The Resemiotization of Science into Graphical Abstracts: Major Semiotic Issues at Stake

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Abstract

This article serves a twofold objective: on the one hand, it questions the alleged universality of much of the current resemiotization of scientific content into graphical abstracts and diagnoses the major causes of ambiguity and misinterpretation. On the other, it intends to reunite the long-dissociated disciplines of Semiotics and Linguistics. Over 70 samples reported to be difficult to interpret by scholarly science bloggers and published in Q1 journals on Physics, Chemistry, Chemical Physics and Physical Chemistry from January 2022 to June 2023 are analysed regarding the five contexts common to Semiotics and Linguistics: situational, actional, psychological, existential and cotextual. Specifically, the focus is set on major interpretive hurdles such as unfamiliar cotexts, jocular overtones, narrative occlusion, cognitive overload, discursive scope, interdiscursivity, and intertextuality. Findings suggest that most causes for misinterpretation seem to derive from compositional strategies and the choice of registers and metaphorical scenarios. A proposal of basic author-oriented semiotics in the form of self-reflection questions is finally provided.

1. The Resemiotization of Science as Backdrop for a Semiotics of Graphical Abstracts

Social semioticians have long stressed the critical issues underlying resemiotization, also known as 'repurposing' and 'semiotic remediation' (Prior, 2013). According to Chandler (2002: 11), "to decline the study of signs is to leave to others the control of the world of meanings which we inhabit", and Kress (2010: 27) states that "representation makers are knowledge makers". Few areas of human activity have undergone such a recent and intense resemiotization process as that of science dissemination. The reason has been twofold: on the one hand, digital affordances have given rise to new rhetorical and representational practices of the traditional IMRD narrative of science reporting (i.e. Introduction-Method-Results-Discussion), a structure detailed and thoroughly studied, among others, by Swales (1990, 2004) and by Gross et al., (2002), the latter diachronically since the very origin of the research article in the XVII century. On the other hand, the current models of science dissemination, which aim at an increasingly more democratic involvement of the citizenship at every stage of the research process, are demanding more transparent channels and strategies of communication in every sense—accessibility, discourse simplification, and appealing formats—as well as assigning new roles to scientists.

Digitalization, according to Luzón and Pérez-Llantada (2019:2), has revolutionized the ways in which researchers "produce, represent, re-use and share information and knowledge". This revolution, however, not only has increased the number of genres but also contributed to the hybridization of traditional scientific ones by borrowing discourses and rhetorical features from other spheres of activity (e.g. the promotional register of Marketing and Advertising in abstracts and article titles, introductions and discussions, and the humorous tone of comic strips or the narrative sequence of graphic novels found in graphical abstracts), and have also broadened up their circulation paths thanks to the various platforms offered by the web. Thus, as Luzón and Pérez-Llantada note (2019:7-8), we may encounter *hyperlinked genres* (and interconnected genre colonies and constellations that create complex genre ecologies), *multigenres* (that is, several genres gathered within one same platform to facilitate intake, as happens in some academic websites and research team blogs), and *add-on genres,* embedded or supplementary materials such as graphical and video abstracts and audioslides, whose function is to promote the research and make it more visible.

Democratization has brought about the adoption of extra-academic roles by scholars: those of graphic designers or filmmakers, journalists, advertisers, marketeers, and entertainers. With the gradual extinction of science journalists as mediators between experts and laypeople, researchers are being put in front of general publics and they are consequently undertaking outreach tasks (Stocklmayer, 2013). The current Open Science trend exemplifies these democratic values of transparency and sharing based on the notion of science as a public good rather than a commodity. The conjunction of digitalization and democratization is progressively leading to a 'context collapse' (Marwick and Boyd, 2011; Puschmann, 2015) that fuses diverse audiences into one and impels to meet their expectations simultaneously.

In digital environments, science dissemination instances have turned into what Page (2018) has called 'shared stories', atypical forms of narrative (2018:9) that abound in online platforms and social networks and reflect (allegedly) shared sets of assumptions and cultural patterns or scripts. This article questions the universality of much of this current resemiotization of research into graphical abstracts (heretofore GAs), diagnose the major causes of ambiguity and misinterpretation, and make the case for a consensual semiotics of the genre sustained by visual literacy on the part of both experts and wide audiences. Alongside this purpose, I intend to contribute to reuniting the disciplines of Semiotics and Linguistics, dissociated for too long.

2. Reuniting Linguistics and Semiotics: The Sign as Central Link

Although the Saussurean notion of language highlights the crucial role of signs (De Saussure, 1983 [1916]), their study has been relegated to Semiotics, usually viewed as a larger science of human cognition and behaviour, whereas Linguistics is more specifically defined as the scientific study of language. The two disciplines bear a sort of 'chicken-and-egg'

or whole-to-part relationship (Tobin, 1990), being the sign the common denominator between them. Some scholars consider Linguistics embedded in Semiotics, while for others the latter is subsumed under the former. Be that as it may, both complement each other: Parret (1983) underscores their interdisciplinary analogies, grounded in their (recently) highly contextual nature, originally absent in De Saussure's (1916) *Cours de Linguistique Générale* because his interest in signs outside the language system concerned only the relationships among them, not the societal frame of their occurrence. As Chandler (2002:215) asserts, "semiotics is invaluable if we wish to look beyond the manifest content of texts", and the relatively recent sociocultural turn of Linguistics makes it converge with Semiotics in blended fields such as Pragmasemiotics, which nurtures from Cultural Studies and brings to the fore issues such as difference, identity and power, ideology (signs function to persuade as much as to refer), politeness strategies, interdiscursive and intertextual practices, medium and mode influence and mediation in disciplinary domains, or the educational, symbolic, and cultural capitals within a given group and across cultures (Thwaites et al., 2002[1994]).

