REVISTA SIGNOS. ESTUDIOS DE LINGÜÍSTICA ISSN 0718-0934
© 2021 PUCV, Chile 54(107) 842-866

Multisemiotic artifacts between modes and media

Artefactos multisemióticos entre modos y medios de comunicación

John A. Bateman
BREMEN UNIVERSITY
GERMANY
bateman@uni-bremen.de

Recibido: 21-VII-2021 **/ Aceptado:** 15-XI-2021
DOI: 10.4067/S0718-09342021000300842

Abstract

The broad field of 'multimodality' covers a rather diverse collection of approaches and perspectives whose greatest common factor is that they investigate communicative situations where distinct forms of expression appear to be synergistically combined. The precise definition of what constitutes a distinct form of expression varies across schools of thought and this results in considerable uncertainty concerning just what is being addressed. A further contribution to uncertainty is the complexity of the phenomena being considered. It is still unclear just what dimensions of variation and stability are best suited to forming robust accounts. In this article I consider Parodi's notion of 'multisemiotic artifacts' as a level of description intermediate between 'semiotic modes', on the one hand, and 'genres' and'media' on the other. I argue that such a level of abstraction provides a beneficial way of characterizing similarities and differences across genres that can aid both practical analysis and theoretical considerations of multimodal variation across communicative situations. Forming more extensive catalogues of such multisemiotic artifacts promises much for future research.

Key Words: Multimodality, multimodal corpora, multisemiotic artifacts, text, semiotic modes, genre, disciplinary texts.

Resumen

El amplio campo de la 'multimodalidad' abarca un conjunto bastante diverso de enfoques y perspectivas cuyo mayor factor común es que investigan situaciones comunicativas en las que formas de expresión especificas parecen combinarse sinérgicamente. La definición precisa de lo que constituye una forma de expresión específica varía entre las distintas escuelas de pensamiento, lo que provoca una considerable incertidumbre sobre lo que se está tratando. Otra contribución a la incertidumbre es la complejidad de los fenómenos que se consideran. Todavía no está claro qué dimensiones de la variación y la estabilidad son las más adecuadas para formar descripciones sólidas. En este artículo

considero la noción de Parodi de 'artefactos multisemióticos' como un nivel de descripción intermedio entre los 'modos semióticos', por un lado, y los 'géneros' y 'medios', por otro. Considero que este nivel de abstracción proporciona una forma beneficiosa de caracterizar las similitudes y diferencias entre los géneros que puede ayudar tanto al análisis práctico como a las consideraciones teóricas de la variación multimodal en las situaciones comunicativas. La formación de catálogos más extensos de estos artefactos multisemióticos ofrece muchas posibilidades para la investigación futura.

Palabras Clave: Multimodalidad, corpus multimodal, artefactos multisemióticos, texto, modos semióticos, género, textos disciplinarios.

INTRODUCTION

The broad field of 'multimodality' covers a rather diverse collection of approaches and perspectives whose greatest common factor is that they address communicative situations where distinct forms of expression appear to be synergistically combined. The precise definition of what constitutes a distinct form of expression is often left vague, ranging from loose alignments with perceptual channels to open-ended lists of suggestive examples (for detailed critique of this situation, see Bateman 2019). Considerable uncertainty concerning just what is being addressed then remains. A further contribution to uncertainty is the complexity of the phenomena being considered: it is still unclear just what dimensions of variation and stability are best suited to forming robust accounts. In this article I consider the notion of 'multisemiotic artifacts', 'introduced' in Parodi (2010a, 2012) as multimodal 'ensembles' that regularly combine distinct expressive resources for particular communicative purposes. Multisemiotic artifacts emerged from detailed corpus analyses of selected genres of academic discourse and the accompanying recognition that characterizing those genres calls for attention to be paid to a broad range of expressive resources beyond the verbal (cf. Parodi, 2010b). Such resources not only occur frequently in academic discourse but also in different configurations according to the disciplines involved. Specific disciplines consequently make different demands and becoming acquainted with those demands is an important component of gaining literacy in the fields concerned. Indeed, the broad use of varied forms of expression is now commonly seen as demanding its own sets of literacies (e.g., New London Group, 2000; Archer & Breuer, 2016; Anstey & Bull, 2018): again, for more extensive references, see Bateman (2021). Nevertheless, the broad question of precisely which forms of expression are used where still requires considerable research.

There are still relatively few approaches within multimodality studies that seek to uncover connections between genres and expressive forms on the basis of corpus analyses (Bateman, Delin & Henschel, 2004; Stöckl, 2004; Bateman, 2008; Parodi, 2010b). Early work was restricted by the highly labor-intensive nature of the multimodal annotation task. It was difficult to prepare enough annotated data to support

quantitative study. Although there are now significant advances being made in particular areas (Cohn, 2020; Hiippala, Alikhani, Haverinen, Kalliokoski, Logacheva, Orekhova, Tuomainen, Stone & Bateman, 2020), this general problem remains even though the utility of the corpus-orientation in principle is clear. Parodi's detailed contrastive analysis of the use of expressives resources beyond the language system in a corpus of texts across different academic disciplines convincingly documents this utility further (Parodi, 2010a, 2012). Particularly interesting for the current discussion is the level of description that Parodi employed for this study: rather than remaining with still problematic notions of, for example, 'image' and 'text', he considered instead 'pre-compiled' combinations of semiotic resources commonly deployed for specific communicative purposes. The main focus of the present article will be to consider these combinations from the perspective of the multimodal account of semiotic modes, media and genres articulated at length in Bateman, Wildfeuer and Hiippala (2017). It will be asked quite specifically to what extent the level of description employed by Parodi can improve the precision and utility of our corpus-based analyses and help to refine conceptually some still rather unclear theoretical distinctions.

The structure of the article is as follows. First, I introduce the main conceptual component of Parodi's multimodal analysis, the *'multisemiotic artifact'*, and set out briefly Parodi's results concerning the use of these artifacts across disciplines. Second, I relate multisemiotic artifacts to a broader multimodal framework, showing how they provide an important intermediary category between semiotic mode and medium. This intermediate status is argued to be similar to the kinds of continua discussed in genre studies between, for example, genres, text types, registers and texts (Fludernik, 2000; Lee, 2001; Martin, 2001). Halliday and Matthiessen (2013) characterise the semiotic dimension involved very generally as 'instantiation'. Adding the intermediary construct of multisemiotic artifacts to our repertoire of multimodal tools will consequently be argued to be a useful practice that is also well motivated theoretically. Third, I consider some of the questions that arise due to continuity, boundaries and permeability among multisemiotic artifacts and the semiotic systems they build on. And, finally, I conclude with some open issues for further research.

1. Parodi's 'multisemiotic artifact'

In the corpus studies reported in Parodi (2010a, 2012), Parodi takes very seriously earlier proposals and results emphasizing the use of diverse semiotic systems for knowledge construction in different disciplines. Drawing particularly on Lemke's (1998) analysis of different ways of making meanings in scientific texts, Parodi provides a contrastive analysis of a random selection across six disciplines of 1043 texts drawn from the PUCV-2010 Academic Corpus, maintaining the overall disciplinary proportions of the original corpus. The six disciplines are distributed across the categories 'basic sciences' (Physics, Chemistry, and Biotechnology) and 'social sciences and humanities' (Literature, History, and Linguistics). An essential question for literacy

in these areas is to what extent different ways of constructing disciplinary knowledge are at play.

