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Larissa D'Angelo / Stefania Consonni (eds.)

New Explorations in Digital Metadiscourse

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New Explorations in Digital Metadiscourse

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Cross-semiotic metadiscourse in science: Visual and verbal epistemicity in digital *vs*. analogue media

1. Introduction

This chapter examines visual-cum-verbal strategies for expressing epistemicity (i.e. extrinsic, propositional or speaker-oriented modality) in scientific discourse and the use thereof in two different media, namely, typically analogue resources such as research articles and newly established on-screen products, in particular digital synopses. The analysed domain is that of specialized medical communication, as one exemplarily involved in today's co-semiotization processes (Iedema 2001; Jakobson 1959; O' Halloran / E / Podlasov / Tan 2013; O' Halloran / Tan / Wignell 2016), whereby scientific knowledge, both new and pre-existing, is progressively being transferred by means of increasingly hybrid and propagative genres, made available by new information graphics technologies and the Web (Lorés 2021; Rebuske Hendges/Salete Florek 2019; Sancho-Guinda 2016, 2021).

Commonly referred to as the 'mode of knowledge', epistemicity codifies the speaker's opinion about the truth proposition of an utterance's ideational contents (Coates 1983; Greenbaum/Quirk 1990; Nuyts 2001; Palmer 2001). Grammatical and lexical resources are chosen from verbal language for their axiological connotations, in order to convey such concepts as the possibility (or lack thereof), high (or low) probability, necessity or certainty that specific scientific facts, or hypotheses, will occur in specific settings. However, the increasing weight conferred in recent decades to visuals and graphics in research articles, and even more so in digital synopses, with the aim of improving and accelerating the consumption, retention and circulation of complex contents, has brought about cross-semiotic inflections of

epistemicity, based in fact on the semantic potential that hybrid constructs can deploy in multi-literacy contexts (Lemke 1998).

The purpose of this study is, firstly, to investigate how the interplay of different semiotics construes the truth status of scientific discourse, simultaneously encoding epistemicity from two different corners of the "scripto-visual pyramid" (Rowley-Jolivet 2002: 28), thus combining verbal (i.e. discontinuous, abstract, temporal) and visual (i.e. contiguous, sensorial, spatial) signs in the textualization of evidence-based knowledge. Secondly, since analogue and digital media deploy verbal and visual language in different proportions and with increasing hybridity, I will look into the epistemological impact that is produced by different versions of word-visual metadiscourse (Saint-Martin 1995; Iedema 2003). Being more radically visually oriented than on-page genres, as well as more linguistically oriented than traditional screen genres such as film and TV (Kress 2003, 2010), computer-mediated screen genres have in fact boosted the multimodal meaning-making potential of scientific communication, thereby showcasing the cognitive affordances brought about by incorporating visualization to verbal contents in specialized knowledge frameworks.

However, and more generally, is co-semiotization to be strictly interpreted as a one-way cultural drive towards the heuristic power of visualization? To deal with this question, I will consider those cases when – within and across discursive artefacts – meanings that may be coaxed into visual structures are also analytically re-encoded by way of linguistic representation. My working hypothesis is that co-semiotization may in fact work both ways, dependent on the specific communicative rationale of different genres with respect to different referential and pragmatic functions. To explore patterns of commonality and change across semiotic environments and media, and to examine how metadiscourse contributes to construe, validate and transfer the truth value of scientific discourse, is therefore the overarching aim of this chapter.

2. Materials

For the purpose of this analysis, I have collected a corpus of 40 open-access research articles and 40 matching digital synopses, published online from December 2017 to June 2018 in the *British Medical Journal* and covering a variety of clinical topics, from diagnostics to surgery, therapy and epidemiology.[1] As of late 2017, the journal has in fact started publishing contents in both formats, so that readers – that is to say, fellow physicians and health specialists – may choose between traditional IMRD scientific prose, i.e. the classical Introduction, Method, Results, Discussion argumentative sequence (Fig. 1 below), and synoptic infographic products (Fig. 2 below).

Designed for interactive full-screen consultation, much in the fashion of structured abstracts, digital synopses provide a ready-to-consult visual transmutation (Jakobson 1959) of a matching research article, thus working as both 'stand-alone mini-texts' (without readers having to read the whole paper), and potential cues to the quick indexing and retrieving of the full article itself (Huckin 2001).

As shown in Fig. 2 below, the typical synopsis in the BMJ corpus is connected to the matching full article by a hyperlink (at the bottom), and composed of several argumentative sections, generally replicating the IMRD structure, which display linguistic parts, as well as graphical items and icons. These sections share the same layout and are interrelated – both separated and linked – by vertical or horizontal blank (or coloured) spaces, bold lines, arrows, geometrical patterns, icons and symbols, etc., reproducing the logical connections and transitions that build the linguistic framework of the IMRD structure. A genre belonging to the universe of data visualization, that is to say, the structuring of empirical data into patterns that combine different sign systems such as words, symbols, icons and indexes (Benking 2005; Kiryuschchenko 2015), digital synopses use graphical representations that facilitate the identification and comparison of qualitative

[1] This will be henceforth referred to as the BMJ corpus.

information, such as processes and procedures, in terms of spatial relationships, networks, diagrams and hierarchies (Friendly 2009).