The analogies detected by Parret (1983) between Linguistics and Semiotics involve metatheoretical aspects (subjectivity, rationality, and intentionality) and heuristic ones (modality and deixis) that describe five types of contexts [FIG. 1]: contextual, existential, situational, actional, and psychological. Cotexts comprise the texts (of any kind and mode), artefacts, and signs surrounding a given sign, together with their coherence and cohesion features, and may build a cultural 'semiotic canon or heritage' at a national, regional, ethnic, status-, gender-, age- and belief-based, educational, religious, occupational, sexual, idiolectal, or disciplinary level. Existential contexts deal with deictic categories (person, space, and time) in the world of objects, states of affairs and events. Situational contexts provide frames (i.e. expectations or 'scripts') that determine the meaning of the communicative occasion and may be institutional (e.g. expectations or 'scripts' at courtrooms, classrooms, hospitals, etc.) or related with life-settings and routines (e.g. shopping, eating at restaurants, etc.). Actional contexts are intentionally conditioned since they depend on the illocutionary forces behind
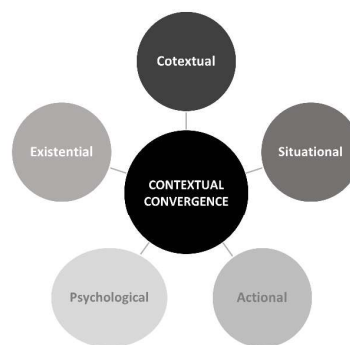

Fig. 1 | Contextual convergence of Linguistics and Semiotics.

speech acts, and psychological contexts are shaped by beliefs and desires.

These five coexisting contexts interact and compete among themselves; therefore, we need to relate signs to relevant shared codes to make sense of them. Clearly, interpretation depends on prior knowledge (Jakobson, 1971; Gombrich, 1972) consisting in code recognition, so the application of inadequate codes will result in what Eco (1965) termed 'aberrant decoding'. This is, precisely, the chief problem with the dissemination of science by means of GAs: authors and viewers hardly share the same code and both the creation and interpretation of meaning lean on De Saussure's 'parole' (i.e. on individual instances of meaning derived from personal experience and knowledge and private interests) rather than on 'langue' (i.e. on the set of systematic rules and conventions for making meaning), which was the priority in the structuralist model that he devised. The referents in the original Saussurean *langue/parole* dichotomy were, respectively, the language and speech acts, comparable with the Chomskian division 'competence/performance'. An interpretation sustained by *parole*/performance in all five contexts (contextual, situational, actional, psychological, existential) is as risky as applying a wrong code right from the outset. For example, transgressing the typical 'sanitized' interpersonal distance of scientific discourse with one's graphical and deictic choices (existential context) or a cultural reference that is too local (cotextual context) may be as confusing as an ineffective metaphorization of the scientific content due to its complexity or remoteness, or as a poor summary that misses the research focus and fails to enhance

the scientific achievement (wrong code).

3. The Graphical Abstract as Bourgeoning Digital Genre in Science Dissemination

To feature the GA genre, we may label it as a *hybrid* or *enculturated* academic practice. This implies that the traditional traits of scientific discourse (i.e. impersonality to reflect objectivity, a factual approach to phenomena, formality, a predominance of simple and past tenses, complex noun phrases, and a targeted audience of insiders in the field of expertise, to name a few), deeply studied by renowned discourse analysts such as Swales and Feak (1994), Hyland (2006), Biber and Conrad (2009), or Pho (2013), tend to fade with the incorporation of other discourses and modes that enrich intersemiosis; that is to say, the construction of meaning through signs.

Hybridity (Bhatia, 1993 and 2004) may affect all four definitory and consolidating pillars of genre: its *purpose, participants, process, and product* (Bhatia, 1993) and be in turn caused by changes in one or more of them. As to purpose, the initial goal of GAs, to inform of scientific and technical accomplishments and make them visible outside the research article text, has gradually given way to a hypertrophic promotion of discoveries and inventions and even to amusement, thanks to the fierce competition among institutions and industries and the digital affordances (e.g. image import and formatting) brought by computer-mediated communication, also responsible for a shift to a more informal register and a foregrounding of authorial presence (Maier and Enberg, 2013) with style singularities, self-portraits, and the recordings of one's own voice in video essays. Regarding participants, GAs are now supposed to widen up their expert audience and address lay viewers/readers, and their crafting process may involve registers other than the scientific one (e.g. literary, photographic, filmic, advertising, cartoon- and comic-book based) and modes (for the time being it stays bimodal—visual and verbal). Such elaboration merges mimesis and creation (i.e. naturalistic and symbolic representations), draws on texts and discourses, and resorts to every type of semiosis, whether through *icons* (i.e. mimetic signs), *indexes* (i.e. signs pointing to metonymic relationships, such as cause and effect or part-whole), or *symbols* (signs arbitrarily associated with real facts or phenomena). As a result, the product is increasingly becoming less recognizable as a scientific summary, and this fuzziness would predictably intensify with a future addition of sound and images in motion, which would unavoidably blur its generic boundaries with the video abstract.