After appropriately problematizing a certain lack of precision in the notions of 'mode' and 'modality' available in the field of multimodality at that time, as well as observing that both terms are already well established in linguistics as grammatical terms in any case, Parodi proceeds to his own classification of the multimodal phenomena relevant for characterizing academic texts. Parodi notes that there appear to be several distinct 'semiotic systems' simultaneously at work in academic texts. For the purpose of his analysis he focuses in without any claims of completeness on just four: the verbal system, the graphic system, the mathematical system, and the typographic system. Each of these has received detailed analysis in the multimodality literature and there is broad agreement concerning their identification, although some systems are evidently broader than others. The graphic system, for example, is considered to cover the use of visual materials set out in two-dimensional space, with common examples including photographs, tables, diagrams, and so on. Moreover, although these systems may occur in individual texts in different proportions, Parodi insists that all four of them are equally constitutive of text. Thus,

> "From this perspective, it is not exact to say, 'the text and the figures', 'the text and the images', or 'the text and the multisemiotic artifacts'. On the contrary, text exists as a complementary and integral unit, and in it the verbal, graphic, mathematical and typographic systems tend to synergetically interact." (Parodi, 2012: 264)

This position is taken up and developed further in Parodi and Julio (2017), drawing on Parodi's general Communicability Theory for exploring texts and text comprehension (CT: e.g., Parodi, 2011). As Parodi and Julio (2017: 19) explain:

> "it is common to find the expression 'the text and the image'. This distinction between two constitutive units seems to advance the idea that the text is basically composed of the verbal system, which is confusing because only one dimension of the textual conception is being emphasized. Text potentially compose many different semiotic systems (verbal, graphics, mathematical, color, typographic, among others). Therefore, the separation between 'text and image' or between 'text and illustrations' is not applicable according to the CT. If the sim is to emphasize the multisemiotic nature of a given text, we propose to use an expression such as 'the text and its constitutive semiotic systems'."

'Text' for Parodi is thus intrinsically a multisemiotic entity, an important orientation that needs to be anchored into the core of any appropriate theory of multimodality. Consequently, the question that Parodi addresses in the corpus study at issue here is just which modal combinations occur in texts in which disciplines and in which proportions.

A further important consideration pursued in Parodi's analysis and the general framework he employs is the view that meaning needs to be seen as arising from interacting combinations of the resources employed, rather than the various systems making their own independent contributions to meaning that are then combined. Parodi cites Lemke's (1998) argument for this in Lemke's influential introduction of the metaphor of 'meaning multiplication':

> "In multimedia genres, meanings made with each functional resource in each semiotic modality can modulate meanings of each kind in each other semiotic modality, thus *multiplying* the set of possible meanings that can be made (and so also the specificity of the particular meaning made against the background of this larger set of possibilities)." (Lemke, 1998: 92)

As argued particularly by Bucher (2011), and subsequently taken up in Bateman et al. (2017), it is actually questionable whether 'multiplication' is the most appropriate metaphor here: in much multimodality work that has followed, the process has been rendered in terms of independently derived 'values' obtained from individual semiotic systems being combined, which is clearly not what Lemke suggests. More broadly, there is now increasing acceptance of the idea that multimodal meaning-making arises out of complex coherent behaviors with a far tighter integration across forms of expression than a 'multiplication of values' suggests. Any resources employed then reflect the coherence of their combination at all levels. In the study of interaction, Mondada (2014) describes this state of affairs in terms of 'complex multimodal Gestalts', while similar points were made by Preziosi (1986: 44) very early on:

> "In the ongoing semiotic bricolage of daily life, we orchestrate and intercalate anything and everything at our disposal to create and maintain a significant world, or simply to get a message across."

This means that analysis of multisemiotic wholes must take care not to introduce problems in analysis that arise from an inappropriate enforcement of analytic boundaries rather than from the nature of the phenomena themselves.

This important realisation is already anchored in Parodi's approach. As Parodi characterised this for his corpus analysis:

> "…the aforementioned systems cannot be radically separated nor thought external to the text, except for methodological reasons, or as a consequence of research focus. The systems are deployed with various intra and intersemiotic relationships and together they give form to the units of meaning …" (Parodi, 2012: 265)

Substantial questions remain, however, concerning just how analysis of the respective contributions of semiotic systems can productively proceed. In Parodi's framework, this is one of the tasks assigned to his notion of the multimodal artifact. Multisemiotic artifacts have rather specific properties that differentiate them from

looser usages – such as, for example, 'semiotic artifacts', which is generally used quite broadly to refer to any material objects drawn into multimodal communicative situations (e.g., van Leeuwen, 2005a). In contrast, multisemiotic artifacts already include the contributions of distinct semiotic systems, and those contributions complement each other for the specific communicative purposes that the artifacts serve. This emphasizes the 'tool-for-a-purpose' aspect commonly ascribed to artifacts. This is a useful step for practical analysis because one is no longer immediately confronted with the task of deriving generalised relations between, for example, contributions in verbal language and contributions in graphical forms consisting of lines and shapes independently of the purpose they are embedded within. Finding such generalized relations remains an unsolved challenge to this day. Instead, by means of multisemiotic artifacts, practical corpus analysis can focus on how quite specific and regularly re-occurring combinations of resources contribute to the overall composition and communicative functions of specific texts.

Such an approach then comes to exhibit many similarities with views of multimodality that treat communication as the achievement of pragmatic effects independently of the specific semiotic systems involved (cf. Bucher, 2011; Stöckl, 2016). Bucher in particular prefers a performative, pragmatic theoretical framework, whereby multimodal communication is always seen as a form of action. In this view, actions can lead to goals that can also be achieved communicatively and this can extend freely across sign modalities. A communicative action approach explains well how interpreters of multimodal artifacts may come to understand novel configurations but does not explicitly address the existence of more or less stable patterns of multimodal resource deployment. Multisemiotic artifacts are precisely such stabilised configurations and so can be profitably considered as objects of study in their own right – particularly when issues of differential use across disciplines and literacy in these distinctive strategies of knowledge building are to be addressed.

Parodi's original corpus analysis as reported proceeded by identifying nine multisemiotic artifacts, each of which draws more or less on the four semiotic systems assumed. The nine types are: diagrams, formulae, geometric figures, icons, illustrations, maps, statistical graphs, tables, and 'compositional webs'. Whereas the first eight follow broad everyday usage of the terms, the nineth, compositional webs, are introduced as integrated, potentially hierarchical, visual layouts where several forms are combined together to form a whole; this is, therefore, clearly something of a composite construction in its own right. Parodi also notes that broader corpus studies may well reveal other multisemiotic artifacts and, in Boudon and Parodi (2014), an additional class of 'statistical complexes' is introduced. Statistical complexes combine all four of the basic semiotic systems as well as further multisemiotic artifacts such as tables and graphs. These contributions all then function together as a unit capable of reflecting quite diverse information. Parodi also emphasizes that the boundaries between

instances of these categories may often not be sharp: I return to all of these important aspects of multisemiotic artifacts in the discussion below.

Each multisemiotic artifact is defined with respect to three criteria: the semiotic systems, or modalities, involved, the function of the artifact, and its particular compositional features. As an example of the use of these definitional criteria, we can compare the definitions that Parodi offers for the relatively similar types of 'geometrical figure' and 'graph'. On the one hand, the geometrical figure is an artifact:

> "that primarily uses the graphic system, although to a lesser degree also uses the verbal, typographic and mathematical systems. It is, for the most part, the representation of space enclosed by lines that shows an object or theoretical concept. Its main components are: the plane, the point, the line (straight, curved, dotted), the surface and the segment …The most common geometrical figures are: squares, rectangles, circles, pyramids and polygons." (Parodi, 2012: 270)

Thus, the central feature of geometric figures are line drawings, usually annotated by further information expressed either as mathematical forms or verbal language; particular typographic variation in the labels may also help distinguish them further. The definition given for statistical graphs is, on the other hand, of an artifact:

> "that primarily combines the four modalities: verbal, graphic, mathematical and typographic. It pictorially represents a visual summary of statistical information. The statistical graphs can be line graphs, bar graphs, pie graphs, histograms, etc." (Parodi, 2012: 270)

Here we can see that the function of the artifact is crucial: although both graphs and geometrical figures may employ lines and areas, include verbal labels, and so on, a geometrical figure is generally not appropriately considered as a visual summary of data. The use of definitions of this kind is clearly beneficial for improving the reliability of analyses beyond more informal assignments of categories. Following a period of training, Parodi reports 96% agreement for type classification among coders of the corpus.

