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On the track of visual style: a diachronic study of page composition in comics and its functional motivation

Abstract

Page layout is one of the most salient features of graphic novels and comics that readers encounter: even before engaging with specific content, an overall impression of the page composition will have already been communicated. In the critical literature on comics and graphic novels it is also commonly claimed that page composition plays a significant role for narrative construction, pacing, and other aspects of reception. However, in contrast to this prominence, methods for engaging systematically with the analysis of page design in comics and graphic novels are still in their infancy. Empirical studies of the workings of visual page composition are rarer still. In this article we report results drawing on a diachronic, corpus-based investigation of page composition that illustrate how it is beneficial to approach page composition employing methods from corpus linguistics and multimodality. We show not only that it is possible to isolate trajectories of change in composition over time but also that such studies can be used to provide evidence of functionally-motivated variation in compositional choices.

Keywords

visual style, page composition, comic books, diachronic visual analysis, methodology, multimodality, page layout

Introduction

Comics and graphic novels are particularly rich in their distribution of communicative tasks across diverse expressive forms. They are often noted for their extensive use, on the one hand, of visual forms of language such as typography and text-positioning, and, on the other, of 'drawn' pictorial depictions. However, the properties of overall page composition or layout design are also central to all comics and graphic novels. Indeed, in one of the most extensive previous studies of this aspect of comics and graphic novels to date, Pederson and Cohn (2016: 7) describe page composition as one of comics and graphic novels' "most overt features", and broad features of page composition and designed layout are commonly suggested to guide interpretative processes with particular force (e.g., Fresnault-Deruelle 1976; Groensteen 2007 [1999]; Postema 2013; Baetens and Frey 2015: 103–133). Although doubt is often voiced that such an apparently flexible facet of design could ever be made susceptible to more systematic, and above all empirical, study, there are now increasing calls for more empirically-founded studies of the properties of comics and graphic novels media (cf. Cohn 2014b; Dunst et al. 2018b) and it is to this growing body of work that the current article orients.

The purely visual aspects of design have proved particularly illusive to systematic inquiry and also raise general challenges for accounts of communication, demanding advances in both methodology and theory. Consequently, in this paper we argue that methods derived from corpus linguistics and multimodality research can effectively reveal not only systematic patterns of change over time but also systematic relations between communicative functions and visual layout. We suggest that this opens the door to detailed explorations of page composition as a *communicative resource* in its own right.

Page composition in comics and graphic novels is also a particularly interesting topic when considered from the perspective of multimodality research. Providing effective treatments demonstrates how important it is to anchor discussions of semiotic resources firmly with respect to both *semiotic modes* and *media* (cf. Bateman 2017). As will be shown below, the operation of 'layout' within the media of comics and graphic novels takes on its own quite distinctive functions that require us to move away from some of the more generic labels found in multimodality research when discussing layout (cf. Kress and van Leeuwen 2006 [1996]: 177). As now noted for several media, including newspapers (Knox 2007; Bateman 2008), online newspapers (Djonov and Knox 2014; Bateman et al. 2007), PowerPoint presentations (Djonov and van Leeuwen 2013), instructional texts (Bateman 2008), and more, 'layout' as an observable property of visually accessible two-dimensional page-based media appears to be used in rather different ways across those media. Consequently, following the model of semiotic modes defined in Bateman (2016), 'layout' will be considered here a target of empirical investigation whose precise forms and functions within the media of comics and graphic novels still need to be determined.

Pages within comics and graphic novels are commonly described in terms of 'grid' organizations within which 'panels', assumed as the main content-bearing units of the media, are placed. This grid organization is, however, quite different to the more common use made of 'grid'-like structures in art and design and so needs to be carefully distinguished with respect

both to its forms and to its functions. Djonov and van Leeuwen (2013) describe two perspectives on grids, one from 'below', where the lines of a grid are used as guides for the placement of elements on a page or canvas in order to help a designer achieve visual coherence and balance, and one from 'above' (which they term composition), where "dynamism and value" are added to "certain positions" on a surface (Djonov and van Leeuwen 2013: 11). In both cases the 'grid' organization is generally not made visually prominent in its own right. The former perspective on grids (and generalizations beyond grid-organizations to include a variety of geometric forms) corresponds to the layout structure level of description given in Bateman (2008); the latter perspective corresponds more to the rhetorical level of description in Bateman (2008), although the particular kinds of 'value' assumed there are quite different to those of Kress and van Leeuwen (2006 [1996]) that are adopted further in Djonov and van Leeuwen (2013).

Within comics and graphic novels, the use of a grid combines aspects of these perspectives while also generally constituting an explicit visual property of page design in its own right. Moreover, when using a grid in these media, it is not the lines of the grid that take center stage but rather the *shapes* which those lines give rise to for presenting content. A grid may, for example, create an array of regular shapes, where no particular panel is emphasized or distinguished from the others, or alternatively be deployed to give rise to a variety of more irregular shapes, which distribute perceptual prominence and inter-connections around the spatial array while also segmenting any presented content. There is no sense in which generalized functions, such as Kress and van Leeuwen's (2006 [1996]) 'given-new' or 'ideal-real', apply to the resulting page compositions.

The workings of layout within comics and graphic novels need also, however, to be differentiated from the three visually-anchored semiotic modes for page-based media developed in Bateman (2008: 175): text-flow, (static) image-flow and page-flow. Whereas there are aspects of the functionality of (static) image-flow, whereby meanings are carried by placing 'images' (broadly construed) in linear sequence, this is insufficient for the evidently two-dimensional use of the page seen in comics and graphic novels. Image-flow would, at best, cover comic strips of the traditional linear 3-6 panel kind found in newspapers. At the same time, the broadly rhetorically-organized functions of layout proposed for page-flow in Bateman (2008) are equally inappropriate, since the placement of materials within the two-dimensional comics or graphic novels page is not generally describable in terms of salience, nuclearity, and degrees and types of rhetorical relatedness following proximity or other spatial relationships as is the case with page-flow.

In short, 'grid-like' forms observable for layout in comics and graphic novels take on certain properties of image-flow, particularly in their establishment of intended logical orders for panels (which must, additionally, be clearly distinguished from the 'reading paths' that readers may be intended to follow), while also extending this considerably to mobilize a far broader range of possible 'inter-panel' relationships supported by two-dimensional page organization. Interconnections of this latter kind are discussed extensively by, for example, Groensteen (2007 [1999]) and raise substantial challenges for systematic treatments. In the rest of this paper, therefore, our concern will be to introduce a specific methodology and framework for subjecting the use of page composition in the media of comics and graphic novels to close empirical analysis.

A functional scheme for characterizing layout in comics and graphic novels

In order to undertake empirical and descriptive investigations of the media of comics and graphic novels playing particular attention to their visual composition, Bateman et al. (2017) motivate a detailed classification network covering the page layout strategies observable in a broad range of comics and graphic novels taken from US, European and Asian publications since the 1930s until the current day. This classification scheme takes Groensteen's (2007 [1999]) notion of the *hyperframe*, a visually accessible holistic ensemble of panels, as its 'entry point' and progressively specifies 'functional distinctions' in design strategies that may abstractly characterize the overall form of the page or double-page spread analyzed.

An extract from this annotation scheme together with illustrative examples of the page organizations covered is shown in Figure 1. Here we can see that the scheme factors away from the 'content' (pictorial or otherwise) of any panels present in order to focus specifically on the possible communicative contributions of the page compositional choices themselves. The purpose of this degree of abstraction is to make composition choices of this kind accessible as an independent dimension of potential variation when studying comics and graphic novels empirically and, as set out by Cohn and colleagues, to allow form and meaning to be triangulated against one another (Pederson and Cohn 2016; Cohn et al. 2017b). Moreover, in contrast to the page layout annotations pursued by Cohn and colleagues, the classification scheme adopted here takes the entire 'page' or 'spread' as its starting point rather than more local spatial relationships between individual panels; the complementary relationship between these approaches is discussed further in the discussion on related work below.

The distinctions shown in Figure 1 constitute a 'backbone' for diverse layout variations which may be further modified and extended by other classification features from the classification scheme as a whole that are applied in parallel. These features include options that capture individual or groups of panels being 'tilted' or 'rotated', receiving or not receiving explicit frames, overlapping or intruding on other panels or groups of panels and so on. Several of these options will be drawn on below. The organization of the classification scheme as a whole is as a network of mutually exclusive alternatives: at each 'choice point' in the network, classification proceeds by picking one and only one of the available features. Thus, the first classification decision is whether a page or spread as a whole exhibits a broadly 'linear', 'radial', or some other more complex organization. Similarly, if the page composition has been characterized as 'linear' (see examples in the figure), then one of the options that needs to be resolved is whether that composition exhibits 'staggering' (i.e., the edges of the created panels do not always exactly align) or 'no-staggering' (i.e., they align). Both positive and negative occurrences are

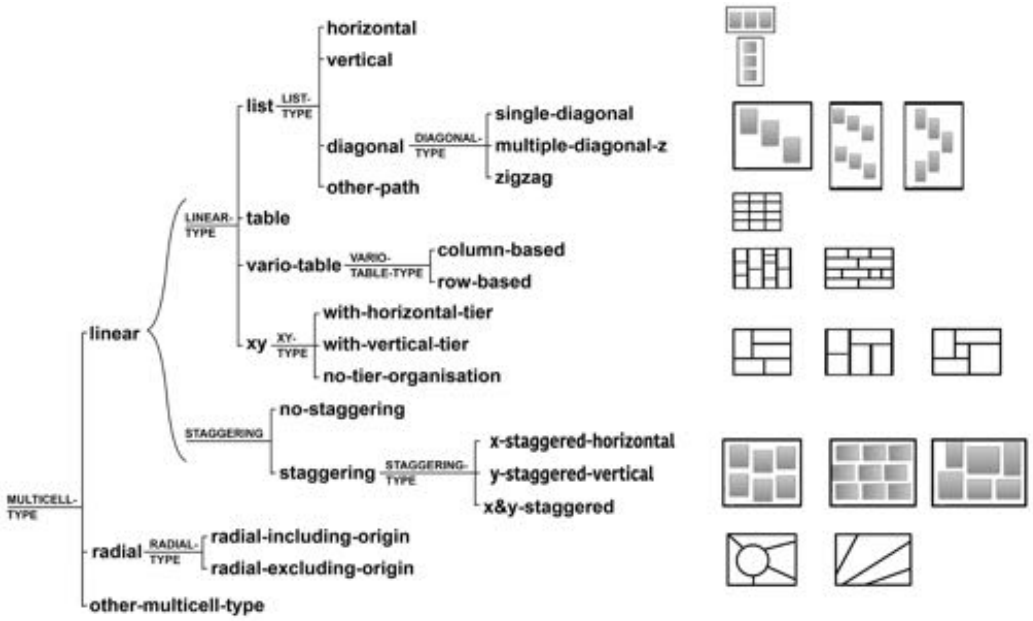


Figure 1. Classification options under 'multicell' configurations (i.e., page designs giving rise to collections of 'cells' such as panels) with example layout realizations for the main features shown on the right (Bateman et al. 2017). Square brackets indicate strict alternatives, curly brackets conjunction.

always explicitly named so that they can be tracked independently and the non-occurrence of a visual property can be seen as clearly as its occurrence. The result is a highly differentiating classification scheme made up of over 100 features which still nevertheless supports reliable application as reported in Bateman et al. (2017).