The recently acquired multifunctionality of GAs consists then of an *informative* aim (by encapsulating research contents), research *promotion* (through the combination of visual and verbal resources and strategies imported from Marketing and Advertising), *engagement* (as attention-getters enticing the viewer/reader to read the full document), and *metadiscursive guidance* throughout the body of text of the scientific paper. In this sense, GAs may be considered complex metadiscourse items that can, even simultaneously, include (and serve themselves as) *code glosses*, especially through embedded tropes (mainly metaphors and metonymies), *goal announcers* offering a preview or 'road map' of the article, *transition markers* (signposting ideas through frames and vectors—arrows and lines), *cognitive directives* that tell the viewer/reader how to interpret the information presented (e.g. emphasizing the importance of a procedural stage with a single 'frozen image' taking up the whole panel space), and *attitudinal markers* (another way of authorial foregrounding, through artwork choices such as fonts, layout composition, colour palettes, and any embellishing element). All the metadiscourse items just listed belong to Hyland's 2005 interactive and interactional taxonomy.

Unless GAs are commissioned to professional graphic designers, who are frequently 'outsiders' of the field of expertise, the multifunctionality described above falls entirely on the scientists' shoulders. They must undertake the roles of artist, science journalist, advertiser, teacher and, lately, of entertainer—of amusing storytellers recounting their research story. However, are they disseminating the right, or better put, the best story possible? Is the four-move IMRD narrative of science infallibly identifiable, or is it simplified and interrupted in the service of language economy and entertaining effects? Do journal guidelines suffice to design a clear GA? GA typologies are timidly emerging in the scholarly panorama to aid novice researchers in their visual choices: some focus on form, like that by Hullman and Bach (2018), comprising five layout patterns (linear, zig-zag, circular, parallel, and
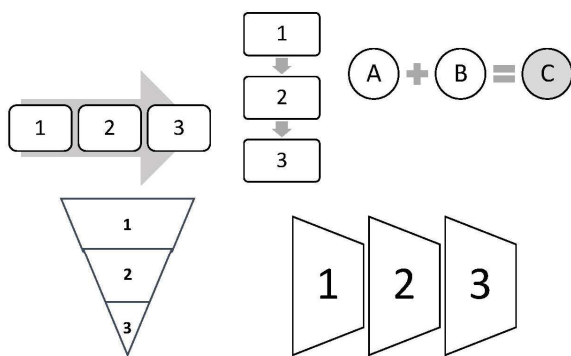
Fig. 2 | Instances of the narrative evolution/denouement type of functional GA layout, with vectors or simply by means of visual juxtaposed collocation. Models selected from Microsoft's Windows 10Pro ('SmartArt').

orthogonal), and others on function (Sancho Guinda, 2021a, 2021b and 2022), which drawing on Elsevier's online exemplars from the publisher's guidelines until 2022, distinguishes four kinds: 'narrative evolutions/denouements', 'zoom-ins', 'classificatory collocations or diagrams', and 'data displays'.

The first of them, narrative evolutions [Fig. 2], shows some change of state or condition, signalling the 'before' and the 'after' stages or indicating the reading/viewing path with vectors or the sequential placement of visual elements (the directionality of equations and chemical reactions subsumes them within this group), and simultaneity is represented with image overlaps.

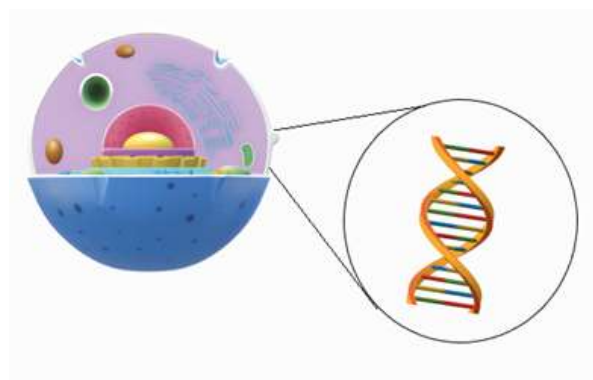The second type [Fig.3], the zoom-in, amplifies detail, frequently with a stylized lens icon or zoom-in

Fig. 3 | Instance of the zoom-in type of functional GA layout, with vectors. Model created by author using Paint 3D's archive images.
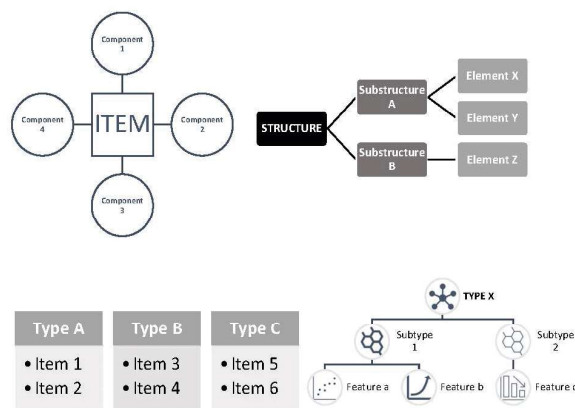

Fig. 4 | Instances of the classificatory collocation/diagram type of functional GA layout. Models selected from Microsoft's Windows 10Pro ('SmartArt').

callout that discloses a substructure or phenomenon invisible to the naked eye, normally at a microscopic level. When zoom-ins are found in bar/column charts and plot line graphs, they constitute 'embedded narratives' that deserve further commentary.

The third GA type, the classificatory collocation/diagram [Fig.4], organizes information and facilitates taxonomies with or without vectors, in which case juxtaposition is used, as in the instance from the second row on the left.