Interesting relationships can be drawn between such definitions and usages found elsewhere. First, there is considerable work on the particular forms that may occur in graphic form (Bertin, 1983; Lohse, Walker, Biolsi & Rueter, 1991; Engebretsen & Weber, 2017; Engelhardt & Richards, 2018); it is useful to compare the multisemiotic artifacts with the finer decompositions offered in treatments of graphics in more detail; this will be expanded on below. Second, the 'application' of these constructs for corpus description and analysis shows many similarities with the earlier looser use of 'mode' seen in Bateman (2008), where styles of page design were documented across time using categories such as 'caption', 'map', 'icon with text', 'graphic', 'drawing', and so on. These terms were not defined explicitly, again drawing instead largely on their everyday interpretations in order to pick out what appeared to be frequently occurring semiotic

practices. It was only in subsequent developments of this work that a more rigorously defined notion of 'semiotic mode' was developed (cf. Bateman, 2011, 2016); some of the implications of this will be returned to below.

Parodi's corpus analysis on the basis of these categories succeeded in revealing quite distinct patterns of multisemiotic artifact usage across disciplines. These differed both in terms of overall frequency and in the distinct kinds of multisemiotic artifacts observed. Figure 1 presents an overview of results based on Parodi's reported counts; the vertical axis show the observed multisemiotic artifacts occurring per page of the analysed texts, while the horizontal axis shows the six disciplines analysed. A substantial difference between the three 'basic sciences' disciplines on the left of the graph and the three 'social science and humanities' disciplines on the right is immediately evident; Parodi discusses this division at some length, setting out a continuum of disciplinary discourse ranging between more predominantly verbal/typographic discourses and more predominantly graphic/mathematical discourses (Parodi, 2012). This is a valuable result as it clarifies considerably the kinds of competencies that need to be developed during socialisation into the respective disciplines. The results are also interesting concerning the different ways in which knowledge is constructed in the respective disciplines, an issue that has become increasingly central in more recent multimodality work as well (Doran, 2018).

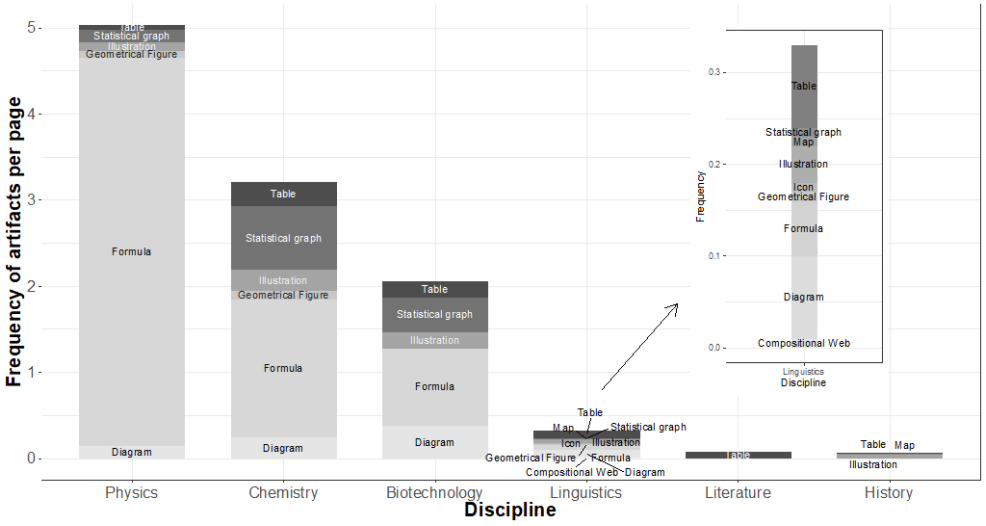

Figure 1. View of the distribution of multisemiotic artifacts per page in the selected corpus across disciplines; the inset shows an increased scale breakdown of the multisemiotic artifacts used in the linguistic texts of the corpus. Data is drawn from that given in Parodi (2010a, 2012), but regraphed across disciplines without scaling to 100% within disciplines – for this reason, some artifacts are not shown because they occur with too low a frequency. Graph generated fully automatically using R and 'ggplot2' (Wickham, 2016).

Parodi also points out that the distinct kinds of multisemiotic artifacts are also distirbuted unevenly across disciplines. While the most frequent use of multisemiotic artifacts overall is evidently provided by the physics texts, the overwhelming majority of the observed artifacts across disciplines are nevertheless formulae. The other kinds of multisemiotic artifacts found in the physics texts are statistical graph, diagram, illustration, geometric figure and table – i.e., six of the nine artifacts identified. Parodi notes here that the overall average in the physics texts of just over five multisemiotic artifacts per page aligns well with the rather similar figures suggested by Lemke (1998), even though Lemke's figures were derived on the basis of a far smaller selection of examples. The least diversity is found in the history texts (with maps, illustrations and tables) and the most in linguistic texts, which include instances of all nine identified artifact types. As can be seen from the inset in Figure 1, within linguistics the distribution is also rather more even across tables, formulae, illustrations, and diagrams – there is no one multisemiotic artifact type that clearly predominates as is the case in the three science disciplines. Again, and as Parodi emphasized, it remains to be seen whether these results are corroborated by larger scale studies.

2. Multisemiotic artifacts as continuous phenomena

A particularly interesting facet of Parodi's account is its view of the identified multisemiotic artifacts as representing a continuum of resources rather than categorially bounded units. Parodi placed multisemiotic artifacts against a background of continuous spaces of variation, and this raises important issues for the question of possible boundaries between expressive forms. As examples of such continuities, Parodi sets out several sets of multisemiotic artifacts which would be aligned with specific categories but to differing degrees of 'prototypicality'. Whereas the criteria introduced above help to make categorization more crisp, the continuity shown between instances within broader artifact types is itself an important semiotic phenomenon. Figure 2 reproduces Parodi's examples of continuous variation within the diagram and graph categories of multisemiotic artifacts.

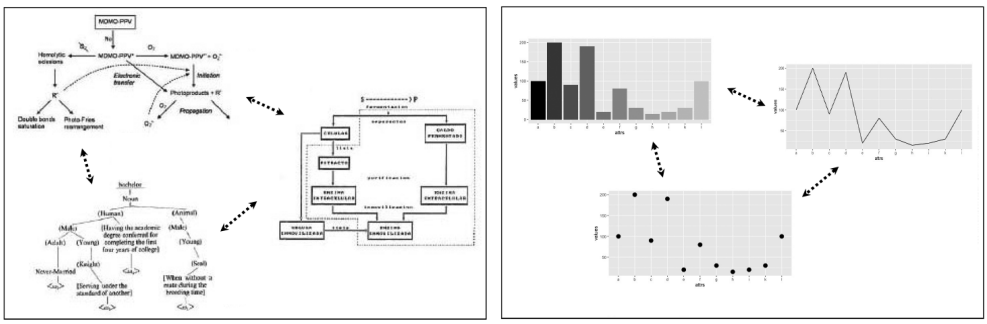

Figure 2. Examples of continuous variation within the diagram (left) and statistical graph (right) types of multisemiotic artefacts (recreated following Parodi, 2010a, 2012: Figures 3 and 4).