This classification scheme makes no assumptions that the distinctions it draws are relevant for media other than comics or graphic novels and so is particularly suitable for the more empirically-driven aims of the current paper. Indeed, spatial configurations that are distinguished by this scheme may well not be differentiated at all in other media (and *vice versa*). This does not preclude similarities or overlaps being found should the appropriate empirical analysis reveal such points of connection, but such a result is not assumed prior to the necessary empirical work having being undertaken. The adoption of the visual forms covered by the scheme may also function as strong media indicators: thus, when found in other media, layouts of these kinds would stand as good evidence for *media depiction* as defined in Bateman (2016), rather than as necessarily suggesting that other media use these forms 'natively', i.e., as an inherent component of their semiotic make-up. All such questions are still considered to require focused empirical study at this time.

A diachronic corpus of comics page layout

As set out in Dunst et al. (2018a), there are increasing calls for more empirically-oriented approaches to comics and graphic novels that address all the communicative resources employed. One of the strategies adopted to support such work is that of collecting and analyzing corresponding corpora. Several comicbook and graphic novel corpora have been constructed and this number is certain to increase rapidly as further empirical studies are undertaken. As always with corpus construction, however, several issues of design need to addressed prior to collection. Corpora can either attempt to achieve broad-scale representativeness of the materials they are covering, as in, for example, Beaty et al.'s (2018) aim of systematically covering a randomly selected but nevertheless diachronically balanced"2%" of all the comic books published in the United States between 1934 and 2014 (the total figure of which is calculated by Beaty et al. on the basis of several standard publication databases at 176,275), or be more focused towards specific genres, cultures or periods. Substantial corpora of the latter kind have been developed by Cohn and colleagues (e.g., Pederson and Cohn 2016), including both cross-cultural collections for contrasting US, European and Japanese styles and more focused collections of US superhero comics published from the 1940s until the present day.

The size and breadth targeted for a corpus depend at the present time rather crucially on the ways in which the corpus will be investigated. For the kind of qualitative analysis that is undertaken in the work of Cohn and in our own approach being reported here, the need to provide qualitative analyses of the material imposes severe practical limits. Such analyses require a considerable investment of time and effort. For approaches that work more quantitatively, it is now becoming possible to employ automatic processing mechanisms of various kinds. In the analyses reported by Dunst and Hartel (2018), for example, 50,000 pages from publications from the mid-1970s to the current day characterized as 'graphic narrative' were analyzed automatically for brightness, information 'entropy' and complexity of shapes and then subjected to statistical clustering methods similar to those we report on for our corpus below. As the range and sophistication of automatic processing grows (e.g., Rigaud and Burie 2018), so too will we be able to expect larger corpora supporting both quantitative and qualitative

investigations. In many respects, therefore, the results we report here need to be seen as exploratory. It is important to exercise considerable caution concerning any generalizations that the analysis may suggest concerning the medium as a whole; more extended, empirical studies will clearly be necessary. Nevertheless, the general methods of analysis we report in this paper naturally extend to support such studies.

Our focus in the present study is specifically on the communicative deployment of visual composition, particularly page layout, and as a step towards this we are explicitly seeking to evaluate the value of adopting the functionally-motivated classification scheme for page layout introduced above. At the present time, classifications of this kind cannot be derived automatically, and so we needed to develop a corpus that was, on the one hand, constrained in size so that the classification scheme could still be realistically applied, but which also, on the other hand, would contain enough variation of the phenomena under study to be revealing. For this, we adopted a similar approach to that of Cohn and colleagues and constructed a corpus of U.S. superhero comicbook pages spanning seven full decades, starting in 1940 and moving on to the 50s, 60s, 70s, 80s, 90s and ending in 2009. The superhero genre is recognized as one of the most long-lived and so offers a considerable range of material that is nevertheless broadly comparable. In this respect, our corpus is best considered a 'special purpose', or specialized, corpus intended to cover a specific subgenre and cultural provenance and trading size for appropriate variation in the specific phenomena we are interested in: i.e., variation in page composition over time.

Despite the clear focus and size limitation of our corpus, we nevertheless explicitly adopted a corpus design strategy that aimed for considerable breadth and balance in the materials collected, respecting standard criteria established for corpus work in linguistics (e.g., Atkins et al. 1992; Sinclair 2005; Baker and McEnery 2015). We first collected a range of 420 publications, drawing primarily on reprints of Superman and Batman stories as these could provide samples for the corpus consistently across decades. We then included just three pages from each story for analysis. We adopted this strategy rather than including many pages from single works so as to avoid introducing any artificial homogeneity and to cover a variety of stories and, consequently, of artists, the assumed principal users of the communicative system under investigation. The stories sampled consequently represented 104 distinct writers (responsible for the script) and 124 pencilers (generally responsible for drawings, deciding page layout, number of panels and shape). Our hypothesis was that this variety would permit a broad diachronic view of the layout variations employed in this subgenre of comics despite its limitation in size. Following our adopted criteria, we collected 18 pages per year, yielding 180 pages per decade. From within each story selected, we included the first three odd pages after the title page. Title pages were excluded as they are designed in terms of layout with different purposes in mind, setting out story title, credits, and so on, which all affect page layout. For similar reasons, spreads – that is, double pages to be read as single large pages – were also excluded from the corpus. These pages would need to be examined in their own right. When any of the initial three pages selected was a page spread, we instead took the next single odd page available. The final size of the corpus overall was then 1260 pages.

The pages of the corpus were subsequently annotated according to the layout annotation scheme introduced above, using the UAM Image Tool (O'Donnell 2008) as proposed in Bateman et al. (2017). Following annotation, the UAM Image Tool was also used to export the annotation results as a csv-file for statistical analysis. The resulting file defined a table with 107 rows, one for each annotation feature defined in the classification network, and 1262 columns consisting of one column for each page annotated and two additional columns identifying the choice points in the classification network and corresponding values of either zero (not selected) or one (selected) for each annotation feature defined. This table served as the basis for the various analyses reported below; all results discussed, as well as the corresponding graphs and tables, were produced on the basis of this data using R (R Core Team 2016) (R3.3.3, 2017) within RStudio (Version 1.1.442, 2018).

Visual 'style' and changing patterns of design

Given the overall data collected, our focus turns now to whether more general patterns of layout composition can be identified. Although there is often discussion of 'visual style' in the visual arts, in design (cf. Rose 2012; Manghani 2013), in 'visual genre' in document design (cf. Kostelnick 1996; Kostelnick and Hassett 2003) and similar, empirical support for such genres or styles is quite underdeveloped. The existence both of an extensively annotated corpus of the kind we adopt here and of a communicative medium in which visual composition is evidently a highly conventionalized and sophisticated aspect of the communications using that medium offers a particularly promising site where visual 'styles' or 'genres' could be expected to manifest themselves.

To explore this possibility further, we adopt and adapt the strategy for investigating *registerial* variation made prominent in Biber's (1995) corpus-based study of spoken and written language varieties. Biber used an extensive statistical analysis of a large set of grammatical features assigned to sentences taken from a broad range of distinct genres varying over spoken and written contexts of use. In particular, he applied methods which allow the overall variation observable in a dataset to be described in terms of a reduced number of 'dimensions' produced automatically by the analysis. A basic property of dimension-reduction approaches of this kind is that the dimensions of comparison do not need to be specified in advance: the dimensions reported are derived from the data as a means of describing a high dimensional space (e.g., the number of grammatical features annotated) in terms of a low dimensional space (i.e., the number of dimensions discovered as statistically relevant). In Biber's case, for example, the grammatical description included results for 67 grammatical features, whose co-variation was characterized best by a reduced solution making use of only 7 dimensions (Biber 1995: 88–91).

The individual grammatical features considered then receive 'weights' along the discovered dimensions so that the positions of texts within the resulting multidimensional space can be calculated and compared. The dimensions themselves

were then 'glossed' in situational terms, such as 'involved versus informational production', 'narrative versus non-narrative concerns', or 'overt expression of persuasion' (Biber 1988: 122). Register is thus best seen as bridging both 'text-internal' and 'text-external' features of texts (cf. Sinclair 2005). The linguistic (internal) properties of texts are assumed to correlate with properties of their situations of use (external); characterizations of register in terms of varying likelihoods of occurrence of grammatical features drawn within texts reflect the internal perspective; characterizations of register in terms of situational dimensions reflect the external perspective. This essentially *functional* account of the nature of register and registerial variation is also adopted in our study here since, in a very similar manner to that set out by Biber, we attempt to find patterns in the distributions of text-internal features (given by our page layout annotation scheme) and correlate these with text-external properties.

