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*Article*

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**‘Mapping’ Knowledge  
Dissemination**DOI: 10.47368/ejhc.2025.103  
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CC BY 4.0**What Metaphors Reveal About the  
Conceptualisation of Immunotherapy in  
Scientific and Journalistic Communication****Nynke Bos** 

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Metaphors are commonly used in communication about complex health issues and interventions, such as immunotherapy. This study maps the use of metaphors in communication about immunotherapy and explores differences and similarities in scientific and newspaper articles, with the aim to reveal the conceptualisation of immunotherapy among academic peers and to a broader public. We compiled two datasets of scientific ( $N = 1,425$ ) and newspaper ( $N = 2,650$ ) articles about immunotherapy. We identified signalled metaphors in text fragments about immunotherapy, determined their source domains, and categorized which aspects of immunotherapy they described. We identified 510 text fragments with a signalled metaphor describing 10 different aspects of immunotherapy, representing 210 different metaphorical words from 23 metaphorical source domains. The two datasets largely described similar aspects of immunotherapy, such as *workings of immunotherapy* and *role or function of immunotherapy*. They referred to similar metaphorical

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source domains, such as WAR and JOURNEY, but their distribution showed different patterns. Furthermore, different metaphorical words were used in the two datasets, with the newspaper articles showing greater diversity. This study shows how immunotherapy is conceptualised and communicated, demonstrates metaphor analysis as a method to gain insight in health issues, and suggests future research with implications for practice.

## Keywords

Metaphors, conceptualisation, knowledge dissemination, discourse analysis, immunotherapy.

Literary devices such as metaphors are often used to describe and explain health-related issues and interventions (Harrington, 2012; Hendricks et al., 2018; Pfeifer et al., 2023; Semino, 2008). Conceptual Metaphor Theory states that metaphors are commonly used to compare a complex concept (this is referred to as the target domain) to something easier or more concrete with which the recipient might be more familiar (which is referred to as the source domain; Lakoff & Johnson, 1980). An example of an often used metaphorical comparison in medical discourse is the 'fight' against cancer, with chemotherapy providing 'soldiers' to 'combat' the cancer (Marron et al., 2020; Semino et al., 2017). Here, the words 'fight', 'soldiers' and 'combat' are used metaphorically to describe CANCER (target domain) in terms of a WAR (source domain).<sup>1</sup> In this way, metaphors are used to make difficult and abstract information, e.g., regarding health issues or novel medical interventions, more concrete and more comprehensible (Boyd, 1998; Brown, 2003; Knudsen, 2005; Kuhn, 1979; Reeves, 2005).

Public awareness of a topic, such as a novel medical treatment or health intervention, is affected by *which* information is provided (first-level agenda setting) and *how* it is presented (second-level agenda setting) (Coleman et al., 2009). The latter, thus how information is presented, is also referred to as framing (Entman, 1993; Scheufele, 2006). The way in which health information is framed logically impacts how people conceptualise this information, which, in turn, can impact their judgments and decisions (Scheufele, 2006; Tversky & Kahneman, 1981). Therefore, framing is often used strategically to shape people's knowledge and perceptions regarding health issues and to promote proposed solutions or therapies (see e.g., Edwards et al., 2001). For example, messages focusing on positive outcomes of health-related prevention behaviours (e.g., the advantages of accepting skin cancer screenings) seem more effective in stimulating these behaviours than messages focusing on negative outcomes when failing to engage in this behaviour (e.g., the disadvantages of rejecting skin cancer screening; Gallagher & Updegraff, 2012).

Metaphors constitute one particular way in which information can be framed, as they provide both linguistic and conceptual content to describe a topic (Burgers et al., 2016). As such, metaphors in health communication provide important insights into how a topic is conceptualised (Gibbs Jr & Franks, 2002; Pfeifer et al., 2023; Semino, 2021). The above-mentioned metaphor CANCER IS WAR, for instance, is often criticized. Using war metaphors can have negative emotional implications for patients (Hendricks & Boroditsky, 2016; Semino et al., 2018; Semino et al., 2017; Sontag, 1978). They can make people feel that they can only recover from cancer if they try hard enough at all costs (Harrington, 2012). If a patient does not recover, it may feel like a personal defeat or they may feel guilt for not doing their best (Hendricks & Boroditsky, 2016; Semino et al., 2017). An alternative source domain to tap from

to describe cancer is JOURNEY, for example, a therapy as the 'route' to cure cancer, which gives a different frame to the disease experience. In a journey, the focus is more on the total disease process rather than smaller instances (Harrington, 2012), which may be less harmful to patients.

In health communication, scientists and journalists both make frequent use of metaphorical framing (e.g., Guliashvili, 2022; Harrington, 2012; Semino, 2021; Williams Camus, 2016). In doing so, they often make use of the same set of source domains (such as WAR or JOURNEY) when describing a particular target domain (such as CANCER). However, within these source domains, there are differences in the use of metaphorical words. The reasons for this difference in metaphor use in scientific and journalistic texts may be due to differences regarding the audience and purpose of the respective outlets (Semino, 2008). Scientists use 'theory-constitutive' (Boyd, 1998; Knudsen, 2003) and genre-specific metaphors (Skorczyńska & Deignan, 2006), either as part of jargon or to discuss novel original thought with peers and healthcare professionals (Bubela et al., 2009; Parkinson & Adendorff, 2004). In contrast, journalists use metaphors with an explanatory, pedagogical goal (Boyd, 1998; Knudsen, 2003) to simplify complicated and often abstract matters, draw the public's attention and contribute to public involvement in (health-related and medical) developments and decision-making, for instance by describing personal stories of patients, their families, or healthcare professionals (Brown, 2003; Bubela et al., 2009; Reich, 2012; Reeves, 2005). In this endeavour, journalists use metaphors more creatively (Knudsen, 2003; Semino, 2008) by not only adopting metaphors from scientific publications, but also adding other metaphors themselves (Armon, 2017; Knudsen, 2003; Stelmach & Nerlich, 2015).