CLINICAL UPDATES

OPEN ACCESS

Diabetic foot

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Foot disease affects nearly 6% of people with diabetes[1] and includes infection, ulceration, or destruction of tissues of the foot.[2] It can impair patients' quality of life and affect social participation and livelihood.[3] Between 0.03% and 1.5% of patients with diabetic foot require an amputation.[4] Most ulcers can be prevented with good foot care and screening for risk factors for a foot at risk of complications.[5] We provide an update on the prevention and initial management of diabetic foot in primary care.

What causes diabetic foot?

Uncontrolled diabetes contributes to the development of neuropathy and peripheral arterial disease by complex metabolic pathways.[6] Loss of sensation caused by peripheral neuropathy, ischaemia due to peripheral arterial disease, or a combination of these may lead to foot ulcers. A systematic review (78 studies from 84 cohorts) reports a prevalence of 0.003-2.8% for diabetes related peripheral neuropathy and 0.01-0.4% for diabetes related peripheral arterial disease.[6] Figure 1 depicts factors that contribute to foot complications.

Diabetes is also implicated in Charcot arthropathy, which involves progressive destruction of the bones, joints, and soft tissues, most commonly in the ankle and foot. Diabetes related Charcot's arthropathy has a reported prevalence between 0.08% and 13%, but there are no high quality epidemiological studies on Charcot's foot.[7 8] A combination of neuropathy, abnormal loading of foot, repeated micro trauma, and metabolic abnormalities of bone leads to inflammation, causing osteolysis, fractures, dislocation, and deformities.[9]

WHAT YOU NEED TO KNOW

- Diabetic foot can be prevented with good glycaemic control, regular foot assessment, appropriate footwear, patient education, and early referral for pre-ulcerative lesions
- Examine the feet of people with diabetes for any lesions and screen for peripheral neuropathy and peripheral arterial disease, which can lead to injuries or ulceration
- Refer patients with foot ulceration and signs of infection, sepsis, or ischaemia immediately to a specialised diabetic foot centre for surgical care, revascularisation, and rehabilitation

Sources and selection criteria

This clinical update is based on recommendations in the standard treatment guideline, The diabetic foot: prevention and management in India 2016, published by the Indian Ministry of Health and Family Welfare.[10] A multidisciplinary guideline development group consisting of surgeons, primary care practitioners, and a patient representative developed these guidelines, with inputs from experts in diabetes, diabetic foot rehabilitation, and vascular surgery. The group included representation from rural and urban India, and public and private sectors.

The guideline development group selected recommendations from the National Institute for Health and Care Excellence clinical guideline 19. Diabetic foot problems: prevention and management. Updated 2016, International Working Group on the Diabetic Foot guidance on the prevention of foot ulcers in at-risk patients with diabetes 2015, National Institute for Health and Care Excellence. Peripheral arterial disease: diagnosis and management. Guideline 147, 2012, and Infectious Diseases Society of America clinical practice guideline for the diagnosis and treatment of diabetic foot infections, 2012.[9 10 11 12] Some recommendations were adopted unchanged, whereas others were adapted taking into account the challenges of a low resource setting, such as availability of public and private health infrastructure, equipment, staffing, and current capacity at different levels of care.

In low and middle income countries barefoot walking, lack of awareness, delay in seeking care, and shortage of trained healthcare providers and foot care services are common factors that add to the burden of foot disease.

How is it diagnosed?

A thorough foot examination is important to detect the disease early. Screening for peripheral neuropathy and peripheral arterial disease can help identify patients at risk of foot ulcers. A history of ulcers or amputations and poor glycaemic control increase the risk.

Assess the patient's general condition for signs of toxicity or sepsis such as feeling unwell, looking sick, showing abnormal behaviour, circulation, or respiration, with or without fever. Examine the feet at each follow-up visit for active disease such as ulceration or gangrene

HOW PATIENTS WERE INVOLVED IN THE CREATION OF THIS ARTICLE

No patients were involved in the creation of this article.

Fig. 1. Typical research article in the BMJ corpus (opening page). *Diabetic foot*. Retrieved from <www.bmj.com/ content/bmj/359/bmj.j5064.full.pdf>.

