee / English term	erweiterte Realität / English term	erweiterte Realität	Realtà aumentata	realitate augmentată	proširena stvarnost / rošírena realnost / augmentativna realnost	Realidad aumentada	Augmented reality / Förstärkt verklighet
Digital avatar	digitální avatar	digitale avatar	avatar numérique	Digitaler Avatar	ditigaler Avatar	Avatar digitale	avatar	digitalni avatar	Avatar digital	digital avatar
Extended reality	rozšířená realita	extended reality	réalité etendue / English term	Erweiterte Realität / English term	erweiterte Realität / English term	Realtà estesa	realitate extinsă	proširena stvarnost / proširena realnost	Realidad extendida	Extended reality / Utvidgad verklighet
metaverse	fiktivní vesmír	metaverse	métavers	Metaversum / English term	Metaversum / English term	Metaverso	metavers	metaverzum	Metaverso	Metaversum
mixed reality	mixovaná realita	mixed reality / gemengde realiteit	réalité mixte	mixed reality	gemischte Realität / English term	Realtà mista	realitate mixtă	mešana realnost / mešana stvarnost	Realidad mixta	Blandad verklighet / English term
Natural Language Processing	zpracování přirozeného jazyka	spraaktechnologie	traitement automatique du language naturel / traitement automatique de la langue naturelle / traitement automatique des langues / English word	Natürliche Sprachverarbeitung	Verarbeitung natürlicher Sprache; natürlicher Sprachverarbeitung / English term	Elaborazione del linguaggio naturale	procesarea / prelucrarea limbajului natural	obrada prirodnog jezika / neurolingvističko programiranje	Procesamiento del lenguaje natural	Natural Language Processing
NLP	NLP	Neuro Linguïstisch Programming	-	NLP	NLP / English term	NLP	NLP	NLP	PLN	NLP
smart glasses	chytré sklo, chytré brýle	smart glass / smart glas / slim glas	lunettes intelligentes	intelligente Brillen / English term	Datenbrille / Smartglass	Occhiali intelligenti	ochelari inteligenți / smart	pametno staklo / pametne naočare	Vidrio inteligente	smart glas

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
digital twin	digitální dvojče	digitale tweeling	jumeau numérique	digitaler Zwilling	digitaler Zwilling / English term / Digitaler Doppelgänge	Gemello digitale	geamăn virtual / digital	digitalni blizanci	Gemelo digital	Digital tvilling
virtual avatar	virtuální avatar	virtuele avatar	avatar virtuel	virtueller Avatar	virtueller Avatar / virtuelle Figur	Avatar virtuale	avatar	virtuelni avatar	Avatar virtual	virtuell avatar
virtual environment	virtuální prostředí	virtuele omgeving	environnement virtuel	virtuelle Umgebung	virtuelle Umgebung virtuelle Umwelt / virtuelles Umfeld	Ambiente virtuale	mediu virtual	virtuelno okruženje / virtuelna sredina	Entorno virtual	Virtuell omgivning
Virtual reality	virtuální realita	virtuele realiteit / English term	réalité virtuelle	virtuelle Realität	virtuelle Realitär / English term	Realtà virtuale	realitate virtuală	virtuelna stvarnost / virtuelna realnost	Realidad virtual	Virtuell verklighet / English term
virtual world	virtuální svět	virtuele wereld	monde virtuel	virtuelle Welt	virtuelle Welt	Mondo virtuale	lume virtuală // univers virtual	virtuelni svet	Mundo virtual	Virtuell värld
VR	VR	VR	VR	VR	VR	VR	VR	VR	RV	VR
XR	XR	XR	XR	XR	XR	XR	XR	AR	Realidad extendida (ER)	XR

6.1.3 Annex 1.3: Neurotechnology keywords

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
Artificial brain	umělý mozek	kunstmatig brein	Cerveau artificiel	Künstliches Gehirn	künstliches (Ge)Hirn	Cervello artificiale	creier artificial	veštački mozak	Cerebro artificial	Artificiell hjärna
Artificial eye	umělé oko	kunstmatig oog	Oeil artificiel	Künstliches Auge	künstliches Auge / Kunstauge / Augenprothese	Occhio artificiale	ochi artificial / bionic	veštačko oko	Ojo artificial	Artificiellt öga
artificial human	umělý člověk	kunstmatig mens	humain artificiel	Künstlicher Mensch	künstlicher Menschen	Umano artificiale	om bionic / cyborg / ciborg	veštački čovek	Humano artificial	Artificiell människa
Artificial organ	umělý orgán	kunstmatig orgaan	organe artificiel	künstliches Organ	künstliches Organ	Organo artificiale	organ artificial	veštački organ	Órgano artificial	Artificiellt organ
Artificial uterus	umělá děloha	kunstmatige baarmoeder	utérus artificiel	Künstlicher Uterus	künstlicher Uterus	Utero artificiale	uter artificial	veštačka materica	Útero artificial	Artificiell livmoder
artificial synaps	umělé synapse	kunstmatige synaps	synapse artificielle	Künstliche Synapse	künstliche Synapse	Sinapsi artificiale	sinapsă artificială	veštačke sinapse	Sinapsis artificial	Artificiell synaps
brain boosting device	zařízení pro posílení mozku		Dispositive/appareil de stimulation du cerveau	Gerät zur Förderung des Gehirns / English term	brain boosting device / Brain-Boosting-Gerät	Dispositivo di potenziamento del cervello	dispozitiv de stimulare a creierului	uređaj za poboljšanje moždanih funkcija	Dispositivo para potenciar el cerebro	–
brain chip	mozkový čip	hersenchip	puce cérébrale	Gehirnchip / Hirnchip	(Ge)Hirn-Chip / (Ge)Hirn-Chip-Implantat	Chip cerebrale	chip / cip în creier / implant cortical / în creier	moždani čip / čip u mozgu	chip cerebral	Hjärnchip

