Visual recontextualisation of meaning in science research articles and News and Views articles

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Abstract

News and Views articles appear in *Nature*-branded journals, summarising and critiquing newly published studies. Written by experts outside the research team, they inform the wider scientific community of novel research, promoting a broader readership as well as cross-fertilisation between fields. Most studies of genres that recontextualise science research articles for a broader audience focus on textual meaning. This article prioritises visual meaning, comparing News and Views articles and research articles. Corpora of research articles and News and Views articles were analysed using social semiotic analysis (Kress & van Leeuwen, 2021); interviews with expert authors of the articles also inform the investigation. Drawing on Daston and Galison (2007), a three-way categorisation was made of conceptual, technologically-produced and mathematical images.

Findings reveal that visual meaning is central in both genres. In research articles detailed and exact meaning is conveyed using graphs and technologically-produced images (e.g., microscope images). News and Views articles use accessible, conceptual images such as schematic diagrams. Research article writers reported planning the article around the images, which function to validate author claims; as readers, experts reported examining images before reading the article. In News and Views articles, the image provides a conceptual overview of the text, matching the genre's purpose in facilitating understanding of a complex study.

Keywords: visual meaning; research articles; News and Views; open science; scientific genre; recontextualisation

Resumen

Recontextualización visual del significado en artículos de investigación científicos y en artículos de "News and Views"

Los artículos de "News and Views" aparecen en las revistas de Nature, resumiendo y criticando estudios recién publicados. Redactados por expertos externos al equipo de investigación, informan a la comunidad científica más amplia de las novedades de la investigación, lo cual fomenta un mayor número de lectores y la fertilización cruzada entre campos. La mayoría de los estudios sobre géneros que recontextualizan artículos de investigación científica para un público más amplio se centran en el significado textual. Este artículo da prioridad al significado visual, comparando los artículos de "News and Views" y los artículos de investigación. Se han analizado corpus de artículos de investigación y de "News and Views" mediante análisis semiótico social (Kress & van Leeuwen, 2021); también se ha obtenido información de entrevistas con algunos autores de los artículos. Basándonos en Daston y Galison (2007), se realizó una categorización de imágenes en tres tipos: conceptuales, producidas tecnológicamente y matemáticas.

Los resultados revelan que el significado visual es fundamental en ambos géneros. En los artículos de investigación, el significado detallado y exacto se transmite mediante gráficos e imágenes producidas tecnológicamente (por ejemplo, imágenes de microscopio). Los artículos de "News and Views" utilizan imágenes accesibles y conceptuales, tales como diagramas esquemáticos. Los autores de artículos de investigación afirmaron que habían planificado el artículo en torno a las imágenes, que sirven para validar las afirmaciones del autor; como lectores, los expertos afirmaron que habían examinado las imágenes antes de leer el artículo. En los artículos de "News and Views", la imagen ofrece una visión conceptual del texto, lo cual coincide con el propósito del género de facilitar la comprensión de un estudio complejo.

Palabras clave: significado visual; artículos de investigación; News and Views; ciencia abierta; género científico; recontextualización

1. Introduction

1.1. The importance of visual meaning in science

Visual expression of meaning is increasingly important in science research writing. This significance is evident in the multiple colourful images in science research articles, including line graphs, bar graphs, dot plots, microscope images, schematic diagrams and others. The shift from paper

publication to online journals has facilitated this increase (Grehan, 2015; Splendiani & Ribera, 2015; Machimbidza & Mutula, 2020). Online journals mean fewer restrictions on the number and type of images, with increasing use of colour. In this article, we are interested in how changing the audiences alters how meaning is expressed visually. To explore this issue, we compare the use of visual meaning between science research articles and News and Views articles (henceforth N&V), which recontextualise research articles (henceforth RAs) for a broader audience.

1.2. The contribution of News and Views articles to open science

One aspect of 'open science' involves the dissemination of scientific knowledge to a broader audience. Fecher and Friesike (2014) identify five conceptualisations in the literature about what open science is: 1) making science accessible to the public; 2) increasing availability of data and intellectual property; 3) improving efficiency to aid scientific collaboration; 4) making tools and services more available to scientists; 5) developing alternative metrics. As a genre providing brief accounts of new RAs, N&V articles fall into the first of these: public science. However, the 'public' is restricted, in that anticipated N&V readers are members of the broader scientific community rather than non-scientists. Nevertheless, N&V articles fulfil the aims of public science by making new studies available to a wider audience. An important part of broadening availability is adjusting the language used to communicate complex ideas. Cribb and Sari (2010) stress the need to adjust the register by simplifying both the lexis and grammar to suit the intended readers. In this article, we consider the role of visual meaning in accomplishing this register adjustment.

1.3. Recontextualisation and popular science genres

Recontextualisation is the process of texts, discourses and genres moving between spatially and temporarily different contexts (Wodak, 2010, p. 23). Wodak notes that recontextualisation is manifested in the incorporation of words, phrases, and larger textual elements into other texts. Our study focuses on images, which, although not strictly textual, are an important element within texts. Recontexualisation can occur between texts and also between genre types (Linnell, 1998), and in our study we expand this to note that recontextualisation can also refer to meaning expressed in one mode being recontextualised in another mode (e.g., meaning expressed in the

textual mode can be recontextualised in the visual mode, and vice versa). Iedema (2003, p. 41) refers to such recontextualisation in which "meaning making shifts from context to context, from practice to practice" as resemiotisation. This includes meaning originally expressed in one mode (e.g., text) being expressed again in a different mode (e.g., visually).

The intertextuality that is part of recontextualisation can be seen in popular science articles (Heekeren, 2021), as they rely on science RAs. Heekeren (2021) notes that popular science articles adapt to the norms of the popular media in which they appear while still depending on and remaining true to scientific communication practices. She found that some popular science images are especially created for the popular medium, but others are adapted from an original RA image through addition or omission. Although this adaptation removes some scientific meaning, it also makes the scientific meaning more accessible to the intended readers of the popularisation. This study examines the extent to which such newly created or adapted visuals are found in N&V articles where readers are members of the broader scientific community rather than non-scientists.

Although similar meaning can be expressed in visual and textual modes, Lemke (1998) stresses that images in science articles combine and interconnect, and that text, images and mathematical expressions are integrated. Lemke disputes the assumption that meaning created in one semiotic mode can be exactly replicated in another because the affordances of each mode are different. Instead, meaning in scientific communication requires the co-deployment of two or more semiotic resources to form joint meaning. Jewitt et al. (2016, p. 3) support this notion of co-deployment, highlighting the importance of acknowledging the distinct potentialities and limitations of different semiotic resources required for meaning-making. Similarly, Björkvall (2018) emphasises the need to understand how different modes work together as a multimodal ensemble to create meaning. The different affordances of each mode of expressions is also recognised by Hafner and Miller (2019, p. 159) as "functional specialisations" where the authors argue that "some modes are better suited to some purposes than others". Focusing on visuals as a mode/resource, we explore how meaning is constructed (and recontextualised) in two different scientific genres.