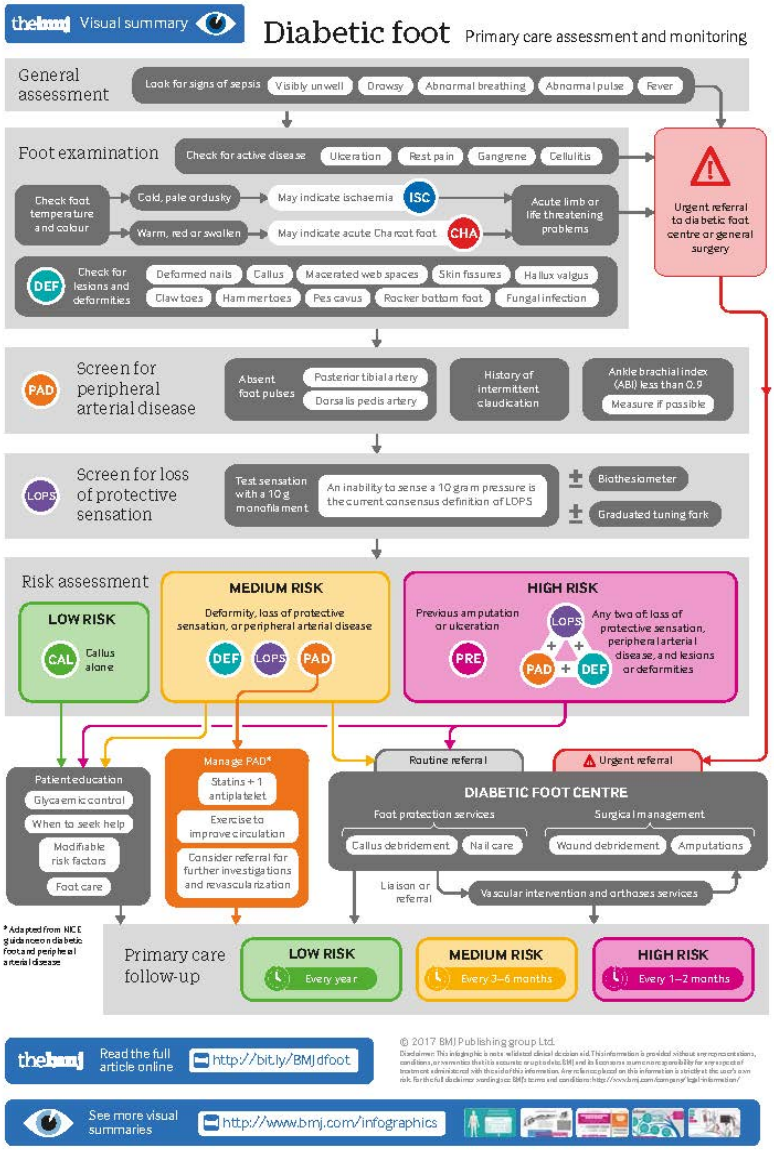

Fig. 2. Typical digital synopsis in the BMJ corpus. *Diabetic foot*. Retrieved from <www.bmj.com/content/bmj/suppl/2017/11/16/bmj.j5064.DC1/chas041916.ww1.pdf>.

The BMJ corpus comprises a total of 166,689 running words and 342 visuals, the distribution of which in the subcorpora is presented in Tab 1.

	Running words	*Visuals*
RESEARCH ARTICLES (40)	151,349	37
	(90.1%)	*(10.8%)*
DIGITAL SYNOPSES (40)	15,340	305
	(9.9%)	*(89.2%)*
TOT.	166,689	342

Tab. 1. Distribution of running words and visuals in the BMJ corpus.

3. Method

Within the framework of Systemic Functional Grammar (Halliday 2004), and incorporating metadiscourse studies, social semiotics and medical linguistics, this study contrasts verbal and visual expressions of epistemicity across two genres in scientific literature, with the purpose of outlining the different multi-literacy ways in which they are concerned with the epistemic status of the knowledge they convey. It is the interplay between verbal and visual epistemic resources that, in the BMJ corpus, defines a range of assumptions or assessments "that a certain hypothetical state of affairs under consideration (or some aspect of it) will occur, is occurring or has occurred in a possible world" (Nuyts 2001: 21), thereby encoding confidence (or lack thereof) in its adherence to accepted truth (Greenbaum/Quirk 1990: 66).

3.1. Verbal metadiscourse

Verbal epistemicity concerns the expression of the logical and representative status of facts or hypotheses, based on a specific (usually

limited) framework of knowledge coordinates. Epistemic markers in the BMJ corpus have been identified on the basis of the following typology, comprising four modalizing orientations (Coates 1983; Palmer 2001), two of which are high modality (H), while two are low modality (L):

1) Possibility (L) conveys weak commitment to the truth status of a proposition, usually as the product of speculation or hypothesis; it is realized via modal verbs or auxiliaries such as *may*, *might*, *can*, *could*, *be supposed to*, etc., and lexical-modal expressions (*possibly*, *apparent*, etc.);
2) Probability (L) conveys flexible prediction or plausible inference, based on deduction from known data and realized via modal verbs, lexical-modal auxiliaries and semi-modals such as *should*, *ought to*, *be likely to*, etc., and lexical-modal expressions (*likelihood*, *probability*, *infer*, etc.);
3) Necessity (H) indicates solid conviction based on strong inference from accepted evidence and is realized via modal verbs and auxiliaries such as *must*, *need to*, etc., and lexical-modal items (*actually*, *indicate*, *show*, etc.);
4) Certainty (H) indicates strong assumption or prediction, albeit conveyed as diminished certainty compared to categorical assertions, and is realized via modal verbs and auxiliaries such as *will*, *shall*, *be due to*, *sure to*, etc., and lexical-modal items (*certain*, *truth*, *always*, etc.).

The four orientations may be placed along a spectrum of increasing epistemicity, from (L), typically signalling "limited knowledge, […] model, theory or method" or "experimental limitations" (Marta 2015: 568), to (H), emphasizing heuristic "involvement with the topic" (Hyland 2005: 53). As Fig. 3 shows, the typology falls within the two polarized functions of hedging and boosting.

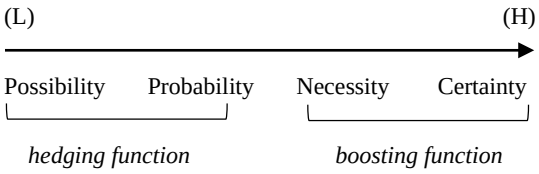

Fig. 3. Modalizing orientations: Low to high modality.