An interesting refinement in the case of our study, however, is that the external features we target are more specific than broad situational dimensions. Indeed, the text-external criteria adopted for sample selection in our corpus reflect a broadly homogeneous 'context of use': i.e., that of US superhero comics. Such 'texts' are generally constituted by adventure narratives in which superheroes encounter (and overcome) a variety of adversaries. Our focus then lies within this and asks to what extent variations in compositional choices can be related back to *narrative* concerns. That is, rather than assuming that dimensions of variation found text-internally are directly characterizable in broad situations of use (or production), we explore to what extent the same method can be applied to reveal choices, and variations of choices, in narrative strategies because it is precisely strategies of this kind that are most commonly discussed in the comics literature. This experimental development proceeds in two stages: first, we explore whether there are systematic patterns in visual 'style' that can be identified on the basis of the corpus at all; and second, we examine whether it is possible to correlate any such patterns found with narrative concerns. Given the preliminary and exploratory status of the research, we refrain from directly 'glossing' any organizational dimensions found and instead look for correlations between differing levels of organizational dimensions; this is clarified and illustrated further below.

Biber's general approach of clustering texts along statistically calculated dimensions of variation therefore establishes a 'topological' account of register variation – a possibility also suggested as beneficial for topological accounts of, for example, genre by Martin and Matthiessen (1991), Lemke (1999), and Martin and Rose (2008: 131). The multidimensionality of such accounts also means that texts that lie close to one another along certain dimensions may, at the same time, lie far apart on other dimensions, as we shall see. As a first exploratory study of visual variation in this spirit, we adopted a slightly simpler approach to dimension reduction in order to examine whether patterns of co-occurrence of *layout* features can serve a similar role to those found for grammatical variation in Biber's account. As Biber explains:

> "almost any linguistic feature will vary in its distribution across registers, reflecting the discourse functions of the feature in relation to the situational characteristics of each register. However, comprehensive descriptions of register variation must be based on the *co-occurrence* and *alternation* patterns among the range of linguistic features." (Biber 2008: 101; original emphasis)

Using the layout features annotated in our corpus in this way was therefore hypothesized as offering a means of succinctly capturing the intrinsic variation in page design present in our corpus as well.

Principal Dimensions of Layout Variation

The particular method we adopted for dimension reduction was the well established technique of principal components analysis (PCA, cf. Maćkiewicz and Ratajczak 1993), calculated using the R package 'FactoMineR' (Lê et al. 2008). The form of the corpus data taken as input to this PCA calculation was a table giving the number of occurrences of each layout feature summed within years. The counts for each feature per year were therefore those resulting from that year's corpus sample of 18 pages. Furthermore, to focus results, we filtered the data so that extremely rare layout features were removed prior to performing PCA. The restricted dataset then contained just 52 layout features from 24 choice points, or systems, in the classification network; this yielded a small improvement in the total degree of variation covered and so is the dataset used in the discussions following.

The 10 best dimensions, or principal components, calculated and their respective contributions to accounting for the overall variation in the data are summarized in Figure 2. This graph shows that the first 5 dimensions cover just over 61% of the total variation in the data and that dimensions 6-10 each make relatively low contributions. In the discussions below, therefore, we focus on just the first 5 principal components.

Interpretations of the Dimensions

As noted above in our discussion of Biber's approach, in PCA the original features of the data – in this case, our restricted set of layout features – are related to the found dimensions in terms of calculated 'weights'. That is, for each dimension one can examine the contribution (positive or negative) made by each of the layout features. This gives the basis for considering what 'meanings' might be attributed to the discovered dimensions. Since the dimensions are themselves just a product of the mathematical process of dimension reduction, they do not come with any preset, or guaranteed, semantic import. Whether they 'make sense' from the perspective of an interpretation of the data needs to be explored in a separate stage of analysis.

In Biber's case reported above, he similarly examined the positive and negative weightings of the grammatical features on the one hand, and the distributions of texts according to those dimensions on the other, in order to suggest plausible

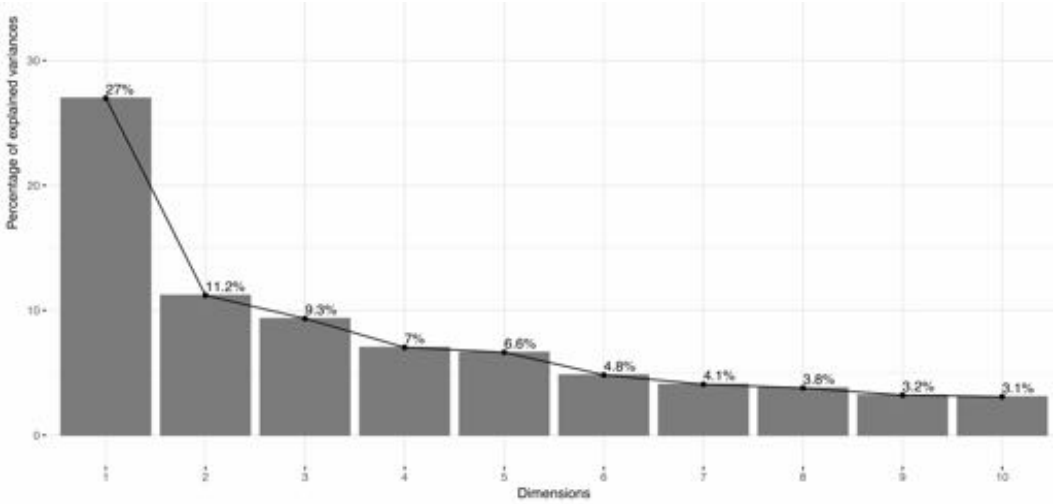


Figure 2. Percentages of variation explained by the PCA-calculated dimensions with respect to the layout features

interpretations for what the dimensions were revealing. We undertake a similar step here, considering the potential *layout* implications of the groupings revealed. Tables 1–5 consequently show the strongest and statistically most significant layout feature weightings for the top five dimensions. The features with positive weightings contribute positively to a placement along the corresponding dimension; conversely, features with negative weightings indicate that a low value along the corresponding dimension is appropriate. Values range from 0, no effect, to ± 1, a more or less categorical indication (which would not normally occur). On the basis of these layout features – examples of all of which can be found in Bateman et al. (2017) – we can therefore hypothesize broad interpretations of each dimension. However, as explained above, for the purposes of this current exploratory study, our interpretations remain as close as possible to the level of abstraction supported by the layout choices: we do *not*, as was the case in Biber's account, proceed to broad situational categories because we do not believe that such a step is warranted with our current state of knowledge concerning the functioning of page composition within this medium.

In contrast, all of the dimensions can be characterized fairly directly in terms of their contributions to the 'complexity' of analyzed pages. Moreover, the more fine-grained descriptions given by the layout features allows us to decompose 'complexity' further in specific directions. This is assumed here to be a useful path to consider since there are often proposals in the comics and graphic novels literature that page design has become more 'complex' in certain respects over time (cf., e.g., Pederson and Cohn 2016). Refining this position further throws useful light on this discussion as we shall see. We consequently 'gloss' the individual dimensions as follows:

- Dimension 1 is strongly associated with a lack of explicit white gutters (the visual space between panels), as a result of coloring from one panel 'bleeding' out behind other panels, with colored or patterned gutters ('grouted'), overlapping panels, gaps in otherwise regular grids, and lack of panel rotations; the dimension is negatively indicated by having explicit gutters and actual panels leaving space unused with respect to the space 'theoretically' made available by the prevailing grid.
- Dimension 2 correlates positively with panels fully using the theoretical space of the grid, lack of panels intruding on each others' space, a lack of inset panels, and simple regular grid space; the dimension correlates negatively with irregular grid spacing, variations in the size and shape of grid panels, and presence of inset panels.
- Dimension 3 correlates positively with explicit gutters, lack of gaps in the overall grid pattern, lack of rotations, and irregular spacing between panels. The dimension correlates negatively, although weakly, with grid organizations being entirely filled with their panels and with pages made up of single 'cells', i.e., without organizing substructure.
- Dimension 4 correlates positively with panels being tilted and rotated, with explicit panel frames, with variations in the size and shape of panels, and with the presence of inset panels; the dimension correlates negatively with space and size variation of panels with lack of tilting and with framing that is only implicitly present due to panels running into one another.
- Finally, dimension 5 correlates positively with regular table grids (sometimes called the 'waffle-iron' form in comics studies), with lack of inset panels, explicit framing and lack of rotation; the dimension correlates negatively with the presence of inset panels, variations in the size and shape of panels created by a grid, and with the generalization of the notion of 'table' that Bateman et al. (2017) term 'vario-tables', where different rows (or columns) can have varying numbers of cells.

In overview, therefore, we might say that dimension 1 is indicative of page irregularity with respect to lack of clear framing; dimension 2 is indicative of strong page regularity in grid shape and sizing; dimension 3 is indicative of strong framing with gaps and irregular spacing between panels; dimension 4 is indicative of tilts and rotations and with panels that vary in size and shape; and dimension 5 is indicative of regular 'waffle-iron' organizations and explicit frames. Higher page

Table 1. Dimension 1 weightings

	correlation	p value
no-gutter	0.839	0.000
cell	0.822	0.000
page-bleeding	0.816	0.000
partially-collapsed-gutter	0.797	0.000
grouted	0.758	0.000
overlapping	0.749	0.000
no-subpanel-segmentation	0.726	0.000
list	0.691	0.000
partial-framing	0.658	0.000
gapped	0.637	0.000
no-rotation	0.630	0.000
no-staggering	0.571	0.000
grid-underfilling	0.566	0.000
no-extraposed-captions	0.565	0.000
intruding	-0.517	0.000
non-gapped	-0.554	0.000
grid-filling	-0.610	0.000
table	-0.645	0.000
staggering	-0.652	0.000
vanilla-frame	-0.707	0.000
non-grouted	-0.758	0.000
non-overlapping	-0.766	0.000
explicit-gutter	-0.845	0.000

Table 2. Dimension 2 weightings

	correlation	p value
simple-grid-spacing	0.627	0.000
no-staggering	0.582	0.000
grid-filling	0.549	0.000
non-intruding	0.529	0.000
no-inset-panel	0.485	0.000
content-bound	0.454	0.000
no-extraposed-captions	0.432	0.000
overlapping	-0.414	0.000
staggering	-0.458	0.000
content-unbound	-0.463	0.000
extraposed-captions	-0.466	0.000
inset-panel	-0.473	0.000
other-framing-devices	-0.492	0.000
grid-space-size-shape-variation	-0.498	0.000
intruding	-0.525	0.000
grid-underfilling	-0.531	0.000
complex-grid-spacing	-0.561	0.000