Scientific research, prototypically published in science RAs, is recontextualised in many genres, for many audiences, from fellow scientists to the public. These genres include conference papers (Rowley-Jolivet, 2002),

science news (Miller, 1998), blog posts (Luzón, 2013), posters (D'Angelo, 2016), and scientific sketchnotes (Fernández-Fontecha et al., 2019). Similarly, N&V articles recontextualise the more formal and difficult-to-understand RA for a different audience.

Studying science blog posts, Luzón (2013) lists images as one of six strategies to tailor information to a particular audience. Luzón points out that while scientists use images following disciplinary conventions which may be hard to interpret by a non-specialist audience, bloggers' incorporation of images address different levels of audience knowledge. Bloggers may use the same images as in the original research, or new images. However, the study does not mention what kind of images from the RAs are selected for a blog post to recontextualise knowledge. The current study investigates this phenomenon further by investigating whether expressing information visually for different audiences results in the use of different image types, and whether different meanings are stressed visually in the two genres examined.

Martin et al. (2019) investigated the perceived cognitive load of infographics compared with text-only abstracts in summarising medical literature. They found that physicians in their study considered the cognitive load of using infographics to understand new research to be much less than using the traditional research abstract format. Similarly, Fernández-Fontecha et al. (2019) found that visual resemiotisation in popularising genres reduces the abstractness of specialised discourse such as RAs. Contrasting four scientific sketchnotes (integrating notes and sketches to explain scientific topics) with the RA on which each was based, they analyse the roles of language, images and mathematical graphs and symbols. They found that the abstractness of specialised discourse is resemiotised in sketchnotes, making scientific knowledge more accessible to non-specialist audiences. They discovered that abstract ideas are 'translated' into concrete depictions by adapting resources like graphs or simple schematic drawings. Similarly, the science education literature on 'multiple representations' shows the benefit of simultaneously expressing concepts textually and visually. Focusing mainly on science textbooks, studies like Ainsworth (2008) have explored the benefits for students of science concepts being repeated in multiple modes, such as diagrams, graphs, equations, and text.

Comparing images in scientific RAs and popular science articles, Miller (1998) concluded that images in scientific RAs are the most newsworthy portion of the article, functioning to present the findings. He notes that

photographs and graphs provide readers with direct access to data, strengthening the research argument. Miller notes that images allow a large amount of data to be condensed, expressing information that cannot be explained as effectively in words. Popularisations, by contrast, portray the study implications without showing the evidence that the photographs and graphs in RAs display. Images in popularisations simplify the meaning in the RA and may thus distort the meaning of the original study.

Rowley-Jolivet (2002) argues that visuals in science research such as graphs and schematics are not transparent but are constructed in nature: "the result of a long chain of transformational processes" (p. 23). Similarly, images produced through technology (e.g., X-rays, SEM or MRI images) focus on "a single analysable feature" (e.g., the skeleton in an X-ray). In doing so, less relevant arguments are eliminated, leaving only one reading possible. Rowley-Jolivet concludes that scientific conference images are used to communicate the main elements of the speaker's argument, improving comprehension. Rowley-Jolivet's analysis takes account of typology, coloured vs. black and white, and left-right organisation (chirality[1]). However, elements such as modality and salience are not considered. Our study seeks to do so, using Kress and van Leeuwen's (2021) framework.

The above review of the literature on recontextualisation of meaning in popular science notes firstly that textual meaning recontextualised as visual meaning (or vice versa) does not mean duplication, but rather that both modes are needed to express meaning (Lemke, 1998; Jewitt et al., 2016; Hafner & Miller, 2019). Our study shows the use made of the visual mode by expert readers and writers. In recontextualisations in popular science, visuals may be newly created or adapted (Luzón, 2013; Heekeren, 2021). As the above review shows, one reason for the creation of new images is reducing the cognitive load for readers (Fernández-Fontecha et al., 2019; Martin et al., 2019) although they may also distort the meaning in the original study (Miller 1998; Rowley-Jolivet, 2002). Our study compares the meanings in the images in both the original and the recontextualisation, and investigates whether such newly created or adapted images result in use of the same or different visual types as found in the original RA.

1.4. Types of images in science research

Daston and Galison (2007) investigate changing perceptions of scientific images and how beliefs about 'objectivity' in depicting science has evolved

over the last 300-400 years. In the 18th century, scientific diagrams aimed to be "true-to-nature": portraying the ideal or typical representation of a flower or insect rather than a particular, possibly flawed, instance. In the 19th century, however, scientists began to prize "mechanical objectivity", where images were produced through technology (e.g., a photograph) without human intervention or distortion. This focus allows the "visible world [to] emerge on the page without intervention" (p. 143). In the 20th century, there was recognition of the "trained judgment" or expertise necessary for the interpretation of scientific images, which are increasingly produced using complex technological methods.

Following Daston and Galison (2007), Heekeren (2021, p. 73) distinguishes between 'mechanically objective' images and visualisations of measured data. In contrast to mechanically objective images like photographs, etc. which 'move nature to the page', visualisations of measured data calculate or transform data into images such as charts, graphs, and maps. Experts need to develop expertise in interpreting both of these image types to be able to understand them. We develop these distinctions between conceptual representations of the ideal/typical, mechanically objective/ technologically-produced images, and visualisations of measured data in our analysis in this article.

In this article, we seek to answer the following research questions:

(i) What visual types are used in News and Views compared with research articles?

(ii) How is meaning expressed visually in News and Views articles compared with research articles?

(iii) What meanings are recontextualised visually in News and Views articles?

2. Methodology

2.1. The corpora

Our study considers visual meaning in Health Science and Physical Science research articles and N&V articles. Our investigation involved reviewing the images in 60 N&V and 30 RAs from *Springer Nature* journals (see Table 1). Thirty of the N&V articles corresponded to the 30 RAs; because N&V

articles usually have only one or two images, a further 30 N&V articles were included in the analysis. There were 796 images in these 90 articles, which were utilised for analysis.