Last, factual displays [Fig. 5] comprise tables and graphs/charts of diverse sorts. Equations, chemical reactions, and even word maps may be also considered part of this kind of layout, whose objective is the communication of findings. Interestingly, while some journals admit the re-use of visuals from the article's text in the GA, others do not and demand the design of others ad hoc or discourage empirical data altogether (e.g. Elsevier's *Cell* and *The Journal of Medical Internet Research,* a pioneer open-access e-health publication).
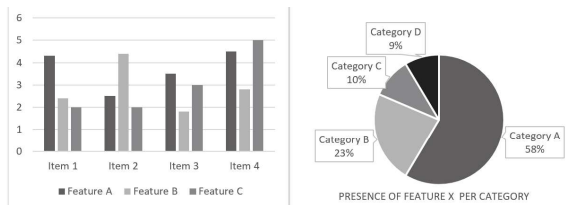

Fig. 5 | Instances of the factual display type of functional GA layout. Models created by author with Microsoft Windows 2010.

It should be noted that the sign combinations making up these four functional GA layouts may constitute the co-text of other sign choices in the same GA, be considered complex signs in themselves, and combine to generate yet more complex signs. Unfortunately (and with few exceptions), the online GA guidelines from reputed scientific journals, no matter from what discipline, are still rather vague and editorial policies perhaps too lenient, so informal registers may easily slip in. Not many journals do reject cartooning, logos, saturated colours, certain font types (such as 'Comic sans', 'Chiller', 'Mystical woods', 'Snap ITC' and the like), generic stock photos, or headshots of the author(s). In this regard, Elsevier's initiative of providing a three-panel GA template [Fig. 6] may dissipate confusion. Indeed, it segments the holistic nature of conventional single-panel GAs, the usual norm, into three genre moves more easily identifiable. Yet it remains to be studied whether this model will prevent authors from shifting registers, either by employing far-fetched metaphorical scenarios (Musolff, 2004) and embodiments or by including distractors such as embellishments.

If we were to pinpoint the main challenges posed by GAs, we could reduce them to three: *transduction, discourse economy,* and the fight against *acculturation.* Transduction (Kress, 2010), Prior's (2013) 'semiotic remediation', is the translation of information from one mode to another: in the case of GAs, from the verbal to the visual. It is inevitably subjective—for example, in evaluating the convenience and efficacy of sign choices—and incomplete (as said, visuals are holistic and in the GA genre must prevail over verbalization). Example (1) is a single-panel GA divided in two to show a sequence of events, probably a change of state or condition (difficult to spot, by the way), but a high degree of expertise is necessary to know within what particular genre move: whether in an introduction stating the technical problem or knowledge gap, in the application of a method, or in its result or out-
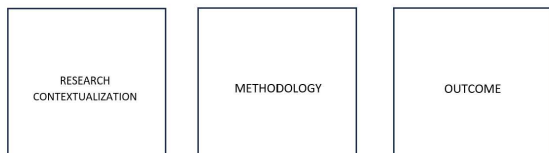

Fig. 6 | Elsevier's tripartite GA template.

come, or whether within the combined moves I+M, or M+R. For non-experts and experts with an untrained eye, the cognitive investment to elucidate all this is too high and time-consuming, which goes against the immediacy expected from a visual summary and its compliance with the politeness maxim of generosity (i.e. minimize effort for others; Leech, 2014) and the conversational cooperation maxims of quantity, manner, and relation (Grice, 1975).

(1)   http://dx.doi.org/10.1016/j.bcp.2009.09.004

Transduction may also cause progressive enculturation; in other words, the gradual assimilation of features from other genres (e.g. registers, texts, metaphors and any other kind of visual or verbal representation) which might end up in acculturation, the loss of distinctive generic features. In addition, from a pragmatics perspective, enculturation may be conducive to cultural transgressions and originate face-threatening acts (FTAs) for groups or individuals, as in Example (2), where the metaphorization of chemical elements as the silhouettes of three people dancing in a disco bar, one of them a woman in a miniskirt and a provocative posture, metaphorizes the ease for chemical bonding of the metal she embodies (zinc). This representation of a female as a seductress depicts a social script or frame alien to Muslim cultures, which might misunderstand it and take it as offensive. Here, the psychological semiotic context (beliefs) is at play together with a cultural cotext (an underlying religious canon of Islamic texts) and a desire to instil some humour (actional semiotic context) to the transduction.

Discourse economy is the basis of GAs' original informative function, as they are intended to summarize research processes and condense the benefits of their outcomes to persuade viewers/readers (mostly institutions, potential investors and clients, and fellow scholars). The actional semiotic context may affect discursive economy if there is an entertaining intention, often a jocular overtone behind the representation of the scientific facts, since added nuances frequently require extra discourse and authors run the risk of occluding the narrative progression of the scientific phenomenon. Example (3) equates a series of molecules and chemical behaviours relative to carbon and silicon with a crime scene already con-

trolled by police, but the motivation of such metaphor remains unclear. Is the chemical reaction in question, like crime, undesirable? Is it that those molecular reactions call for further investigation? Is the police line delimiting research access into the 'science scene', similar to a crime scene? Why are the chemical elements involved written on the street cobblestones just as the chalk outlines surrounding the corpse in actual crime investigations? For what reason is the acronym 'HAT' (i.e. 'hydrogen atom transfer') written in loud-red capital letters, as if it was a blood splash on the ground? This detective-like conundrum engenders a cognitive overload of metaphorical mappings between source and target domains that can only be solved by interviewing the article authors: 'ad hoc pointers' or 'metaphorical triggers' (Yus, 2009), which are the indicators that mark the incongruency of a denotative interpretation, are too weak because the metaphorical scenario chosen is well-known round the world and a shared code of chemical expertise is taken for granted.