Research on emerging technology suggests that metaphors can facilitate communication about subject matter that is new to both scientific as well as non-expert audiences (e.g., Droog et al., 2020). Similarly, metaphors may play an important role in communication about novel medical interventions. Immunotherapy is such a medical intervention that is innovatively used for increasingly diverse applications. More conventional therapies, such as chemotherapy for cancer, target the disease itself (in this case cancer cells). Immunotherapy, by contrast, is a host-directed therapy that targets a patient's immune system to treat the disease, in this case by helping the body to better recognize, attack and destroy cancer cells (Dillman, 2011). This promising therapy has not only proven effective in the treatment of various cancers (Esfahani et al., 2020) and allergies (Chu et al., 2019), but is also an upcoming therapy for infectious diseases such as COVID-19 (Van de Veerdonk et al., 2022).

As immunotherapy holds tremendous promise for science and society, it receives increasing attention in scientific and journalistic media. However, to date, and to the best of our knowledge, research on metaphors about immunotherapy is scarce. A few studies investigated metaphor use in immunology in general, in scientific (Semino, 2008) and popular scientific (Downing & Mujic, 2009) texts. One other study examined metaphor use to describe immunotherapy during conversations between healthcare providers and patients in clinical oncology (Hianik et al., 2019). These studies show that metaphors are typically used to describe a range of aspects related to immune-related content, including descriptions of the immune system, diseases (Downing & Mujic, 2009), how immunotherapy works, and which side effects the therapy has (Hianik et al., 2019).

This literature on immunology reflects the above-mentioned observation that scientific articles and popular science articles use relatively similar source domains, with distinct metaphorical manifestations. Namely, Semino (2008), Downing and Mujic (2009), and Hianik et al. (2019) all found that source domains such as WAR ("the immunologic 'weapons'"),

JOURNEY (“viruses ‘traveling’ from infected cells to healthy counterparts”) and HUMAN BEINGS (“wake up’ the immune system”) were commonly used when describing immunological processes. However, metaphors used in scientific articles often refer to expert vocabulary (Semino, 2008, p. 159), such as ‘agents’, ‘mechanisms’ and ‘targets’, while popular scientific discourse uses metaphors in a creative way (e.g., the popular scientific ‘cell suicide’ for the conventional scientific metaphor ‘programmed cell death’; Semino, 2008).

The existing small body of literature on metaphors for immune-related topics provides some interesting first insights into how immunology is metaphorically communicated to different audiences, but is yet unable to reveal how immunotherapy is conceptualised and communicated among academic peers and to a broader public. It is evident that scientists and journalists use metaphors in distinct ways (Semino, 2008), with the potential to shape the way how scientists and the general public think and feel about a health-related topic (e.g., Hendricks et al., 2018; Scherer et al., 2015). As such, we assume that metaphors may play a role in the acceptance of immunotherapy among these two types of audiences. It is therefore highly relevant to understand how both scientists and journalists conceptualise and communicate immunotherapy by means of metaphor. Scientists gain health-related knowledge and communicate this to peers using metaphors. At the same time, journalists learn about health-related developments through these metaphors and determine which of these they will use when communicating with non-expert audiences. However, the two groups may deploy metaphor in different ways (which might, in turn, differentially impact their respective audiences). Therefore, the aim of this study is to map current communication about immunotherapy in both scientific and newspaper articles. To this end, this study asks:

*RQ1:* How are metaphors used to describe immunotherapy?

*RQ2:* (How) Is metaphor use different for scientific versus journalistic articles?

For both research questions we specify (a) which aspects of immunotherapy are described, (b) which source domains are referred to, and (c) which metaphorical words are used.

## Methods

To analyse communication about immunotherapy in the scientific and newspaper discourse, we performed a content analysis of metaphor use in English scientific and newspaper articles.

### Materials

We created two datasets: one for scientific review articles via MEDLINE and one for British national newspaper articles via NexisUni. In both databases, we searched for articles published before 1 January, 2021 (as data were extracted in 2021) that contained the term ‘immunotherapy’ or variants thereof (\*immunotherap\* OR \*immuno-therap\* OR \*immunetherap\* OR \*immune-therap\* OR “immune therapy” OR “immune therapies”). To create the scientific dataset, we used the PubMed-filter ‘Review’ and we searched for these terms in the title and/or abstract supplemented by the Mesh term for immunotherapy in articles in core clinical journals (National Library of Medicine, 2021). To create the newspaper dataset, we selected newspaper articles from British national newspapers containing the search terms.

The search in the databases resulted in 2,932 scientific articles, of which we selected the 1,443 articles that we could download automatically from EndNote, and 3,628 newspaper

articles, which we manually downloaded from the NexisUni database. For the scientific articles, we automatically converted the PDF files of the articles to .txt files and only kept the main text of the articles, thus excluding sections such as the reference list, abstract and tables. The scientific dataset did not contain any duplicates, but we had to remove 18 articles because we were unable to export the PDF files. Because both digital and print versions of newspaper articles were present in the newspaper database, newspaper articles with more than 95% overlap (978 articles) were removed from our dataset. After this, 1,425 scientific articles and