	Health science RA	Physical science RA	Health Science N&V	Physical science N&V
Number of articles	15	15	30	30
Number of words in the corpus	98267	66895	36158	29239
Number of images	372	320	38	66

Table 1.Corpora in the study

2.2. Visual Analysis

Analytical framework

Drawing on the assumption that RAs and N&V articles will employ images in different ways, we use Kress and van Leeuwen's (2021) grammar of visual design as our analytical framework. Based on Systemic Functional Linguistics (Halliday & Matthiessen, 2013), this framework enables researchers to comprehensively describe how visual components convey meaning in context. The framework consists of three interrelated meaning dimensions (metafunctions): representational, interpersonal, and compositional; these are evaluated through a set of underlying visual resources.

i. Representational

The representational metafunction reflects how a semiotic system represents content, ideas, or objects. Kress and van Leeuwen (2021) propose that content is represented either conceptually or narratively in images. Conceptual representations can be classificatory, analytical, or symbolic. They represent static ideas and objects without dynamic forms of actions. In contrast, narrative processes express meaning through actions characterised in vectors formed by human actions (such as gaze or gesture) or using arrows or diagonal lines.

ii. Interpersonal

The interpersonal dimension involves the relationship between the participants of an image (whether human or otherwise) and their viewers. It concerns the representation of *contact* between participants and viewers: whether information is offered to viewers (*offer* images) or whether a social

response is demanded (*demand* images, marked by gaze). Secondly, this metafunction suggests the *social distance* between the image participants and viewers suggested by the size of the visual frame indicating how far or close the image participants are from the viewers. Interpersonal meaning is also reflected in the *attitude* of image participants expressed through the angle of visual representation. When viewers are 'below' the image, the image participants are represented as more powerful and vice versa. Finally, this metafunction concerns the *modality* of images: how real/true an image is represented as being based on different visual markers of reality or truth (modality) such as colour modulation (using shades of the same colour), differentiation (using a range colours), and saturation (how bright/dull the colours are). This notion of realness/truth also depends on the lens or coding orientation through which the image is viewed (technological, naturalistic, sensory, abstract) and the particular social or institutional context (i.e., scientific, artistic) to which the image belongs. A line graph created with a limited number of unsaturated colours can be considered to have low modality in a natural everyday setting. However, it may have high modality in a scientific setting where those graphs are used as 'blueprints' to visually represent data, and colour is not as important to achieve the purposes of visual representation of data.

iii. Compositional

The compositional metafunction expresses how both representational and interpersonal meanings create a coherent whole. Exploring the compositional dimension involves analysing the composition of individual images or investigating the spatial organisation of images and written text within the overall layout. Three resources are considered during analysis: 1) salience (how specific participants attract viewer attention while others do not), 2) information value (how placement —left/right and top/bottom— within a composition connotes a particular meaning) and 3) framing (how lines or frames are used to establish connection/division).

Categorisation and analysis of images

We began by categorising the 796 images by type (e.g., photographs, line graphs). To do so, we drew on the labels used by the authors of the articles, supplemented by an online search to enhance our understanding of the image's common function. For images we found difficult to categorise, we sought validation from scientific research experts during interviews. Our resulting taxonomy of images can be found in Table 3 in Section 3: Findings

below.

After identifying the most frequently occurring image types in each genre and discipline, fourteen RA images and eight N&V images were selected for further exhaustive analysis using Kress & van Leeuwen (2021). Since some articles contained images combining more than one image type, an image of that type (Figure 4) was included in the in-depth analysis.

2.3. Interview with Scientific Research Experts

To support our analysis of visual meaning in our two genres, five experts agreed to be interviewed[2], four online and one in person. Our interview participants were two Physical Science research article authors, two Health Science research article authors and one Physical Science News and Views author. Three of the interviewees were the corresponding authors of research articles from our corpus and all were leading researchers in their disciplines; every research article in the corpus had been recontextualised in a corresponding N&V article, which was also included in our corpus. However, we were unfortunately able to recruit the author of only one N&V article in our corpus. News and Views articles are commissioned by the journal editor and written by leading researchers, often a reviewer of the original article. In writing a N&V article, authors are reporting on the work of others rather than on their own work, and N&V articles that they write are likely to be less important to them compared with their own RAs. It may be this that lead to N&V authors' greater reluctance to spend time being interviewed about this genre. However, the four RA authors who were interviewed were well aware of the process of creating N&Vs articles, and were therefore able to provide input on the N&Vs genre. This interview data from disciplinary experts informed the visual analysis and provided expert insight into the meaning of the visual recontextualisation in Health Science and Physical Science RAs and N&V articles. The interview data was transcribed, coded, and analysed to identify expert insights which further informed the visual analysis.

3. Findings

3.1. What experts said about visual meaning

The expert interviewees pointed out that both science RAs and the N&V articles target an expert audience. N&V articles serve a range of purposes. Firstly, they simplify complex science and "give the big picture" (HS2) so

that those outside the immediate field can understand it. N&V articles make new research more widely accessible: "people who are not involved in the research topic can read a News and Views. But they cannot read the primary research article without passing through a little bit of, let's say, literature" (N&V1). One interviewee (HS1) characterised N&V articles as "a great way to present quite complicated and complex articles in a very digested and maybe lay audience type of way"; another interviewee concurred noting that "they have very good visuals [that] digest the information in an easier way" (PS1). Another interviewee reported that reading N&V articles enables an expert reader to quickly decide whether to read the full article.

The News and Views author also mentioned functions beyond simplification, involving "cross-fertilising between fields" and "enlarg[ing] the community". N&V articles can thus be seen as promoting scientific collaboration across fields. He noted that "from the editor's point of view, [N&V articles] put the primary research article into a broader perspective for the readership". The News and Views author also stressed how N&V articles explore the implications of new research:

> in a primary research article, you're not allowed to dream of the future implications of your research, okay. So that is not scientific. But that is something that can be done here, like we try to trigger a little bit of imagination of the readers into the future perspectives of these current technologies and physical phenomena etc. (N&V1)

The primacy of the images for RA authors came through in the interviews. Interviewees mentioned that in writing an RA "the figures are prepared first", that "the main job, the main work is done by the figures" (PS1), and that "the figures are really the storyline for the article" (HS1). One author also mentioned the importance of the images for readers: "even like when I read papers, I would first look at the figures, because we are trained to look at certain types of data" (PS1). Another author supported this saying that "we know that some other scientists tend to not read the text almost at all unless they are junior investigators, and they need the guidance of the text" (HS2). The information value of images was also noted: "the information content of a picture is so much higher than written text" (PS2).

The value and role of different types of images was also noted for RAs. Graphs were important in establishing the validity of what is claimed by "illustrating it in a numerical way". As one author noted: "if I was reading this, and they didn't show me what these data looked like [in a graph], I

would be more sceptical of what it was that they were quantifying" (HS1). Another compared the value of graphs to other images:

> The photograph essentially only shows a small picture, right? And one has to show that that's not only that particular cell […] that showed something. Then one needs a bar graph that summarises the same finding across many different samples to show that there is a consistent trend. (HS2)

Technology-produced images such as micrographs are valuable in providing persuasive evidence: "We decided that we really wanted to show the micrographic representation of the graph. To hit people, make them really realize and believe the data" (HS1). Another author mentioned that with technology-produced images "all of them are basically from very specialised software" (PS1) and undergo a lot of processing.

Images of different types are also used in combination (see Figure 6). A single figure could include images reflecting the concept/steps of the method, raw data acquired by microscope, and then the results in different conditions (so that the readers know that researchers have not 'cherry picked' one condition) and reliability testing.

Schematic diagrams in N&V articles were characterised as conceptual overviews of the research (PS2), which are "very helpful in understanding the work as a whole" and "very powerful" (HS1). On the other hand, supporting Miller's (1998) finding that popularisations can distort the meaning of the original study, schematic diagrams can "sometimes distract and overinterpret the material. They […] can misrepresent what the data is really showing". They can be "powerful, but they can easily be used in a way that is not rigorous" (HS1).

