DOES MEAT CAUSE CANCER?
The discursive construction of meat carcinogenicity in a corpus of scientific texts

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Abstract – In 2015, the International Agency for Research on Cancer (IARC) published a report on the carcinogenicity of red and processed meat, incorporating red meat in Group 2A carcinogens (probably carcinogenic to humans) and processed meat in Group 1 (carcinogenic to humans). This announcement attracted immediate interest from other scientists, especially in medical research, where the relation between cancer and food has been investigated extensively for many years. This paper aims to analyze the discursive construction of meat carcinogenicity in a set of scientific papers published in the wake of the IARC communiqué. For this purpose, an electronic corpus was assembled from a range of academic journals featured in the database *Elsevier Science Direct*, for a total of 384,491 words, which were fully POS-tagged, partially parsed using a systemic functional grammatical formalism, and subsequently analyzed on Antconc. The methodology adopted to analyze these data is a combined corpus assisted discourse analysis approach, focusing mainly on experiential noun group structures, specifically those involved in patterns of nominalization, which typically aim to achieve monorefentiality in scientific discourse. However, in this corpus, the denotational boundaries of *meat* (what animal-based foods count as *meat* or *meat products*; what animals have *red* rather than *dark* or *white* meat; the exact nature of *meat processing*) are not entirely clear, and this "semantic debate" (Lippi *et al.* 2016, p. 2) is central to the preoccupations of medical and nutrition experts. Therefore, conclusions show that linguists could make a useful contribution to cancer science by devising a set of universally agreed definitions of meat types, so as to agree on the level of health risk that each may cause.

Keywords: corpus-assisted discourse analysis; Systemic Functional Linguistics; cancer; meat; IARC.

1. Introduction

This paper presents a corpus-based study of the discursive reaction of the scientific community[1] to the publication, in October 2015, of a report entitled

[1] As detailed in Section 3 of this paper, we consider agricultural, biological, biochemical, genetic, environmental, medical, dental and nursing sciences, as defined by categories used in the *Elsevier Science*

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Carcinogenicity of consumption of red and processed meat, issued by the International Agency for Research on Cancer, the IARC (International Association for Research on Cancer).

The aim of this study is to investigate how meat carcinogenicity is not only described in scientific papers published in the wake of this IARC communiqué, but also constructed, both scientifically and discursively.[2] The research questions we address involve the identification of the main discursive features used to construct meat carcinogenicity, and especially the reference of *meat* and its byproducts in extralinguistic reality. This concern is shared by linguistic and medical studies, as both undertake to achieve a univocal categorization of animals that provide *red meat*, and an unambiguous definition of *meat processing*. As a matter of fact, what counts as *red meat* and *meat processing* is not an objective datum, either in discourse or in science, as the reference of these expressions may vary across different languages and cultures.

To achieve this goal, firstly, we provide some theoretical background to this study, both sociocultural (the role, extent and understanding of meat eating in human nutrition today, according to a number of academic and popular scientific sources) and linguistic (ecolinguistic approaches to the discursive construction of animals as food). Secondly, we describe the dataset that was assembled for this study, and the way it was tagged and explored on corpus programs, to bring out significant patterns in the discursive construction of meat as a potential carcinogen. Thirdly, we illustrate the main findings of our study, focusing on the structure of the noun group, which exhibits a series of features of scientific language, typically aimed to achieve monorefentiality in the choice of terminology. Indeed, our data suggest a denotational uncertainty as to what exactly qualifies as *meat*, i.e.

- whether it includes poultry and fish;
- what animals correspond to the various colours of meat, i.e. whether pork should be considered *red*, and therefore identified as a potential carcinogen by the IARC, or if younger animals are better classified as *white*, and therefore uninvolved in this issue;
- finally, what exactly is meant by *processing*, i.e. whether *processed meat*, which the IARC considers certain to increase the risk of cancer, only

Direct database. Although the majority of the studies are medical, the sample includes all the articles which referenced the IARC report on meat carcinogenicity in or before August 2017.

[2] In this study, the notion of 'discursive construction' refers generally to the basic pragmatic concept that "speaking is doing", traceable to Austin's observation that "saying something will often, or even normally, produce certain consequential effects upon the feelings, thoughts, or actions of the audience" (Austin 1962, p. 101). Therefore, although the author is aware that this framework has been widely used in critical and socioconstructivist discourse theory, these further theoretical elaborations of the role of speech acts in constructing reality are beyond the scope of this paper.

includes foods made from pork, like bacon and salami, or also poultry-based ones, like chicken sausages and cold cuts obtained from turkey or fowls.

Finally, we present our conclusions, by addressing a recurrent issue in the scientific articles analyzed, i.e. the authors' surprisingly high level of metalinguistic awareness of the semantic conflict around what counts as meat, and also around what should be considered as evidence that meat may represent a health hazard. One article in our sample (Lippi *et al.* 2016) explicitly calls for cooperation between clinical scientists and linguists towards the definition of a set of universally agreed definitions of meat, trying to overcome the problem of culture-specificity in the understanding of what animals are good to eat, and/ or correspond to various meat colours. Suggestions are therefore made to take up this challenge, so as to enable consumers to receive more objective information than they can access now about the level of health risk that each animal-based food may cause.