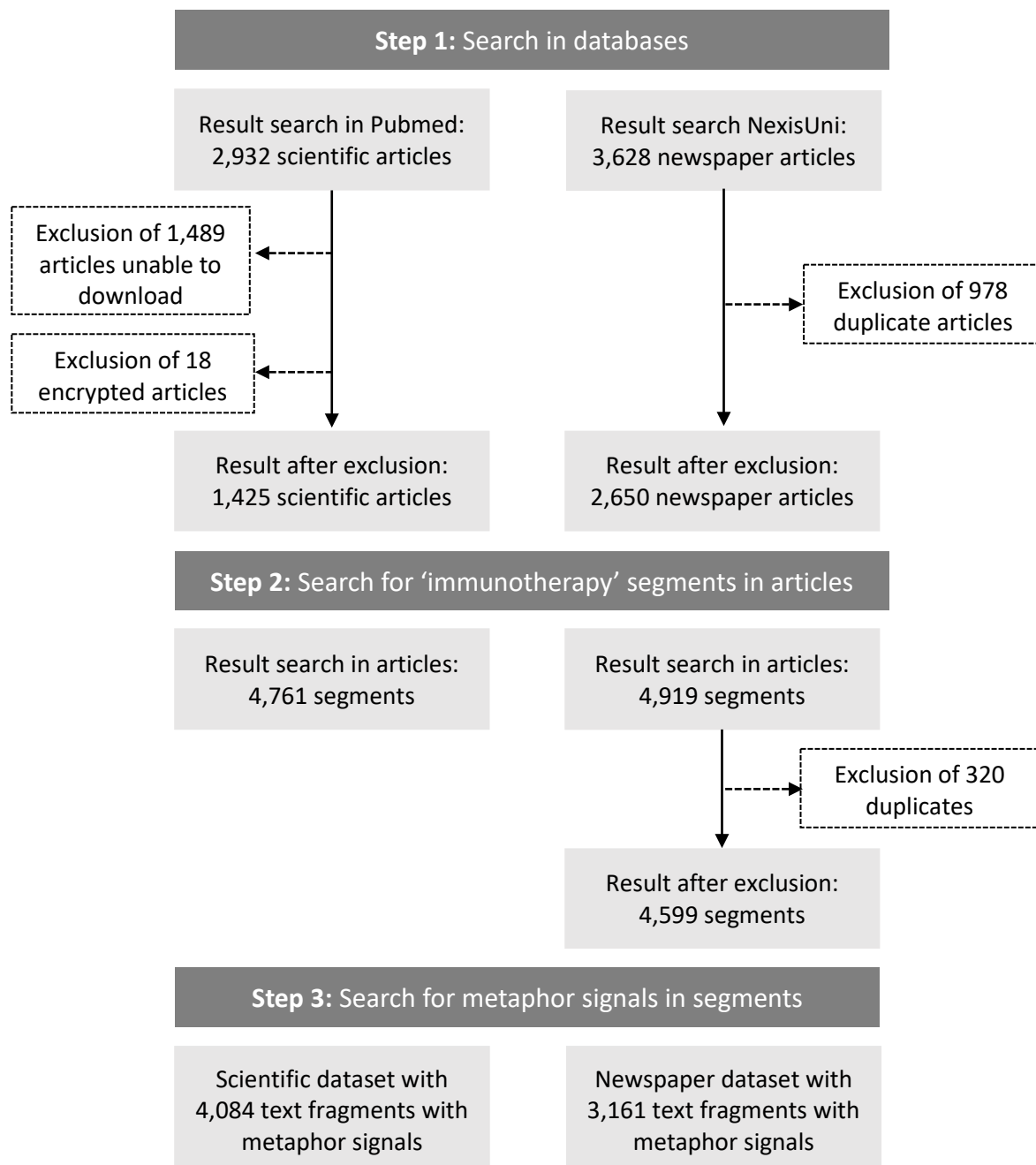


Figure 1. The Steps for Creating the Two Datasets

Note. After the dataset was created, a number of fragments still contained duplicate information. We therefore manually removed these from the dataset.

2,650 newspaper articles remained. These steps and the following steps for creating the two datasets are shown in Figure 1.

We used AntConc Version 3.5.8 (Anthony, 2018) in two steps. The first step was to extract text segments of 400 characters in which immunotherapy or any of its variants (see above) were mentioned.<sup>2</sup> This resulted in 4,761 segments from the scientific dataset and 4,919 segments from the newspaper dataset. For the newspaper dataset, segments with more than 95% overlap (320 segments) were once again excluded. For the scientific dataset no such duplicate removal was necessary. In the second step, similar to for instance Droog et al. (2020) and Skorczynska and Ahrens (2015), we subsequently searched these text segments for the presence of metaphor signals, such as 'like', 'kind of', 'metaphorically speaking', the use of inverted commas, etc., that can be used in the close vicinity of a metaphorically used word to signal its metaphorical use (e.g., Goatly, 1997; Semino, 2008). We used the list of signals from Pasma (2011, p. 237), supplemented with double quotation marks. Identifying and analysing signalled metaphors is a good proxy for mapping how immunotherapy is conceptualised metaphorically, because the signals may draw the reader's attention to the metaphorical nature of the communication (e.g., Reijnierse, 2017; Steen, 2008), and because signals are typically used for explanatory purposes (e.g., Skorczynska & Ahrens, 2015). We found 4,084 fragments (200 characters<sup>3</sup>) in the scientific text segments and 3,161 fragments in the newspaper text segments mentioning immunotherapy and containing a possible<sup>4</sup> metaphor signal. These 7,245 fragments constitute the final dataset for our analyses.

### *Coding Procedure*

To answer the research questions, three consecutive coding stages were performed. First, we identified metaphorically used words by applying the principle of contrast and comparison that are central to metaphor, as described in the Metaphor Identification Procedure Vrije Universiteit (MIPVU; Steen et al., 2010). Next, we determined if and which aspects of immunotherapy the attested metaphors referred to. Finally, we identified which source domains were used to describe these aspects by applying the Metaphorical Source Domain Identification Procedure (MSDIP; Reijnierse & Burgers, 2023).