3.2. Visual types in research articles and News and Views articles

Table 2 shows that RAs have more images per article than N&V articles and more images per 1,000 words. Thus, the purpose of images is not simply to make the articles more accessible or easier to understand. If this were the case, N&V articles, which have a broader, potentially less-informed readership than RAs would have more images/1,000 words.

	Health science RA	Physical science RA	Health Science N&V	Physical science N&V
Total images	372	316	38	66
Images/1,000 words	3.8	4.8	1.1	2.3

Table 2. Number of images in each corpus

Table 3 shows the image types in RAs compared with N&V articles. We categorised the images into three types:

a) Conceptual depictions (e.g., schematic representations).

b) Technologically-produced images (Daston and Galison's 2007 "mechanically objective" images). These images are of two types:

   a) macroscopic (e.g., photographs and X-rays). These images are visible to the naked eye, and capture an "existing structure or process" (Heekeren, 2021, p. 73).

   b) microscopic (e.g., microscope images). As discussed above, interviewees reported that there is "a lot of processing in generating these images", which are "prepared in a certain way so that they look nice", and it might be necessary to "change the colours" (PS1).

   As discussed by Daston and Galison (2007), to a greater or lesser degree, the trained eye of an expert is needed for technologically-produced images to be fully understood. This is particularly true of the microscopic images. However, although photographs have high modality/truth value to modern viewers (Kress & van Leeuwen, 2021), they too do not reflect "nature" and have potentially been manipulated in some way (e.g., different lenses may have been used).

c) Visualisations of measured data (Heekeren, 2021), that is, images that depict data mathematically (e.g., graphs). These require mathematical knowledge to be understood.

Research articles in our corpus were weighted towards graphs and technologically-produced images. As might be expected, graphs (especially line graphs and bar charts) were the most frequent types in RAs. Microscope images were also frequent in RAs; photographs and schematic representations were fairly common.

In contrast, in N&V articles, schematic representations were the only common types in both disciplines. Although Table 3 shows several Physics photographs, these were mostly from a single article, and only 13% of N&V articles contained photographs. Health science N&V articles also contained several flowcharts, illustrations and infographics; only a few physical science N&V articles included line graphs. This is surprising, given that the expected N&V readers are members of the disciplinary community or at least of the broader scientific community, and thus very familiar with meaning expressed in graphs.

3.3. How meaning is expressed visually in News and Views articles and research articles

Below we analyse visual expression of meaning in the most frequent image types in Table 3, analysing representational, interpersonal and compositional meaning for each type using Kress and van Leeuwen's social semiotic framework. To compare the kinds of meanings presented visually in RAs compared with N&V articles, we present an in-depth analysis of four graphs (visualisations of measured data), a photograph and two microscope images (technologically-produced), and two schematic representations (conceptual depictions). We also discuss what meanings, whether visual or textual, are recontextualised visually in N&V articles.

Image categories		Image types	Health science RA	Physical science RA	Health Science N&V	Physical science N&V
Conceptual depictions		Circuit diagram	0	2	0	0
		Flowchart	4	6	7	0
		Illustration	1	3	5	3
		Infographic	1	0	4	0
		Molecular model	0	8	0	2
		Schematic representation	**24**	**34**	**15**	**28**
		Venn Diagram	2	0	1	0
Technologically-produced images	Macroscopic	Photograph	**7**	**46**	**3**	**17**
		Screen shots	0	5	0	0
		Xray	3	0	0	0
		Map	2	0	0	0
	Microscopic	3D model/reconstruction	0	3	0	0
		Optical microscopic image	**43**	**38**	0	1
		Blot	**22**	2	0	0
		Electron microscope image	4	9	0	1
		Heat map/diagram	7	3	0	0
		Scientifically processed microscopic image	0	24	0	1
		Spatial mapping	0	2	0	1
		STM topography	0	20	0	0
Visualisations of measured data (graphs)		Arc plot	1	0	0	0
		Band diagram	0	1	0	0
		Bar chart	**48**	**17**	0	0
		Box plot	**43**	0	0	0
		Density plot	3	0	0	0
		Dot plot	**53**	3	0	2
		Emission/Concentration Map	1	0	0	0
		Histogram	3	2	0	0
		Kaplan-Meier plot	7	0	0	0
		Line graph	**54**	**68**	1	4
		Magnetic field-angle phase diagram	0	6	0	1
		Pie chart	0	1	1	0
		Scatterplot	**17**	3	0	0
		Scheme	0	2	0	0
		Segrè chart	0	0	0	1
		Spectrum	0	6	0	3
		Stability diagram	0	4	0	1
		Table	**14**	2	1	0
		Transcription analysis	8	0	0	0
		Total images	372	320	38	66

Table 3. Types of images in RAs and N&V articles

Visualisations of measured data (graphs)

As reflected in Table 3, most RA images, particularly in health science, stressed mathematical meaning. The most frequent images were line graphs (Figure 1), but bar charts (Figure 2), box plots (Figure 3) and dot plots (Figure 4) were also typical in RAs, although almost absent from N&V articles.

Regarding representational meaning, in Kress and van Leeuwen's (2021) framework, graphs express conceptual (rather than narrative) meaning. As indicated above, for Kress and van Leeuwen conceptual images represent static ideas and objects without dynamic forms of action. They view graphs as analytical structures which analyse the mathematical relationship between two variables, noting that most graphs concern spatial and/or temporal meaning. While all four graphs in Figures 1-4 do express conceptual analytical meaning as indicated by Kress and van Leeuwen, of the four graphs, only Figure 3, demonstrating drug intensity (y-axis) in six layers of cells (x-axis), at two different times (6h and 24h), shows a spatial relationship (six layers) and a temporal relationship (two different times). In contrast, Figures 1, 2 and 4 express meanings related to variables other than space or time. The line graph (Figure 1) shows how photon luminescence (TPL) on the y-axis varies with different excitation energy levels shown on the x-axis. The bar graph (Figure 2), although at first glance temporal, actually shows the percentage of children (y-axis) in distinct age bands (x-axis) who died of covid (black bars) compared with those who died of other causes (white bars). The dot plot (Figure 4) shows the number of lung nodules (y-axis) under two different conditions (DKK1 secretion and pLenti) (x-axis)[3]. From the viewer's perspective, understanding of these graphs depends on the reader's knowledge of the grammar of mathematical visual display, which is a point made also by O'Halloran (1999).

Interpersonally, the graphs offer the viewer information rather than making a social demand. Figures 1-4 show reduced modality with limited use of colour[4]. Figure 2 uses a single colour, black, to create salience, while Figure 1 uses green (one-photon absorption) and blue (two-photon absorption) to draw readers' attention to the distinction. Figure 3 uses blue and purple to alert readers to the temporal comparison. Frame size in graphs does not suggest social distance as represented by long/medium/closeup shots (as in narrative images). The angle of representation is eye-level, which does not code whether the reader is socially 'above' or 'below' the image participants.