Table 3. Dimension 3 weightings

	correlation	p value
multicell	0.885	0.000
gridding	0.843	0.000
gutter	0.824	0.000
non-gapped	0.619	0.000
complex-grid-spacing	0.431	0.000
grid-underfilling	0.409	0.000
no-rotation	0.399	0.001
grid-space-size-variation	0.360	0.002
untilted	0.352	0.003
content-bound	-0.238	0.048
grid-filling	-0.281	0.019
cell	-0.295	0.013

Table 4. Dimension 4 weightings

	correlation	p value
tilted	0.545	0.000
rotation	0.543	0.000
explicit-framing	0.520	0.000
complete-framing	0.501	0.000
grid-space-shape-variation	0.488	0.000
grid-space-size-shape-variation	0.488	0.000
inset-panel	0.419	0.000
simple-gridding	0.365	0.002
list	0.340	0.004
no-inset-panel	-0.317	0.007
complex-gridding	-0.341	0.004
grid-space-size-variation	-0.452	0.000
untilted	-0.457	0.000
implied-framing	-0.547	0.000

Table 5. Dimension 5 weightings

	correlation	p value
table	0.531	0.000
no-inset-panel	0.453	0.000
extraposed-captions	0.449	0.000
explicit-framing	0.405	0.001
no-subpanel-segmentation	0.377	0.001
no-rotation	0.358	0.002
subpanel-segmentation	-0.236	0.049
non-gapped	-0.240	0.045
grid-space-size-shape-variation	-0.250	0.037
complex-gridding	-0.269	0.025
inset-panel	-0.272	0.023
non-intruding	-0.285	0.017
no-extraposed-captions	-0.301	0.011
vario-table	-0.605	0.000

scores for dimensions 2 and 5 suggest, to a certain extent, regularity; higher page scores for dimensions 1, 3 and 4 show contrasting types of irregularity.

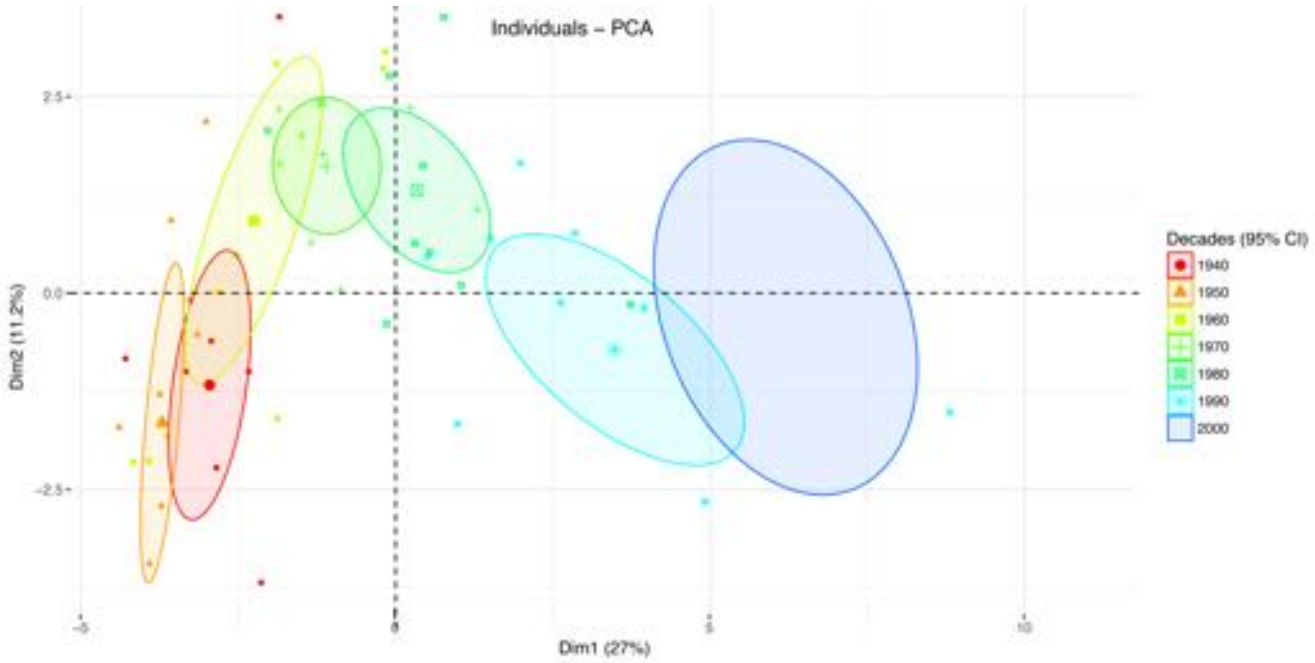


Figure 3. Data items from the corpus (sampled by year) plotted against dimensions 1 and 2 of the PCA, showing clusters of data items labeling decades with 95% confidence ellipses

Towards characterizations of visual 'register'

Given the dimensions calculated by PCA and our approximate interpretations or glosses of those dimensions, we proceed in this subsection to our main task, that of examining whether there are any regularities to be observed across the dataset with respect to their deployment of composition strategies lying along these dimensions. For this question, we used the calculated dimensions and corresponding feature weights and plotted the items of the dataset according to those items' scores along each of the dimensions. As explained above, each data item corresponds to the feature occurrences for the 18 pages in the corpus sampled for a single year. Consequently, a data item for, for example, 1948 would be placed in a corresponding two-dimensional graph according to the total scores the year achieved along the two dimensions selected for each graph. Taking dimensions 1 and 2 as examples, therefore, the selected year, 1948, would be given two values: one value along dimension 1 making use of the weights for the individual layout features given for that dimension, and another value for dimension 2, given by the corresponding weights for dimension 2. This is then repeated for all data items, i.e., all years, and for all combinations of two dimensions for the purpose of producing two-dimensional 'scatter plots'. Within such plots, years that have similar scores along dimensions appear closer together, while years with dissimilar scores appear further apart.

In addition, when producing such graphs, it is possible to calculate overall 'clusters' that represent how particular selected classes of data items group together (or not). Clusters can be shown graphically as ellipses, of which there are two main kinds: confidence ellipses and prediction ellipses. A confidence ellipse refers to the mean of a set of values and the extent to which the values of the set differ from the mean; a prediction ellipse captures how likely a new sample is to fall within the space indicated by the ellipse. In the PCA graphs used in this paper we adopt confidence ellipses with a 95% confidence level, meaning that one can be 95% certain that the true mean values for the selected samples lie within the intervals indicated by the ellipses' axes. The more 'spread out' an ellipse is along any dimension, the more the underlying data samples differ from the mean. A wide ellipse along any dimension thus indicates that there is considerable variation within the selected sample.

For purposes of diachronic study, we labeled data points according to the decades within which the individual years occurred. Thus the data items for 1940–1949 were labeled additionally as belonging to the decade '1940s', and so on for all data items. We then used collections of samples for each labeled decade to calculate confidence ellipses: that is, we show, for each decade, the area within which we can be 95% certain that the mean value of pages from that decade actually lie. Figure 3 shows the results for this procedure for dimensions 1 and 2 for all data items, i.e., all years covered in the corpus, and including the confidence ellipses calculated according to labeled decades. Here it is crucial to emphasize that this decade labeling plays absolutely no role in the PCA analysis; the dimensions of the PCA were calculated solely on the feature occurrences within each data item sample, *without any explicit notion of time*. There is then no *a priori* reason to expect that clustering of the data points by decade would be regular.

In contrast to this, however, the graph does indeed reveal a strong systematicity in the development of layout style, and consequently of the page composition strategies, used over time. Data items corresponding to the 1940s are clustered second from the left in the graph with approximate central coordinates (-3, -1) with respect to dimensions 1 and 2 respectively. The 1950s then move further to the left, with slightly lower scores along both dimensions. The remaining decades then form a

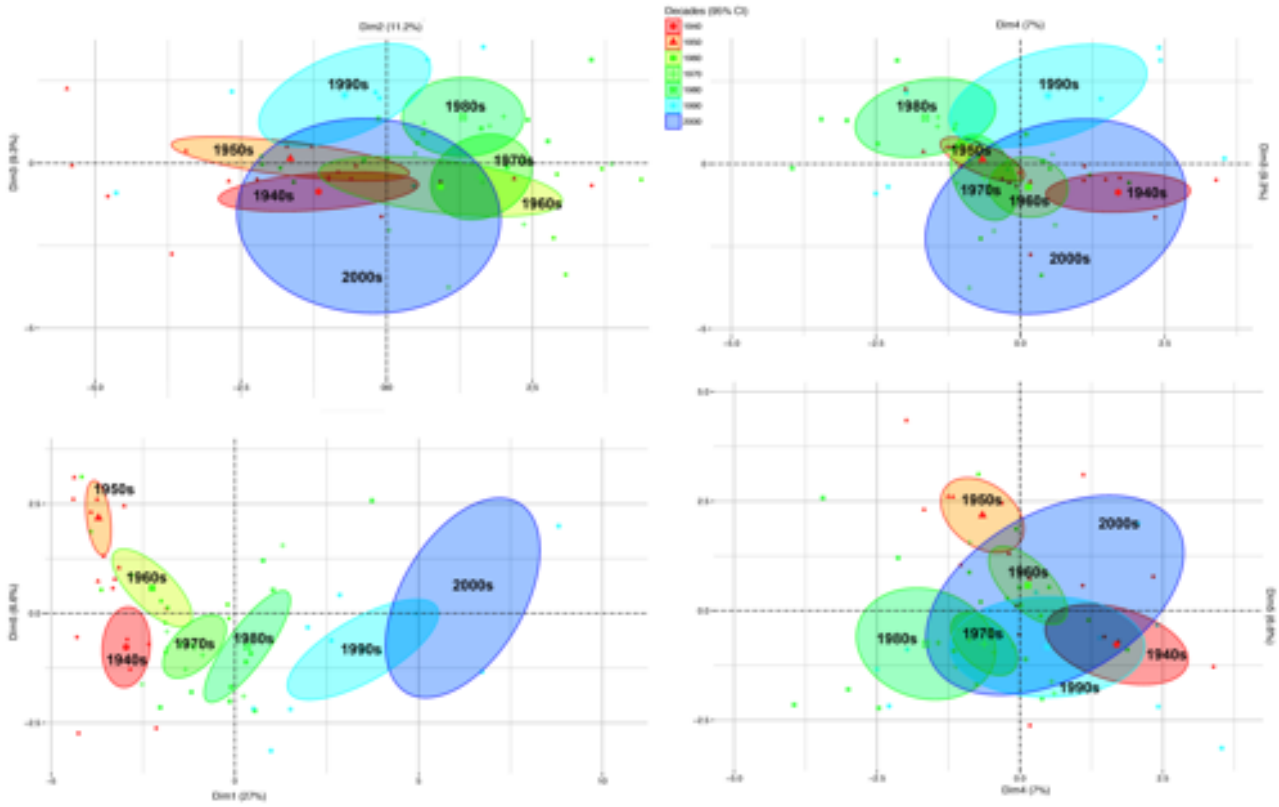


Figure 4. Pairwise PCA dimension plots for the dataset, showing clusters labeling decades with 95% confidence ellipses