(2) https://doi.org/10.1039/C5CP04498G

(3) https://doi.org/10.1002/chem.201204157

Acculturation stems from persistent enculturation and involves cotexts (signs, codes—interdiscursivity—and scenarios that are too remote or far-fetched and may be psychologically motivated), and changes in the interpersonal distance provided by the existential context through discourse appropriation (e.g. direct appeals to the viewer/reader through interrogatives and pronominal use, expressive punctuation, etc.). Example (4) contains these elements, typical of the discourse of Advertising. The result is a GA hardly identifiable as such. Rather, it resembles a billboard advertisement.

(4) https://doi.org/10.1039/C3CC44118K

Transduction (with its associated dangers of incompleteness, subjectivity and enculturation), discourse economy (with its risk of cognitive overload) and acculturation (owing to far-fetched or too local cotexts/codes and presumably occluding scientific narrative, altering interpersonal distance and hindering the identification of the genre as a GA) are the three major

CHALLENGES	SEMIOTIC CONTEXTS INVOLVED	MATERIALIZATIONS OR EFFECTS IN DISCOURSE

Transduction	• Cotextual
	• Existential
	• Situational
	• Psychological
	• Actional
		• Incompleteness (esp. in single-panel GAs), fuzzy genre moves
		• Subjectivity and enculturation
		  ○ Stylization: embellishments and humorous prettification*
		  ○ Connotation + metaphorical embodiments and scenarios
		  ○ Interdiscursivity, intertextuality
		• Folklore, folk wisdom references
		  ○ Cultural transgression (FTAs)
		  ○ Jocular overtone

Discourse economy	• Cotextual (wrong codes hard to decode—e.g. metaphorizations) • Actional (added illocutionary force—e.g. emotions such as humour or irony)	• Jocular overtone • Narrative occlusion • Cognitive overload • Excessive implicitness • Uncertain discourse scope for expressing the encapsulated idea (discourse? sentence? phrase? word?)
Acculturation	• Cotextual (remote or wrong codes) • Existential (through interdiscursivity) • Psychological (underlying beliefs and desires) • Situational (expected frames or scripts)	• Narrative occlusion • Interpersonal closeness (e.g. expressive punctuation, rhetorical questions, 'we/you' pronouns, direct appeals) • Jocular overtone • Folklore + folk wisdom

Tab. 1 | Major issues at stake in GA design and their semiotic contexts and textual effects. (*) Prettification is the cartooned or emoji rendition of inanimate items, such as molecules, usually in an anthropomorphic manner (Sancho Guinda 2019, 373).

issues at stake in GA design. In Table 1 I map them out systematically to raise awareness of the challenges and semiotic contexts intervening and of their materializations and effects. Different semiotic context may produce the same materializations and effects.

The coming pair of sections will describe the incidence of those materializations/effects in a recent corpus of GAs from highly empirical fields and considered problematic by science bloggers.

4. Materials and Methods for the Study of Graphical Abstract Encoding

With the intention of finding out what semiotic materializations and effects preponderate as causes of GA inefficacy, a total of 72 GA samples compiled between January and 2022 and June 2023 by the science blog TOC ROLF (https://tocrofl.tumblr.com/) were scrutinized. As aforementioned, this blog is known among scholars for posting and commenting on GAs considered ineffective or bizarre. It feeds from journals' tables of contents, scientists' tweets

(today brief communications on the platform newly called 'X'), personal science blogs, and spontaneous scholarly contributions. The time span chosen corresponds to the latest posts.

The scientific disciplines dealt with pivot around Physics, Chemistry, Chemical Physics, and Physical Chemistry, all of them empirical domains with (in principle) very little room for subjectivity, and the 44 journals involved are placed in the first quartile, according to editorial databases such as Scopus, Scimago, and Web of Science. Figure 7 displays the percentages of journal publishers present in the corpus and Table 2 specifies their titles.

Because of their disparate criteria, journals' guidelines or instructions for authors do not help to establish shared semiotic codes for GA design. The American Chemistry Society (ACS), for example, demands "simple but informative" GAs that uphold the standards of a scholarly professional publication. Graphics must be entirely original (the ones present in the manuscript should be discarded) and balance images and verbal description. They should be easy to read and lean, not incur information clutters. Logos, caricatures or photographs of living or deceased people are discouraged and the use of colour is welcome. It provides competently crafted exemplars and poorly designed samples as well.

Elsevier, by contrast, includes only four exemplars (a considerable reduction of its initial 16-sample catalogue, online from 2016 to 2022) and facilitates the three-panel template shown in Figure 5. It coincides with ACS in requesting original images and in the avoidance of distracting and cluttering stimuli. Its distinctive instructions are the marking of a clear
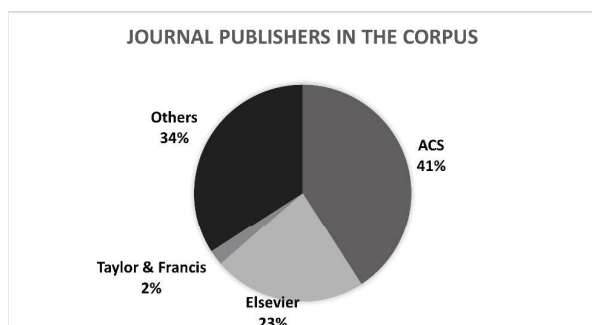
start and end and the indication of possible viewing/reading paths: from top to bottom and from left to right (which, incidentally, could be accused of ethnocentrism for favouring cultures with languages scripted from left to right—e.g. Romance and Germanic). Much more lenient are the guidelines from Taylor & Francis, limited to format requirements (a landscape orientation of the panel with a 2-length: 1-height ratio and legibility at a width of 525px), and from publishers within the category of 'others' [Fig. 7]. *Angewandte Chemie*, for one, famous for its eccentric and informal GA compositions and one of the most salient titles in TOC ROLF's archive, simply asks for compliance with the journal's ethical and legal conditions and reminds authors that GAs should stimulate curiosity.