**Stage 1: Identifying Signalled Metaphors.** For each of the 7,245 fragments in our final dataset, we determined whether the potential metaphor signal in a fragment was indeed used to signal a metaphorically used word. Metaphorically used words can either be direct by signalling a comparison between two distinct domains (e.g., 'immunotherapy acts like a safety net'; Steen et al., 2010, pp. 38-39), or indirect by signalling a word of which the meaning in the context of the fragment differs from, but can be compared to, a more 'basic' meaning of that word (e.g., "immunotherapy will 'teach' her body..."; Steen et al., 2010, pp. 32-33). We only coded the first relevant metaphorical word following the metaphor signal. Other metaphorical words were not part of our analysis. We looked up 'basic' meanings in one or multiple of the following online dictionaries: *MacmillanDictionary* (n.d.),<sup>5</sup> *Merriam-Webster* (n.d.), or *Longman Dictionary of Contemporary English Online* (n.d.). Fragments containing signals serving other functions (such as introducing a list or providing an example) were discarded. Because inter-coder reliability tests on 10% of the dataset were only borderline satisfactory (Cohen's  $\kappa$  between .53 and .65, we double coded the full dataset by three coders

(NB, LV and GR) and discussed differences between coders until consensus was reached for all cases.

**Stage 2: Identifying Relevance to and Categorizing Aspects of Immunotherapy.** For each signalled metaphor identified in stage 1 of the coding procedure, we first determined the relevance to immunotherapy. We identified a metaphor as relevant when it, for example, explicitly described immunotherapy (e.g., 'The new treatment has been hailed as the greatest step forward in cancer research' which is categorized as *role or function of immunotherapy*). Because inter-coder reliability tests on 10% of the dataset were unsatisfactory (Cohen's  $\kappa$  between .13 and .53), we double coded the full dataset by the three coders and discussed differences between coders until consensus was reached for all cases.

Second, we categorized which aspects of immunotherapy the signalled metaphors described. The full dataset was double coded by the three coders, after which we used an iterative, consensus-based approach to determine which aspect was described (cf., Lorenz-Spreen et al., 2023). When it was not possible to determine the relevance to immunotherapy or to categorise the aspect of immunotherapy based on the fragment, we looked up more context in the scientific or newspaper article in which the fragment occurred.

After stages 1 and 2, out of the 4,084 text fragments with a potential metaphor signal in our scientific dataset, 301 (7.4%) fragments from 183 scientific articles remained containing a signalled metaphorical word that described an aspect related to immunotherapy. Similarly, in our newspaper dataset, out of the 3,161 text fragments with a potential metaphor signal, 209 (6.6%) fragments from 175 British newspaper articles remained containing a signalled metaphorical word that described an aspect related to immunotherapy.

**Stage 3: Determining Source Domains.** We determined metaphorical source domains for each of the relevant signalled metaphors that we identified in the previous step. Because metaphorical words can have multiple possible source domains (e.g., Reijnierse & Burgers, 2023; Ritchie, 2003), we inductively determined all possible source domains based on the basic-meaning definitions of the metaphors in the online dictionaries mentioned in stage 1. First, all three coders summarized source domain meanings of the signalled metaphors based on the words' definitions in online dictionaries. For example, the metaphorical word 'fight' has source domain meanings in the dictionary relating to WAR and to SPORTS. In this process, we used the semantic field labels proposed by the UCREL semantic analysis system (Rayson et al., 2004) for inspiration. After the newspaper dataset was coded, we jointly established metaphorical source domains, using an iterative, consensus-based approach (cf., Lorenz-Spreen et al., 2023). The scientific dataset was coded by the first coder (NB) based on the same criteria, and discussed with the second coders (LV and GR) until consensus was reached for all cases.

## Results

We first describe the characteristics of the articles. Next, we discuss the most common aspects of immunotherapy, the most metaphorical source domains used to describe immunotherapy, and the variation in metaphorical words used to describe immunotherapy, including the differences between the two outlets. Finally, we provide further explanation of how the most common metaphorical source domains were reflected in the two datasets, including exemplary quotes.

Table 1. Distribution of Medical Conditions as Main Topic in Both Article Types Containing Metaphors to Describe Immunotherapy

Medical Condition	Scientific Articles		Newspaper Articles		Total Articles	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Cancer	143	78.1	143	81.7	286	79.9
Allergies	12	6.6	13	7.5	25	7.0
Other conditions	28	15.3	19	10.8	47	13.1
Total	183		175		358	

### Descriptives

The total of 358 scientific and newspaper articles in which we found signalled metaphors describing an aspect related to immunotherapy covered the therapy mostly in the context of cancer and allergies (see frequencies in Table 1). The remaining articles covered a variety of other conditions that appeared in fewer than 10 articles, such as fertility problems, blood disorders and autoimmune diseases. To ensure that the metaphor comparison between the two article types was not confounded by differences in the type of medical condition that is described in relation to immunotherapy, we performed a Chi-Square test using IBM SPSS statistics (version 27). We found no significant association between the medical conditions and type of articles, ( $\chi^2(2) = 1.59, p = .453, \text{Cramer's } V = .07$ ).

### Aspects of Immunotherapy Described With Metaphors

Based on the iterative coding process described in the methods section, we identified 10 different aspects related to immunotherapy described with metaphors (Table 2). All aspects appeared in both the scientific and the newspaper dataset. *Workings of immunotherapy* was the most common aspect in both the scientific dataset and newspaper dataset, but the order of the other categories differed between the two datasets. Exploring any association between article type and metaphorically described aspects of immunotherapy, we found a difference of the prevalence of aspects across the scientific and newspaper datasets ( $\chi^2(10) = 128.72, p < .001, \text{Cramer's } V = .50$ ). The scientific dataset contained relatively more fragments covering the aspects *workings of immunotherapy, application or administration of immunotherapy and moderators for immunotherapy* compared to the newspaper articles. By contrast, the newspaper dataset contained relatively more fragments covering the aspects *role or function of immunotherapy, medical condition, consequences of immunotherapy, and research on immunotherapy* (for frequencies see Table 2).

### Metaphorical Source Domains Used to Describe Immunotherapy

We identified a total of 23 different source domains in the 510 text fragments containing a signalled metaphor (Table 3). Most source domains appeared in both datasets, except for TIME and EDUCATION which both only appeared in the newspaper dataset. The source domain WAR was the most common source domain in the scientific and newspaper datasets together (22.7%), followed by PERSON (16.9%), JOURNEY (12.2%), BUSINESS & FINANCE (12.0%) and PEOPLE'S ACTIONS, STATES & PROCESSES (11.4%). The three most common source domains differed per dataset. The most common source domains in the scientific dataset were PERSON (24.6%), WAR (19.9%) and BUSINESS & FINANCE (18.9%). The most common source domains in the



newspaper dataset were WAR (26.8%), PEOPLE'S ACTIONS, STATES & PROCESSES (19.6%) and JOURNEY (11.0%).