3.2. Visual metadiscourse

Within the social semiotics framework (Kress/Van Leeuwen 1996, 2001; Van Leeuwen 2005), epistemicity may be defined as an integrated system of visual deixis that provides an image of the metacognitive background shared by a particular cultural group. This study systematizes the following parameters for visual modality in polarized cues (High *vs*. Low modality), so that they can easily be identified and quantified in the BMJ corpus:

1) Representation, or articulation of detail: H (formal abstraction) *vs*. L (rendering of detail);
2) Contextualization, or articulation of background: H (no background) *vs*. L (detailed background);
3) Depth, or articulation of perspective: H (no depth) *vs*. L (perspective);
4) Colour saturation, modulation and differentiation: H (black/white, monochrome, flat colour) *vs*. L (colour saturation, colour palette, modulated colour);
5) Illumination: H (no shadow) *vs*. L (representation of light and shade).

Arranging themselves in various ways and proportions, these parameters can produce four coding orientations – namely, Sensory, Naturalistic, Abstract and Technological (Bernstein 1981). These orientations can be ranked in increasing degrees of epistemicity according to contexts and purposes, but such modality scale is not fixed, for markers are polypragmatic, so that different modal meanings may

be expressed on the basis of the same visual markers. For instance, high epistemicity in technical drawing is usually based on low values of all markers (abstraction, no background, no perspective, monochrome or flat colour, no pictorial illumination); whereas in children's literature it typically entails articulation of detail, full background, articulated perspective, colour saturation, full colour palette, pictorial illumination.

For this reason, this study ranks the four coding orientations, from (L) to (H), on the basis of the scientific realism paradigm (Coopmans 2014; Kostelnick 1993; Latour 1987; Vertesi 2014). Scientific visuals, operating through the "filtering, uniforming, upgrading and defining" (Rowley-Jolivet 2002: 23) of phenomena, are high in modality when they follow the abstraction and decontextualization tendency of technical discourse, thus addressing discipline-specific questions such as "Can we measure the real dimensions from it?", "Can we find out from it how to set up the experiment?" (Kress/Van Leeuwen 1996: 170; see also Myers 1990). Based on this, the 342 visuals in the BMJ corpus have been scanned with respect to the following scale:

1) Sensory (L): based on sensory or emotional effects (i.e. the illusion of touch, taste and smell), this orientation has high values in all markers; it has high modality in promotional and persuasive contexts, but low modality in scientific discourse;
2) Naturalistic (L): this context-sensitive code depicts reality as would 'normally' be seen with the naked eye. Today's standard is mainstream photo-realism, producing high modality in journalism, advertising and art. Not so in purely scientific discourse: An X-ray or CAT scan image represents a specific case study, not a scientific law;
3) Abstract (H): visualizing phenomena in terms of general configurations, functions or 'truths', regardless of superficial details, abstraction represents laws, turning empirical observation into high-modality scientific generalization;
4) Technological (H): applying whenever visuals work as blueprint for the implementation of specialized procedures or protocols, this code provides guidance throughout complex operations. Turning observation into the ability to control empirical phenomena, it has high modality in scientific discourse.

The four coding orientations can be distributed along a spectrum of increasing epistemicity, which again falls within the polarized functions of hedging and boosting (Fig. 4). Pointing to generalization and objectivity, Abstract and Technological visuals have a boosting function; pointing to the material perception of individual differences, Sensory and Naturalistic visuals function instead as hedges.

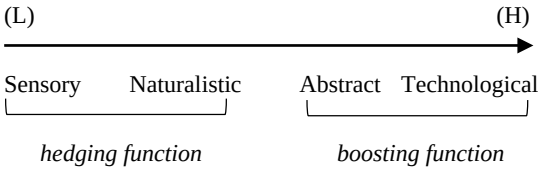

Fig. 4. Coding orientations: Low to high modality.

4. Results

As Tab. 1 above shows, verbal *vs*. visual metadiscourse is represented in the subcorpora in inverted proportions. Research articles, totalling 90.1% of running words, predictably use verbal language approximately ten times more frequently than digital synopses (151,349 *vs*. 15,340), while digital synopses employ nearly ten times more visuals (305 *vs*. 37). It is however worthwhile further contrasting the frequency and distribution of each verbal and visual marker within the two analysed media.

4.1. Verbal metadiscourse

Tabs. 2 and 3 detail the frequency and distribution of verbal markers within each subcorpus.

TOT. MARKERS (RESEARCH ARTICLES)	*Possibility (L)*	*Probability (L)*	*Necessity (H)*	*Certainty (H)*
90.5	*hedging function*		*boosting function*	
	57.6 *(63.7%)*	2.3 *(2.5%)*	13.2 *(14.6%)*	17.4 *(19.2%)*

Tab. 2. Verbal metadiscourse in research articles (normalized freq. per 10,000 words).

TOT. MARKERS (DIGITAL SYNOPSES)	*Possibility (L)*	*Probability (L)*	*Necessity (H)*	*Certainty (H)*
157.7	*hedging function*		*boosting function*	
	97.8 *(62%)*	54.8 *(34.8%)*	1.3 *(0.8%)*	3.9 *(2.4%)*

Tab. 3. Verbal metadiscourse in digital synopses (normalized freq. per 10,000 words).