2. Theoretical background

A recent *National Geographic Education* project, entitled *What the World Eats*,[3] has highlighted a generalized increase in the consumption of meat worldwide over the past few decades, especially in countries which have joined the capitalist society only in recent times, like China, but also in parts of the world that have a traditionally meat-rich diet. For example, in the United States, global meat consumption per person has increased by 30% between 1961 and 2011, despite public awareness of the risks of cholesterol, saturated fats, and other nutrients that especially certain meats are rich of: these health scares have apparently not affected the American consumer's hunger for meat, as beef alone has grown by 50% in terms of tons consumed over the five decades considered. Although, interestingly, seafood is considered a type of meat[4] in this *National Geographic* project, no attempt is made to categorize meat types according to colour: this, instead, is a fundamental preoccupation of the IARC study under discussion, as its findings state that *red* meat is likely to increase cancer risk, but they do not mention white. Figure 1 below, taken from a *Cancer Research UK* (CRUK)

[3] The project illustrates a detailed breakdown of food types and nutrients eaten by people in various countries of the world, in terms of grams and calories, with a special section about meat consumption, divided into types of animals eaten. The project, built in conjunction with the *National Geographic* series *Future of Food*, and based on FAO statistics, is freely accessible at https://www.nationalgeographic.com/what-the-world-eats/ .

[4] Fish is known to have an "ambiguous position" (Montanari 2015, p. 72) in many food cultures, probably because it is a Christian symbol. In fact, in the Middle Ages, eating fish was admissible during Lent and other 'lean' periods of the year, while dairy and eggs were excluded, due to their being excrete by animals.

commentary of the IARC report, and based on the IARC classification of carcinogens, illustrates a possible association between animals, meat types and processed food items.

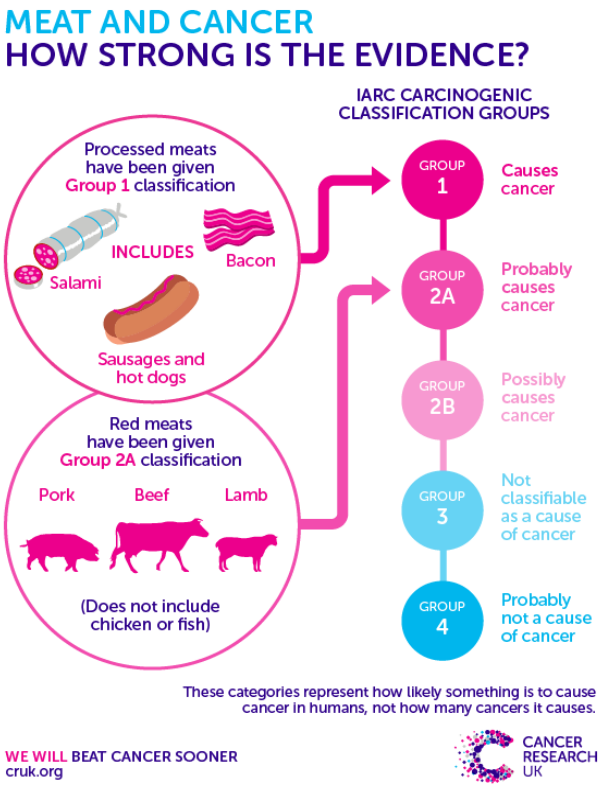

Figure 1
CRUK infographic on the relation between meat and cancer (Dunlop 2015).

Figure 1 suggests quite a neat and tidy breakdown of meat types in precise correspondence with animal species, with pork, beef and lamb qualifying as *red*, and chicken and fish being explicitly excluded from the IARC classification. However, this schematization is at least partially at odds with what the IARC itself writes in its report.

> Red meat refers to unprocessed mammalian muscle meat – for example, beef, veal, pork, lamb, mutton, horse, or goat meat – including minced or frozen meat; it is usually consumed cooked. Processed meat refers to meat that has been transformed through salting, curing, fermentation, smoking, or other processes to enhance flavour or improve preservation. Most processed meats contain pork or beef, but might also contain other red meats, poultry, offal (e.g. liver), or meat byproducts such as blood. (IARC 2015, p. 1599)

This contradiction between the CRUK and IARC categorization, as well as the slightly tentative language used by the IARC (as evidenced, for example, by the weak modal *might* in the excerpt reported above), is only partially surprising: as we see in Section 4 of this paper, the semantic scope of *meat* is at least partially open to interpretation, because it is culture-dependent. This uncertainty about what counts as what type of meat is also visible from the

top-left-hand area of Figure 1, where *salami*, *bacon*, and *sausages and hot dogs* are shown in the *processed meats* grouping, but the use of emphatic caps for the word *includes* suggests that there might be more items in this group.