*Table 2.* Distribution of the 10 Different Aspects of Immunotherapy That Were Described With Metaphors Across Both Datasets

Aspect of Immunotherapy	Explanation	Scientific Fragments		Newspaper Fragments		Total Fragments	
		<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Workings of immunotherapy	How immunotherapy works as a treatment	101	33.6	48	23.0	149	29.2
Role or function of immunotherapy	The role or function of immunotherapy in the treatment of a medical condition	26	8.6	47	22.5	73	14.3
Medical condition	The medical condition for which immunotherapy is used	32	10.6	35	16.7	67	13.1
Application or administration of immunotherapy	The way in which immunotherapy is applied or administered	51	16.9	3	1.4	54	10.6
Moderator for immunotherapy	A specific state of the body that is conditional for immunotherapy to work	38	12.6	2	1.0	40	7.8
Workings of the body	How the body works, in a healthy state or under immunotherapeutic treatment	25	8.3	13	6.2	38	7.5
Other treatment	Other treatments in comparison or combination with immunotherapy	16	5.3	12	5.7	28	5.5
Consequence of immunotherapy	Subjective or objective effects of immunotherapy	2	0.7	24	11.5	26	5.1
Research on immunotherapy	Interpretations of a study on immunotherapy	3	1.0	14	6.7	17	3.3
Type of immunotherapy	Different types of immunotherapy	6	2.0	1	0.5	7	1.4
Other	Fragments that did not fit into one of the formulated categories	1	0.3	10	4.8	11	2.2
<b>Total</b>		<b>301</b>		<b>209</b>		<b>510</b>	

### Variation in Metaphorical Words Used to Describe Immunotherapy

To gain further insight into how the different metaphorical source domains were expressed in language, we examined the variation in metaphorical words used to describe immunotherapy in both datasets. The 510 text fragments with a signalled metaphor (i.e., tokens) in our datasets represented 210 (41,1%) different metaphorical words (i.e., types). To determine the variation of metaphors within each source domain, we calculated the type-token ratio (TTR). We calculated the TTR by dividing the number of types by the number the tokens for each source domain.

The newspaper dataset was more heterogeneous than the scientific dataset in terms of the variation of metaphorical words, meaning that it contained more uniquely used metaphorical words. Appendix 1 in the Supplementary materials provides an overview of the TTR and metaphorical words within each of the 23 source domains across the two datasets.

**Table 3.** Distribution of the 23 Different Source Domains of Metaphors Used to Describe Immunotherapy Across Both Datasets

Metaphorical Source Domain	Scientific Fragments		Newspaper Fragments		Total Fragments	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
WAR	60	19.9	56	26.8	116	22.7
PERSON	74	24.6	12	5.7	86	16.9
JOURNEY	39	13.0	23	11.0	62	12.2
BUSINESS & FINANCE	57	18.9	4	1.9	61	12.0
PEOPLE'S ACTIONS, STATES & PROCESSES	17	5.6	41	19.6	58	11.4
LAW & ORDER	39	13.0	10	4.7	49	9.6
MACHINERY	42	14.0	4	1.9	46	9.0
BUILDING & ARCHITECTURE	28	9.3	17	8.1	45	8.8
NATURAL PHENOMENON	29	9.6	11	5.3	40	7.8
COMMUNICATION	15	5.0	7	3.3	22	4.3
PLACE	15	5.0	7	3.3	22	4.3
RELIGION & SUPERNATURAL	1	0.3	19	9.1	20	3.9
FLORA & FAUNA	3	1.0	9	4.3	12	2.4
SPORT & GAMES	2	0.7	8	3.8	10	2.0
MEDIA & ENTERTAINMENT	5	1.7	3	1.4	8	1.6
CHEMISTRY	3	1.0	4	1.9	7	1.4
TIME	0	0	7	3.3	7	1.4
CLOTHING	2	0.7	4	1.9	6	1.2
FOOD & DRINKS	1	0.3	5	2.4	6	1.2
SPACE	1	0.3	4	1.9	5	1.0
COMPUTER	3	1.0	2	1.0	5	1.0
DISTANCE	1	0.3	3	1.4	4	0.8
EDUCATION	0	0	4	1.9	4	0.8
Other	7	2.3	7	3.3	14	2.7

*Note.* Since metaphorical words can have more than one source domain meaning (see, e.g., Reijnierse & Burgers, 2023; Ritchie, 2003), the percentages in Table 3 add up to more than 100%.

### *Similarities and Differences in Metaphors for Immunotherapy in Scientific and Newspaper Articles*

In this section, we provide a detailed explanation of how the five most common metaphorical source domains were reflected in the two datasets, by providing exemplary quotes. We describe the similarities and differences between the two datasets, including the variation in aspects of immunotherapy that are explained with metaphors as well as the specific metaphorical words that are used.

**Source Domain WAR.** The source domain WAR contained metaphorical words in which (something related to) immunotherapy was described in terms of a war, such as ‘enemy’ and ‘bombs’. Only a few metaphorical words occurred in both datasets, such as ‘target’ and ‘weapon(s)’. The variation in metaphor use in the scientific dataset was low (TTR 0.25). This was mainly caused by the metaphor ‘target’, which occurred 37 times in this dataset, accounting for 61.7% of all metaphorical words in the WAR domain. In the scientific dataset, most WAR-related metaphorical words (including ‘target’) were used to describe the aspect *workings of immunotherapy* (71.7%). Example 1 below displays an example from our dataset, in which the metaphor signal is in **bold** and the relevant metaphorical word is underlined. In Example 1, CTLA-4 (a protein receptor) was described as an object that can be attacked, as in a war where people or buildings are intended to be attacked.