Although both genres cover the same contents and follow the same macro-structure, it may immediately be noticed that digital synopses overall employ almost twice as many epistemic markers as traditional articles (157.7 *vs*. 90.5). This tendency to the on-screen verbalization of epistemicity may in fact be surprising for two reasons. On the one hand, as mentioned above, the word count ratio between digital and traditional media is 1:10. On the other, although digital synopses pivot on visualization and graphical language as an overarching semiotic mode, the newly established genre seems to rely on the verbal display of modalized meanings more than research articles, thus appearing to be explicitly concerned with the linguistic expression of assessments or assumptions with respect to the truth status of the information it provides. This tendency may be interpreted as a possible cross-semiotic strategy that scientific discourse has been developing in recent years, with a view to construing social and disciplinary legitimization for new

and propagative media as reliable tools for knowledge transfer within the scientific community.

As concerns the distribution of the four modalizing orientations within the subcorpora, the most frequent mode – evenly represented in research articles and digital synopses (63.7% and 62% respectively) – is Possibility. Epistemic metadiscourse realized at the linguistic level, that is, shows a clear prevalence of low-modality meanings in both on-page and on-screen media, irrespective of their being traditional or innovative, or more or less oriented towards visualization or verbalization. This is not a startling occurrence: verbal language in scientific communication tends by tradition to deploy a hedging function, typically indicating the partiality or potential subjectivity of methodologies and results – a tendency that is the result of two salient historical facts of medical discourse.

On the one hand, hedging has been a standardized feature of specialized communication since the inception of experimental science in 17th-century Royal Society (Bazerman 1988), as a part of the rhetorical construction of credibility, from Robert Boyle's essays (Gotti 2003) to the current post-1978 IMRD format (Marta 2015). The accurate technical report of procedures and experiments, along with the presentation of hard empirical evidence, needed to be linguistically separated and purified from the individuality of conjectural speculation or ideological bias. Hedging is therefore embedded in the disciplinary evolution of scientific discourse, for acknowledging the limitations of one's method, results or interpretation has become a crystallized practice for the codification and validation of new knowledge claims, and for presenting them to the scientific community, so that they can eventually merge with the accepted scientific 'truth' (Knorr-Cetina 1999).

On the other hand, today's leading medical paradigm, Evidence-Based Practice (Greenhalgh 2010), is based on the strict self-assessment (and self-framing) of newly acquired experimental knowledge within a pyramidal hierarchy of methodologies, ranked in ascending levels of scientific rigour according to their reliability (i.e. containment of bias and neutralization of subjective factors). The epistemological function of linguistic hedging in research articles has thus been maximized as of the mid 1990s, that is, as Evidence-Based Practice internationally

spread as the new top-standard healthcare framework (Sackett et al. 1996).

The much higher frequency of the two boosting orientations, Necessity and Certainty, in analogue media (14.6% and 19.2%) than in digital genres (0.8% and 2.4%) may also correlate with the particular epistemological accreditation of each medium. Overall, while hedging represents 96.8% of modalizing orientations in on-screen texts, it only represents 66.2% of the research article subcorpus, where 33.8% (that is to say, one marker out of three) perform instead a boosting function. This means that boosting is ten times more frequent – and perhaps epistemologically needed – in research articles than in digital synopses. Interestingly enough, boosting effects, especially the use of Necessity markers such as *indicate* and *show*, and Certainty markers such as *will*, *sure*, *ensure*, etc., are mainly used in research articles whenever solid evidence from top-ranking evidence-based experimental designs is presented, such as for instance definitive results from Randomized Controlled Trials (i.e. the golden-rule pinnacle of the pyramid of evidence; Greenhalgh 2010: 18-45). One example is provided below:

> However, data from a large multicentre study (2966 pregnancies, of which 56% of women had congenital heart disease, 32% valvular heart disease, and 7% cardiomyopathy) *showed* that pregnant women with heart disease are more likely to encounter episodes of arrhythmia (overall rate 2%).[2]

Coherently with their disciplinary collocation within the Evidence-Based hierarchy of knowledge advancement, conclusive experimental results tend to be metadiscursively framed in research articles as strong (or incontrovertible) inference from reliable data analysis.

But while the analogue IMRD structure directly reflects the probabilistic stance of 17th-century experimental proceedings, and may for this reason easily incorporate typically Evidence-Based boosting strategies,[3] digital synopses are a product of the growing visualization of culture (Fuery/Fuery 2005), i.e. a process rooted, as multimodal

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2 Retrieved from <https://www.bmj.com/content/360/bmj.k478>.

3 Albeit as dispreferred strategies, when compared to the much higher frequency of hedging (66.2%).

analysis and social semiotics have shown (Kress/Van Leeuwen 1996, 2001; Van Leeuwen 2005), in lay communicative environments (such as advertising and other promotional/persuasive genres) much earlier (and to a much greater extent) than in specialized dissemination contexts. Although extremely propagative and more than potentially hegemonic, digital genres are therefore, and obviously so, a less consolidated transmission channel for scientific knowledge. Which may be among the reasons why, although the contents exposed are exactly the same as those in traditional articles, hedging may be perceived in digital communication as a more fruitful approach, in order for meanings and theories to be consulted, shared and assimilated by the scientific community.

4.2. Visual metadiscourse

The distribution and frequency of epistemic coding orientations is shown in Tabs. 4 and 5.

It may immediately be noticed that across media only a minority of visuals express low modality: hedging orientations cover 2% of the digital synopsis subcorpus and 40.5% of the research article subcorpus. While Sensory visuals are not attested at all,[4] the Naturalistic orientation is an interesting case, being twenty times more frequent in on-page than on-screen visuals.