Within each group, the representations are indeed rather different from one another, although certain structural properties remain. For the diagrams there appear to be visually connected components, whereas for the graphs there appear to be different uses of a designated two-dimensional area for showing relations between and across values. As long as these properties hold (and no doubt others still to be determined), then variation may not take instances outside of the broad limits of the respective artifact type. However, precisely what dimensions of variation are allowed for any particular multisemiotic artifact remain to be determined.

To make progress on this with the general aim of achieving more robustly applicable categories for further corpus-based analyses and for teaching their use, we must determine more specifically just what dimensions of variation are relevant. This is not yet offered by their characterizations in terms of the four semiotic systems assumed. Indeed, there appears still to be a considerable gap in semiotic abstraction between very general resources, such as "strokes that form a pictorial representation of information of all kinds" (Parodi, 2012: 263), and the specific forms making up the multisemiotic artifacts, such as the "squares, functional or related operators (e.g. arrows, brackets, braces, etc.), bullets, numbering, size and type of font … and colors" (Parodi, 2012: 269) of diagrams.

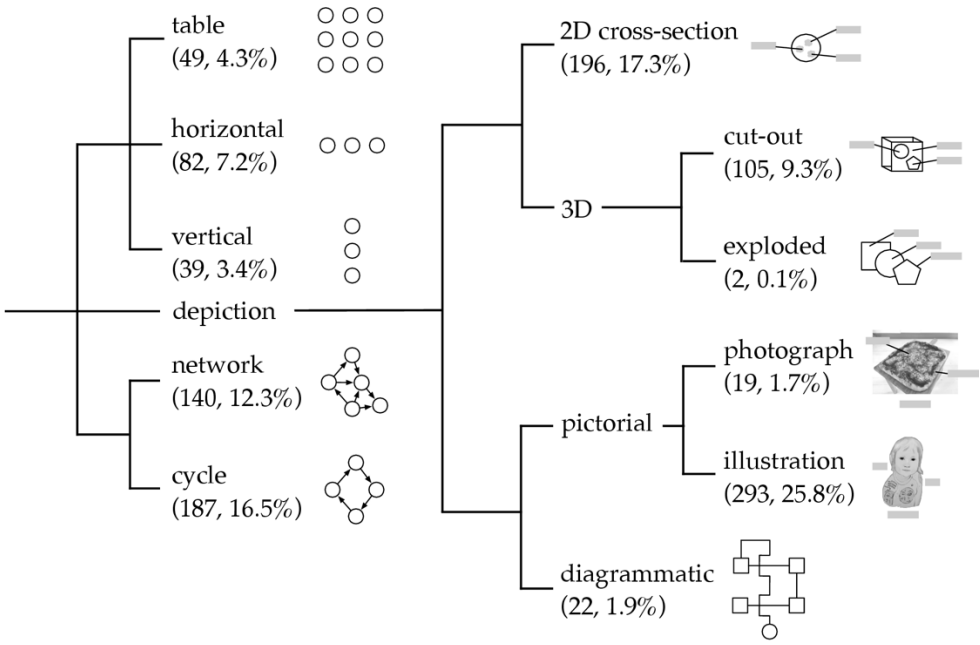

Figure 3. A typology of diagram macro-groups developed with respect to the corpus discussed in Hiippala et al., with counts and percentages of occurrence for that corpus (Hiippala et al., 2020: Figure 4)

As remarked above, in the particular case of diagrams there have been many further proposals. Building on Engelhardt's account of graphics (Engelhardt & Richards, 2018), for example, Kembhavi, Salvato, Kolve, Seo, Hajishirzi and Farhadi (2016) set out a formal level of diagrams in terms of 'blobs' (which may contain any kind of material as long as it is visually discernible as a distinct unit), texts, arrows, and arrowheads, and a range of semantic relations that bind these elements together, such as relations for adding labels to components of a diagram. This is refined considerably in Hiippala et al. (2020) by introducing more general discourse relations to bind components as well as a set of particular 'macro-groupings' characterized in terms of connectivity between elements in a graph. A classification network for these macro-groups is shown in Figure 3. In the figure we can see both similarities with diagrams and overlaps with other types of multisemiotic artifacts discussed by Parodi (e.g., tables, illustrations). Hiippala and Bateman (2021) use these subclasses of diagrams as functional units for corpus analysis in very much the same way as undertaken by Parodi for his specified multisemiotic artifacts. Note, however, that the macro-groups listed in Figure 3 were only collected together and jointly classified as diagrams because they were already labelled as diagrams in the original collection of materials that served as the basis for the corpus work reported on. It is likely that a more discriminating functional characterization as carried out by Parodi would help draw further distinctions here as well. The typology also shows that there are useful characterizations made in addition to those of Parodi concerning the formal structure of the representations, such as 'networks' and 'cycles' as subtypes.

A further indication of unresolved issues with respect to boundaries can be found in the particular choices of semiotic systems made by Parodi for defining multisemiotic artifacts. Each of the four systems described appears itself to involve further semiotic resources and so, in this respect, already 'shares' certain properties with the multisemiotic artifacts they are intended to help define. This raises the question as to the extent to which those systems can be reliably distinguished from multisemiotic artifacts and 'viceversa'. The mathematical semiotic system, for example, almost necessarily draws on verbal insets, typography and uses of space and composition for imparting meanings (O'Halloran, 2005). As a consequence, and as Parodi (2012: 264) makes clear:

> "… when defining the mathematical system, though one could think of it as an autonomous system and that it would be very simple to separate it from the verbal, graphic and typographic, the empirical analysis of a particular text shows an intrinsic complexity. This is not a problem in and of itself, as what it does is to show the nature of the textual multimodality and the synergy of the interrelated systems. Actually, the mathematical system is partially supported by the verbal co-text and makes explicit use of the graphic and typographic systems."

Although one might ask whether the 'mathematical system' is then actually itself also a multisemiotic artifact, this is a less appealing option to take. On the one hand, Parodi's definitions of multisemiotic artifacts includes notions of compositionality and structure that the mathematical system 'as system' does not. Moreover, whereas graphs and diagrams lend themselves well to being described as (communicative) artifacts for specific purposes, this is again less convincing for the 'system' of mathematical expressions as a resource.

In fact, this leads us back directly to a reassessment in terms of Halliday and Matthiessen's (2013) dimension of instantiation. Characterizing the mathematical semiotic system as a multisemiotic artifact because it also makes use of several other semiotic systems does not seem appropriate because it is still 'less unstantiated' than the more specific and semi-fixed realisations that we find in the listed multisemiotic artifacts. In other words, whereas mathematical expressions provide a general resource for making (certain kinds of) meanings, statistical graphs, diagrams, and so on seem to lie further towards the instantiated pole of an overarching semiotic system. That is: artifacts constitute instantiated collections of resources that are 'ready built' to serve particular functions, analogously to the assumption often made for genres at a discourse level and for (partially) idiomatic grammatical constructions at a grammar level.

Parodi's intuition that there appears to be a difference in kind here between the semiotic systems and the multisemiotic artifacts making use of them therefore needs to be preserved. However, in order to make these distinctions more robust so that they can be drawn on effectively in analysis, it is necessary to dig deeper. A competent user of graphs might well consider graphs more from the 'system' end of a continuum of instantiation and so treat them as a resource similarly to the treatment of the mathematical system as a source of equations and formulae. It would be beneficial, therefore, if we could characterize the differences and overlaps between these constructs more tightly. For this, we can consider the properties of multisemiotic artifacts more closely. As noted above, and discussed by Parodi, the boundaries of some of the multisemiotic artifacts appear to be permeable in just the same way that some of the semiotic systems are. If we consider, for example, the extract shown in Figure 4 taken from one of the chemistry texts that Parodi uses as an illustration of a multisemiotic text drawing on several multisemiotic artifacts,[1] we see that producing the precise semiotic delineations involved is not without challenges.

