The changing pages of comics: Page layouts across eight decades of American superhero comics

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Abstract

Page layouts are one of the most overt features of comics' structure. We hypothesized that American superhero comics have changed in their page layout over eight decades, and investigated this using a corpus analysis of 40 comics from 1940 through 2014. On the whole, we found that comics pages decreased in their use of grid-type layouts over time, with an increase in various non-grid features. We interpret these findings as indicating that page layouts moved away from conventional grids and towards a "decorative" treatment of the page as a whole canvas. Overall, our analysis shows the benefit of empirical methods for the study of the visual language of comics.

Keywords: visual language; comics; page layout; external compositional structure; superheroes

Introduction

One of the most salient features of visual narratives in comics is the way that the elements are arranged on a page—the "external compositional structure" (ECS) of a page's layout (Cohn 2013a, b). In this sense, the composition is "external" to the panel—i.e., it plays a role in a larger structure like a page—rather than "internal" (i.e. what is inside of a panel). In American and European comics, page layouts are thought to be read in a left-to-right and down, "Z-path" order, inherited from written language, though studies have shown that various complex spatial arrangements of panels push readers to navigate pages in ways that deviate from this path (Cohn 2013a, Cohn, et al. 2015). Despite this experimental work, virtually no research has empirically examined what structures of ECS appear in actual comics. In this study, we therefore investigated these spatial arrangements of panels, and other features of ECS, in a corpus of comics. Specifically, we were interested in whether ECS has changed over time in American superhero comics from the 1940s through the present era of the 2010s.

While ECS can interact with the content of a visual narrative sequence (Cohn 2014), ultimately these are separate structures. This difference should be apparent because panels of a comic can be rearranged into several layouts without affecting the understanding of the content across sequential images, so long as the order of panels is maintained. For example, a 6-panel sequence could be arranged as 6 horizontal panels, 6 vertical panels, a 2x3 grid, or a 3x2 grid, though such changes in ECS would not necessarily change the meaning. Indeed, experimental work has shown that eye-movements to the content of panels did not differ when panels were shown in a 3 x 2 grid compared to one panel at a time (Foulsham, et al. 2016), implying that the change in layout made no impact on comprehension. Meanwhile, behavioral testing has confirmed that comic readers have explicit preferences for what order to read comic panels, even in the absence of image content (Cohn 2013a, Cohn, et al. 2015).

Nevertheless, several theorists have implied an inextricable link between ECS and meaning (Barber 2002, Caldwell 2012, Postema 2013). For example, Barber's (2002) thesis argued that panel-to-panel transitions exist not only between juxtaposed images, as in McCloud (1993), but also between all panels in a larger page layout. This idea is central to Groensteen's (2007) notion of "arthrology" whereby panels are "braided" together both linearly and across whole pages. This same notion is also echoed by Postema (2013: 29), who states that "variations in the layout will alter the signification of the images within the panels" and that "panel size…the number of panels on a page…panel border or frame used, and the shape, size, and frequency of the gutter will potentially change the meanings of the images." This idea also underlies the discussion of the tension between a "linear" reading of the panels and their holistic simultaneity in a page layout (Fresnault-Deruelle 1976, Molotiu 2012).

Other theorists have implicitly conflated meaning and layout by focusing on the function of page layout in the service of a broader narrative. Peeters (1998 [1991]) characterized layouts with no influence on meaning as either conventional (grids) or decorative (non-grids), while rhetorical and productive layouts fuse aspects of meaning to the layouts themselves. Groensteen (2007) reinterpreted Peeters' taxonomy in terms of interacting features of regular, irregular, discrete, and ostentatious dimensions, though roughly the same categories as Peeters' emerged. Such descriptions allow us to interpret the broad aesthetic traits of page layouts but do not readily allow for characterizing the component parts of layouts themselves. Indeed, focusing solely on confluences of layout with meaning does not allow properties of ECS to be described in isolation. As we will show, properties of layout alone *can* be characterized—themselves proof of their independence from meaning—and thus provide a basis for how these separate systems of layout and meaning may connect (Cohn 2014).