Lexical issues like the correspondence between countable nouns identifying animals and mass nouns standing for their meat are actually quite widely studied in ecolinguistic literature, especially in the branch that looks at the discursive representation of animals, not only as food, but also as pets, pests, and other, often adopting a corpus assisted discourse analysis approach (Cook 2015; Gilquin, Jacobs 2006; Pak, Sealey 2015). This area of study has focused quite closely over the years on a variety of texts about the natural world, including animals, showing a tendency, especially but not exclusively in scientific and agribusiness registers, to use mass nouns, often in the experiential role of Classifiers, to describe animals used for food (e.g. meat, poultry, venison, fish). This implicitly reinforces notions whereby animals, or at least those we eat, are "mere tonnage of stuff" (Stibbe 2014, p. 595; Fusari 2017, p. 140; Fusari 2018a, p. 297-304). Scholars pursuing this strand of ecolinguistics, endeavouring to investigate the human understanding – or, sometimes, *mis*understanding – of environmental issues, including meat eating, typically claim to follow in the footsteps of M.A.K. Halliday, specifically his keynote address delivered at the 1990 World Congress of the International Association of Applied Linguistics (AILA). Here, Halliday denounced the existence of "a syndrome of grammatical features which conspire […] to construe reality in a […] way that is no longer good for our health as a species" (Halliday 1990, p. 193). This discursive construction conveys, or even "engrammatizes" (Halliday 1990, p. 198), the idea that environmental resources, including the animals we eat, are inexhaustible, and can be tapped indiscriminately to accommodate progressive human demographic, economic and industrial growth. Halliday concluded that "the semantics of growthism" is a kind of hegemonic discourse, just like classism and sexism, and that it is a problem for biologists and physicists just as much as it is for linguists (Halliday 1990, p. 199). In the specific case of meat, the "ethics of semantics" adopted when talking about it is considered a problem also by animal industry professionals, especially those in charge of taking decisions about how to provide consumers with information about "the processing stage, in which cattle are transformed to beef and chickens become broilers or roasters, breasts, and even more vaguely, nuggets" (Croney, Reynnels 2008, p. 389). This has a clear impact on the ideologies embedded in scientific discourse, as "the 'black-boxing' that is entailed by nominalization might indicate an acceptance of the proposition as no longer requiring discussion" (Hunston 2013, p. 626).

Vague language is especially favoured by the discourse of agribusiness industry, to spare the consumer the most gory details of animal production, in what is an instance of discursive erasure (Stibbe 2012), a set of discourse strategies often used not only by the meat industry, but also by various other businesses that use animals (Fusari 2017).[5] Through discursive erasure patterns, animals are effectively removed from public consciousness, e.g. by not discussing them at all, by referring to them through euphemisms, or most typically by "treating the living world in the same discursive way as a stock of objects" (Stibbe 2015, p. 152). While this contributes to making animal industry practices more socially acceptable, and to "calming down the consumers" (Domingo, Nadal 2016, p. 114) in relation to the environmental and ethical impact of meat eating, including potential diet-based health issues (Packwood Freeman 2009), it also tends to drastically simplify reality. For example, unsettled terminological issues include which animals are good to eat (e.g. horse meat is considered a very nutritious type of red meat in some countries, while it elicits disgust in others), which provide red, white and dark meat, and what exactly is meant by *processing*, *carcinogen* or *carcinogenic* (Vicentini, Grego 2018, p. 362). Even the nature of tinned products, like Spam, as either meat or as an entirely different semantic category, is a matter of debate. These classifications are rooted in cultural differences, and can be explained in terms of historical motivations (Montanari 1993; Rodriguez-Wittmann 2014), but they also have a crucial impact on the scope and representativeness of epidemiological studies, which are obviously influenced by the way members of research teams class meat and animal types in their respective languages and cultures. This is why the contribution of linguistic studies can prove fundamental for a better understanding of meat carcinogenicity.

3. Methodology

For this study, a combined corpus assisted discourse analysis methodology was adopted (Partington *et al.* 2013), first on an unannotated corpus, and subsequently by tagging the corpus both for Parts of Speech using the TreeTagger engine developed by Schmid (1994), and for some Systemic Functional grammatical categories, especially those related to experiential

[5] Stibbe has stressed many times that discursive erasure is a pervasive phenomenon, extending well beyond nominalization and euphemism, and reaching into more complex issues of human consciousness as reflected in language. Although, for these reasons, a univocal definition of erasure is rather difficult to provide, it can be defined as "a story in people's minds that an area of life is unimportant or unworthy of consideration. An erasure pattern is a linguistic representation of an area of life as irrelevant, marginal or unimportant through its systematic absence, backgrounding or distortion in texts" (Stibbe 2015, p. 146).