1. Moreover, single-cell analysis has been essential in identifying susceptible subpopulations of tumor cells that can serve **as targets** for immunotherapy (...). (Scientific dataset; Beaumont et al., 2020, p. 476)

The newspaper dataset contained, in contrast to the scientific dataset, more unique metaphorical words in the WAR domain which were used relatively less frequently (TTR 0.46). In addition, the newspaper dataset showed a more varied picture in terms of aspects related to WAR metaphors for immunotherapy. The aspects *workings of immunotherapy* (39.2%), *medical condition* (21.4%) and *role or function of immunotherapy* (16.1%) were most commonly described. In Example 2, the workings of immunotherapy were described as weaponizing the immune system to treat cancer, as during a war someone can be weaponized to attack the opponent.

2. A pioneering cancer treatment that ‘weaponises’ the body's immune system (...). (Newspaper dataset; Pemberton, 2017)

In addition, ‘advance’ was used 11 times in the newspaper dataset, which accounted for 19.6% of all metaphorical words in the WAR domain. In Example 3, the WAR domain was used to describe the role of immunotherapy in the treatment of a medical condition. Specifically, the emergence of immunotherapy as a cancer treatment was compared to movement by an army in a war (i.e., ‘advance’).

3. Immunotherapy is seen **as** one of the greatest advances in cancer treatment in decades. (Newspaper dataset; Connor, 2016)

**Source Domain PERSON.** The source domain PERSON contained metaphorical words in which (something related to) immunotherapy was described in terms of a person, such as a general or a body (part). Except for the metaphor ‘backbone’, which occurred in both the scientific and

the newspapers datasets, the two datasets contained different metaphorical words to express this source domain. The variation of metaphors in the PERSON domain in the scientific dataset was relatively low (TTR 0.32). This was mainly caused by the metaphorical word ‘agent’ that occurred 33 times, accounting for 44.6% of all metaphorical words in the PERSON domain in this dataset. The fragments in which ‘agent’ was used metaphorically mostly described the *application or administration of immunotherapy*. Consequently, this aspect was the most common within the scientific dataset (37.8%). In Example 4, the application of immunotherapeutic drugs was compared to a person who does business for another person or a company (i.e., ‘agent’).

4. (...) several experimental immunotherapeutic drugs are currently being explored at this stage **as** single agents or in combination. (Scientific dataset; Francini & Taplin, 2017, p. 39)

The PERSON-related metaphorical words in the scientific dataset described a variety of aspects related to immunotherapy. In addition to *application or administration of immunotherapy* as described above, *workings of immunotherapy* (18.9%) and *workings of the body* (13.5%) were also common aspects. In Example 5, the PERSON domain was used to describe the workings of a body with an indirect relation to immunotherapy. Here, a protein was given person characteristics and was described as someone who accompanies another person (i.e., ‘chaperone’).

5. Originally isolated and identified **as** a chaperone protein essential for assembly of immunoglobulin molecules, and thus named binding immunoglobulin protein (BiP) (...). (Scientific dataset; Shields et al., 2012, p. 781)

Similar to the pattern we found for the source domain WAR, the variation of metaphors in the PERSON domain was higher in the newspaper dataset (TTR 0.75) compared to the scientific dataset. These fragments were mostly about the *workings of immunotherapy* (58.3%), see for instance Example 6. Here, cancer cells were compared to a person who pretends to be someone else (i.e., ‘imposter’), with immunotherapy helping the body to recognize these cells.

6. Known as PD-L1 immunotherapy, it helps a person's body fight cancer cells by recognising them **as** imposters. (Newspaper dataset; Daily mail, 2015)

**Source Domain JOURNEY.** The source domain JOURNEY contained metaphorical words in which (something related to) immunotherapy was described in terms of a journey, such as ‘vehicles’ or ‘guide’. In contrast to the source domains WAR and PERSON, the use of metaphorical words in the two datasets showed mostly similarities. Several metaphors appeared in both the scientific and newspaper dataset, such as ‘approach’ and ‘step’. In addition, the variation in the use of metaphorical words was quite similar for both types of datasets within this domain (TTR 0.38 for the scientific dataset and TTR 0.34 for the newspaper dataset). The datasets were also quite similar in describing aspects of immunotherapy. In both the scientific and newspaper datasets, the aspects *workings of immunotherapy* (33.3% and 26.1%, respectively) and *role or function of immunotherapy* (28.2% and 26.1%, respectively) occurred frequently. Example 7 (scientific dataset) and Example 8 (newspaper dataset) provide two examples of a description of the role of immunotherapy in the treatment of a medical

condition in terms of a JOURNEY. In both examples, immunotherapy as an upcoming treatment was compared with a path or road that leads to a place (i.e., ‘approach’).

7. Immunotherapy **seems** to be a very promising approach for treatment of liver tumors. (Scientific dataset; Chiriva-Internati et al., 2008, p. 838)
8. The children are involved in trials of immunotherapy treatment, hailed **as** the most promising approach to cancer since the development of chemotherapy nearly 80 years ago. (Newspaper dataset; Highfield, 2008)

The two datasets also contained some differences in describing aspects of immunotherapy within the JOURNEY domain. For instance, an aspect that appeared mainly in the newspaper dataset was *research on immunotherapy* (30.4%). In Example 9, research on immunotherapy as a treatment for cancer was described in terms of a spacecraft mission to the moon (i.e., ‘moonshot’).