TOT. VISUALS (RESEARCH ARTICLES)	*Sensory (L)*	*Naturalistic (L)*	*Abstract (H)*	*Technological (H)*
37	*hedging function*		*boosting function*	
	0 *(0%)*	15 *(40.5%)*	12 *(32.5%)*	10 *(27%)*

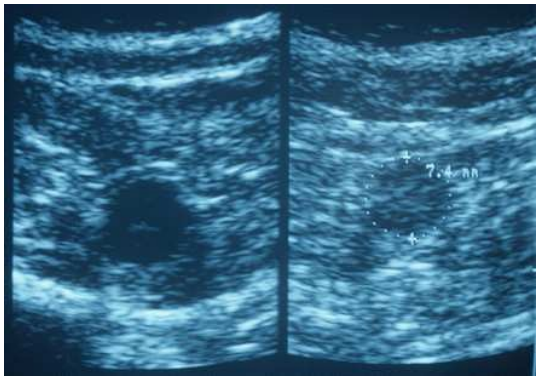
Tab. 4. Visual metadiscourse in research articles.

[4] For these are significant not in technical but in persuasive contexts.

TOT. VISUALS (DIGITAL SYNOPSES)	*Sensory (L)*	*Naturalistic (L)*	*Abstract (H)*	*Technological (H)*
305	*hedging function*		*boosting function*	
	0 *(0%)*	6 *(2%)*	112 *(36.7%)*	187 *(61.3%)*

Tab. 5. Visual metadiscourse in digital synopses.

Taken individually, although boosting orientations account for 59.5% of cases, Naturalistic is in fact the most frequent orientation in research articles.



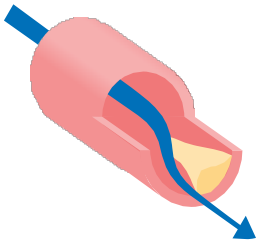


Fig. 5 (left). Typical Naturalistic visual (from the research article subcorpus): Deep vein thrombosis. Retrieved from <www. bmj.com/content/360/bmj.k351>.

Fig. 6 (right). Typical Abstract visual (from the digital synopsis subcorpus): Peripheral artery disease. Retrieved from <www.bmj.com/content/360/bmj.j5842>.

An example of a Naturalistic visual is provided in Fig. 5, showing an ultrasound picture of lower limb veins (a normal deep vein to the left, a thrombosed deep vein to the right). In scientific writing, Naturalistic visuals – photographs, X-rays, CAT scans, etc. – typically accompany the presentation of particular case studies, providing material evidence to the diagnosis or therapy suggested by the author. Although this type

of perceptual evidence cannot be transferred to fellow doctors using words, for it has to be physically apprehended in order to be significant, Naturalistic visuals have but a low degree of epistemicity. In the context of knowledge dissemination, they are useful for illustrating individual situations (e.g. diagnostic pictures, damaged body parts, etc.), but not for visualizing general laws, as their eidetic potential is low. In other words, evidencing how experimental science stems from the observation of nature's potentially confusing variety, Naturalistic visuals tend to perform a hedging function.

Fig. 6 (above) depicts a similar referent to the one in Fig 5, but the orientation in this case is Abstract, as can immediately be seen from the correlation among the five parameters of visual epistemicity defined in 3.2 above. Here, the scientific tenability and generalizability conferred to the picture of a clogged artery is definitely higher. Providing raw perceptual data, still to be interpreted by the scientist, Naturalistic visuals pivot on their iconicity and potential polysemy (i.e. a complex referential load, pointing to the necessity of disambiguation on the part of the viewer), for they reproduce the unorganized complexity of 'real' phenomena. Abstract and Technological visuals are instead monosemic and eidetic (i.e. endowed with a one-way referential load, which requires no interpretation on the part of the viewer). Their stylised, high-modality conceptual outline extracts discipline-specific meanings from the natural world, the decoding of which rather calls for specialized knowledge frameworks that may guide viewers to see through the visual conventions used to process reality.

While Naturalistic visuals have the anecdotal function of supporting arguments with perceptual proof, Abstract (and Technological) visuals have an epistemological function, i.e. the reification of evidence via visual patterns (Lemke 1998). Empirical data are cleared from surface details, until the representation reaches a generalizable, always tenable and applicable status. Making reality "tractable for scientific investigation" (Coopmans 2014: 39), abstraction is especially used in the BMJ corpus in order to make particular systems of data – such as the clinical picture visualized in Fig. 5 above – quickly and systemically graspable by way of graphical language and spatial relations.

While Abstract visuals are fairly equally represented in on-page (32.5%) and on-screen media (36.7%), the Technological orientation is much more frequent in digital synopses than in research articles (61.3% *vs*. 27%). Fig. 8 shows a typical Technological visual. It is a decision tree, schematizing how a treatment plan for Parkinson's patients may be adjusted over time to take account of ongoing symptoms.