trajectory moving steadily to the right, i.e., increasing in their dimension 1 values, with their dimension 2 values peaking for the 1970s and then gradually decreasing again. The more recent data items from the 2000s, appearing rightmost in the figure, also show a larger 'spread' in values than the others, indicative of more internal variation, although still relatively disjoint with their nearest neighbors from the 1990s.

Interpreting these clusters against the glosses proposed for the dimensions above then leads to the following account of the development of page design in comics over time. Both the 1940s and 1950s exhibit clear framing (low values along dimension 1) combined with a certain degree of page irregularity with respect to grid shape and sizing (low values along dimension 2). The 1960s, 1970s and 1980s then progressively increase their grid regularity (with increasing values along dimension 2) while simultaneously reducing clear framing (increasing values along dimension 1). The 1990s then show a marked decrease in grid regularity (lower values along dimension 2) combined with a further reduction in clear framing (higher values along dimension 1). This trend is continued still further in the 2000s.

Similar accounts can be given with respect to the other dimensions calculated from PCA as well, although visualizing a five dimensional space naturally presents some problems. Figure 4 consequently shows pairwise comparisons, beginning with dimensions 2 and 3 upper right and then running clockwise through the pairs 3-4, 4-5, and 1-5 respectively, maintaining one common axis for comparison across each consecutive pair. To ease comparison, the clusters here are additionally labeled with their respective decades. Given the descriptions proposed for the individual dimensions above, it is then perhaps not surprising that the plot of dimension 1 against dimension 5 (lower left) shows the cleanest separation as these are almost opposites with respect to their interpretations. All clusters apart from the 1990s and 2000s appear here as separate. Dimension 5 also places the most distance between the 1940s and the 1950s as well, with the 1940s appearing with negative values (indicating less regularity) and the 1950s with positive values (indicating high regularity).

This is particularly interesting from the perspective of discussions of the development of the art form. For example, the so-called 'Golden Age' of superhero comics (e.g., Harvey 1996: 50), typically located historically in the 1940s and early 1950s, has been described as developing from simple into "convoluted art styles" (Couch 2001: 61). However, the criteria by which 'simple' and 'complex' are distinguished are often quite heterogeneous: relatively simple narratives can readily be expressed in rather convoluted grid structures and *vice versa*. Suggestions that the grids employed in the Golden Age were simple and regular (Harvey 1996: 59) may need, therefore, to be treated with some caution. It is important to disentangle the various facets of 'complexity' more finely and on a stronger, more reliably applicable methodological basis.

Summarizing the trajectories for dimensions 3–5, we can make the following approximative generalizations. For dimension 3, the 1940s exhibit relatively weak framing with few grid-gaps and regular spacing between panels, followed by slightly stronger framing and more irregular spacing in the 1950s before the 1960s and 1970s return to the 1940 values and weak framing; the 1970s and 1980s then exhibit far stronger framing including grid-gaps, and unfilled grid partitions, and

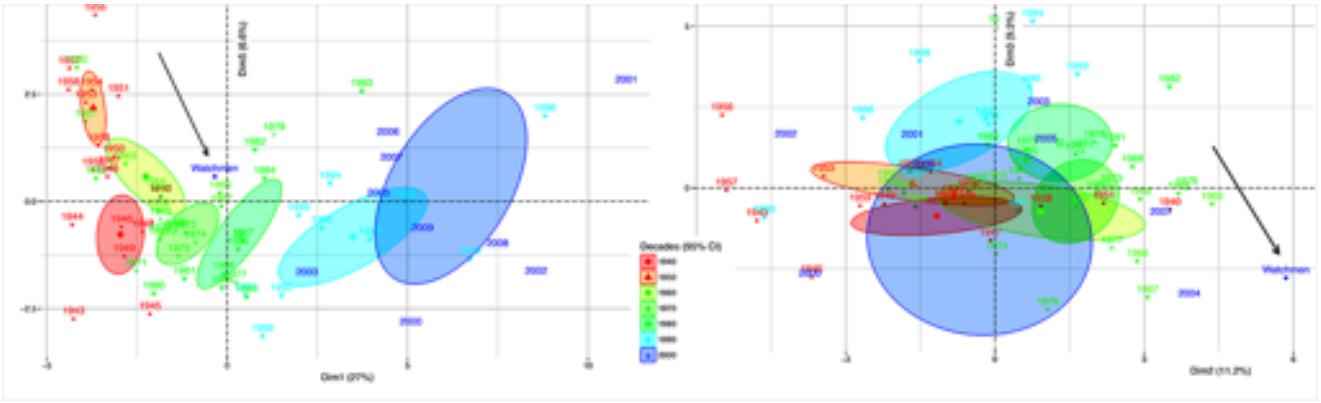


Figure 5. Comparison plots of the annotated corpus with the layout properties of *Watchmen* along the dimension pairs 1 and 5 (left), and 2 and 3 (right), added and indicated by arrows

more irregular spacing, followed again by a return to far weaker framing in the 2000s. For dimension 4, the 1940s begin with tilts and rotations, explicit and complete frames and panels varying in size and shape; this variability reduces substantially in the 1950s, 1960s and 1970s, reaching an absolute low in the 1980s; the 1990s and the 2000s then show a value similar to the 1960s with few tilts, rotations and other variations. Finally, for dimension 5, the 1940s, 1970s, 1980s and 1990s all have approximately the same low value, indicating a lack of simple table-like grids, some inset panels, and a certain amount of variation in grid shapes and sizes; the 1950s, in contrast, show a strong tendency for regular table-like grids, captions extending beyond their panels, and no inset panels; this tendency reduces in the 1960s, although remaining stronger than it becomes in the 1970s; the 2000s then range over the entire set of values exhibited by the previous decades, averaging out at a level similar to that of the 1960s.

We consider the relatively large spread exhibited by the 2000s to reflect a genuine diversification in the compositional styles of the more recent publications together with re-use of compositional strategies found in earlier decades. Another view on this is offered by using the decades as predictors for dimension values: the 2000s then offer little discrimination because they appear to draw considerably on all the strategies available. We also examined whether an increase in the 'resolution' of the data would provide a better picture of what is occurring. For this, we worked with the layout classifications of the individual pages rather than with the the data aggregated by decade. The resulting overview brings out well the extent of the variation but also fails to reveal any clear sub-groupings. To probe this further, therefore, we conducted hierarchical clustering with respect to the layout features on just the pages from the 2000s. Hierarchical clustering places together the individuals which are closest to one another on the branches of a dendrogram. Examining the top divisions produced in this manner suggested no organization in terms of dates of publication, however; further studies will be necessary here in order to find other production features that may correlate with the division.

The use of decades as a criterion for clustering is, therefore, rather arbitrary and so we might ask whether more motivated distinctions between stylistic periods could be drawn. This can be approached both from the data itself, seeking temporal intervals that may give a clearer picture, and from the actual contexts of production of the kinds of comics included in the study. By these means it might prove possible to find indications of influences of technological developments or cultural contact. Further research is clearly needed.

Visual Style Attribution

As a further indication of the possible applications of the dimensions of variation produced by analysis of the layout-annotated corpus, we consider in this section the use of the 5-dimensional space as a means of positioning page designs stylistically. Since the PCA establishes a procedure for converting a set of layout feature occurrences to positions along the five dimensions established, it is equally possible to take other, previously unseen, data items to investigate where those data items would be positioned within the overall space.

As an illustration of this method, we took a random selection of 36 pages from the main storyline of the well-known *Watchmen* graphic novel written by Alan Moore, with artist Dave Gibbons and colorist John Higgins (DC Comics, 1986-1987). These pages were first annotated with the same layout features as used above, yielding 36 feature sets. Since our 'sample rate' for the main corpus was only 18 items a year, we scaled the new sample to make it commensurate with the data items in the main corpus. This then provided as a single additional 'data item' identified not by year, as in the main corpus, but by source. It is then straightforward to calculate the coordinates of this data item along each of the five dimensions previously established on the basis of our annotated corpus as a whole and so to plot the result in a cluster graph as performed above for the data items labeled by decades.

Watchmen offers a particularly appropriate target for an exploration of this kind because its compositional style is striking in many ways and it has received much attention in the literature. These discussions offer center on the way in which the compositional choices made serve both to highlight aesthetic choices and to make references to other styles and periods of

comicbook design and range from the impressionistic to more careful engagements with the situation of production. King and Page (2017: 187), for example, suggest a deliberate orientation to the style of early superhero comics, evoking a nostalgia for the Golden Age of comics in the US; Wolk (2007: 239, 243) suggests direct influences from artists active in the 1950s and 1960s; while both Groensteen (2007 [1999]) and Baetens and Frey (2015: 103–133) reflect on how the formal choices of composition within *Watchmen* achieves a variety of extended effects for recipients. The breadth of these discussions makes it very interesting, therefore, to see where *Watchmen* falls within our calculated space of layout strategies.