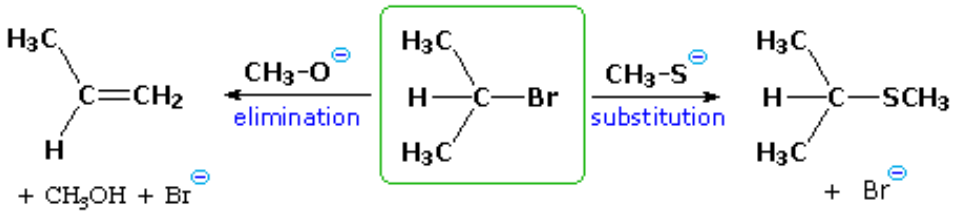

Figure 4. An extract from a multisemiotic chemistry text used in Parodi (2010a, 2012).

In the original page this segment is embeded within an itemized bullet list of flowing text, with various linguistic elements referring to aspects of the formula. Even within the formula, however, we see that this is a clear example of where the semotic systems "cannot be radically separated" (Parodi, 2012: 265). This case cannot plausibly be allocated solely to the class of 'formula' because it draws on diagrammatic elements and icons as well. Moreover, the particular kinds of diagrammatic elements are complex and specific to the discipline. In particular, and only briefly, we see in this 'formula' a diagrammatic representation of two chemical reactions, one identified as 'elimination' and the other as 'substitution'. The nodes in this diagrammatic representation are expressed in what in chemistry terms is called a 'displayed formula' (with formula here being used in the sense of a chemical formula). Display formulae show all the elements participating in a compound connected by lines indicating the bonding between those elements. A carbon atom can have up to four bonds (generally) and so can have up to four lines extending from each carbon atom (represented by 'C') in the diagram. It is possible, however, to have double and triple bonds as well, which are then indicated by double and triple connecting lines. One of these occurs in the diagram node on the lefthand side of the diagram between the central carbon atom ('C') and a further compound CH_2 that, because of its frequent occurrence as a unit, is not given its own internal bonding diagram. Thus, we can see in all of the display formulae in the figure that each carbon atom has four (notional) lines coming from it – i.e., single lines count as single bonds, double lines count as two bonds, and so on. Similarly, each hydrogen atom ('H') has only one line coming from it because it can only form one bond.[2]

This is, however, only the most basic of diagrammatic representations of organic chemical compounds. The lines are used because bonding is important for characterizing the properties of such compounds. In more complex representations, aspects of the three-dimensional structure of compounds can also be indicated by using different kinds of lines, some of which indicate that the depicted bond lies flat in the plane of the paper, others which indicate bonds extending either towards the observer or away from the observer. For organic compounds such configurations may be significant for reactions and so need to be captured. Finally, there are representations that conventionalize still further, leaving particular combinations of elements, most typically connections between carbon and hydrogen, implicit because these are always present in organic hydrocarbon compounds; spelling them out is then redundant: it is

only their 'position' within a compound that needs to be registered. Particularly prominent and chemically important configurations, such as the benzene ring, receive their own further fully conventionalized diagrammatic representations. A thorough multimodal characterization of the historical development of this notation system would clearly be interesting in its own right.

A number of possibilities could therefore be followed for capturing the kind of multimodal artifacts seen in these chemistry formulae. One would be to extend the diagrammatic or formula multisemiotic artifacts so that they explicitly include subvarieties, such as 'chemistry formulae'. In many respects, however, such chemistry formula already seem to exhibit much of the generality and productivity that we find in mathematical expressions. Indeed, there are also 'general formulae' that describe entire families of substances, such as C_nH_{2n+2} for alkanes, which necessarily blend mathematical expressions with chemical formulae quite literally. Such varieties of semiotic openness must therefore always remain possible. The development of such representational systems over time is also particularly interesting and provides useful constraints on the formalization of the semiotic mechanisms involved just as has been pursued for other 'notational' systems, such as mathematics (O'Halloran, 2005), tables (Baldry, 2000; Hurst, 2006), and so on. In this respect, then, chemistry formulae appear analogous to other 'second order' semiotic modes, in that the material regularities that the mode requires to make its meaningful distinctions are generally regularities provided by 'other' semiotic modes. In the diagram in Figure 4 this applies to the labelling of the reaction arrows using written language, the use of symbols drawn from written language to identify elements and the numbers of atoms, the imported use of mathematical operators for (metaphorically) indicating combination of compounds in terms of addition, as well as the diagrams themselves. Moreover, it will always be the case that still further meanings can be made by incorporating aspects of other semiotic systems. The central rounded box, for example, appears to be a compositional element indicating the topic or the focus of the discussion at that point in the text rather than being a detail of chemistry formulae.

In short, although multisemiotic artifacts appear to offer a practically useful level of description for characterizing multisemiotic texts, the discussions above leave open several issues concerning the appropriate level of abstraction for the construct. And this particular kind of 'intrinsic complexity' induced by permeable boundaries is not without side-effects: in particular, it can add considerable uncertainty to analysis.

3. Multisemiotic artifacts and their relations to semiotic modes, media and genres

We have shown how Parodi's notion of multisemiotic artifacts appears to provide a useful level of abstraction for engaging in multimodal corpus analysis. At the same time,

however, we have also seen that questions concerning the reliability of boundaries and the precise theoretical positioning of the construct still require closer attention.

As mentioned in passing above, Parodi's characterization of multisemiotic artifacts is similar in certain respects to a treatment in terms of genre – particularly when considered in terms of the influential view of genre promoted in Lemke (1999), where genres are seen as labels assigned to 'regions' within a higher dimensional space of rhetorical strategies. Particular bundles of rhetorical strategies may over time be jointly deployed with sufficient regularity as to constitute a recognized usage, receiving a characterization as a genre. Over time, such bundles may then change, with the consequence that established genres may evolve and other genres may emerge. In the multisemiotic artifact case, such rhetorical strategies would be conceived of as drawing on a variety of semiotic systems. This can also be related productively to other notions of genre, such as, for example, Parodi's (2014) own definitions and uses of 'discourse genres' as sociocognitive entities, as well as to models of partial idiomaticity and fixed 'constructions' within the lexicogrammar. In both cases one also has general resources that become partially restricted for specific communicative purposes. In recent discussions, this idea has been extended to show the possibility of multimodal constructions as well (Steen & Turner, 2013; Dancygier & Vandelanotte, 2017). Nevertheless, both an anchoring 'below' to less abstract levels of the meaning-making and 'above' to communicative functions raise issues. In particular, distinguishing multisemiotic artifacts, or multimodal genres, or multimodal constructions, can readily raise difficult to maintain boundaries that complicate analyses as we have seen in the previous section.

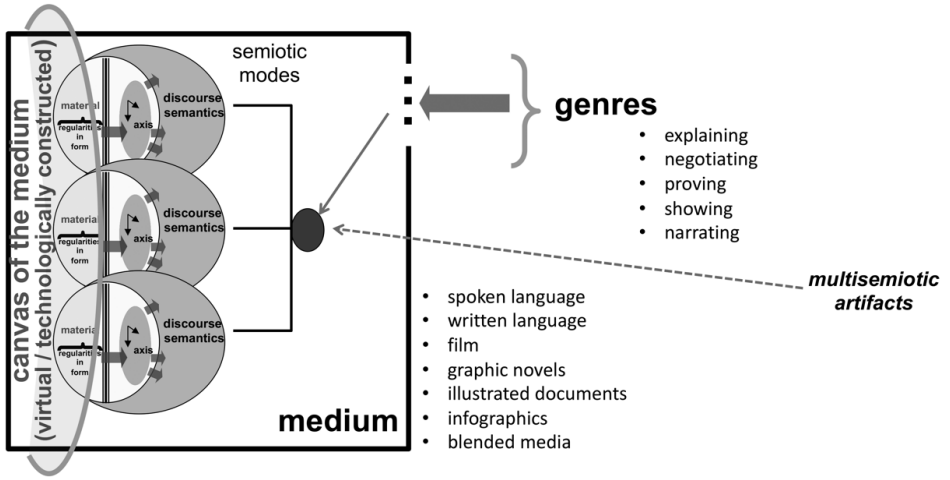

Figure 5. The relationships between semiotic modes, media, and genres as defined by Bateman et al. (2017). In this model, a medium is an institutionalized collection of semiotic modes (depicted as the ovals running down the lefthand side of the diagram) that are then available for realizing genres. The intermediate position of multisemiotic artifacts is indicated with respect to this.