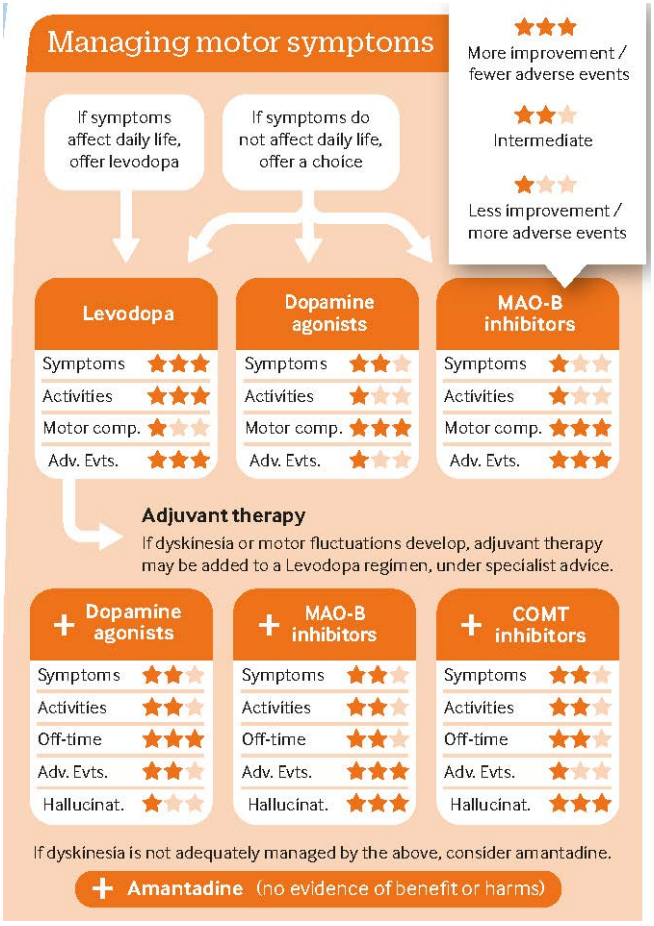


Fig. 8. Typical Technological visual (from the digital synopsis subcorpus): Parkinson's disease: Updated NICE guidance. Retrieved from <www.bmj.com/content/bmj/suppl/2018/02/01/bmj.j5842.DC1/morr041877.wi.pdf>.

The positive or negative impact of medicines on patients is graphically condensed by way of a star-rating system (the key to which is in the white box at the top right of the picture), and cause-effect relationships between actions are rendered through arrows and + signs. Technological visuals, that is, allow articulated, multi-variable data systems – not simple configurations of elements, but dynamic sequences, procedures or protocols – to be further abstracted, by way of graphical patterns and symbolic icons which enable the viewer to synoptically gain knowledge not just about the physiology of the process being schematized, but also about how to manage or control it. This boosts the expressed commitment of scientific discourse to the objectivity, factuality and reliability of its contents.

For this reason, Technological visuals may be said to provide science with "its most powerful tool: the visual display" (Latour 1987: 67). As will be argued in the Discussion section of this paper, this seems to suggest a possibly increasingly persuasive function performed by medical discourse, in particular by newly established on-screen genres. As "theory-laden" constructs (Vertesi 2014: 21), covering 61.3% of orientations, Technological visuals appear in the BMJ corpus as a prerogative of on-screen communication. This is not the case with research articles, in which they only appear in 27% of cases. Again, this is an unsurprising fact. In traditional IMRD prose, which does not obey the same space constraints as full-screen synopses – for readers may browse (or scroll, in the case of PDF) documents at will –, complex protocols are conveyed at length through verbal argumentation. In the research article matching the synopsis from which Fig. 8 was extracted, the procedures composing the treatment plan are fully resemiotized. Thus, the graphical arrangement of orange and white tags, the rows of stars and arrows simultaneously appearing in the synopsis is alternatively codified in the following string of words:

> Oral levodopa remains the preferred first line medicine for people with troublesome motor symptoms. When starting treatment, give information about adverse events. For dopamine therapy, these adverse events may include impulse control disorders (particularly dopamine agonists), excessive sleepiness, and hallucinations and delusions (all Parkinson's disease treatments but particularly dopamine agonists). […]

> When a person with Parkinson's disease develops dyskinesia or motor fluctuations (including 'wearing off' episodes when effects of medication start to wear off in between medication doses) adjuvant therapy may be added, on advice from a healthcare professional with specialist expertise in Parkinson's disease. [5]

The temporal and logical relationships between symptoms and medicines, which the synopsis schematizes by way of a flow diagram enriched with icons (i.e. stars), directional vectors (i.e. arrows) and mathematical symbols (i.e. the + sign), are here configured and textualized using linguistic transitions. For instance, the white arrow connecting "adjuvant therapy" to the "Levodopa" orange tag in Fig. 8 codifies the same temporal meaning as the subordinate sentence "*when* a person with Parkinson's disease develops dyskinesia or motor fluctuations"; the + sign appearing next to "Dopamine agonists", "MAO-B inhibitors" and "COMT inhibitors" visualizes what the article lexicalizes (in this case, with added deontic meaning) as "adjuvant therapy *may be added*".

While on-screen communication seems to entrust the eidetic potential of Abstract and Technological visuals with the task of boosting science's power to construct the visible, thus using visualization to maximize the epistemological discernibility of the investigated phenomena (Rowley-Jolivet 2002; Lemke 1998;), in the case of analogue media verbal metadiscourse remains the preferred option for expressing confidence in the truth proposition of scientific contents, as the high frequency of Necessity (14.6%) and Certainty markers (19.2%) indicates. Albeit with complementary cross-semiotic styles, both research articles and digital synopses seem however to have developed a growingly persuasive function, hybridising over time the informative and referential mission of specialized communication, which was the heritage of modern Empiricism, with more explicitly promotional and interactional functions.

[5] Retrieved from <https://www.bmj.com/content/358/bmj.j1951>.