meanings expressed in Transitivity patterns. This kind of grammatical tagging, based on a systemic formalism, can now be performed in a semi-automatic way, on a specialized corpus program developed by Mick O'Donnell at the Universidad Autonoma de Madrid, the UAM Corpus Tool (O'Donnell 2011). However, quite a lot of manual editing is still required, due to the presence of a physiological rate of error in the software output. This error rate should not be considered to be a limitation of the UAM software, but it is best viewed as intrinsically connected with the multi-tiered nature of Systemic Functional Linguistics, which entails the frequent conflation of functions in a single element, and is also sometimes open to interpretation, or multiple possibilities, in the grammatical labelling that can be associated with each phraseological pattern (Fusari 2016, p. 249). The deriving complications for corpus tagging can be more or less severe depending on the level of detail, or "delicacy" (Halliday, Matthiessen 2004, p. 45) that the researcher aims to achieve, but they cannot be fully eliminated, making the Systemic Functional grammatical formalism by far the most difficult to tag automatically in a corpus (O'Donnell 2005; O'Donnell, Bateman 2005; Fusari 2016). It is also, however, the most rewarding type of tagging for a meaning-centred analysis like the one performed in this study, because "the labelling of [Systemic Functional] grammatical features provides an interface to analysis at higher levels of abstraction that formal markup cannot, and does not aspire to, achieve" (Bartlett, O'Grady 2017, p. 6). These higher levels may include rhetorical strategies, which previous research has identified as being central to the way scientific beliefs about health issues are socially constructed, both within the relevant discourse communities, and among the general public (Arluke, Cleary, Patronek, Bradley 2018, p. 218). The lexicogrammatical features of scientific language (Halliday, Martin 1993) that contribute to construct the discursive reality of meat carcinogenicity are therefore better analyzed within a social semiotic (Halliday 1978, p. 2; Hestbaek Andersen, Boeriis, Maagerø, Seip Tonnessen 2015; Matthiessen 2017) than a structurally oriented methodological framework.

The corpus used for this study was assembled from *Elsevier Science Direct*, a large database of research journals available on subscription, looking for the keywords *IARC*, *meat,* and *cancer* in the sections:

- Agricultural/ Biological Sciences;
- Biochemistry;
- Genetics/ Molecular Biology;
- Environmental Science;
- Medicine/ Dentistry;
- Nursing/ Health Professions.

The search was made in August 2017, retrieving 39 articles, for a total of 384,491 words, complete with all references and appendixes. Files were then converted from PDF to TXT for perusal on Antconc (Anthony 2014).

The analysis related in this paper was also preceded by a pilot study (Fusari 2018a), performed in December 2015, which proved instrumental to the identification of the research questions worth addressing in subsequent studies such as the present one. The pilot study analyzed the discursive reactions to the IARC report not only from scientific sources, but also from animal rights ones, showing a high degree of intertextuality and register hybridity in the discursive construction of this scientific fact. The pilot study involved a much more restricted set of data (just below 50,000 words), to facilitate a manual close reading of all the texts, and as a way to test the reliability of automatic or semi-automatic corpus analysis, especially in relation to Systemic Functional tagging. The features analyzed (vocabulary, grammatical metaphor, and aspects of evaluative language, or Appraisal) showed that animal rights sources tended to appropriate the typical features of scientific language, mainly nominalization and the experiential structure of the noun group more generally (Bloor, Bloor 2013, pp. 140-148), to increase their credibility and claim for objectivity, while in fact their discursive aim was not so much informative as it was persuasive, i.e. trying to exploit the IARC communiqué to strengthen their arguments to convince people to go vegan. However, not even the scientific texts analyzed in our pilot study (two medical and one in the area of natural science) were devoid of ideological import, as they were not particularly concerned with the carcinogenicity of meat *per se*, or with the intrinsic truthfulness of the IARC findings, but largely evaluating the adherence of the IARC and other studies to the methodology of modern science, and therefore also their respect of the discursive order of science.[6] As these results seemed very promising not only for discourse analysis, but also for the study of genre integrity, hybridization, colonization, bending and mixing (Garzone 2015, p. 685), a decision was taken to expand the corpus, starting from scientific articles, as reported in this paper, and leaving animal rights texts as a potential development for further research.

4. Data and discussion

Given the focus of this study, and the keywords that were retrieved from *Elsevier Science Direct* to build the corpus, it is unsurprising that *cancer* and

[6] This is quite typical of the contemporary language of science, as "the method of science is realized again in the discourse it uses" (Tribble 2017).

meat are the two most frequent lexical words, and that the most recurrent premodifiers of *meat* are *red* and *processed*, in the noun group *red and processed meat*, referring intertextually to the title of the IARC report under discussion. What is more interesting is that there seems to be a denotational difference between the conventional use of *meat* as an uncountable mass noun, and its plural, *meats*, which in these texts identifies meat that is in some way unconventional. These *meats* may include less typically eaten animals (e.g. ostrich), and meat substitutes for vegetarians, vegans, as well as for those increasing numbers of people who are not strict vegetarians, but try to reduce the amount of meat they eat, and describe themselves (or, to be more accurate, are described by nutritionists, e.g. Graça, Oliveira, Calheiros 2015, p. 87) as 'flexitarians'.