To help characterize the positive role that multisemiotic artifacts may play for analysis, I will draw now more specifically on the overall model of multimodal communication developed by Bateman et al. (2017). The standard positioning of material, semiotic modes, media and genres within this model is shown schematically in the diagram in Figure 5. Methodologically, this model permits quite diverse semiotic possibilities to be co-active in any examined semiotic artifact or performance. In all cases, the sole point of access is the materiality to be analyzed and connections are made to semiotic modes solely in terms of the range of material variation that each semiotic mode is responsible for. It is then often the case that a shared portion of materiality is co-organized by several distinct semiotic modes: this turns out to be particularly important for covering the permeability of multisemiotic artifacts and semiotic systems discussed above. The co-organization of material by semiotic modes occurs at a particular 'location' within the overall framework. This location is provided by the 'medium' being used. The framework defines a medium as a socioculturally institutionalized grouping of semiotic modes for specific communicative purposes (Bateman et al., 2017). Media are then 'places of practice' where the orchestrated co-deployment of semiotic modes is highly likely to bring combinations and mergers of semiotic modes into play: since the co-deployment of distinct semiotic modes is inherent to their functioning, those semiotic modes may become successively more intertwined. This echoes the suggestion of Winkler (2008: 213) that media be considered 'biotopes' for semiosis: precisely in this sense, then, media function as melting pots for semiotic activity – for multisemiosis.

Considering where multisemiotic artifacts may be positioned against the backdrop provided by this model brings both historical and individual variation to bear. As remarked above, the multisemiotic artifacts discussed have undergone more or less extensive trajectories of development over time. Moreover, what may be an easily readable and highly conventionalized chemical formula for those socialized into the discipline, may for others be an example of a more general diagram with its approximate details of interpretation only decoded or guessed by analogy or experience with other diagrams. This is always the case with semiotic modes, as Kress and colleagues have long emphasized:

> "…the question of whether X is a mode or not is a question specific to a particular community. As laypersons we may regard visual image to be a mode, while a professional photographer will say that photography has rules and practices, elements and materiality quite different from that of painting and that the two are distinct modes." (Kress, Jewitt, Ogborn & Tsatsarelis, 2001: 43)

Combining this with the more empirical orientation followed by Bateman et al. (2017), a semiotic mode is then a current 'best hypothesis' for explaining the

mobilization and interpretative consequences of a particularly circumscribed range of material regularities.

This allows us now to proceed without a prior identification of some set of privileged semiotic systems out of which multisemiotic artifacts are to be built. Instead, we can see multisemiotic artifacts first as conventionalized solutions to communicative tasks whereby a selection of options from a set of semiotic modes available in a medium are pre-selected. For example, chemistry formulae can be seen as conventionalized pre-selections from a diagrammatic semiotic mode combined with written language and mathematical expressions as required. As a visuospatially realized expression, many further aspects of the materiality are still available for further semiotic modes, such as the diagrammatic representation of emphasis (by boxing, typographical choices, positioning, and so on).

With increasing conventionalization within a community of practice there is also nothing to prevent such pre-selections emerging as semiotic modes in their own right. In such cases, interpretations that would previously have been supported by more general discourse semantics are 'fixed' or restricted for the purposes of the specific newly emerging semiotic mode. For example, the letters used in chemistry formulae are no longer 'readable' simply as letters, they are direct symbolizations of the types of elements and compounds constructed in the discipline. Similarly, connections between nodes of a diagram are no longer interpretable simply as connection of some kind, instead quite specific patterns of bonding, together with the linking of those patterns into entire theories of chemical composition, are indicated. Thus, on the one hand, a semiotic mode of diagrams would be defined primarily in terms of recursive structures of visually distinguished elements with connections realised by lines and arrows (Hiippala & Bateman, 2021). In the case of chemistry formulae, on the other hand, such general semiotic resources are partially locked into rhetorical strategies specific to the communicative needs of identifying chemical substances and reactions. Such meanings are not derivable without more background knowledge from organic chemistry and so we might consider the degree to which a semiotic mode has emerged as indicative of the corresponding level of literacy in the respective field.

In short, multisemiotic artifacts can be positioned on an instantiation continuum ranging from partially pre-specified uses of existing semiotic resources for particular communicative functions to semiotic modes in their own right. For a semiotic mode, the meanings of the technical features available (visual blobs, connecting lines, and so on) are restricted to the meanings defined within that semiotic mode and are no longer available for generic 're-purposing'. The extent to which this can usefully be seen as a semiotic mode in its own right – i.e., a semiotic system specifically for the expression of chemical reactions – depends crucially on the literacy of the users involved. Whereas it is (arguably) perfectly possible for a less experienced reader of chemistry formulae to relate those formulae to the meanings made by the general semiotic system of diagrams

(if that reader is familiar with diagrams), and so to decode some of their meaning, experienced members of the community of users of chemical formulae may deploy the chemistry expression system in its own right. This is also readily evident when considering, for example, the multsemiotic artifacts of statistical graphs. Here particular patterns and lines are strongly constrained – for example, lines in the graph have completely different functions to the lines expressing the axes of the graph. And, again, although certain properties of the graph may be deduced by the inexperienced reader by application of more generic (and less committing) diagrammatic and layout forms, others will not be intelligible without learning.

This use of the instantiation dimension echoes to some extent Martin's (2010) proposals that a mechanism of 'coupling' across features of distinct semiotic systems offers a powerful method for treating multimodal discourse. Coupling refers to the phenomenon that meanings made in different parts of a semiotic system, or several semiotic systems, can be coordinated in order to express 'more' than the selections considered individually. Painter, Martin and Unsworth (2013), for example, draw on coupling to characterize relations holding across written language and images in what they term a 'bimodal' medium of children's picturebooks. Mutually supportive meanings made visually and verbally show that instantiation needs to be considered as passing through distinct semiotic systems in an orchestrated fashion. With multisemiotic artifacts such orchestration is taken further and is itself conventionalized. Multisemiotic artifacts therefore correspond to co-ordinated paths of partial instantiation re-occurring so as to serve together recognizable communicative purposes.

The presence of multisemiotic artifacts as candidates for subsequent emergence as semiotic modes also helps reappraise some of the definitional properties of semiotic modes. In particular, semiotic modes may need to be considered in terms of their level of inter-dependence with other semiotic modes. Previously, some researchers have considered the autonomy of semiotic systems as an indicator of their status as semiotic modes, but there can readily be disagreement on this point. For example, van Leeuwen (2005b) proposed that typography be seen as a meaning-making system in its own right (and so should be accorded semiotic mode status), whereas Morrissy (2017) argues against semiotic mode status precisely by virtue of the 'lack' of independence of typography. The position here is that it is perfectly possible for semiotic modes to emerge (perhaps typically from multisemiotic artefacts) that are 'intrinsically' dependent on other semiotic modes. Page composition is a good example of this, since it only exists by virtue of other material that is being composed on a page and that material can be drawn from any semiotic mode sharing an appropriate 'canvas', or materiality. This was also the case with the chemistry formulae discussed above.