9. The cancer ‘moonshot,’ as it has been dubbed, will focus on areas such as immunotherapy and genomics. (Newspaper dataset; Blakely, 2016)

**Source Domain BUSINESS & FINANCE.** The source domain BUSINESS & FINANCE contained metaphorical words in which (something related to) immunotherapy was described in terms of, for example, ‘company’ and ‘dividend’. Except for the metaphorical word ‘maintenance’, the two datasets contained different metaphorical words expressing this domain. The variation of metaphors in the scientific dataset within the BUSINESS & FINANCE domain was low (TTR 0.14). This is mainly due to the frequency of the metaphorical words ‘agent’ (33 times) and ‘maintenance’ (11 times), which together accounted for 77.2% of all metaphorical words. The metaphorical words ‘agent’ and ‘maintenance’ were mainly used to describe the *application or administration of immunotherapy*, which also means this was the most frequently described aspect of the scientific dataset within this domain (56.1%). Example 10 shows a case in our scientific dataset in which the application of immunotherapy was compared to the financial meaning of maintenance: “money that you pay to your ex-wife or ex-husband to help her or him and your children after you are divorced” (Macmillan dictionary, Definition 3, MacmillanDictionary, n.d.).

10. The idea of using BCG **as** maintenance immunotherapy in acute leukemia dates back to the late 1960s. (Scientific dataset; Rashidi et al., 2016, p. 764)

Similar to the dominant pattern of the source domains WAR and PERSON, the variation of metaphor use within the BUSINESS & FINANCE domain was higher in the newspaper dataset than in the scientific dataset. The four metaphors in the newspaper dataset each only appeared once (TTR = 1). An example of a metaphor in the newspaper dataset is ‘company’, see Example 11. In this example, the functioning of the body during an illness was compared to a company that provides services.

11. In essence, the body is acting **as** its own pharmaceutical company. (Newspaper dataset; Swanton, 2018)

**Source Domain PEOPLE’S ACTIONS, STATES & PROCESSES.** The source domain PEOPLE’S ACTIONS, STATES & PROCESSES consisted of metaphorical words in which (something related to)

immunotherapy was described in terms of people's actions such as 'hiding', states such as 'professional', and processes such as 'memory'. Except for the metaphorical word 'step(s)', the two datasets contained different metaphorical words expressing this source domain. In contrast to the source domains described above, the variation of the metaphorical words in the PEOPLE'S ACTIONS, STATES & PROCESSES domain in the scientific dataset was high (TTR 0.94). The scientific fragments in this domain were mainly about the *workings of the body* (29.4%) and *workings of immunotherapy* (29.4%). Example 12 displays a case in which the workings of the body were described in terms of a person's state (i.e., 'professional'). In this example, an antigen was given a personal characteristic with special skills and qualifications.

12. Antigen recognition and T-cell signaling activation, or 'priming', of naive T cells that recognize tumor cells must be initiated by 'professional' antigen. (Scientific dataset; O'Day et al., 2007, p. 2615)

The variation of metaphorical words in the newspaper dataset in this domain was also relatively high (TTR 0.61), but lower compared to the scientific dataset. The lower variation was partly caused by the metaphorical word 'step', which occurred 7 times in the newspaper fragments, accounting for 17.1% of all metaphorical words in the PEOPLE'S ACTIONS, STATES & PROCESSES domain. Example 13 shows an example of the newspaper dataset in which the word 'step' was used metaphorically. This example describes immunotherapy as an upcoming treatment for cancer in terms of a movement made by a person. The metaphorical word 'step' was often used to describe the *role or function of immunotherapy* (19.5%), as in Example 13. In addition to this aspect, the newspaper dataset mainly contained fragments that described the aspects *workings of immunotherapy* (29.3%) and *medical condition* (19.5%).

13. The new treatment has been hailed as the greatest step forward in cancer research since chemo was first introduced in the 1940s. (Newspaper dataset; Parry, 2018)

## Discussion

In this work, we have mapped metaphor use in scientific and newspaper articles to show how aspects related to immunotherapy are conceptualised and communicated between academic peers as well as to the wider public. We found a difference in terms of which immunotherapy-related aspects were described with metaphors in scientific versus newspaper articles. We also found that both outlets largely draw on the same source domains to describe immunotherapy-related issues, but that the metaphorical words they use to do so differ. Our results are in line with previous research and extend it by 1) focusing on metaphors in written communication about immunotherapy and 2) further specifying (dis)similarities in metaphor use between the two types of articles.

Similar to previous research (e.g. Semino, 2008; Downing & Mujic, 2009), our findings showed that scientific papers and newspaper articles largely use the same source domains to conceptualise immunotherapy, such as WAR and JOURNEY. Yet, we also found that the relative frequency of the source domains varied per outlet. On the one hand, the source domains PERSON and BUSINESS & FINANCE, for example, were used more frequently in the scientific articles than in the newspaper articles. This may be due to the fact that the metaphorical comparisons within these domains were predominantly used to describe the application or administration of

immunotherapy (“suitable ‘candidate’ for immunotherapy” and “‘maintenance’ therapy”). This aspect is almost absent within the newspaper articles. This may be attributed to the fact that scientific articles aim to report research results and increase scientific knowledge of academic peers and other specialists (Bubela et al., 2009; Parkinson & Adendorff, 2004), naturally resulting in a focus on more technical aspects of immunotherapy being described. On the other hand, the newspaper articles referred more frequently to source domains such as RELIGION & SUPERNATURAL and FLORA & FAUNA compared to the scientific articles. The metaphorical comparisons within these domains are mainly used to describe subjective consequences of immunotherapy (“It’s like a ‘miracle’” and “It felt like ‘ants’ were crawling all over my body”). In contrast to scientific articles, newspaper articles typically use descriptions of people’s subjective experiences to engage the general public in health-related topics (Bubela et al., 2009; Reich, 2012). This is a novel finding that provides in-depth insight into the specific ways in which immunotherapy is conceptualised for different audiences. Eventually, the different prevalence of source domains, i.e., the different ways in which immunotherapy is framed, may impact the way scientists versus the general audience think about immunotherapy (see Conrad, 1999; McCombs & Shaw, 1972).