The relation between the two most frequent lexical words, *cancer* and *meat*, is consistently (332 hits) framed as one of *causal/ clear/ neutral/ overall/ convincing/ positive/ potential/ reported/ (non/no/statistically) significant/ strong/ weak association*, evaluated not so much against hard data, but more often in a set of 'meta-analyses', i.e. secondary analyses of previous observational or statistical studies, including, but not limited to the IARC's. This emphasis on observing a cancer-meat *association* (more rarely, *connection*) in the scientific literature confirms findings from our pilot study, referenced in Section 3 of this paper, showing that the main concern of the articles is not meat carcinogenicity in itself: the focus is rather on the adherence of the IARC and other studies to the methodology of modern science, and therefore also on their respect of the discursive order of science more broadly defined. In this sense, the intrinsic truthfulness of the IARC findings, or the extent to which they should revolutionize the public's eating habits to protect them against cancer risk, is beside the point: what matters is the rigour of the scientific analysis provided, as well as the soundness of its methodological approach.

Table 1 illustrates the 20 most frequent lexical words in our corpus,[7] highlighting the articles' tendency towards nominalization (e.g. *consumption*, *intake*) and intertextual reference to the IARC and other research (e.g. *study/ies*, *analysis*) which may reveal a scientifically significant association (e.g. *associated*) between eating meat, especially in large amounts (e.g. *high*), and developing cancer, especially certain types (e.g. *gastric*).

[7] The query was restricted to nouns and adjectives to facilitate the identification of patterns of nominalization and agency in ideational experiential analysis. As shown by the presence of two forms of the word *study* in Table 1, the corpus is still unlemmatized at this stage in the project.

Rank	Freq	Word
1	3469	cancer
2	3207	meat
3	1690	food
4	1442	risk
5	1161	consumption
6	985	health
7	959	red
8	815	studies
9	755	dietary
10	755	study
11	722	processed
12	713	analysis
13	703	intake
14	677	products
15	663	human
16	628	high
17	618	diet
18	553	gastric
19	514	associated
20	499	total

Table 1
Most frequent nouns and adjectives.

Although frequency alone, as illustrated in Table 1, is not necessarily revealing of the nature of texts (Baron, Rayson, Archer 2009), calculating word frequency is a good starting point for most corpus analyses, especially for fairly small specialized corpora like the one under analysis here, as it tends to highlight both the topics that are most frequently mentioned in the texts, and the order of magnitude of the data at hand (Fusari 2018b, p. 6). To interpret frequency correctly, it is, however, always necessary to take a step further towards investigating patterns of use, as evidenced in collocations, word clusters and concordances.

The collocate list of *meat* (Table 2), obtained with Mutual Information[8] and sorted by frequency, also shows the repetitive behaviour of some keyword clusters (e.g. *red and/ or processed meat consumption*), as well as the most important terms associated with *meat* in the articles, which are indicative of the authors' interest in the semantic relation between meat, its colour (e.g. *red*, *white*), and the animals that may provide it. These include not only *poultry*, *fish* and *beef* (which appear in Table 2 as the most frequent), but also *pork*, *lamb* and *goat*. All these animals are classed as providing red meat, except in two articles (Domingo, Nadal 2017; Lippi *et al.* 2016), which

[8] Mutual information is one of the most commonly used statistical collocation extraction techniques. Specifically, "mutual information is the quantity that measures the mutual dependence of the two words/word combinations" (Metin, Karaoğlan 2011, p. 177).

mention animal age as a factor leading to the potential classification of young pigs as providing *white*, rather than *red* meat, possibly as a result of lower heme iron concentration in their muscles.

Rank	Freq	Freq L	Freq R	Stat (MI)	Collocate
1	1659	707	952	389.551	and
2	1290	1052	238	346.591	of
3	1050	967	83	703.637	red
5	758	379	379	482.463	meat
6	710	571	139	688.140	processed
7	613	170	443	598.417	consumption
8	359	50	309	599.041	products
9	326	141	185	448.613	or
10	225	154	71	575.647	total
11	210	54	156	516.245	intake
12	197	47	150	276.733	cancer
13	178	29	149	388.746	risk
14	100	3	97	522.751	science
15	96	88	8	698.275	artificial
16	79	29	50	622.068	poultry
17	75	24	51	412.878	associated
18	68	9	59	528.569	fish
19	68	28	40	436.734	beef
20	67	22	45	488.952	quality

Table 2
Collocates of *meat*, first 20 hits sorted by frequency.

Clusters on left and cluster on right (Table 3 and 4) of *meat* show that, while most articles[9] restrict their focus to the subject of the IARC report, i.e. red and processed meat, others open up the space for an extension of other animal-based foods that may play a role in cancer (e.g. *meat and meat products*, *meat and charcuterie*, *meat and fish*, *meat and dairy* in Table 3), or mention the existence of alternative meat-like products (some *artificial*, Table 4), which may be safer from the point of view of cancer risk, but could also, at the same time, satisfy the consumer's hunger for meat.

[9] The number of articles in which each cluster appears is shown in the column entitled 'Range'.

Rank	Freq	Range	Cluster
1	398	20	meat consumption
2	162	22	meat products
3	122	16	meat intake
4	104	12	meat and meat
5	81	8	meat science
6	41	4	meat quality
7	37	4	meat production
8	25	12	meat and processed
9	24	2	meat and charcuterie
10	21	8	meat and fish
11	19	2	meat quality traits
12	18	1	meat quintile
13	13	6	meat and dairy
14	11	5	meat cooking
15	11	5	meat processing
16	11	1	meat quartile
17	10	2	meat and pancreatic
18	10	2	meat substitutes
19	10	4	meat-based
20	10	5	meat and colorectal

Table 3
Word clusters with *meat* on left.