Two comparison plots are shown in Figure 5, both of which identify the regions as indicated before plus an additional data point in each graph corresponding to where *Watchmen* falls in this space. The plot on the left of the figure uses the dimension pair 1 and 5 as this showed the best separation according to decades above; the plot on the right shows additional information for the dimension pair 2 and 3. Combining dimensions 1 and 5 places *Watchmen* (visible near to the center of the graph) closest to the 1970s, although in relation to dimension 5 the graphic novel overlaps more with the 1960s and the 2000s. In this sense, then, the layout might be said to achieve an aim of suggesting earlier periods of comics design. Combining dimensions 2 and 3, however, places the graphic novel at a considerable distance from the pages annotated in our corpus; in this case the graphic novel is visible to the extreme right in the graph shown in the figure. Here, only dimension 3 overlaps with the 2000s, while dimension 2 shows an exceptionally high value, indicating an extreme preponderance of simple grid-spacing and no staggering of panels, no mutual intrusions and no inset panels. In all cases, the positioning of the *Watchmen* data point well outside of the calculated confidence ellipses argues that the distribution of composition features adopted by *Watchmen* is indeed genuinely different to those pages in our corpus. The formal 'simplicity' indicated here is quite evident visually when reading the graphic novel, but our analysis shows in addition that it is still stronger by far than is the case for any of the pages in our corpus in any of the decades covered. For completeness, we can also note that along dimension 4, a dimension not shown in our graphs, *Watchmen* is placed close to the central point, thus showing again no distinctive features of tilting or of variations in grid size.

This placement of a previously unexamined set of layout decisions against the background calculated for our corpus shows how it is possible to address 'registers', or visual styles, even when these have *not* been previously observed or classified in the corpus analysis. The topological approach is thus very suitable for phenomena such as page design, where variation and creativity are assumed to be playing major roles and where it is evidently the case that there will always be further variation to address. In other words, we are by no means limited in our descriptions to pages that have already been analyzed. It is sometimes suggested that analyzing creative (and thereby relatively 'open') design in terms of pre-determined catalogs of features is inherently limited; here, however, we can see that this does not present a problem – in fact, quite the contrary is the case: the corpus analysis provides a backdrop against which creative experimentation can be brought out with particular clarity.

Functional Visual Style

In this section, we turn to our final point of discussion concerning *text-external* interpretations of the dimensions of variation revealed in the previous sections. For this, we explore to what extent we might apply our topological approach to visual style to broader, more functional communicative goals pursued within comics and graphic novels. For this, we extend the account given so far by finding *independently derived* characterizations of the variation found in the pages analyzed. More specifically, it was mentioned above how it it is commonly assumed in the comics and graphic novels literature that differences in visual design are significant for interpretations and readers' engagements with the materials so presented. However, discussions of this kind are overwhelmingly based on particular cases and interpretations offered with respect to single, non-generalized variations in page layout.

Given that we have now established a space of possibilities for characterizing page layout variation quite generally, we can ask whether it is also possible to find systematic correlations between positions in this space and other levels of descriptive abstraction. For present purposes, we focus on narratively-relevant descriptions. In this respect, our question shows analogies with Cohn's (2014a) explorative investigations of the relation between layout and Cohn's particular characterization of 'narrative'; we return to some of the differences and complementarities between our approach and Cohn's below. Cohn concludes:"These mappings between narrative and layout could be explored through corpus analyses of comic pages and experimental manipulation" (Cohn 2014a: 8). Here, we pursue only the first option, that of corpus analysis.

Several rather broad proposals for capturing narratively-relevant properties of comics have been made in the literature. However, these have rarely been claimed to relate reliably to properties of composition. Indeed, in some cases, for example, McCloud's (1994) well-known categorization of types of transitions between panels, doubt is commonly expressed as to whether they can be applied reliably at all, despite the fact that they continue to be widely used (cf. Gavaler and Beavers 2018). To explore this issue further, we selected two groups of relatively theory-independent narratively-motivated categories for closer consideration. From McCloud's categories we adopted his 'moment-to-moment', 'action-to-action', 'subject-to-subject', 'scene-to-scene', and 'aspect-to-aspect' transitions. In addition, we included the following categories motivated from functional treatments of textual organization: point-of-view (termed 'projection'), where, for example, a character reads a letter and its content is shown in the panel(s) following, and the variations 'recollecting', 'recounting', and 'recreating' (Matthiessen 2015: 9). The latter group targets diverse diegetic temporal relations between the 'current time' of the narrative and other events of relevance to the unfolding narrative: in particular, the 'recreation' of past events in a manner similar to flashbacks in film, the 'recounting' of past events, where a character narrates past experiences to other characters

in a sequence of panels, and the 'recollecting' of past events, where a character revisits past events that are presented to the reader as thoughts. Almost regardless of theoretical orientation, such distinctions commonly appear as necessary when characterizing narrative development.

We then annotated selected pages from our corpus according to these categories so as to create a set of independent descriptions of the data expressed at different levels of theoretical abstraction. Whereas the layout features described above are related solely to visual compositional properties of the pages analyzed, the 'narrative' features relate in contrast solely to interpretations of the intended narrative development carried by those pages. In order to make the application of the narrative categories more straightforward, the narrative classification of pages was kept relatively 'lightweight' : in particular, all that was decided was whether a particular page exhibited a relation of the kind indicated or not. Precise information about where in a page, which panels might be involved, etc. was not used as this could be a source of considerable uncertainty. The lightweight 'presence' or 'non-presence' of a narrative feature was considered sufficient for a highly exploratory study of the kind currently envisaged.

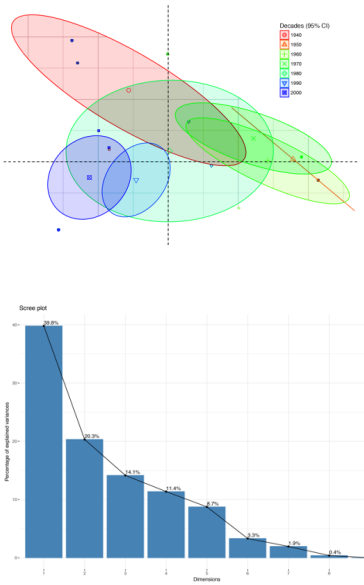
Moreover, for the superhero genre it can reasonably be hypothesized that the relations between panels on page will be dominated by simple temporal sequence. Including our full corpus for a consideration of narratively-motivated layout decisions might consequently exhibit relatively little variation, although Cohn (2018: 314) suggests that this tendency has become less in more recent US publications. To counter this possibility, we imposed several further restrictions to produce a subcorpus more likely to exhibit narrative relations beyond simple temporal sequence. First, to reduce the scale of the corpus, we took the first and last two years of each of the seven decades, i.e., 1940, 1941, 1948 and 1949, and so on until 2009, in order to produce a temporally-balanced subcorpus. Second, we selected from this subcorpus all pages which deviated in their visual composition from straightforward table, vario-table, or horizontally organized 'xy' layouts, etc. – i.e., all the pages exhibiting the layout feature 'complex-grid-spacing'. The final subset consequently spanned the full time range of the original corpus while still raising the likelihood that narratively-relevant variation in layout composition would be present. For a larger study, these restrictions should naturally be removed; but for the purposes of an initial exploration appeared adequate since we also aimed to keep the workload for narrative annotation within practicable limits.

Even with the lightweight annotation we applied, considering individual pages with respect to their 'contents' still represents a considerable investment of effort. Our more focused subcorpus was then seen as a reasonable way of (i) assessing whether more detailed and comprehensive analyses might be worthwhile, and (ii) exploring whether the general approach for relating distinct levels of descriptive abstraction that we adopt would be revealing of relationships at all. Given the relatively simple characterization of narrative configurations covered, we could also then regard any correlations found as offering a baseline against which more sophisticated narrative categorizations might be measured.

Following this selection process, our narrative subcorpus consisted of just 68 pages including contributions from all decades. The average contribution per decade was 9 pages, although the 1990s contributed twice as many as the average and the 1960s rather less than half the average. We then conducted an independent PCA analysis based solely on this narrative subcorpus, retaining 5 dimensions covering 94.3% of the variance for the purposes of the discussion below. A scatter plot of the top two dimensions showing clusters for labeled decades is shown upper left in Figure 6 together with an overview of how the dimensions calculated contributed to the coverage of the variance in the data overall; the tables on the right of the figure list the corresponding narrative feature weightings for the calculated dimensions. The cluster plot shows well that it by no means the case that straightforward progressions or trajectories of selected properties of the pages will show disjoint developments over time. We saw above that the characterizations of the top dimensions for the layout properties did spread out over time; this progression was also maintained when PCA was performed for layout on just the pages remaining in the narrative subcorpus. The narrative distinctions show no such trajectory at work. Instead it is interesting that there appears to be considerable differences in the *extensions* or 'spread' in narrative functions over time. Some are relatively restricted, as shown in the narrower confidence ellipses for the 1990s and 2000s, whereas others, such as the 1980s, show considerable internal variation. Similar results occur for the other PCA dimensions as well. Whether these patterns reoccur with larger samples will require further study.

Another perspective on the dimensions revealed by the PCA analysis can be gained by examining the relative strengths of the contributions made by the original narrative annotation features in the calculations of the principal components. This can be seen in the two contrasting plots shown in Figure 7, in which the strengths and 'directions' of narrative annotation features with respect to the derived narrative dimensions are shown. The left-hand plot shows the contributions to narrative dimensions 1 and 2; the right-hand plot shows the contributions to narrative dimensions 3 and 4. The darker and longer the respective arrows are drawn, the stronger the corresponding contribtions to the calculated principal components are. From these graphs we can see rather directly which annotation features group together with respect to a narrative dimension and which operate in different directions. For example, for dimensions 1 and 2 we can see that the annotation features 'projection', 'subject-to-subject', 'aspect-to-aspect' and 'moment-to-moment' all point in a similar direction contributing almost equally (by virtue of being at 45 degrees) to both dimensions. These contributions are, however, positive for dimension 2 (vertical) and negative for dimension 1 (horizontal). Similarly, 'recounting', 'recollecting', and 'recreating' are all aligned and contribute positively to dimension 1. In contrast, the right-hand graph calculated with respect to dimensions 3 and 4 dimension 3 pulls 'recounting' and 'recollecting' apart to be almost diametrically opposed along dimension 3. This can also be seen from the very high correlation shown for 'recollecting' within narrative dimension 3 in FIgure 6 above.