Page layouts can be characterized by several spatial arrangements between panels (first classified in Cohn 2013a, b). The most basic arrangement is a **grid** (Figure 1a), where panels, like text, are ordered from left-to-right and down—a *Z-path*. Grid layouts maintain contiguous borders between all panels, and can be considered the default layout of pages. Slight variations to this pattern result in **staggered** panels, either **vertically** (1b) or **horizontally** (1c). In a horizontal stagger, the horizontal borders between panels are contiguous, but the vertical borders are not. Inversely, vertical staggering maintains contiguous vertical panel borders, while the lower borders are not aligned. If a vertical stagger was pushed to an extreme, it would vertically stack panels next to a large horizontal panel whereby the bottom borders are then contiguous, which is called **blockage** (1d). Layouts can also vary the distances between panels—the "gutter." While "normal" gutters may be defined by the patterned trends of each artist, sizeable gaps between panels create **separation** (1g), while **overlap** (1h) occurs when the borders of one panel jut into the space of another.

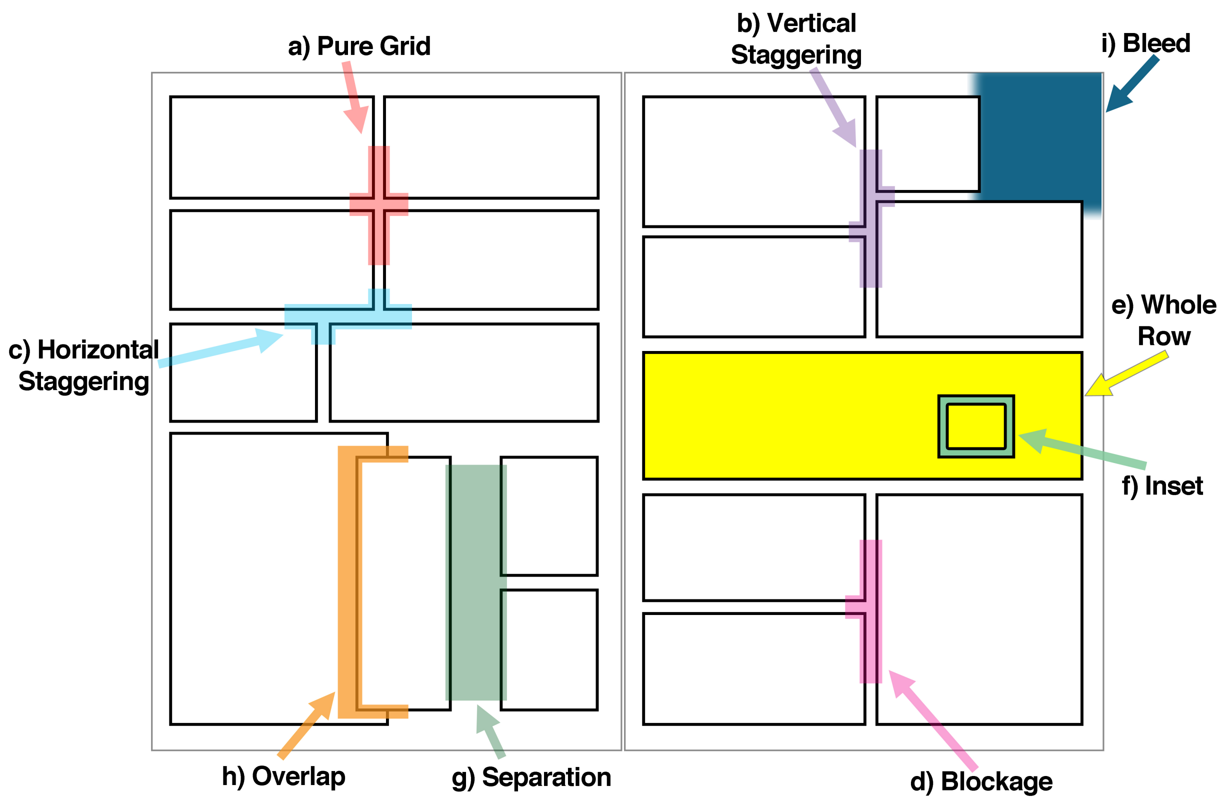

Figure 1. Schematized features of panel arrangements in page layouts.