Rank	Freq	Range	Cluster
1	639	28	red meat
2	486	33	processed meat
3	86	1	artificial meat
4	85	20	of red meat
5	73	2	total red meat
6	49	2	cultured meat
7	45	5	total meat
8	43	2	white meat
9	34	6	consumption of meat
10	32	2	processed red meat
11	26	9	cooked meat
12	22	3	effects of meat
13	22	2	in vitro meat
14	21	5	cured meat
15	18	6	type of meat
16	17	3	eating meat
17	17	3	samples of meat
18	16	3	conventional meat
19	15	1	imitation meat
20	14	2	poultry meat

Table 4
Word clusters with *meat* on right.

The clusters also highlight a preoccupation with the amount and cooking methods of meat (i.e. *quintile*, *quartile* and *cooking* in Table 3; *total* and *cooked* in Table 4), as well as with the body organs for which the evidence of a relation between cancer and meat consumption is stronger (*pancreatic* and *colorectal* in Table 3).

Another issue that emerges from these data is whether *poultry* and *fish* count as meat: not all articles espouse the classification of poultry as a kind of meat, as some refer to *cooking or processing of white meat and poultry*, *enhanced/ high intake of white meat or poultry*, *fermented meat or poultry*, making a distinction between the two. Although the FAO/ WHO Food Standards Programme, in its Codex Alimentarius,[10] defines meat as "all parts of an animal that are intended for, or have been judged as safe and suitable for, human consumption" (Codex Alimentarius Commission 2005, p. 6), so potentially including not only birds, but also fish, consumer perceptions are actually much more variable. Even the *Dietary Guidelines for Americans* (U.S. Department of Health and Human Services, U.S. Department of Agriculture 2015), an official US government report published every 5 years, is not entirely clear on whether *poultry*, *meat* and *fish* fall within the same subgroup of *total protein*, or qualify as distinct foods (McNeill, Belk, Campbell, Gifford 2017, p. 37).

Other areas of semantic uncertainty, as briefly seen above, extend to the association between animals and meat colours. Some articles are very explicit in stating that the colour of meat, as well as its breakdown into food types, e.g. *processed meat*, may vary greatly across cultures. Semantic ambiguities in this context include the reference of *charcuterie* (Table 3) and *cured meat* (Table 4) as including or excluding products that are made from the meat of chickens, and the status of *dark* meat as identifying some specific parts of animals (i.e. the thighs and legs of chicken, turkey and fowl) which actually qualify as providing *white meat* when the body of the animal is considered in its entirety. This semantic debate has an obvious impact also on the evaluation of the degree of cancer risk that each of these meat types or products may pose, as what exactly counts as what meat colour remains open to interpretation.

Cooking methods are also brought into cause by some of the texts in this corpus, as a culture-specific variable that may affect not only the understanding, but also the degree of carcinogenicity of different types of meat and meat products. For example, a particular combination of deep frying, high cooking temperatures, food drying, and spice use by Indians is mentioned in one article (Gandhi *et al.* 2017) as being implicated in raising the rate of

[10] The Codex Alimentarius is a collection of food safety standards developed by a joint FAO/WHO Commission established in 1963. The full list of Codex standard and guidelines is available on the FAO website: http://www.fao.org/fao-who-codexalimentarius/codex-texts/all-standards/en/.

stomach cancer, despite low red meat intake. This suggests that consumer behaviour and cultural practices, like cooking, may be as important as food choices in terms of health. In fact, although the wide majority of the texts in this corpus are clinical studies, they exhibit a constant preoccupation not only with how consumers cook their food, but also with how they think and feel about it, as shown in the concordance in Table 5.

1	raises an important problem of acceptance by **consumers**. A third route for the future is simply
2	should not mean adverse health effects for the **consumers**, a number of issues (e.g., specific fish and
3	50% uptake seems unlikely to be acceptable to **consumers**. Consumer acceptability barriers in some
4	global adoption of insects as a food source is **consumer** acceptability (Looy et al., 2013; Shelomi,
5	and Schlüter, 2013). But issue of limited **consumer** acceptability is prevalent particularly in western
6	, Roosen, J., & Bieberstein, A. (2014). **Consumer** acceptance of new food technologies: Causes and
7	the objective messages to society. 5.3. **Consumer** food purchasing behavior. Consumer acceptance
8	appearance and aroma, and having high **consumer** acceptance (http:// www.likemeat.eu/). These
9	D. (2015). Impact of terminology on **consumer** acceptance of emerging technologies through the
10	. However, some experts showed that **consumer** acceptance of meat substitutes depends mainly on
11	factor in purchase decisions. Without **consumer** acceptance, otherwise appropriate food processing
12	sensory congruence issues and good **consumer** adhesion. In the case of food additives and
13	ever, policymakers, researchers and **consumers** alike are often overwhelmed by the complexity of
14	ally significant differences between **consumers** and non-consumers of these meats in case-control
15	matrices, which is important for both **consumers** and food manufacturers for producing healthier
16	the combination of food discarded by **consumers** and due to over-consumption halves from the
17	(Neu5Gc) into the tissues of red meat **consumers** and the subsequent interaction with inflammation
18	to note that, depending on the type of **consumer** and his/her expectations, it appears possible to
19	ally linked to the standard of living of **consumers** and is therefore of a financial nature which
20	eat product is hugely important to the **consumer**, and in some cases overrides fear of chemicals and

Table 5
Concordance of *consumer** (including plural), first 20 lines sorted right, first 20 lines.