We can also superimpose the views of scatter plots shown so far clustering pages according to calculated PCA dimensions on the one hand, and the strengths and directions of contributing narrative annotation features on the other. An example



	Narrative Dimension 1	
	correlation	p value
Recreating	0.8712	0.0000
Scene-to-Scene	0.8351	0.0000
Recounting	0.6272	0.0000
Recollecting	0.4521	0.0001
Aspect-to-Aspect	-0.2934	0.0152
Projection	-0.2975	0.0137
Action-to-Action	-0.5758	0.0000

	Narrative Dimension 2	
	correlation	p value
Projection	0.7668	0.0000
Aspect-to-Aspect	0.5801	0.0000
Recreating	-0.2701	0.0259
Recounting	-0.2814	0.0201
Action-to-Action	-0.7515	0.0000

	Narrative Dimension 3	
	correlation	p value
Recollecting	0.8384	0.0000
Subject-to-Subject	0.4347	0.0002
Recounting	-0.6045	0.0000

	Narrative Dimension 4	
	correlation	p value
Subject-to-Subject	0.4812	0.0000
Recounting	0.3950	0.0009
Recreating	0.3449	0.0040
Aspect-to-Aspect	0.3269	0.0065
Scene-to-Scene	-0.4729	0.0000

	Narrative Dimension 5	
	correlation	p value
Aspect-to-Aspect	0.5434	0.0000
Projection	0.3479	0.0037
Recollecting	0.2996	0.0131
Subject-to-Subject	-0.6597	0.0000

Figure 6. Upper left: Scatter plot of the top two dimensions (horizontal: 39.8% and vertical: 20.3% of the variance in the data covered respectively) of the PCA for the narrative annotations and below this the range of variation covered in the data across the dimensions overall. Tables on the right show the respective feature weightings for the top five dimensions.

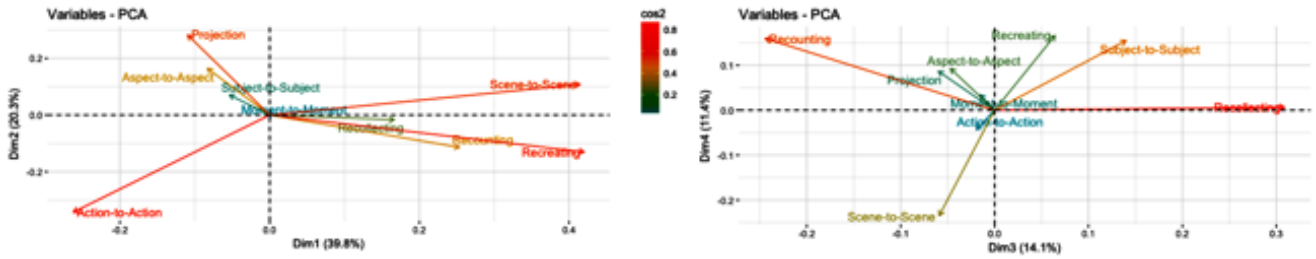


Figure 7. Strength and direction of narrative annotation features to the calculated principal components representing narrative dimensions. The left-hand plot shows narrative dimensions 1 and 2; the right-hand plot shows narrative dimensions 3 and 4.

of this kind of representation is given in Figure 8. Here the left-hand graph of Figure 7 is combined with a cluster plot showing, in this case, individual pages positioned along narrative dimensions 3 and 4. Here we adopt the higher 'resolution' of considering individual pages rather than the grouping by decade used above because this reveals some rather more fine-grained details. Space precludes further discussion here but, as an illustration, we can consider the upper right-hand corner of the figure where two pages appear as clear outliers with respect to narrative dimension 3: one from 1989 and the other from 1990, both from Superman comics.

If we ask what properties give rise to this positioning in the graph it is always possible to go back to the original pages and their coding. In fact, consulting the page from 1990 reveals a rather striking composition. The left-hand side of the page is dominated by a single large panel showing Superman looking down over the city of Metropolis; this panel bleeds 'behind' all the other panels on the page. The top quarter of the page is a single horizontal sequence of four small panels, each with their own white frames. The lower right-hand third of the page is then made up of three larger panels stacked vertically. The first of these panels has a usual thin demarcating line as frame, whereas the lower two have distinctive rectangular frames with curved corners. The transition between the first of these three vertically stacked panels and the final two is signaled textually to be a visualization of earlier events that had led to Superman's 'present' predicament. Returning to the graph, we can readily see that the strongest contribution to dimension 3 is indeed the narrative annotation feature 'recollecting'. This then gives a clear indication of compositional design choices being invoked for rather specific narrative constructions. Similar accounts can be given for most of the other pages positioned around the 'edges' of the graph. For pages more centrally placed, there are usually several contributing factors and so descriptions of what is occurring become more complex.

We now take our final step towards bringing together the account of page layout and narrative strategies by considering the narrative dataset as a whole. The two groups of PCA results we have reported so far – those for layout and those for narrative – characterize the data of the corpus at two quite distinct levels of abstraction: the former driven by the text-internal layout properties of the pages analyzed and the latter by the text-external narrative functions of panels within those pages. These levels of abstraction can therefore be considered analogously to different 'strata' within the linguistic system. To explore whether any regular relationships between these levels could be found, we examined whether values for pages on any of the narrative dimensions could be used to predict values for pages along any of the layout dimensions. This can be seen as a way

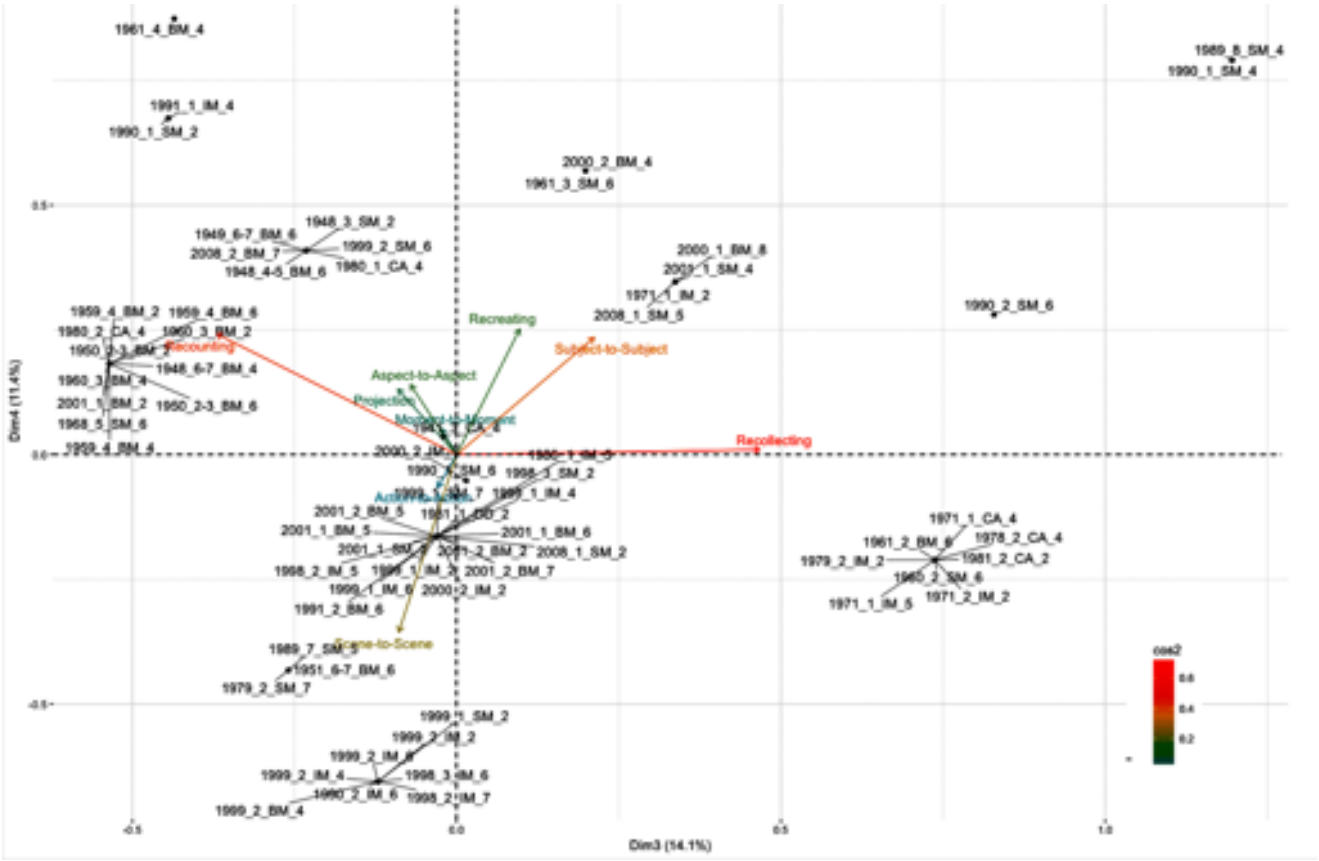


Figure 8. Combined view of pages clustered according to narrative dimensions 3 and 4 and the respective contributions of the underlying narrative annotation features

of avoiding the more impressionistic labeling of dimensions of variation found within PCA more generally and as carried out in Biber's study. To the extent that we can find correlations, we achieve a statistically motivated 'labeling' of the lower level of abstraction in terms of the higher (or, indeed, *vice versa*).