Psychological experimentation has indicated that modulating these features of ECS can divert a reader to or from the standard Z-path, depending on the degree to which panels are staggered, separated, or overlapped (Cohn 2013a, Cohn, et al. 2015). Observation of these patterns has contributed towards a theory that rows and columns in page layouts form hierarchic structures, in which horizontal and vertical groupings embed within one another (Cohn 2013a, b). Such theories have been based on experiments that examine comic readers' preferred choices for navigating through these features of page layout (Cohn 2013a, Cohn, et al. 2015), and recent computational research has posited similar structures in the service of automatically generating page layouts and/or extracting them from a corpus of comics (Cao, et al. 2012, Tanaka, et al. 2007). This structure underlies the layouts of actual pages, in addition to the principles a reader uses to navigate them. In other words, a reader will reconstruct the overall structure in their head as they navigate through a page, just as a creator draws on this internal structure when creating a page. Thus, a page's layout is a reflection of the cognitive patterns of a creator and accessed by those of a reader.

Beyond these aspects of panel arrangements, pages have other characteristics that may or may not affect the reading order of a layout. For example, panels may take one of many shapes, the standard being rectangles, but also irregular shapes like circles, triangles, etc. In addition, panel borders may differ, such as the contrast between a standard frame with a line and the absence of a drawn border altogether, or a "***bleed***" (1i) of the content extending past the edge of the page. To date, no experimental studies have yet explored how variability across these dimensions might influence comic page understanding, nor have any previous corpus studies examined them across various books.

Given these aspects of page layouts, we asked two questions: 1) how might these features arise in page layouts of comics? and 2) has the usage of these elements changed over time? To address these questions, we coded American superhero comics from the 1940s through the present decade (2010s). American superhero comics were chosen for this study due to the longevity of this genre, which began in the late 1930s (Duncan, et al. 2015). Researchers have also intuited that this genre has changed over time with regard to various features (themes, style, production values, etc.), including layout (e.g., Duncan, et al. 2015: 119). Though prior corpus analyses have examined other aspects of the structure of the visual language used in comics (Cohn 2011, Cohn, et al. 2012, Forceville 2005, 2011), to our knowledge, no prior published works have yet explored facets of page layout. Thus, in this study we seek to both investigate our research questions as well as establish a precedent for future studies comparing within and between other genres of comics.

We coded various dimensions of ECS, including relative directionality between panels, arrangements of panels on a page (e.g., blockage, overlap, separation), properties of gutters, and shapes of panels. Overall, we predicted that ECS in American superhero comics has become more complex over time, relying less on grid-type layouts that are more imitative of text. In terms of Peeters' (1998 [1991]) classifications, we predicted that pages have become more decorative and productive over time, and less conventional.

Methods

Materials

Forty superhero comics were chosen spanning from the 1940s to the 2010s. We defined "superhero comics" as books that come from the "mainstream" genre of American comics, which feature a main or several main protagonist(s), imbued with heroic or fantastical powers that allow them to fight for justice or the good of mankind, while often concealing their own identities (Coogan 2006, Hatfield, et al. 2013). These works are also associated with their prototypical publishers, like Marvel Comics and DC Comics. Such comics are typically drawn, and printed in color, with a style that exaggerates the strength and sexuality of both the male and female forms, often in action-based sequences and dynamic settings (Duncan, et al. 2015).

All comics were chosen from the American superhero genre, and most were published by Marvel (17) and DC Comics (11). We selected five comics from each decade, from 1941 to 2014, with the intent of having one or two books from the beginning, middle, and end of each decade. Some comics from the 1940s, 1950s, and 1960s, now listed as public domain, were pulled from online archives (www.comicbookplus.com). Comics from the 1960s to 2014 were selected out of a broader research library. A full listing of works analyzed appears in the Appendix.