Their reduced modality in terms of colour, frame size and angle strongly reinforces the analytical function, projecting a detached, objective stance. Ideologically, this aligns with a view of science as impersonal and objective.

Compositionally, as argued by O'Halloran (1999), the axes provide explicit horizontal and vertical alignment representing stability, in contrast to the curve (Figure 1), which she views as suggesting dynamism and change. In all four graphs, the scales on the axes have distinct representational meaning which does not align with Kress and van Leeuwen's (2021) framework, where left/right is interpreted as expressing given/new information and top/bottom placement suggests ideal vs. real. The framing achieved by the graph axes draws the readers' attention to the two variables displayed.

In Figures 2, 3 and 4, the categories (age groups in Figure 2, layers in Figure 3, and lung nodules in Figure 4) are framed by the white space (Ledin & Machin, 2020), encouraging the viewer to contrast the age groups, layers or numbers of lung nodules. Another layer of framing is seen in Figure 2 in the differentiation of colours between the bars white vs. black in the compounded structure. The use of black colour also increases the salience of Covid-19 death, drawing the viewer's attention to it. While the use of black and white in a graph may be considered "usual", the contrasting effect between black and white suggests that this move, whether calculated or not, foregrounds specific visual elements (Ledin & Machin, 2020, p. 173; Kress & van Leeuwen, 2021, p. 202). In Figure 2, the saturated black stands out against the white background of the visual space, highlighting these black bars and the meaning they represent. This visual salience is further reinforced when we consider the textual information presented in the bolded title of the graph where the writer's intention of emphasising Covid-19 death is unmistakable.

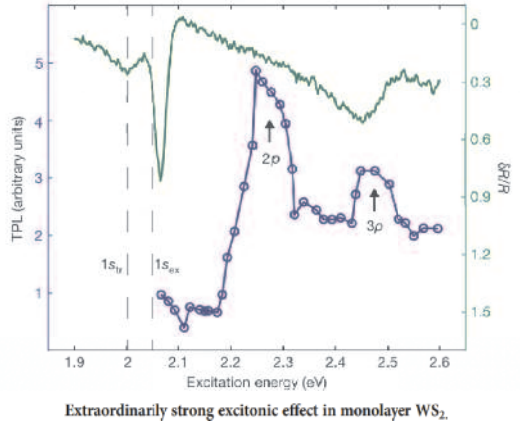


Figure 1. Line graph [RA16, Physics] (Reprinted by permission from Springer Nature: Nature: Probing excitonic dark states in single-layer tungsten disulphide, Ye et al., 2014)

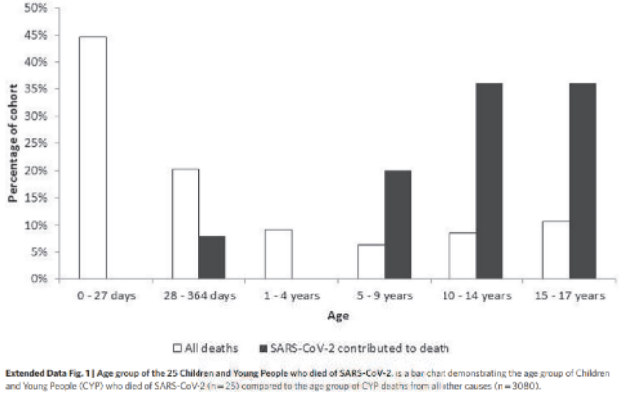


Figure 2. Bar graph [RA13, Health] (reprinted with permission from Springer Nature: Nature Medicine: Deaths in children and young people in England after SARS-CoV-2 infection during the first pandemic year, Smith et al., 2022)

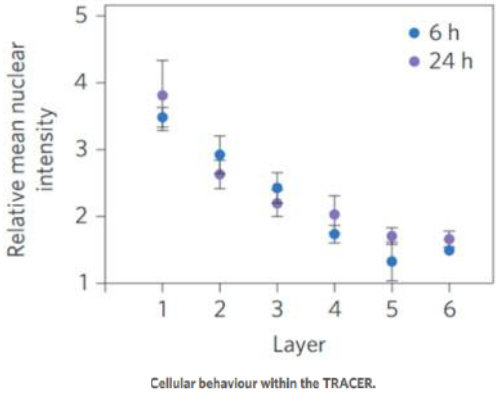


Figure 3. Box plot [RA12, Health] (reprinted with permission from Springer Nature: Nature Materials: A three-dimensional engineered tumour for spatial snapshot analysis of cell metabolism and phenotype in hypoxic gradients, Rodenhizer et al., 2015)

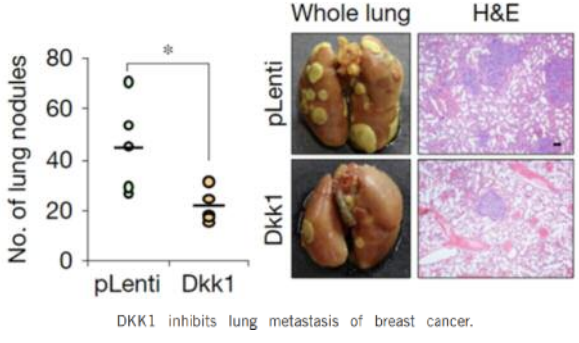


Figure 4. Dot plot, photograph and optical microscope slide [RA9 Health] (reprinted with permission from Springer Nature: Nature: Antibody and TLR7 agonist delay viral rebound in SHIV-infected monkeys, Borducci et al., 2018)

Technologically-produced images

Figure 4 shows not only the dot plot discussed above, but also photographs of cancerous nodules growing on mouse lungs under DKK1 or pLenti conditions ("whole lung" in Figure 4), and optical microscope slides ("H&E", reflecting the staining technique used). The three images work together to show the quantity of nodules on the lungs. The dot plot indicates the number of nodules under each condition. Likewise, the photographs of lungs depict this in the real-world dimension: what the nodules look like in

a real lung. From the two optical microscope images, expert readers can identify the structure of lung nodules. Here, the dot plot offers statistical evidence, the photographs provide insight into the real world of anatomy, and the microscopic images enable insights associated with scientific knowledge. Including three different image types sharing the same visual function (showing quantity) operates to convince the readers that there are fewer lung nodules under the DKK1 environment, and this claim can also be observed statistically. This three-part image demonstrates Miller's (1998) claim that photographs and graphs provide readers with direct access to the data, strengthening the research argument.