Table 6. Linear model for Layout Dimension 1

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-0.0000	0.1180	-0.0000	1.0000	
Dim.1.N	-0.7948	0.1619	-4.9098	0.0000	***
Dim.2.N	-0.3771	0.2266	-1.6643	0.1011	
Dim.3.N	0.0833	0.2715	0.3068	0.7600	
Dim.4.N	-0.9333	0.3030	-3.0804	0.0031	**
Dim.5.N	-0.5779	0.3455	-1.6725	0.0995	*

Adjusted R-squared: 0.338, F(5,62)=, $p < 0.0000$

Table 7. Linear model for Layout Dimension 4

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.0000	0.0919	0.0000	1.0000	
Dim.1.N	0.1289	0.1262	1.0218	0.3108	
Dim.2.N	-0.0835	0.1766	-0.4730	0.6378	
Dim.3.N	-0.1631	0.2116	-0.7706	0.4439	
Dim.4.N	-0.4433	0.2361	-1.8775	0.0652	.
Dim.5.N	0.9142	0.2693	3.3952	0.0012	**

Adjusted R-squared: 0.151 F(5,62)=3.38, $p = 0.0091$

For our exploration we consequently fitted linear regression models taking the narrative dimensions as independent variables (indicated by 'N' in the tables reporting results) and the layout dimensions as dependent variables. Linear models are made up of a linear sum of independent variables (in our case the values along our respective narrative dimensions) multiplied by coefficients estimated by the fitted model. The models then capture the extent to which values along any of the narrative dimensions contribute to the prediction of a value along the layout dimensions. Significant results were found for models predicting values for the layout dimensions 1 and 4 as shown in Tables 6 and 7. Layout dimension 3 also had a low significance predictor from narrative dimension 3 ($t = 2.24, p = 0.029$) but the model overall was not significant ($p = 0.149$). The coefficients of the respective models are the values given in the 'Estimate' columns of the tables. The dependent value when all the independent values are zero (i.e., where the fitted regression line crosses the respective graph axis) is given by the 'Intercept'. The probability that the variation of values for a fitted coefficient includes zero, and so does not make a contribution, is given by the values in the rightmost column of the tables.

The rows in the tables marked with asterisks therefore show the narrative dimensions that did make a statistically significant contribution to a prediction for the specified layout dimension. The values for the t-values in the column before this indicate the strength of the contribution, while the sign of this value (positive/negative) indicates the direction of that contribution. Thus, for example, narrative dimensions 1, 4, and 5 all made significant negative contributions to a model predicting values for layout dimension 1; naturally since the 'directions' of the PCA dimensions are arbitrary, the

negative/positive distinction needs to be read against the respective weights given in the individual PCA analyses. Similarly, for layout dimension 4, narrative dimension 4 again made a significant negative contribution, while narrative dimension 5 contributed in a positive direction. In short, *lower* values for narrative dimensions 1, 4 and 5 reliably predicted *higher* values for layout dimension 1, while *higher* values for layout dimension 5 predicted similarly higher values for narrative dimension 4. It is also possible to calculate the regression models in the reverse direction, i.e., using positions along the layout dimensions to predict positions along the narrative dimensions. These naturally align with the associations found above. Thus, layout dimension 1 is a highly reliable predictor for narrative dimension 1, layout dimensions 1 and 4 taken together are mildly significant predictors for narrative dimension 4, and layout dimension 4 again strongly predicts narrative dimension 5.

We can, of course, also characterize these relationships in terms of our interpretations of the calculated dimensions at both levels of abstraction directly. We described layout dimension 1 above as capturing pages associated with lack of gutters, coloring from one panel 'bleeding' behind other panels, and gaps in otherwise regular grids. We have now argued that, with respect to our data, this dimension is a strong predictor for narrative dimension 1. This dimension, as indicated in Table 6 and shown visually in FIgure 7 above, is itself strongly correlated with 'scene-to-scene', 'recreating' and 'recollecting'. We can thus hypothesize that a common layout strategy for expressing such relationships are precisely those layout properties just given. This appears plausible as all of these narrative strategies need to show closer 'connections' between events than those that typically occur with simple temporal progression. Similar conclusions can be drawn from layout dimension 4, characterized above as correlating with tilting, with variations in panel sizes and shapes, and with inset panels. This layout dimension reliably predicts narrative dimension 5, which the corresponding table in Figure 6 tells us has significant contributions from 'aspect-to-aspect' and 'projection'. Again, we can consequently hypothesize variations in shape and size and inset panels as page design strategies regularly employed within the genre of our corpus for expressing perceptual relations ('projection') and multiple views of single situations ('aspect-to-aspect'). This also offers some support for our current working hypothesis that the correlations revealed by our regression models are indeed picking out functional relations between levels of abstraction rather than simply echoing purely statistical correlations arising from the nature of PCA; further study is, however, necessary for this consideration as well.

Results of this kind are then particularly suggestive as it has been very difficult previously to systematically relate general higher-level narrative concerns to lower-level, more formal compositional strategies on anything more than a case-by-case basis. The results presented here suggest that the method we have applied may well be useful for characterizing the expressive strategies of broader sets of data. In addition, since the 'fit' of the predictive models we have described still show considerable room for improvement, they may also be evidence of the need to employ more discriminating sets of narrative categories. In order to probe these associations more closely, however, it is clear that it will be necessary to pursue a range of more extensive studies which not only involve datasets that are larger (in terms of size) and broader (in terms of genres covered, etc.), but also which draw increasingly on appropriately designed reception studies in order to evaluate the predictions made.

Discussion and Related Work

As noted above, discussions of the communicative functions of page layout within comics have primarily been restricted to accounts of specific cases, often from a literary or interpretative perspective (e.g., Postema 2013). There are also proposals within the comics research community for descriptive schemes that would allow different uses of layout to be characterized in terms of their 'effects', although such schemes have rarely engaged with empirical recipient studies. Peeters (2007 [1998]), Caldwell (2012), and Chavanne (2015) all suggest different perspectives on how to characterize page composition in comics and graphic novels but, as Groensteen (2007 [1999]: 97–99), Ahmed (2016: 19), Pederson and Cohn (2016), and others note, none of these schemes achieve the precision necessary for an application in broader corpus-based studies. There have also been useful discussions of changes in page composition over time, although again drawing more on illustrative examples (e.g., Lefèvre 2009). It has consequently only been in the detailed work of Cohn and colleagues that such studies have moved towards genuinely corpus-based work (Pederson and Cohn 2016; Cohn et al. 2017b).

To support this, Cohn and colleagues developed a new level of page description termed 'External Composition Structure' (ECS) that allows pages to be described reliably in terms of layout relationships between neighboring panels – for example, whether those panels have aligned or misaligned gutters. ECS has been used both to address empirically how variations in comics layout may correlate with particular reading path choices made by readers and to explore variations in visual page style over time. In many respects, the work reported here follows the line of development begun by Pederson and Cohn (2016) and Cohn et al. (2017b), who similarly report on studies examining corpora populated by pages from superhero comics spanning several decades. A closer comparison of the results found with respect to this corpus with our own would therefore be most worthwhile. The analyses reported here complement Cohn and colleagues' studies in several respects. First, by adopting the annotation scheme introduced in Bateman et al. (2017), we explore our corpus at the *page* level rather than in terms of more local panel organization. Second, we have pursued clustering and dimension reduction analysis both with respect to layout features and with respect to exploratory narrative characterizations of the pages. And third, we have examined whether it is possible to find methods for showing reliable and systematic correlations between these levels of description.

In terms of broader linguistic issues, we also see the approach taken here to relating distinct levels of description as a potentially useful mechanism for any semiotic system, including language. Until now, the value of topological descriptions of data items has been suggested with respect to several linguistic phenomena, including grammar, semantics, type type and registerial variations (e.g., Martin and Matthiessen 1991; Lemke 1999). Here, we have, on the one hand, argued that it is beneficial to employ notions of registerial and similarly organized diachronic variation to the visual domain and, on the other, opened up a further way of exploring relations between multiple layers of description where each layer may be characterized topologically rather than in terms of particular feature selections. This is then particularly interesting as a possible treatment of linguistic 'stratification' based on the non-directional notion of *meta-redundancy*: i.e., "two things are 'redundant' when they go together in a predictable way" (Lemke 1995: 168). The results above show that this also appears to hold between our two 'strata' of comicbook page layout and narrative functions. How this may be applied in further areas, both for visual communication and semiotic modes more generally, now awaits further research.

Conclusions and Outlook

In this article we have presented several new exploratory approaches to the empirical, corpus-based investigation of visual communication. Although all of the methods discussed may be applied to visual composition strategies in other media as well, we focused for present purposes on comics and graphic novels as these constitute an area in which page composition has been developed particularly far. Addressing how composition strategies have changed over time and investigating their potential relations to communicative functions was consequently seen as an excellent litmus test for the approach as a whole.

As a result of the study, we have been able to argue several significant points to be borne in mind when addressing visual communication empirically and to demonstrate several new methods for visual communication research.

- First, we have demonstrated that it is not only possible to determine trajectories of change with respect to layout and page composition in the pages of our corpus, but also to suggest correlations between those trajectories of change and developments in the narrative strategies employed over time. If these correlations can be shown to reoccur with broader sets of data, this would open up several new directions of research for understanding visual communication.
- Second, these results also show clearly the value of being far more focused in terms of the media-specificity of our objects of study; rather than adopting broader, and so less precise, composition categories, our adoption of a fine-grained analytic scheme developed particularly for the purposes of characterizing comicbook layouts appears to support more incisive analytic results.
- Third, we have shown how it is possible explore visual register as a functionally motivated semiotic resource in precisely the same manner as previously pursued for linguistic varieties.
- And fourth, we have illustrated how many of the basic principles and methods of corpus-based research developed in linguistics can indeed be beneficially applied in other domains, in the present case, particularly in the study of visual communication. In general, however, the same methodological approach could be explored equally for any multimodal artifacts or performances.

Clearly, to achieve more fine-grained correlations as well as more broadly applicable results, it will be necessary to conduct similar analyses with respect to more, and more varied, data. Here extensions to include genres beyond superhero comics as well as taking in comics and graphic novels from differing cultural contexts along the lines pursued in Cohn et al. (2017a) would be particularly valuable. Explicitly exploring possible correlations between the approach employed here and other detailed approaches, particularly that of Cohn and colleagues, also suggests itself as a promising and beneficial line of inquiry to be pursued in the future.

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