The comics were examined panel by panel according to the criteria listed in the Areas of Analysis. Books were analyzed in their entirety or up to the first 25 pages. Some older books included side stories unrelated to the main character of the book and were excluded from analyses. Across all forty comics, this amounted to 896 pages with 4,732 panels. All coded data is part of the Visual Language Research Corpus (VLRC), located online at http://www.visuallanguagelab.com/vlrc.

Areas of Analysis

We analyzed how each panel on a page contributed to the ECS. Panels were analyzed both for attributes they held independently (e.g., a panel's shape) and their relations with surrounding panels (e.g., the border shared between two panels). These specific aspects of ECS fell into four fields: directionality, panel arrangements, gutter space, and panel shape. We also took into account the number of pages in a book, the number of panels per book, and the number of panels per page.

Directionality

Directionality refers to the spatial relationship between panels on a page. We defined this relationship between panels by approximating the centerpoint of a panel in relation to the centerpoint of the narratively preceding panel. The vector between these points was coded in terms of one of eight directionalities (*right*, *left*, *up*, *down*, and in-between). For example, a 2 x 2 grid uses relations of right, down-left, right (as seen in Figure 1a). Because we coded directionality in terms of a panel's relationship to its prior panel, the starting panel of a page was recorded as being the *first panel*, with no directionality.

Panel arrangements

Our analysis of panel arrangements focused on the different orientations of panels on a page, the most basic and iconic of these arrangements being a ***grid-type layout***, where panels are organized into rows that are stacked vertically. This arrangement is most exemplified by the ***pure grid*** (Figure 1a), which maintains contiguity between both horizontal and vertical gutters of juxtaposed panels. Some arrangements are slight deviations from the grid pattern, like ***vertical*** (1b) and ***horizontal staggering*** (1c), where panel borders are not contiguous within an otherwise grid-like layout. More significant deviations may use ***blockage*** (1d), where one larger, longer panel is set next to smaller panels in a vertical column, suggesting a vertical reading order. Other deviations include ***whole row*** (1e) panels, where a panel extends fully from the left to the right side of a page, or a ***whole column*** panel, where a panel extends from the top to the bottom of a page. Some arrangements eschewed the grid pattern altogether, such as ***insets*** (1f), where one panel is inside of another, ***dominant*** (1e) panel.

Gutter Space

We also examined the distance between panels, i.e., the space of the "gutter." A ***normal gutter*** was considered as a standard width between two panels, which naturally grouped panels together given the idiolectical characteristics of each book (e.g., Cohn 2013a, Cohn, et al. 2015). Inversely, gutter spaces were deemed as using a ***separation*** (1g) if they extended beyond this "standard" distance. Gutter spaces were sometimes nonexistent, resulting in either a ***no gutter*** distinction, where two panels were separated by only a line drawn between them, or an ***overlap*** (1h), where one panel is placed into the space of another panel.

Panel Shapes

We also considered the shape of a panel, including more expected shapes like squares or rectangles, but also circles, triangles, irregular shapes (panels without any distinct geometric shape), and diagonals (as if diagonally spanning from opposite corners of a square). Panel borders were also considered. ***Borderless panels*** were defined as those where images had no depicted frame around them, while ***bleeding panels*** (1i) were specific panels without borders where any of the sides of the panel appeared to extend beyond the edge of the page boundary.

Data Analysis

A trained coder recorded properties panel by panel for each area of analysis described above. We then calculated the mean proportion for each area under analysis by dividing the sum instances out of the total number of panels per book. Our primary analysis focused on the longitudinal change of these features across years of publication. We therefore ran Pearson's correlations with an alpha set to .05 between these means and the original publication date for the books. We report additional correlations between analyzed features where relevant.