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
brain computer interface	rozhraní propojující mozek s počítačem / neuralink	hersencomputerinterface	interface cerveau-ordinateur	Gehirn-Computer-Schnittstelle / English term	(Ge)Hirn-Computer-Schnittstelle (BCI) / English term	Interfaccia computer cervello	interfață neuronală / creier-mașină / creier-calculator	interfejs mozak kompjuter / mozak-kompjuterski interfejs	Interfaz cerebro-ordenador	brain computer interface
brain enhancement	vylepšení mozku	hersen verbetering	amélioration du cerveau / augmentation cognitive	Verbesserung des Gehirns	(Ge)Hirn-Verstärkung, (Ge)Hirn-Verbesserung / English term	Potenziamento del cervello	îmbunatățirea creierului	poboljšanje mozga	Mejora cerebral	–
brain implant	mozkový implantát	hersenimplantaat	implant cérébral	Gehirnimplantat	(Ge)Hirn-Implantat	Impianto cerebrale	implant cortical / în creier	moždani implant / implant u mozgu	Implante cerebral	Hjärnimplantat
brain machine interface	zařízení pro komunikaci mezi mozkem a externím zařízením	brein-machine interfaces	interface cerveau-machine	Gehirn-Maschine-Schnittstelle	Gehirn-Maschine-Schnittstelle / brain-machine-interface (BMI)	Interfaccia macchina del cerveallo	interfață neuronală / creier-mașină	interfejs mozak mašina	Interfaz cerebro-máquina	brain machine interface
brain machine interaction	interakce mezi mozkem a zařízením	brein-machine interaction / hersen-machine interaction	interaction cerveau-machine	Gehirn-Maschine-Interaktion	Gehirn-Maschine-Interaktion	Interazione cervello macchina	interacțiune creier-mașină	interakcija mozga i mašine	Interacción cerebro-máquina	brain machine interaction
brain to brain	rozhraní mozek-mozek		cerveau à cerveau	von Gehirn zu Gehirn	(Ge)Hirn zu (Ge)Hirn	Da cervello a cervello	creier la creier	telepatija	De cerebro a cerebro	Hjärna till hjärna
cyborg	cyborg	cyborg	cyborg	Cyborg	Cyborg	Cyborg	cyborg / ciborg	kiborg	Cyborg	cyborg
cognitive enhancement	kognitivní vylepšení	cognitieve verbetering	amélioration cognitive	kognitive Verbesserung	kognitive Verbesserung / Kognitionsförderung	Potenziamento cognitivo	îmbunătățirea funcțiilor cognitive	kognitivno poboljšanje / oboljšanje kognitivnih funkcija	Mejora cognitiva	–
mind reading machine	zařízení pro čtení myšlenek	gedachteleesmachine	machine à lire dans les pensées	Gedankenlesemaschine / Gedankenlesegerät	Gedankenlesemaschine	Macchina per leggere la mente	mașină de citit gândurile	mašina za čitanje misli	Máquina de leer la mente	Tankeläsningsapparat
neural control	nervová kontrola	neurale controle	contrôle neuronal	neuronale Steuerung / neuronale Kontrolle	neuronalle Kontrolle/Steuerung	Controllo neurale	control neuronal	kontrola nerava / kontrola nervnog sistema	Control neuronal	Neural kontroll
neural interface	neurální rozhraní	neuraal interface	interface neuronale	neuronale Schnittstelle / neuronales Interface	neuronalle Schnittstelle / neuronalles Interface	Interfaccia neurale	interfață neuronală	neuronski interfejs	Interfaz neuronal	Neuralt gränssnitt
neural prostheses	nervové protézy	neuroprothese	prothèses neurales	Neuralprothesen	Neuroprothese	Protesi neurale	proteză neuronală	neuronska proteza	Prótesis neuronal	Neurala proteser
neuromorphic computing	neuromorfní informatika	English term	informatique neuromorphique	neuromorphe Datenverarbeitung / neuromorphes Computing	Neuromorphic Computing / neuromorphes Rechnen	Calcolo neuromorfico	calcul neuromorf	neuromorfno računarstvo	Informática neuromórfica	Neuromorfisk ingenjör / English term