Our findings also showed that the metaphorical words that were used to describe aspects related to immunotherapy largely differed between the two outlets. While both outlets, for instance, conceptualised immunotherapy in terms of WAR, differences occurred in terms of the selection and variation of the metaphorical words in both outlets. Specifically, the five most common source domains discussed contain shared and distinct metaphorical words. This finding corroborates previous research showing that journalists not only adopt metaphors from scientific articles, but also add other metaphors themselves (Armon, 2017; Droog et al., 2020; Knudsen, 2003; Stelmach & Nerlich, 2015).

Concerning the variation of the use of metaphors, the scientific dataset typically contained a relatively limited number of different metaphorical words that occurred rather frequently to express a certain source domain (low type-token ratios). Notably, metaphorical words such as 'agents' and 'targets' occurred prominently in the scientific dataset. This suggests the use of jargon or technical metaphors that describe concepts for which no (non-metaphorical) alternative descriptions are available (e.g., Semino, 2008) and can be related to the ‘theory-constitutive’ function of metaphor use (Boyd, 1998; Knudsen, 2003). By contrast, the news dataset generally contained a wider range of metaphorical words to express the same source domain (high type-token ratios). These findings confirm previously found patterns of metaphor use in specialist versus non-expert discourse showing that metaphors from scientific publications ‘open up’ in journalistic discourse (e.g., Knudsen, 2003), with journalists adding more, different and possibly more creative metaphors to their articles (see also Semino, 2008). This suggests that metaphors are used to communicate information in an accessible way to the general public, and to draw the reader’s attention (Brown, 2003; Reeves, 2005), following the ‘exegetical’ or ‘pedagogical’ function of metaphors (Boyd, 1998; Knudsen, 2003). As a result of these differences in the choice of metaphorical words within the source domains, it is conceivable that the general public may form a different concrete image of issues related to immunotherapy compared to academic peers.

While our current study provides a first comparison between scientific and journalistic ways of conceptualising and communicating immunotherapy, it also has some limitations. The first of these is related to the creation of the datasets. In the scientific dataset, we only included literature reviews based on our expectation that they would provide a more comprehensive

overview of the literature and contain more metaphors due to their narrative nature, in comparison to articles on medical trials. In the newspaper dataset, we only selected British national newspapers, due to their availability in English, and we were limited to the articles available in the NexisUni database. These selection criteria may limit the generalizability of our findings to other types of scientific articles and newspapers from other countries.

A second limitation is the decision to focus our analysis on signalled metaphors. Even though we argued in the methods section that such signalled metaphors are suitable for mapping conceptualisations of immunotherapy, this decision implies that we have not analysed non-signalled metaphorical words used to express concepts related to immunotherapy. As previous research has shown that the majority of metaphorical words is non-signalled (Steen et al., 2010), follow-up research that takes non-signalled metaphors into account, will provide a broader picture on how immunotherapy is conceptualised metaphorically. While we expect that such analysis may yield a more diverse set of metaphorical words in the articles, we also expect that it will provide few new source domains. Therefore, performing such additional analyses for the current research purpose might cost more (as manual metaphor identification is very laborious) than they yield.

The results of our analysis provide insight into the occurrence of metaphors in scientific and journalistic discourse about immunotherapy, but it is also important to carefully consider the potential effects of metaphors in health communication. Previous research has shown that metaphorical frames can influence people's emotional appraisals, perceptions, intentions, and eventually even behaviour, towards health-related topics (e.g., Hauser & Schwarz, 2015, 2020; Hendricks et al., 2018; Krieger et al., 2010; Scherer et al., 2015). Future research is needed to explore to what extent metaphors about immunotherapy impact healthcare professionals, patients, and the general public. Along the same lines, it is important to explore whether (and which) metaphors contribute to the audience's comprehension of the communicated health intervention. Although metaphors have the purpose to explain complex concepts in an easy way, they do not always improve understanding. Hianik et al. (2019), for instance, showed that metaphors to explain immunotherapy as used in conversations between healthcare providers and their patients in clinical oncology were only understood about half of the time. Shared understanding between patients and healthcare providers regarding the disease and available treatment options plays an important role for patients in making informed decisions about medical care (Street et al., 2009) and could potentially lead to higher treatment acceptance by patients (McCabe, 2021). In future research, it is therefore important to not only examine the persuasiveness of metaphors for immunotherapy, but also the extent to which they contribute to shared understanding and shared decision-making.

## Conclusion

This study contributes to the understanding of how immunotherapy is metaphorically conceptualised and communicated among scientists and to the general public. It serves as a first step toward understanding communication about this complex medical intervention. While journalistic and scientific outlets largely conceptualise immunotherapy in the same way (same source domains), the verbal information differs to some extent (different metaphorical words). Considering the potential effects of immunotherapy metaphors on people's comprehension, attitudes and acceptance, future research is needed to explore the effects of these metaphors on



the audience. Any such effects might even impact medical outcomes. For instance, they might influence the adoption (or not) of a medical intervention by healthcare professionals, and the acceptance (or not) of the intervention by patients.

## Notes

1. Following conventions in metaphor research, references to source and target domains are written in small capitals (cf. Lakoff & Johnson, 1980). Metaphorically used words are written between single quotation marks.
2. We tested various search window sizes, and found 400 characters to be sufficient to identify immunotherapy-relevant sections in both the scientific and journalistic texts.
3. Similar to note 2 above, we tested various search window sizes, and found one of 200 characters to be sufficient for our purposes.
4. We refer to 'possible' metaphor signals here, because some of the signals (e.g., 'as', 'like') have other discourse functions as well, and may not always be accompanied by a metaphorically used word. See Coding procedure, stage 1.
5. Unfortunately, this dictionary ceased to be available online in mid-2023.

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No ethical approval was necessary for this research.

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## Conflict of Interest

The authors report there are no competing interests to declare.

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**W. Gudrun Reijniere** contributed to this work as a senior researcher at IQ Health, Radboud University Medical Center. At that time, she was also an assistant professor at the Centre for Language Studies, Radboud University. Currently, Gudrun is an Assistant Professor of Language and Communication at Vrije Universiteit Amsterdam, where she studies the role of metaphor in science communication.