Results

Basic page features

Pages were found to contain an average of 5.04 panels per page per book (mean range: 3.6–7.4). However, a correlation with publication date suggested a steady decrease towards fewer panels being used per page over time, $r(38)=-.706$, $p<.001$. This declension went from an average of 6.5 panels per page in the 1940s to an average of 4.2 in the 2010s. Pages were also found to use an average of 2.67 rows, though this did not change with publication date ($p=.136$).

Directionality

We first asked whether page layouts departed from using a grid over time by analyzing the basic directionality of the position of one panel and it subsequent panel. Directions associated with the Z-path, i.e., rightward and down-left, decreased across eras (all $rs < -.727$, all $ps < .001$), while only downward directions increased over time, $r(38)=.785$, $p<.001$, as in Figure 2. Directions moving up, up-right, and down-right did not correlate with original publication date (all $ps > .115$). Leftward and up-left directions were excluded from analyses because of too few data points.

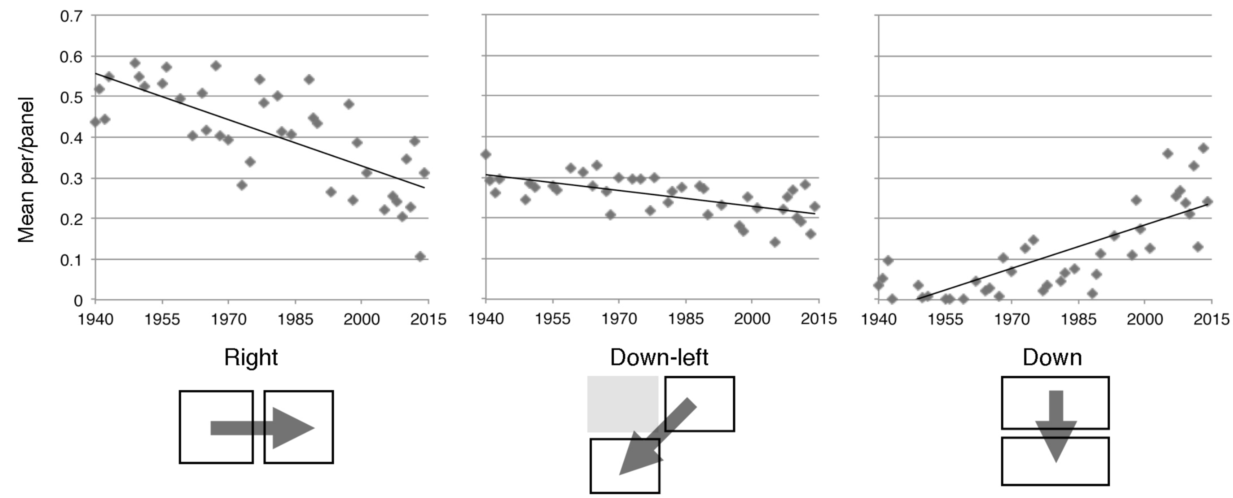

Figure 2. Significant correlations between date of publication for books and average number of rightward, down-left, and downward directions used between juxtaposed panels.

Panel arrangements

Our next question was whether the arrangement of panels deviated from that of grids, beyond just directionality. An analysis of grid-type layouts as a whole found a negative correlation with original publication date, suggesting that layouts deviated from the grid across time, r(38)=-.420, *p*<.001.

We further analyzed the traits of this overall type of layout by breaking it down into different arrangements. Pure grids with both contiguous horizontal and vertical borders showed no change over time (*p*=.211). However, positive correlations suggested a significant decrease in the use of horizontal staggers, r(38)=-.515, *p*<.001, and an increase in inset panels, r(38)=.344, p<.05. Some change was suggested of the usage of vertical stagger (p=.101), and the usage of blockage (*p*=.104), though these increases did not reach the threshold of statistical significance. In addition, we found a strong increase over time for the use of panels spanning a whole row, r(38)=.854, *p*<.001, a whole column, r(38)=.319, p<.001, or a whole page (i.e., splash pages), r(38)=.680, p<.001.