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN (Germany)	GERMAN (Austria)	ITALIAN	ROMANIAN (w/diacritics)	SERBIAN	SPANISH	SWEDISH
neuromorphic engineering	neuromorfní inženýrství	English term	ingénierie neuromorphique	neuromorphes Engineering / neuromorphe Technik	Neuromorphic Engineering	Ingegneria neuromorfica	inginerie neuromorfă	neuromorfno inženjerstvo	Ingeniería neuromórfica	Neuromorfisk data / English term
neuroprosthetic	Neuroprosthetics / vývoj nervových protéz	neuroprostese	Neuroprothèse / prothèse neurologique	Neuroprothetik	neuroprosthetisch	Neuroprotesico	proteză neuronală	neuroprostetika	Neuroprotésico	Neuroprotetik
neurotech	neurotechnologie	neurotech	-	neurotech	Neurothech	Neurotecnologico	neurotehnologie	-	Neurotecnología	Neuroteknologi / neuroteknik
neurotechnology	neurotechnologie	neurotechnologie	neurotechnologie	Neurotechnologie	Neurotechnologie	Neurotecnologia	neurotehnologie	neurotehnologija	Neurotecnología	Neuroteknologi / neuroteknik
transcranial electrical stimulation	transkraniální elektrická stimulace	transcraniële elektrische stimulatie	stimulation électrique transcrânienne	transkranielle elektrische Stimulation	Transkranielle elektrische Stimulation / Transkranielle Gleichstromstimulation/ Elektrostimulation/Hirnstimulation	Stimolazione elettrica transcranica	stimulare electrică transcraniană	transkranijalna električna stimulacija	Estimulación eléctrica transcraneal	Transkraniell elektrisk stimulering
thought control	ovládání myšlenek	gedachten controle	Contrôle des pensées	Gedankenkontrolle	Gedankenkontrolle / Gedankensteuerung	Controllo del pensiero	controlul gândirii	kontrola misli	Control del pensamiento	Tankekontroll
Wearable organ	nositelné orgány	draagbaar orgaan	Organe portable	Tragbares Organ	tragbare künstliche Organe / tragbare Körperorgane	Organo indossabile	organ portabil	-	Órgano portátil	Bärbara organ

6.2 Annex 2: ELSI keywords in all languages

ENGLISH	CZECH	DUTCH	FRENCH	GERMAN	ITALIAN	ROMANIAN	SERBIAN	SWEDISH
ethics	etika	ethiek	éthique	Ethik	etica	etică	етика	etik
privacy	ochrana osobních údajů	privacy	vie privée	Datenschutz	privacy	confidențialitate	приватност	integritet
fairness	spravedlnost	eerlijkheid	équité	Fairness	correttezza	corectitudine	поштење	rättvisa
discrimination	diskriminace	discriminatie	discrimination	Diskriminierung	discriminazione	discriminare	дискриминација	diskriminering
bias	předsudky	vooroordeel	préjugés	Voreingenommenheit	bias	prejudecată	склоност	fördomar
human rights	lidská práva	mensenrechten	droits de l'homme	Menschenrechte	diritti umani	drepturile omului	људска права	Mänskliga rättigheter
negative impact	negativní dopad	negatieve impact	impact négatif	negative Auswirkungen	impatto negativo	impact negativ	Негативан утицај	negativ påverkan
vulnerable group	zranitelná skupina	kwetsbare groep	groupe vulnérable	gefährdete Gruppe	gruppo vulnerabile	grup vulnerabil	рањива група	utsatt grupp
accountability	odpovědnost	verantwoordingsplicht	responsabilité	Rechenschaftspflicht	responsabilità	responsabilitate	одговорност	ansvarsskyldighet
integrity	integrita	integriteit	intégrité	Integrität	integrità	integritate	интегритет	Integritet
physical integrity	fyzická integrita	fysieke integriteit	intégrité physique	körperliche Unversehrtheit	integrità fisica	integritatea fizică	физички интегритет	fysisk integritet
security	bezpečnost	veiligheid	sécurité	Sicherheit	sicurezza	securitate	безбедност	säkerhet
justice	spravedlnost	rechtvaardigheid	justice	Gerechtigkeit	giustizia	justiție	правда	rättvisa
dignity	důstojnost	waardigheid	dignité	Würde	dignità	demnitate	достојанство	värdighet
society	společnost	samenleving	société	Gesellschaft	società	societate	друштво	samhälle
well-being	blahobyt	welzijn	bien-être	Wohlbefinden	benessere	bunăstare	благостање	välbefinnande
fundamental rights	základní práva	grondrechten	droits fondamentaux	Grundrechte	diritti fondamentali	drepturi fundamentale	темељна права	grundläggande rättigheter
sustainability	udržitelnost	duurzaamheid	durabilité	Nachhaltigkeit	sostenibilità	durabilitate	одрживост	hållbarhet
law	právo	wet	droit	Recht	legge	lege	закон	lag
responsibility	odpovědnost	verantwoordelijkheid	responsabilité	Verantwortung	responsabilità	responsabilitate	одговорност	ansvar
legal	právní	juridisch	juridique	Recht	legale	juridic	правни	juridiskt

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@TechEthosEU

TechEthosEU

www.techethos.eu

info@techethos.eu