Regarding the interpersonal function, the modality in this image varies with the readers. To a non-expert, the photographs of the whole lung with nodules probably have the highest modality since it appears the closest to 'reality', holding the greatest truth value. Quantitative researchers may consider the dot plot as possessing the highest modality since statistics provide strong evidence of a claim's validity. For cancer researchers, the microscopic image may contain the greatest truth value. The authors draw on these different contextual dimensions to create this three-part image. Together these three images serve to reinforce the author's argument, as described by Rowley-Jolivet (2002) and Miller (1998). This image visually presents and strengthens the authors' claim by providing evidence that is statistically, generally and professionally 'validated'. As an expert said in an interview, without this visual evidence, readers would be more sceptical of claims.

Compositionally, Figure 4 is framed into three parts, suggesting that viewers consume information according to the common reading flow: from left to right (Rowley-Jolivet, 2002; Kress & Van Leeuwen, 2021). Drawing on Rowley-Jolivet's (2002) notion of chirality, this arrangement represents a claim-evidence relationship with the photographs and microscope slides functioning as evidence for the author's claim in the dot plot.

A second microscope image is found in a N&V article (Figure 5), which shows "randomly oriented" protein particles on the left which have been "aligned, classified, and averaged to determine the 3D-structure of the particle" (Bates, 2018, p. 771) depicted on the right. The multiple images of particles on the left were used (in the original RA) to reconstruct the 3D-structure on the right, shown from both a frontal and side angle (xy, xz). The arrow connecting the participants is a vector (representing an action)

indicating that the random particle images on the left are "aligned, classified and averaged" together to become a clearer and more detailed 3D-structure of the particle on the right. The 3D reconstruction seen in Figure 5 is however only an artist's illustration (recontextualisation) of an original technologically produced 3D reconstruction (see Figure 6). Interestingly, the N&Vs image creator opted to represent this process as a transformation — one thing simply becoming another, while the written caption clearly shows the process to be more complex ("aligned, classified and averaged to determine the 3D-structure"). This exemplifies Miller's (1998) point, reiterated by experts in our interviews, that in simplifying, popularisations may distort the original study's meaning.

Figure 5, from a N&V article, is a conceptual representation of the main finding of the RA. However, as the RA author explained in an interview, the N&V image (Figure 5) is "only the concept. But of course, how they actually do it, so the detail of the method, it's not explained. So this is the concept".

Interpersonally, Figure 5 is an offer image which, consistent with the objective and dispassionate representation of scientific research, does not involve participant gaze. While the colours of the optical microscopic images on the left have low colour saturation, the 3D-structure illustrations on the right are highly saturated. This juxtaposition highlights the effectiveness of the novel particle reconstruction process using colour to identify and measure the organisation of each component. Unlike most RAs and some N&V articles, the use of colour in this N&V image does not have low saturation, so does not align with the technological coding orientation typifying science. The microscope image in the N&V article, although it still has low colour differentiation and modulation, differs from most images found in RAs, in the intensity of the colours (high colour saturation). However, the lack of background distinguishes this image from naturalistic images, characterising it as a technological image.

Compositionally, the placement on a black background in Figure 5 presents the coloured particles on the left as a single unit. By contrast, placement on a white background and use of saturated colours make the 3D reconstructions on the left highly salient. This reflects the purpose of the novel method which is to describe a clearer, more measurable view of the particle. The two 3D reconstruction illustrations use the same colours (visual rhyming), and this, together with the letters *xy* and *xz*, identify them as different views of the same participant. There is a clear left/right division in

the image with spacing between two participants. This lends itself to a given/new information value interpretation: the left-hand participant is the given or known output of raw particle images; the right-hand participants are the novel fused/reconstructed super particle, the outcome of the research method. The arrow stems from the left and points towards the right, confirming this given/new information value. The shape of the arrow makes it look as if the particles on the left are absorbed into the particle on the right side; in a way this is what happens: the particles on the left are aligned, fused and averaged together to create the super particle on the right.

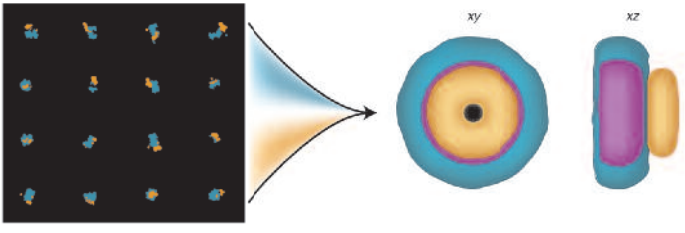


Fig. 1 | Single-particle analysis of multicolor SMLM images. Noisy images of randomly oriented, incompletely labeled particles (left) can be aligned, classified, and averaged to determine the 3D structure of the particle (right). Two-color imaging allows the spatial organization of any number of components to be measured by means of alignment of each component (e.g., the orange and purple rings shown here) with a reference structure (green ring), which is imaged in each sample.

Figure 5. Microscope image and illustration [N&V2 Physics] (reprinted with permission from Springer Nature: Nature Methods: Single-particle analysis for fluorescence nanoscopy, Bates, 2018)

What meanings are visually recontextualised in Figure 5? As the caption of Figure 5 states, the figure includes "images of…particles", which have been averaged "to determine the 3D structure of the particle" (Bates, 2018, p. 771). Together with its caption, Figure 5 recontextualises both textually and visually the findings of the RA from which it is drawn. Interestingly, the image(s) in Figure 5 are drawn from the more detailed five-image figure from the RA reproduced in Figure 6. Figure 5 results from both omissions and additions to Figure 6, as also found by Heekeren (2021). Omitted are images b, c and d from the RA (Figure 6), which show the method (**b**), close-up views (**c**), and the mathematical depiction of the data in the graph in **d**. Only the first and last images (**a** and **e**) have been used to construct Figure 5 from the N&V article; significantly the scales/units in **a** and **e** in Figure 6 are omitted from Figure 5, which provides instead a simplified overall conceptualisation of the RA findings. The graph at the bottom right of image **a**, demonstrating reliability, has also been left out. Additions in Figure

5 which were absent from Figure 6 include the orange and green colour of the particles on the left, and the arrows pointing to the reconstruction of the 3D protein structure on the right. Again, this serves to simplify and emphasise the overall concept or overall "narrative" of the research findings.