This means that semiotic modes may well be regularly co-deployed within media in order to 'collectively' 'cover' some intended communicative purpose, leading to the

development of semiotic resources that appear to have all the properties of semiotic modes but which are, nevertheless, not capable of 'standing alone' – that is, due to their regular co-occurrence with other semiotic modes, meanings can be distributed across those modes without requiring that each mode by itself be capable of carrying those meanings. The original definition of multisemiotic artifacts brings a property of just this kind into the foreground. All of the artifacts described by Parodi are intrinsically multisemiotic in the sense of requiring contributions from various semiotic systems to operate. The generalization of this position made here is that such artifacts may draw on any semiotic configuration functioning as a semiotic mode, rather than selected semiotic systems that are granted a more 'basic' status as potential contributors to multisemiotic artifacts. Thus, the 'mathematical' semiotic system is shown more as a semiotic mode in its own right that has developed and diverged from combinations of the verbal writing system and certain page compositional properties. This semiotic mode may then be employed further wherever it is communicatively appropriate. Moreover, for inexperienced users of the mathematical system, use will be made primarily of the written language system to understand what is present rather than reading expressions with respect to their own semiotic mode. Here, as elsewhere, it is likely that the use of the possibilities of any 'accompanying' semiotic modes also be restricted in particular ways – that is, co-present semiotic modes may be deployed respecting specific 'registers'. Registerial variation is as a consequence equally relevant here and probably holds for any sufficiently developed semiotic mode.

A considerable benefit of embedding the use of semiotic resources in a framework of this kind is then that we can talk both of multisemiotic artifacts as partially pre-given forms and of interconnections and intersemiotic relations holding between such components. It will always be possible for material left uncommitted by the requirements of some semiotic mode or modes to be taken up and used by other semiotic modes should this be communicatively required. The addition of the rounded box for textual emphasis in the chemistry equation of Figure 4 was a clear example of this – a possibility that is now naturally covered by the semiotic mechanisms that I have outlined here.

CONCLUSIONS

Multisemiotic artifacts as defined and used by Parodi present a hitherto under-developed segment of the semiotic instantiation continuum ranging from semi-fixed uses of resources parasitic on other semiotic modes through to semiotic resources already exhibiting the features of fully blown semiotic modes in their own right. Analytically and methodologically they are therefore a very useful construct, precisely because they make empirical study possible without a prior commitment to semiotic mode status. Collections of reoccurring semiotic properties may be bundled and investigated for their distributions across different types of texts and contexts and also for their own internal composition and variations. Formalizing multisemiotic artifacts

in this way allows us to characterize both their 'semi-fixity' and their permeability and interaction with other semiotic systems. A range of further empirical research can be envisioned on this basis, both distributional, in further corpus studies, and experimental, in that differing degrees of literacy might be explored by investigating the extent to which participants recognize specific interpretative conventions constituting a semiotic mode rather than importing interpretative schemes from more 'general' forms of expression that might appear to fit the material regularities at hand. There may also be educational consequences in that it might prove beneficial to explicitly target areas of conventionalization where the use made of material regularities in some semiotic mode deviates from what might have been expected without knowledge of that semiotic mode.

For all of these concerns, Parodi's detailed multimodal corpus work still stands as a beneficial and highly relevant point of departure for multimodality research. Several of Parodi's subsequent extensions and applications of his framework already show profitable lines of development capable of bearing considerable fruit. Following on the distributional, corpus-based work described here, for example, Parodi, Julio and Recio (2018) and Parodi and Julio (2020) employ eye-tracking techniques for deepening our understanding of discourse comprehension, both verbal and multimodal. Similar paths are now being followed in several areas of empirical multimodality research. Moreover, changes in the physical details of any stimulus are generally only of consequence for reception when they are 'semiotically' relevant. The precision of experimental methods is therefore substantially improved when the 'structural organization' of the materials receiving analysis can already be drawn on in experimental design and hypothesis formation. This is precisely the information provided by the compositional facets of multisemiotic artifacts. The developmental trajectory of Parodi's engagements with multimodality has consequently been quite exemplary, opening up many paths for future studies.

REFERENCES

Anstey, M. & Bull, G. (2018). *Foundations of Multiliteracies. Reading, Writing and Talking in the 21st Century*. London: Routledge.

Archer, A. & Breuer, E. (Eds.) (2016). *Multimodality in Higher Education. Studies in Writing Series* (Volume 33). Leiden, Boston: Brill.

Baldry, A. P. (2000). English in a visual society: Comparative and historical dimensions in multimodality and multimediality. In A. P. Baldry (Ed.), *Multimodality and multimediality in the distance learning age* (pp. 41-89). Campobasso, Italy: Palladino Editore.

Bateman, J. A. (2008). *Multimodality and genre: A foundation for the systematic analysis of multimodal documents*. Basingstoke: Palgrave Macmillan.

Bateman, J. A. (2011). The decomposability of Semiotic Modes. In K. L. O'Halloran & B. A. Smith, (Eds.), *Multimodal Studies: Multiple Approaches and Domains* Routledge Studies in Multimodality (pp. 17-38). London: Routledge.

Bateman, J. A. (2016). Methodological and theoretical issues for the empirical investigation of multimodality. In N.-M. Klug & H. Stöckl (Eds.), *Handbuch Sprache im multimodalen Kontext* number 7 *in* 'Handbooks of Linguistics and Communication Science (HSK)' (pp. 36-74). Berlin: de Gruyter.

Bateman, J. A. (2019). Afterword: Legitimating Multimodality. In J. Wildfeuer, J. Pflaeging, J. Bateman, O. Seizov & C. Tseng (Eds.), *Multimodality: Disciplinary Thoughts and the Challenge of Diversity* (pp. 297-321). Berlin: de Gruyter.

Bateman, J. A. (2021). What are digital media?. *Discourse, Context* & *Media,* 41.

Bateman, J. A., Delin, J. L. & Henschel, R. (2004). Multimodality and empiricism: Preparing for a corpus-based approach to the study of multimodal meaning-making. In E. Ventola, C. Charles & M. Kaltenbacher (Eds.), *Perspectives on Multimodality* (pp. 65-87). Amsterdam: John Benjamins.

Bateman, J. A., Wildfeuer, J. & Hiippala, T. (2017). *Multimodality – Foundations, Research and Analysis. A Problem-Oriented Introduction*. Berlin: de Gruyter.

Bertin, J. (1983). *Semiology of graphics. Diagrams, networks, maps*. Madison, WI: University of Wisconsin Press. Translated *Sémiologie graphique* (1967) by William J. Berg.

Boudon, E. & Parodi, G. (2014). Artefactos multisemióticos y discurso académico de la economía: Construcción de conocimientos en el género manual. *Revista Signos. Estudios de Lingüística 47*(85), 164-195.

Bucher, H.-J. (2011). Multimodales Verstehen oder Rezeption als Interaktion. Theoretische und empirische Grundlagen einer systematischen Analyse der Multimodalität. In H.-J. Diekmannshenke, M. Klemm & H. Stöckl (Eds.), *Bildlinguistik. Theorien – Methoden – Fallbeispiele* (pp. 123-156). Berlin: Erich Schmidt.

Cohn, N. (2020). *Who Understands Comics?: Questioning the Universality of Visual Language Comprehension*. London and New York: Bloomsbury Academic.

Dancygier, B. & Vandelanotte, L. (2017). Internet memes as multimodal constructions. *Cognitive Linguistics 28*(3), 565-598. DOI: https://doi.org/10.1515/cog-2017-0074

Doran, Y. J. (2018). *The Discourse of Physics: Building Knowledge through Language, Mathematics and Image*. London and New York: Routledge.