Corpus samples have been examined according to the following semiotic effects (see Table 1): cognitive overload, jocular overtone, remote or inadequate non-scientific cotexts, intertextuality, interdiscursivity, occlusion of narrative progression, and semiotic scope (i.e. the extension of the graphic's verbal paraphrase: whether discourse, sentence, or phrase). For instance, Example (4) is too complex to be epitomized in one sentence and needs a full-discourse verbalization. On a different note, although intertextuality and interdiscursivity may be the cause of unshared cotexts, they will be treated separately, as it is not always so: unfamiliar cotexts can be created without their intervention. Finally, sample rating was assisted by two professors of Chemical Engineering from the Technical School of Industrial Engineering and Design at the Universidad Politécnica de Madrid, Spain,

Fig. 7 | Percentages of journal publishing houses represented in the corpus.

Tab. 2 | Specification of journal titles from the corpus.

TITLES SPECIFICATION	**ACS** *Applied Biomaterials, Applied Materials & Interfaces, Bio & Medchem, Catalysis, Central Science, Crystal Growth & Design, Inorganic Chemistry, Journal of the American Chemical Society, Journal of Chemical Theory and Computation, Journal of Natural Products, Macromolecules, Materials Au, Nano, Omega, Organic Letters, Organic Process Research & Development, The Journal of Organic Chemistry, The Journal of Physical Chemistry Letters* **ELSEVIER** *Cell Press, 50 Chem, Chemical Engineering Journal, Chemosphere, iscience, 50 iscience, Journal of Organometallic Chemistry, Materials Today Chemistry, Molecular Cell, Polymer Degradation and Stability* **TAYLOR & FRANCIS** *Synthetic Communications* **OTHERS** *Angewandte Chemie, Canadian Journal of Chemistry, Chemical Communications, Chemical Science, Chemical Society Reviews, Chemistry: A European Journal, Computer Physics Communications, Dalton Transactions, Macromolecular Rapid Communications, Nature, Nature Communications, New Journal of Chemistry, RSC Advances, The Journal of Organic Chemistry*

who have a solid physics background and reached a minimum overall coincidence rate of 85%.

5. A Diagnose of Graphical Abstracts' Misinterpretation

The analysis of the 72 TOC ROLF samples reveals that, while verbal abstracts are defined, in Swales and Feak's words (2009: 2), as "stand-alone min-texts" summarising a study's topic, methodology and key findings, most of their graphic counterparts are dependent add-ons. They do need to be placed close to the verbal summary (at its side, to the right or left, or above/below it) and even in this way they may not even ensure full understanding. It is telling that no corpus sample was found apart from the verbal abstract in the journal where it was published. Viewers/readers are thus forced to shift back and forth from the verbal to the visual version of the abstract to grasp the scientific content. The comprehension of the visual text is yet more compromised if the GA appears by itself in the journal's table of contents, just with the support of the title; hence the name of the critical blog TOC ROLF: 'Table of Contents. Rolling on the Floor Laughing'.

GA authors in general do not seem to be aware of the double impact of signs: their paradigmatic and syntagmatic dimensions, closely interwoven. For example, if a researcher wants to visually qualify a given technical procedure as correct, convenient, desirable, etc, (s)he needs to select a sign and place it in an environment where it will oppose to other signs or combine with them to form more complex units of

Fig. 8 | Main interpretive hurdles in the studied corpus
(The 'scope' percentage indicates the proportion of samples that can be paraphrased only with discourse)

meaning. If there is more than one sign candidate for selection, they all will hold a paradigmatic relationship (i.e. of substitution) along an imaginary vertical axis. Selection will depend on the nuances, connotations, and degree of (cross-)cultural rootedness that each sign can transmit. At the same time, the combinatory and contrastive relationships that each sign may hold with other signs in the semiotic environment where it is inserted, occurs along a horizontal axis. Paradigmatic/vertical relationships, in sum, may be understood as 'lexical', whereas syntagmatic/horizontal ones, which require firm cohesion and coherence, as 'syntactic'. By way of illustration, a given chemical reaction could be visually evaluated using the following paradigmatic options: a happy-face emoji, tick and thumbs-up icons, the colour green, or verbal qualifiers of the type 'YES', 'OK', 'RIGHT' or 'CORRECT'. These signs may inter-combine to reinforce their meaning and be, for example, coloured in green.

Analogously, their opposites should be a sad emoji face, cross and thumbs-down icons, the colour red, and verbal descriptors such as 'NO', 'WRONG' or 'INCORRECT'. They may be likewise reinforced coloured in red. Although the meanings of each of these paradigmatic candidates are crystal-clear and have been internationally lexicalized since long, syntagmatic associations must be consistent (e.g. emojis with emojis, ticks with crosses, etc.) to process the information more immediately. Such consistency, equivalent to a word-against-word (word-antonym) relationship, is more difficult to attain when the semiotic scope expands from the word to the sentence or further to discourse. Most GAs give a full picture (i.e. a complex idea, a narrative process, or an argument) that can be barely paraphrased with a single sentence, and even less condensed in a word. Awareness of the dynamicity of the sign as one of its prominent properties (i.e .the conversion of sentences and discourses into signs, especially of narratives) would spare many cognitive overloads (excessive detail or overstimulation that retards and/or ruins interpretation), failed syntagmatic combinations, and inaccurate correspondences or mappings between the source and target domains in a given metaphorization.