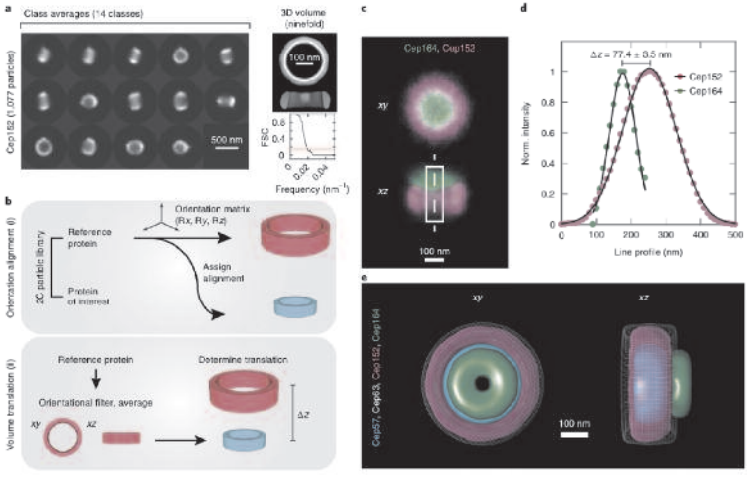


Fig. 1 | Multicolor single-particle reconstruction. a, Purified human centrosomes immunolabeled for Cep152 were imaged by high-throughput SMLM. After filtering, 1,077 particles were classified and used to reconstruct a 3D model (upper right) with a Fourier shell correlation (FSC) resolution of 52 nm (frequency, 0.019 nm^{-1}) (lower right)). **b**, Multivolume alignment from two-color (2C) particles: (i) orientational alignment by reconstruction of the reference protein (magenta) and assignment of single-particle orientations to the protein of interest (cyan), and (ii) volume translation from side views. **c**, Top (*xy*) and side (*xz*) views for Cep152–Cep164. **d**, The views from **c** were fit to Gaussian distributions to determine Δ*z*. Norm., normalized. **e**, Reconstruction of the protein pairs Cep152–Cep164, Cep152–Cep57 and Cep57–Cep63 yielded a four-color map of the human centriole. Data in **c**,**e** are from two independent experiments with similar results. Data in **d** are the mean and s.d. from the Gaussian fitting of averaged 2C projections from **c** ($n = 102$).

Figure 6. Image from RA on which Figure 5 is based [RA2 Physics] (reprinted with permission from Springer Nature: Nature Methods, Multicolor single-particle reconstruction of protein complexes, Sieben et al., 2018)

Conceptual depictions: Schematic representations

Below we consider two schematic representations, the most frequent image type in N&V articles: one from physical science (Figure 7) and one from health science (Figure 8). As will be seen, these images recontextualise as an image the main idea that the N&V article expresses.

Figure 7, from a N&V article, reports that a single layer of the metal molybdenum diselenide is highly reflective, constituting a near-perfect mirror. Figure 7 visually recontextualises what is conveyed textually in both the article title ('Mirrors made of a single atomic layer') and the strapline ('researchers have demonstrated that atomically thin materials can be highly reflective' [Mak & Shan, 2018]). Representationally, this schematic

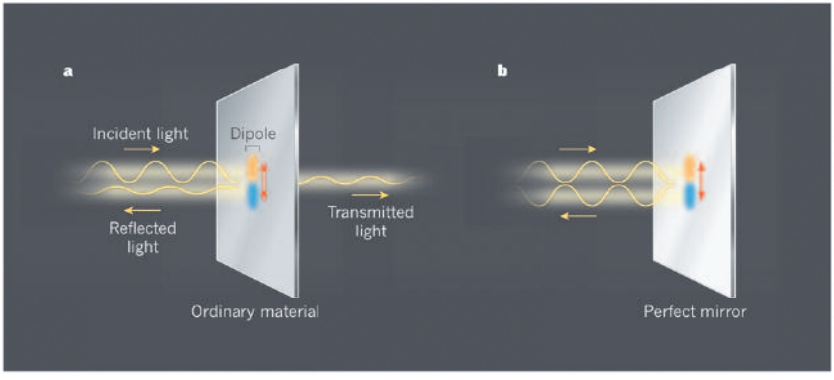
representation is classificational, because it represents two different kinds of material as well as their two consequent responses to light. The two participants have "the same size and the same orientation" (Kress & van Leeuwen, 2021, pp. 76–77) and uniform colours. The image distinguishes for readers the difference between the two mirror types.

Incidental light, indicated by a yellow wavy line and a yellow arrow (the vector), falls on **a**, the conventional material or **b**, the perfect mirror (goals). There is no source (actor) emitting the light because the image depicts how the different materials behave rather than what emits the light. So although there is a narrative element embedded in the image, it is of the narrative event type, there are no human participants. Thus, an objective style is maintained even in N&V articles. As Heekeren (2021) notes, genres that increase accessibility to science remain true to the practices of scientific communication such as, in this case, omission of human participants to appear objective.

Interpersonally, this is an offer image, and consistent with the objective value system of scientific research, there is no participant gaze. There is no high colour modulation, and, as in RAs, the use of colour in this N&V image aligns with a technological coding orientation where colour has low truth validity. The eye-level does not reflect any power dynamic between the viewer and image participants, except to give the viewers an optimum view. The lack of background in schematic representations characterises them as technological images.

Compositionally, the grey mirrors and the yellow light rays stand out against the black background conveying the comparative purpose of the image. There is a clear left/right division in the image with spacing between two participants. The conventional material on the left, with the perfect mirror on the right reflects their given-new status. Visual rhyming is evident in the similar colours in the two participants.

The N&V article containing Figure 7 recontextualises meaning from the RA which contained the line graph in Figure 1. Meaning in Figure 1 is detailed and mathematical, reporting exact measurements of photon luminescence in the metal monolayer, which results in the perfect mirror depicted in the schematic diagram in Figure 7. Figure 7 does not recontextualise the meaning in Figure 1, but is rather a simplified conceptual image which recontextualises the overall textual meaning in the N&V article, which in turn recontextualises both textual and visual meaning in the RA.



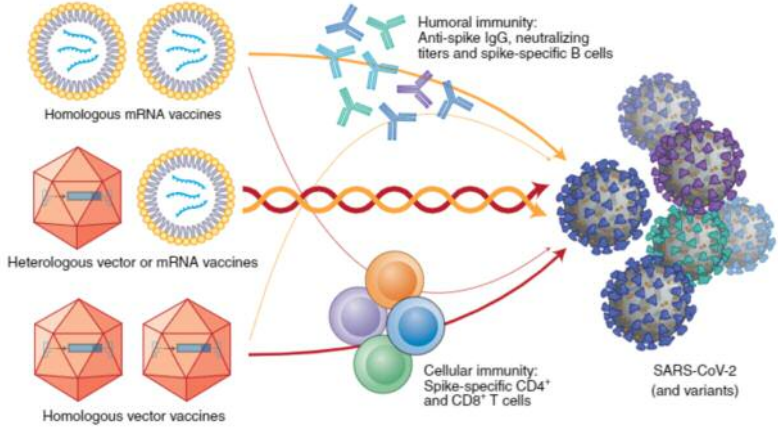
A conventional material versus a perfect mirror.

Figure 7. Schematic representation [N&V16 Physics] (reprinted with permission from Springer Nature: Nature: Mirrors made of a single atomic layer, Mak & Shan, 2018).

Like Figure 7, the schematic representation in Figure 8 summarises the overall textual meaning of the N&V article: the finding that two different types of vaccine as dose 1 and dose 2 are more effective than two doses of the same vaccine. The strapline of this N&V article summarises and recontextualises for a broader readership the finding of the RA on which it draws, stating (Deming & Lyke, 2021, p. 1510) that "dosing with the adenovirus-based ChAdOx1 (AstraZeneca) vaccine followed by an mRNA vaccine induced stronger immune responses than did the homologous ChAdOx1 vaccine series". The schematic representation in turn expresses this meaning visually.