Engebretsen, M. & Weber, W. (2017). Graphic modes. the visual representation of data. In C. Cotter & D. Perrin (Eds.), *The Routledge Handbook of Language and Media* (pp. 277-295). London and New York: Routledge.

Engelhardt, Y. & Richards, C. (2018). A framework for analyzing and designing diagrams and graphics. In P. Chapman, A. Moktefi, S. Perez-Kriz & F. Bellucci (Eds.), *Diagrams 2018: Diagrammatic Representation and Inference* of *Lecture Notes in Computer Science* (pp. 201-209). Heidelberg and Berlin: Springer.

Fludernik, M. (2000). Genres, text types, or discourse modes? Narrative modalities and generic categorization. *Style, 34*(1), 274-292.

Halliday, M. A. K. & Matthiessen, C. M. I. M. (2013). *Halliday's Introduction to Functional Grammar* (4 edn). London and New York: Routledge.

Hiippala, T., Alikhani, M., Haverinen, J., Kalliokoski, T., Logacheva, E., Orekhova, S., Tuomainen, A., Stone, M. & Bateman, J. A. (2020). AI2D-RST: A multimodal corpus of 1000 primary school science diagrams. *Language Resources and Evaluation* 55, 661-688. DOI: https://doi.org/10.1007/s10579-020-09517-1

Hiippala, T. & Bateman, J. A. (2021). Semiotically-grounded distant viewing of diagrams: Insights from two multimodal corpora. *Journal of Digital Scholarship in the Humanities*. DOI: https://doi.org/10.1093/llc/fqab063

Hurst, M. (2006). Towards a theory of tables. *International Journal of Document Analysis, 8*(2), 123-131.

Kembhavi, A., Salvato, M., Kolve, E., Seo, M. J., Hajishirzi, H. & Farhadi, A. (2016). A diagram is worth a dozen images. In *Proceedings of the 14th European Conference on Computer Vision (ECCV 2016)* (pp. 235-251). Cham: Springer.

Kress, G., Jewitt, C., Ogborn, J. & Tsatsarelis, C. (2001). *Multimodal teaching and learning. The Rhetorics of the Science Classroom*. London and New York: Continuum.

Lee, D. Y. (2001). Genres, registers, text types, domains, and styles: Clarifying the concepts and navigating a path through the BNC jungle. *Language Learning and Technology, 5*(3), 37-72 [on line]. Retrieved from: http://llt.msu.edu/vol5num3/lee

Lemke, J. L. (1998). Multiplying meaning: visual and verbal semiotics in scientific text. In J. Martin & R. Veel (Eds.), *Reading science: Critical and functional perspectives on discourses of science* (pp. 87-113). London: Routledge.

Lemke, J. L. (1999). Typology, topology, topography: Genre semantics. MS University of Michigan [on line]. Retrieved from: http://academic.brooklyn.cuny.edu/education/jlemke/papers/Genre-topology-revised.htm

Lohse, G., Walker, N., Biolsi, K. & Rueter, H. (1991). Classifying graphical information. *Behaviour & Information Technology, 10*(5), 419-436. [on line]. Retrieved from: http://dx.doi.org/10.1080/01449299108924300

Martin, J. R. (2001). Language, register and genre. In A. Burns & C. Coffin (Eds.), *Analysing English in a Global Context: A reader Teaching English Language Worldwide* (pp. 149-166). Clevedon: Routledge.

Martin, J. R. (2010). Semantic variation – modelling realisation, instantiation and individuation in social semiotics. In M. Bednarek & J. R. Martin (Eds.), *New Discourse on Language Functional Perspectives on Multimodality, Identity, and Affiliation* (pp. 1-34). London: Continuum.

Mondada, L. (2014). The local constitution of multimodal resources for social interaction. *Journal of Pragmatics*, 65, 137-156.

Morrissy, S. (2017). Inexplicable in the last resort: A critique of Theo van Leeuwen's identification of typography as a mode. *Information Design Journal, 23*(2), 184-193.

New London Group (2000). A pedagogy of Multiliteracies: Designing social futures. In M. Kalantzis & B. Cope (Eds.), *Multiliteracies: Literacy Learning and the Design of Social Futures* chapter 1 (pp. 9-38). London: Routledge.

O'Halloran, K. L. (2005). *Mathematical discourse: Language, symbolism and visual images*. London and New York: Continuum.

Painter, C., Martin, J. R. & Unsworth, L. (2013). *Reading visual narratives: Image analysis of children's picture books*. London: Equinox.

Parodi, G. (2010a). Multisemiosis y Lingüística de Corpus: Artefactos (Multi)Semióticos en los Textos de seis Disciplinas en el Corpus PUCV-2010. *Revista de lingüística teórica y aplicada*, *48*(2), 33-70.

Parodi, G. (2010b). Research challenges for corpus cross-linguistics and multimodal texts. *Information Design Journal, 18*(1), 69-73.

Parodi, G. (2011). La teoría de la comunicabilidad: Notas para una concepción integral de la comprensión de textos escritos. *Revista Signos. Estudios de Lingüística*, *44*(76), 145-167.

Parodi, G. (2012). University genres and multisemiotic features: Accessing specialized knowledge through disciplinarity. *Fórum Lingüístico*, *9*(4), 259-282.

Parodi, G. (2014). Genre organization in specialized discourse: Disciplinary variation across university textbooks. *Discourse Studies, 16*(1), 65-87.

Parodi, G. & Julio, C. (2017). More than words: Contending semiotic systems and the role of disciplinary knowledge in specialized text comprehension. *Ibérica,* 33, 11-36.

Parodi, G. & Julio, C. (Eds.) (2020). *Comprensión y discurso: Del movimiento ocular al procesamiento cognitivo*. Valparaíso: Ediciones Universitarias de Valparaíso.

Parodi, G., Julio, C. & Recio, I. (2018). When words and graphs move the eyes: Multimodal causal relations and eye tracking techniques. *Journal of Eye Movement Research*, *11*(1), 5.

Preziosi, D. (1986). The multimodality of communicative events. In J. Deely, B. Williams & F. E. Kruse (Eds.), *Frontiers in Semiotics* (pp. 44-50). Bloomington, IN: Indiana University Press.

Steen, F. & Turner, M. B. (2013). Multimodal construction grammar. In M. Borkent, B. Dancygier & J. Hinnell (Eds.), *Language and the Creative Mind* (pp. 255-274). Stanford, CA: CSLI Publications.

Stöckl, H. (2004). *Die Sprache im Bild — Das Bild in der Sprache: Zur Verknüpfung von Sprache und Bild im massenmedialen Text. Konzepte - Theorien - Analysemethoden*. Berlin: de Gruyter.

Stöckl, H. (2016). Multimodalität – Semiotische und textlinguistische Grundlagen. In N.-M. Klug & H. Stöckl (Eds.), *Handbuch Sprache im multimodalen Kontext* number 7 *in* 'Handbooks of Linguistics and Communication Science (HSK)' (pp. 3-35). Berlin: de Gruyter.

van Leeuwen, T. (2005a). *Introducing social semiotics*. London: Routledge.

van Leeuwen, T. (2005b). Typographic meaning. *Visual Communication*, *4*(2), 137-143.

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. New York: Springer-Verlag. [on line]. Retrieved from: https://ggplot2.tidyverse.org

Winkler, H. (2008). Zeichenmaschinen: Oder warum die semiotische Dimension für eine Definition der Medien unerlässlich ist. In S. Münker & A. Roesler (Eds.), *Was ist ein Medium?* (pp. 211-222). Frankfurt am Main: Suhrkamp Verlag.

NOTES

[1] Cf. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/chapt7.htm

[2] A (covalent) bond is formed when a pair of atoms share a pair of outer (energy level) electrons: hydrogen has one such outer electron that may participate in sharing, while carbon has four.