The use of wrong codes, not always caused by the introduction of texts and discourses, yields the highest incidence in the corpus as a cause of misin-
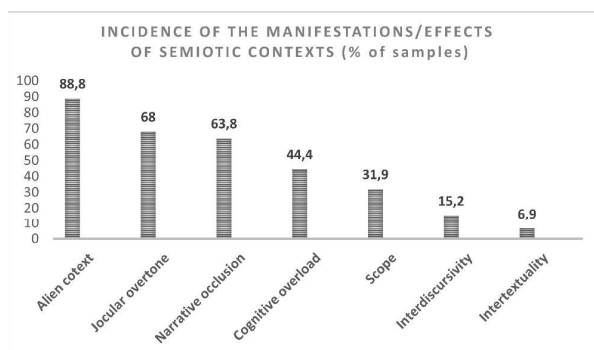
terpretation [Fig. 7], which tends to be the result of multiple causes and effects: the 'interpretive hurdles' shown in the bar chart are frequently interrelated, as Examples (5-12) will show.

(5) https://tocrofl.tumblr.com/ post/713418012586278912/httpspubsrscorgencontentarticlepdf2018cc (TOC ROLF archive page)
https://doi.org/10.1039/C7CC07180A (definitive GA version in the article published online)

Example (5) shows a parachuting bunny with several ad hoc pointers or metaphorical triggers (the molecular structures and chemical elements on the parachute canopy and strings and the rabbit's legs). There are no verbal labels and the stock photograph, of a realistic quality although manipulated, sets in a jocular tone because of the animal's personification and a humorous detail (the smaller rabbit-eared emergency parachute over the canopy), not due to stylizations such as cartooning or comic-book speech balloons, nor to the scientific discourse consisting in chemical formulas. The grounds for the metaphorical mapping remain unknown, as they are not deducible from the verbal abstract either. Is the catalysis described as smooth as a parachute ride performed by a small fluffy animal? Why choose a rabbit? Do the molecules involved have anything to do with rodents? Why place the metaphorical triggers in those concrete positions? Narrative occlusion and cognitive overload, as well as overinterpretation (Eco, 1990) are served. Curiously enough, the link to the article on the blog archive page leads to a different GA, probably because the Royal Society of Chemistry only admits original artwork and the rabbit image is a free-download one. This may have led the authors to substitute their original 2018 submission with a plain chemical reaction consisting in all the metaphorical triggers used on the parachuting image to comply with the journal's more recent GA guidelines.

Example (6) presents a much less intricate code, a map of a treasure hunt, accessible from the cotexts of literature, film, and folklore (children's games) and not brought in 'out of the blue' as the image in (6). The presence of the coupled metal catalysts inside a treasure chest suggests that they are a valuable reward. This connotation is made explicit in the verbal abstract with expressions such as "powerful tool",

"value-added products", and "representative advancements", which give the idea of a final gain.

(6) https://doi.org/10.1039/D2CS00371F

Contrastingly, Example (7) exhibits a faint metonymical basis for the cotext: an inclusion-exclusion dynamics mentioned in the verbal abstract and represented graphically in schematic human-like figures standing in line and carrying a block to help build some structure. The childlike style of the rendition and its derived jocular overtone obscures interpretation and trivializes the scientific content, despite the ad hoc pointer/metaphorical trigger, a mathematical equation, on top of the drawing.

(7) https://doi.org/10.1039/D2RA03447F

The creation of cotexts via intertextuality and interdiscursivity may obey to instrumental purposes concerning clarity and appeal in the exposition of scientific facts, to the promotion of the research in question, and to a desire to improve interpretation by resorting to a common GA cotext that may in the end become a shared disciplinary code. These are the respective cases of Examples (8), (9), and (10).

(8) https://pubs.acs.org/doi/10.1021/jacs.2c03631
(9) https://doi.org/10.1139/cjc-2021-0237
(10) https://doi.org/10.1039/D2CS00912A

In (8), the intertext of Greek mythology is visually introduced, in particular the myth of Medusa. The hair strands in the rendition of the character's head function as a classifying tree diagram that presents the diverse methods or applications of the tool described in the abstract and the article (mass spectrometry). There seems to be no other motivation for the use of this intertext, as it is not mentioned in the verbal abstract and the researchers are of Russian origin. This semiotic choice presupposes encyclopaedic knowledge from non-European scholars, which transgresses the cooperative maxims of clarity and relation and the politeness maxim of generosity. Example (9) advertises a spectroscopic method for characterizing both iron-sulphur proteins and peptides, precisely through the visual and verbal discourses of Advertis-

ing: with arresting colours and enlarged typography, and direct appeals to the viewer/reader (second-person pronouns, imperatives, and a colloquial rhetorical question). Example (10) gathers interdiscursivity and intertextuality: the memorable filmic scene *of Lord of the Rings* in which Gandalf the sorcerer raises his arms and blocks the way to the Balrog, a powerful demonic monster from the Middle Earth, and its accurate quote. This strategy confirms the authors' membership to the community of practice of chemical physicists and physical chemists, whose prolific use of this cotext is turning it into a common code to describe catalytic chemical reactions and phenomena related with molecular attachment (here involving glycopolymers). Collective disciplinary identity is thus achieved by means of certain 'endemic' images in GAs.

With regard to jocular overtones, stylistic imitation may act as a booster or intensifier of the humorous effect. In (11), a molecule of oxoammonium salt suffering from oxidation is 'anthropomorphized' as a patient at the doctor's surgery. The rendition style, the scene frame and the fonts in legends and balloon speeches remind viewers/readers of American cartoonist Gary Larson's distinctive comic strips, renowned for their scientific content and offbeat humour. See, for example, https://za.pinterest.com/pin/54746951706280397/ and his official website at https://www.thefarside.com/.