Consumer *acceptance*/ *attitudes*/ *behavior(u)r*/ *choice*/ *demand*/ *expectations* etc. are actually seen as having an impact on all aspects of the relationship between meat eating and human health, from the possibility to market meat substitutes (both natural, like tofu, seitan and insects, and artificial, like in vitro/ cultured meat) to the scientific validity of epidemiological studies (for example, participants in research investigating eating habits are described as not being always accurate when they estimate the amount and type of food they eat), reaching to linguistic issues, both in doctor-patient communication (i.e. educating individuals to eat or avoid certain foods to live a healthier life) and in communication campaigns (i.e. information provided by government agencies to make scientific discoveries understandable by the general public, often through the filter of their specific policy priorities). The concordance in Table 5 can only provide a limited amount of context, for reasons of space, but it still manages to capture the multifarious dimensions of consumer acceptance in relation to meat eating, e.g. whether – often depending on their culture of origin – they will consider insects to be edible and to fall within 'meat' (line 4); how food technologies like GMOs or in vitro meat can work

for environmentally-minded consumers (line 6 and 9); and what role meat substitutes (line 10) and chemical additives (lines 12 and 20) may play in their choices. Overall, concordance data extracted from this corpus show that, in medical research papers, the consumer is not discursively constructed as a passive or impotent spectator of the meat/ cancer debate, but as a fundamental player in the response to new scientific narratives and discoveries about the relation between health and food more generally. This dialogic scenario, with consumers playing an active role in negotiating science through discourse, has also emerged in a recent linguistic study of the same IARC communiqué (Vicentini, Grego 2018), focusing on how meat carcinogenicity was reported to the general public both by the media and by scientific institutions.

As many as five articles in our own corpus mention *terminology* as having a direct impact on consumer acceptance of food and food processing technologies, showing quite a high level of metalinguistic awareness on the authors' part, including about the heterogeneity of meat definitions. Other articles dwell on the rhetorical strategies that could or should be used to either "calm down the consumers" (Domingo, Nadal 2016, p. 114), or to make them take action to reduce the amount of meat they eat, and it is suggested that this should be done by using "positive language" (Arena *et al.* 2017, p. 425), i.e. not by recommending that meat eating be avoided completely, like tobacco smoking,[11] but by presenting meat avoidance as an opportunity to try out new foods and enjoy a more varied diet. The use of metaphor is explicitly mentioned in one article as a potential communication tool to achieve this goal:

> While there are several metaphors to use to describe and explain actions once a person has been diagnosed with a chronic disease, there are very few metaphors to discuss the ways we prevent disease and promote HL[12] behaviors. Metaphors have profound influences on how people attempt to solve problems, particularly health problems. The ways in which we choose to message promotion of HL behaviors or prevention of chronic disease can have a profound effect on whether an individual is persuaded to act accordingly. The use of positive language or asset modeling are far superior in terms of prevention. (Arena *et al.* 2017, p. 425)

Another, even more basic metalinguistic issue that recurs in this corpus is the referent of meat itself, i.e., what we mean exactly by *meat*, and the denotational and connotational differences with other related words, like *muscle* and *protein*, as shown in the example below, taken from an article about the possibility to grow artificial meat from stem cells:

[11] The IARC has classed processed meat in the same group of carcinogens, 1A, as cigarettes, but this does not necessarily mean that meat and tobacco are equally dangerous, as explained in a FAQ list published by the World Health Organization in the wake of the publication of the IARC report under discussion (WHO 2015).

[12] The acronym HL stands for 'Healthy Living', as explained in the same article.

> The fact that artificial meat proponents have called their product "artificial meat" and not "artificial muscle" or even "artificial muscle proteins" (which would be more accurate) recognises implicitly that the word *meat* represents positive values: so, for example, meat is a symbol of force (inherited from the fact that primitive hunters had to be strong to hunt wild animals) and of high nutritional value (meat provides proteins in quantity and quality and many micro-nutrients which are beneficial for health) […] In fact, meat is a widely-consumed food in the world in different forms (fast cooking, slow cooking, ready-prepared meals, cured meats etc.), which shows how popular it is. In reality […] the product which is produced by stem cell culture is, from a strictly technical and semantic point of view, muscle tissue, (and even this point can be debated) and not meat. (Hocquette 2016, p. 169)

However, perhaps the clearest indication of how important it would be to achieve a set of universally agreed definitions of meat subtypes is in one of the very first articles that appeared in an *Elsevier Science Direct* journal in the wake of the IARC communiqué (Lippi *et al.* 2016). This article, an oncology paper published as a pre-print in 2015, and also investigated as part of our pilot study (Fusari 2018a) mentioned in Section 3 above, describes setting the "semantic debate" on what animals correspond to what meat colour, and providing a decisive definition of "processing", as "unavoidable steps in future clinical studies aimed to investigate the association between meat consumption and cancer" (Lippi *et al.* 2016, p. 12). The contribution linguists could make towards taking these steps is no doubt fundamental, and it is a challenge for further research, in both medicine and linguistics together, as we see in our conclusions.