5. Discussion and conclusions

Results hitherto suggest that the metadiscoursal codification of epistemicity in the BMJ corpus relies upon various strategies of cross-semiotic collaboration between the verbal and the visual mode, as well as upon different combinations of hedging and boosting effects. In both genres, the multi-literacy construction of epistemicity seems to serve the pragmatic purpose of adding an interactional (eminently persuasive) function to the referential and informative load of scientific discourse, so as to favour the interest and receptivity of the scientific community. This contributes to promote the validation, legitimization and dissemination of medical discourse, favouring the transfer of knowledge into the common stock of formulations of the current epistemic culture. Cross-semiotic epistemicity, whereby the truth status of discourse is a result of the synchronous functional-semantic cooperation (or co-semiotization) of the scriptural and the graphical mode, has for this reason become an increasingly prevalent feature of scientific discourse, one that is associated with the disciplinary matrix of science itself (Bazerman 1988; Lemke 1998; Myers 1990).

The BMJ corpus also evidences that different dissemination media work on different degrees of word-visual combination. In digital communication, verbalization and visualization carry out opposite operations: while the scriptural code construes the credibility and facticity of scientific discourse by way of hedging (96.8%), visual language encodes the same meanings through boosting orientations (98%). Cross-semiotic boundaries appear a little less sharp in on-page communication, where visualization performs a broadly boosting function (59.5%) and verbalization mainly a hedging one (66.2%). In both analysed media, however, epistemicity is conveyed through the hybridization of the discontinuous sequencing of abstract and temporal signs, which forms verbal language, with the contiguous synchronicity of sensorial and spatial signs, which form visualization.

It is the degree of alignment of the two semiotic systems that carries out the metadiscoursal labour of expressing the discourse's epistemic status. But the proportion in which this hybridization occurs

is determined by different communicative purposes and pragmatic contexts. As the comparison between Fig. 8 and its linguistic transmutation has shown, when dealing with particularly complex sequences of data (such as the therapeutic plan for Parkinson's disease analysed in section 4.2 above), medical discourse may employ different co-semiotization solutions: analogue genres privilege verbalization and the linearity of causal-temporal progression, while on-screen genres adopt the synoptic and instantaneous visualization shown in Fig. 8. The interesting countertrend shown by on-page hedging Naturalistic visuals (40.5%) and boosting Necessity-Certainty markers (33.8%), balancing the low frequency of Technological visuals (27%), as well as the propensity of on-screen discourse to the verbalization of (especially low) epistemicity, may however indicate that metadiscoursal co-semiotization processes are perhaps more complex than today's verbal-to-visual momentum seems to suggests (O' Halloran / Tan / Wignell 2016; Tufte 2001).

The heuristic power of visualization, and today's undeniable drive towards visual culture, may indeed not be the one and only key to contemporary science's multi-literacy practices. From a cognitive standpoint, the BMJ corpus suggests that both the verbal and the visual mode are mutually mobilized towards one another, for the strategies it displays seem to stem from the representative affordances and constraints of both semiotics. On the one hand, when organising the description of phenomena in synoptical, indexical or topographical fashion (Benking 2005), science tends to use the spatial facilitation offered by graphic visualization – which in certain contexts, such as on-screen communication, may trigger the immediate grasping of data sets more easily than the temporality of the scriptural medium would allow (Lorés 2021; Rebuske Hendges/Salete Florek 2019; Sancho-Guinda 2016, 2021). On the other hand, in its linear and irreversible sequencing of discrete signs, verbal language offers the advantage of formulating complex configurations of meaning, such as introducing details or distinctions and typologizing categories, as is testified by various typical features of written scientific language (e.g. the use of extended noun phrases, pre- and post-modifying prepositional phrases, etc.), whose function is linked to the legitimization of its informative and instructional value.

In addition, considering the hermeneutics of verbal and visual communication, it is worthwhile noticing that – despite the immediate and synchronous intelligibility of the spatial configurations and systemic relations that are offered by visualization – reading visuals, as much as reading words, entails not just construing meanings from what we see or read, but also from what we know (Kostelnick 1993). Conversely, when dealing with verbal language, readers may resort to a variety of visualization strategies – for instance, those favouring the topicalization and organisation of linguistic contents, either prospectively (e.g. typographical conventions, the IMRD structure itself) or retrospectively (e.g. cognitive maps). The two semiotics, in other words, are equally cognitive in nature, and complementary in interpretation. Their interplay may, for these reasons, allow for functional and communicative developments of scientific discourse that – especially at a metadiscoursal level – significantly increase those instantiated by one resource alone.

It should finally be noticed that among the most relevant consequences of verbal-cum-visual semiotization is the constant rematerialization of scientific discourse in today's evolving mediascape, which contributes to its progressive reification and propagation – both increasingly widespread and increasingly capillary – within epistemic ideologies (Knorr-Cetina 1999). As knowledge is transferred across shifting semiotic systems, new and hybrid epistemic practices are progressively elaborated, in order to promote it across ever more propagative semiotic modes (Iedema 2001; Lorés 2021; Rebuske Hendges/Salete Florek 2019; Sancho-Guinda 2016, 2021). This reinforces the construction of science's prestige, i.e. its relevance and authority within the ideological environment producing it. From 17th-century Royal Society experimental reports to post-1978 IMRD research articles, academic posters (D'Angelo 2016), and the recent codification of digital synopses, scientific discourse has in other words produced increasingly ever more persuasive and powerful categorizations of empirical reality, in which – as the BMJ corpus shows – the cross-semiotic construction of metadiscourse plays a significant role.

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