(11) https://doi.org/10.1021/acs.joc.2c01097

To conclude, the last example will prove that Elsevier's panel triptychs, while being effective for delimiting genre moves, do not discourage authors from jocular and informal encodings. Example (12) proposes a three-stage roadmap for modern electrorheological fluids and disseminates through cartooned stylization.

(12) https://doi.org/10.1016/j.mtchem.2022.101066

The metonymic sign choices in this example are several: a drop stands for the fluid, a live wire for electricity, a change of physical shape into a brawnier build denotes behavioural transmutation under an electric field, and sunglasses and a deck chair suggest relaxation. The associations are interconnected and made easier to appreciate thanks to a no-frills design: panel labelling is minimal, with an opening direct question typical of Advertising (using a second-person pronoun, unthinkable in research writing) and two nouns as keywords.

6. Points for Reflection: A Proposal for Semiotic Self-Guidance

If Brandt (2020: 38) calls humans 'the iconic species' because iconicity is the most natural and easiest-to-decode form of semiosis, and aesthetic and functional perceptions are two different processes within the same mental architecture, scientists should question to what extent it is necessary or convenient to encode specialized content metonymically and metaphorically. By and large, journal instructions for authors are becoming everyday more specific and restrictive, but do not yet inform about semiotic efficiency and the various contexts it entails (i.e. contextual, existential, situational, actional and psychological), at least in a cohered fashion. Guiding researchers context-by-context to opt for the optimal semiotic strategies would certainly be too tiring and confusing, since they often overlap and sign combinations and constellations may behave as a unitary sign (e.g. as happens with literary or filmic narratives such as with *Lord of the Rings* or Aesop's fable *The Tortoise and the Hare,* both typical of research on catalysts' reactions). Dividing semiotic awareness into the three levels of sign interpretation put forth by Morris (1970 [1970]): *semantic, syntactic* and *pragmatic* promises to be more controllable and practical, in spite of potential semiotic conversions and overlaps. A reasonable step-by-step proposal consisting in self-reflection questions could be this:

I. SEMANTIC LEVEL *(Sign Semantics)*
  - Iconic, metonymic (indexical), or metaphorical representation of the item, process or phenomenon under study?
    - What is the scope of the idea to be transmitted (a discourse chunk—a narrative or argument, a sentence, a word)? In other words, how is it more easily paraphrased? What types of sign adapt more easily to those extensions?

- Is an iconic representation too difficult or unappealing?

- Are metonymic (i.e. indexical) relationships clear enough or easy to infer? For example, cause-and-effect, part-whole (e.g. instrument/tool for function or process, conduct or container for substance, etc.)?

-Does the cognitive load/effort significantly increase with metonymic and metaphorical representations?

- Is the metaphor, metaphorical scenario or metonymy chosen known cross-culturally or too local, as well as their associated frames or 'behavioural scripts'?

- Is it too comprehensive or complex?

- Does it involve narrative? If so, is the narrative progression or plot clear or easy to deduce?

- Will I use any sign with an arbitrary motivation (i.e. symbols)? If so, how will I gloss or explain it in the GA?

- Is the sign chosen the clearest and most economic among all other possible options? (i.e. paradigmatic relationships)

- Is it convenient to stylize graphics? What would be the gain?

II. SYNTACTIC LEVEL *(Sign Syntax)*

- Can the sign chosen combine with others consistently to express affinities and oppositions or make up a coherent scenario or narrative? (i.e. syntagmatic relationships)

- Can any of the sign combinations become a sign in itself? If so, is it hard to interpret?

- Is narrative progression obscured by too many signs or by difficult inferences? Is there an overabundance of stimuli? (i.e. cognitive overload)

- Can I adopt 'pre-fab' signs or resources, such as the repertoires facilitated by Kress & van Leeuwen (1996) or Machin (2016)?

III. PRAGMATIC LEVEL *(Sign Pragmatics)*

- Does my representation minimize the viewer/reader's effort? Or does it require specific or encyclopedic knowledge? (politeness and cooperative maxims, cognitive overload)

- Is there an overabundance of stimuli, including loud colours with no conceptual function and other embellishments? (cognitive overload)

- Is narrative progression obscured by difficult in-

ferences or an informal register or jocular overtone? (i.e. cognitive overload/poor choice of code or cotext)

- Are borrowed texts really functional to put across the content, or superfluous? How do they contribute to clarity? (intertextuality and interdiscursivity, cognitive overload)

- Is there a reduction of interpersonal distance by means of a jocular overtone or any other strategy? Does it affect the comprehension of scientific content? Does it live up to the journal and research field standards? (existential context)

- Is humour justified and straightforward, if used, or does it imply subtle irony and extra knowledge? (politeness and cooperative maxims, cognitive overload)

- What do realistic mimesis and stylizations, if any, contribute?

- Does the representation incur cultural transgression or intercultural offence? (psychological and situational contexts)

- Does the representation chosen use semiotic resources frequent in my community of practice? Does it work and strengthen disciplinary bonds or does it feel out of place? Are my colleagues able to interpret the content in the right way and appreciate overtones and aesthetic elements?

It is my wish that this proposal helps scientists to become more conscious and critical of their semiotic choices for GA design. Surely journal instructions for the crafting of GAs will get more refined in the coming years as to the genre's division into moves and the expression of aesthetic and promotional features, and new templates might be launched by big journal publishers soon. Let us hope for the best.

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