5. Conclusion

This paper has investigated the discursive construction of meat carcinogenicity through a case study of a series of scientific articles that were published shortly after the release of the announcement that the IARC had placed red and processed meat in its list of cancer-causing agents. The IARC's is not the only existing classification standard for carcinogens,[13] but it is very well reputed throughout the scientific community, so this statement had a tremendous impact both on science and in the media, arousing, at the same time, interest and controversy (Kelland 2016).

Although the sources we have examined show that scientists are very preoccupied with consumer acceptance when making recommendations and drawing conclusions about eating habits, it appears quite clear that the aim of these publications is *not* to inform consumers about the potential health hazard of eating certain types of meat: the addressees of the articles under

[13] Other standards have been developed mainly in the United States, by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Toxicology Program (NTP).

investigation are other scientists involved in cancer studies, who are co-constructing the connection between various types of meat-based foods and the development of cancer in humans. In doing so, scientists are providing each other with references and evaluations, often in the form of meta-analyses, which are necessary to make a scientific claim acceptable by the methodological and discursive conventions of the scientific community. This is why, in communicating with the general public, the WHO has been much more explicit than the IARC has been in its original report (IARC 2015), stating that "the latest IARC review does not ask people to stop eating processed meats" (Härtl 2015). Such an invitation is never extended in the articles in our corpus, as it would simply fall outside the scope of scientific literature.

Scientific literature, as exemplified in the small corpus we have investigated, does not actually aspire to provide some "silver bullet" truth[14] that will settle a given matter definitively, either for the public and or for other scientists. Its aim is rather to "persuade readers [i.e. other members of the relevant discourse communities] of the scientific acceptability of the knowledge claims presented" (Allen *et al*. 1994, p. 280), especially through the rhetorical instruments of cross-reference and evaluation. It would certainly be unfair, and perhaps also grossly misplaced, to state that the only, or even the main preoccupation of scientific literature is rhetorical: however, at the same time, it is undeniable that rhetoric plays a vital role in linguistically constructing the reality of modern science, both in terms of metadiscourse (Hyland 2017) and in more fundamentally grammatical ways (Halliday 1989).

As concerns the studies assembled in our corpus, to make it even clearer that their fundamental concern is not the intrinsic truthfulness of their findings, but their adherence to the methodology and discursive order of modern science, the WHO (2015) has explicitly addressed one specific issue raised by the general public, i.e. the fact that processed meat has been placed in the same category of carcinogens as cigarettes and asbestos:

> Processed meat has been classified in the same category as causes of cancer such as tobacco smoking and asbestos (IARC Group 1, carcinogenic to humans), but this does NOT mean that they are all equally dangerous. The IARC classifications describe the strength of the scientific evidence about an agent being a cause of cancer, rather than assessing the level of risk. (WHO 2015, p. 9)

The difference between "strength of scientific evidence" and "level of risk" in the excerpt above may be less than clear for a non-specialist audience (as the public may rightfully believe that there is a cause-effect relation between

[14] On the problematic and multiple notions of truth in medical writing, see Skelton 1997.

the two) but it is a very important distinction in terms of the discursive construction of a scientific fact.

Our study has highlighted another area of semantic uncertainty that raises fundamental questions about how consumers should be informed about the level of health risk involved in meat eating, i.e. the exact meaning of the word *meat*. Some examples shown in Section 4 of this paper have actually revealed quite an amazing level of metalinguistic awareness on the part of medical scholars writing about the IARC report, specifically in conjunction with a set of culture specific issues, e.g. the colours, ethical values, and cognitive metaphors that are associated with eating animals. The branches of linguistics that are explicitly mentioned in this corpus as capable of making a useful contribution to medical research on the meat-cancer relation run the gamut of our fields of study, including terminology, metaphor, rhetoric, and ethnolinguistics.

Perhaps the most stimulating development for further research in this area would consist in taking up the challenge launched by one of the articles collected in this corpus (Lippi *et al.* 2016), which quite openly calls upon linguists to help epidemiologists and clinicians develop a set of universally accepted definitions of meat and of its various byproducts. Such definitions are expected to be instrumental in overcoming the multiple issues of culture-specificity that make the existing terminology databases and taxonomies in this branch of medical studies still largely inconclusive and less than comprehensive.

However, the very fact that these concepts are specific to different cultures may actually make it rather complicated to reach a universal terminological agreement, and especially to bring it home to the general public, who are likely to continue thinking of meat in terms of the associations it has in their cultures.

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