Representationally, the image shows the vaccine structure and vaccine mechanism generalised to its major components: lipid layer, and single strands of RNA. In reality, the vaccine structure is more complex than this image represents. The image is what Kress and van Leeuwen (2021) call an analytical process which relates participants in a part-whole structure. The "wholes" at the left of the image are the spherical lipid mRNA vaccine, as well as the orange polyhedral-shaped vector vaccine; the "parts" in the central part of the image are the spike proteins and t-cells. In the central part, the yellow arrow shows the logical connection between the round yellow vaccine and the anti-spike IgG, while the red arrow shows the logical connection between the tetrahedral vaccine and the T cells. The right part of the image (SARS-CoV-2 (and variants)) is a symbolic process: given the pandemic situation at the time, this coronavirus structure symbolises the familiar image of the Covid-19 virus. This right-hand part of the image is

made salient in being the most 3D-like component, spheres with several protein spikes. It also has a comparatively higher colour saturation and modulation than participants on the left, with more intense shading and depth (black and grey shadows), making it appear larger and real. This component is also pointed at by the arrows.



A heterologous SARS-CoV-2 vaccine platform induces strong immunity.

Figure 8. Schematic representation [N&V33 Health] (reprinted with permission from Springer Nature: Nature Medicine: A 'mix and match' approach to SARSCoV-2 vaccination, Deming et al., 2021)

There is limited interpersonal function in this image with the absence of gaze. In comparison with a naturalistic coding orientation, analytical images have low modality since too much life-likeness and detail distract viewers from the analytical purpose of the visual (Kress & Van Leeuwen, 2021). This can be observed in the limited use of colour, reduced colour tone, modulation, and saturation in this image. The 2D-representation of the image components also indicates a lack of depth, making it difficult to establish interactive meaning via contact, distance, and point of view. However, the use of modality markers in the manner explained above fall in line with an abstract coding orientation where the image "reduces the specific to the general, and detailed representation to the representation of essential qualities" (Kress & van Leeuwen, 2021, p. 164). Thus, we see this image carrying the conceptual essence of the N&Vs article presented in an objective manner associated with scientific and technical visuals.

Compositionally, the image is framed into three parts, suggesting that viewers consume information according to the common (western) left-to-

right reading flow (Rowley-Jolivet, 2002). The information is sequenced so that the viewers encounter the analytical process in the first and second panels and the symbolic process in the third panel. More specifically, the 'whole' in the analytical process is presented first on the left, followed by the 'parts' in the centre and finally the symbolic process to the right. The analytical process presented in the first two panels represents the vaccine structure and mechanism making it a visual recontextualisation of the RA findings.

Overall, schematic diagrams provide a conceptual overview of the research study. They are newly designed images that recontextualise textual meaning in the N&V article (and by extension in the RA), rather than recontextualising any one image in the related RA.

4. Discussion and conclusions

News and Views articles recontextualise meaning in RAs for a broader audience, with both text and images playing a part in doing so. As Lemke (1998) argues in relation to RAs, in N&V articles, visual and textual meaning work together to express the meaning of the research. In this article we have argued that in both RAs and N&V articles, visual meaning is not supplementary to textual meaning, nor illustrative of it; rather it is central to meaning-making. As indicated in interviews with RA authors, experts may start by reading the visual meaning in the images in RAs, or even limit their reading to the images, as these provide depth as well as detailed information about the findings of the research. Thus, it cannot be concluded that textual meaning is recontextualised visually; equally the opposite could be argued, that text recontextualises the visual meaning.

In contrast with RAs, N&V images provide not detail, but a conceptual overview of research findings. Despite N&V readers being disciplinary insiders, N&V articles avoid abstract mathematics-based images, as reported for other popular genres (Fernández-Fontecha et al., 2019). Visual meaning can provide a quick understanding of the article. As Martin et al. (2019) found in relation to infographics, visual meaning can be more easily remembered. This accessibility of the schematic diagrams in N&V articles is recognised by one of our expert informants who reported that in conference presentations she uses the schematic diagram from the N&V article based on her RA. However, our interviews indicated support for

Miller's (1998) claim that such simplifications can distort the original study's meaning.

For the most part, N&V images do not recontextualise the meaning of images in RAs, but rather complement and recontextualise the textual meaning in the N&V article, in a similar process to that in RAs. However, as we have discussed in relation to Figure 5 and Figure 6, there are cases where RA images are adapted for use in the N&V article. In such cases, as seen in our discussion, conceptual meaning is stressed in the N&V article, and detail and mathematical meaning is removed.

Unlike RA images, which provide depth and detail to evidence claims, N&V images present an accessible conceptual overview of the main argument, thus supporting reader understanding. They can be understood by a wider audience, and the reader does not need to be an expert in the field. Not only do RA images provide more depth and detail, they are also likely to be abstract (e.g., graphs), and to result from complex methods (e.g., microscope images). Being technologically or mathematically produced, these image types realize impersonal objectivity which is a core value of scientific knowledge. These need the reader to understand both the visual grammar of mathematics and graphs (O'Halloran, 1999) and the methods and what the images resulting from these methods imply. This expert knowledge is not necessary for the reader of an N&V article. Accommodating the reader through the use of more accessible images such as schematic representations is a visual equivalent of the adjustment in lexis and grammar in popular genres noted by Cribb and Sari (2010) and Luzón (2013).

Although N&V images provide a conceptual overview of the main ideas and findings of the article rather than its detail and accuracy, they do, as Heekeren (2021) found, remain true to the objective impersonal value system of science. Representationally, conceptual images rather than narrative ones are used. Interpersonally, as in RA images, the absence of human gaze, reduced colour modulation and eye level perspective means that angle is not an indicator of social distance. Equally, background, which has high truth value in naturalistic images, is removed. Compositionally, following the expected reading flow, schematic diagrams showed a left/right, given/new organisation, which was not evident in graphs, microscopic images, or photographs.

A contribution of this study is its in-depth social semiotic analysis of detailed abstract visual meaning in research articles compared with

conceptual visual overviews in News and Views articles, a genre with a broader readership. In addition, our analysis of a genre that recontextualises meaning for disciplinary insiders contributes to the literature on open science by demonstrating similar processes at work to those found in popularisations for lay readers.

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NOTES

[1] Rowley-Jolivet (2002, p. 31) borrowed this term from stereochemistry which refers to the autonomous existence and relational information between visual components set up next to each other on the left and right.

[2] Ethics approval was obtained from the Human ethics committee at our institution (ID 0000030572).

[3] This discussion focuses on the dot plot only. We discuss the photograph and the microscope image below.

[4] It should be noted that the visual parameters of modality (e.g., colour vs. black and white) tend to change over time and across communicative domains, (see Consonni, 2020). However, because of the brief period of time over which the selected articles were published and because our corpora are limited to two science disciplines, the study is unable to trace changes of this sort.