Nevertheless, collapsed across publication date, pure grids on average (M=.46, SD=.27) were used significantly more than the other variations such as horizontal (M=.29, SD=.27) or vertical staggers (M=.03, SD=.11), blockage (M=.06, SD=07), or insets (M=.012, SD=.03), all ts > 2.4, all ps < .05. Pure grids were also used more than whole rows (M=.2, SD=17), whole columns (M=.007, SD=.02), and whole splash pages (M=.02, SD=.02), all ts > 5.5, all ps < .001.

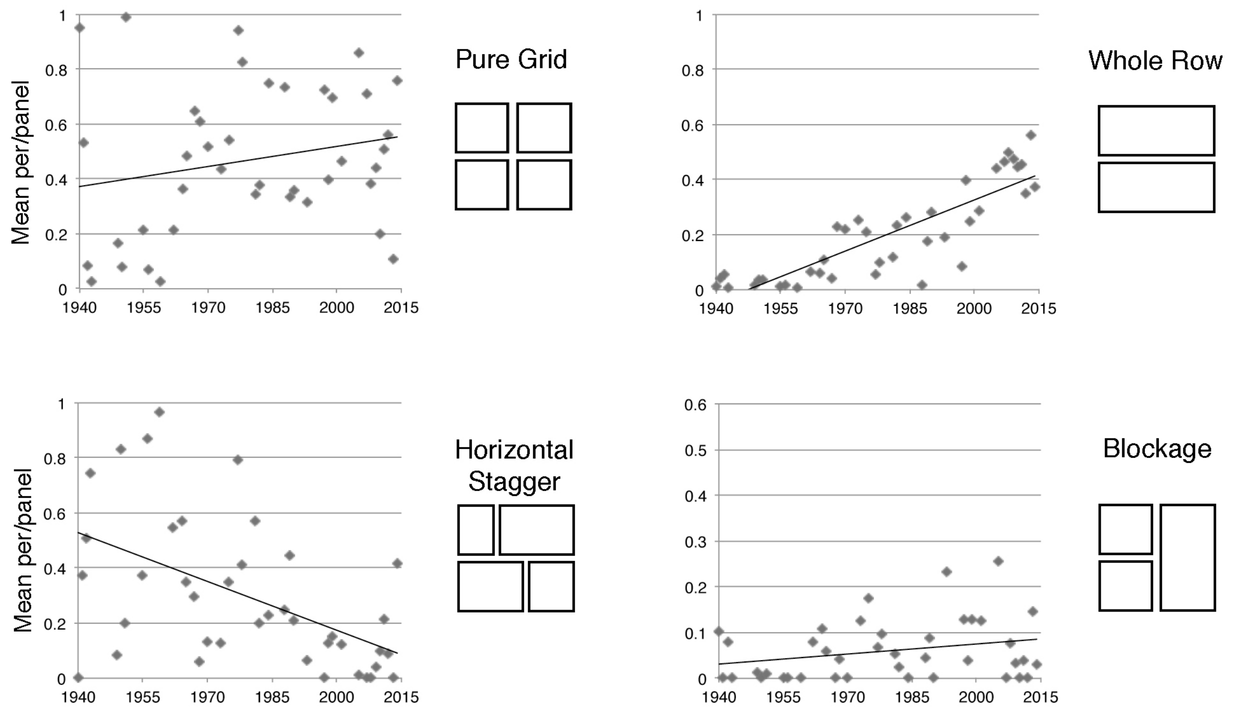

Figure 3. The usage of different types of panel arrangements over time. Pure grids showed no significant change over time, though dramatic changes were shown for horizontal staggers and whole rows spanning the length of a page. Blockage increased, though did not reach statistical significance (note difference in scale for blockage).

We also used correlations to examine the relationships between directionality and panel arrangements. Specifically, panels spanning whole rows showed a highly positive correlation with downward directions, $r(38)=.922$, $p<.001$, while negatively correlating with rightward and down-left directions (all ps < -.605, all ps < .001) characteristic of pure grids and horizontal staggers.

Whole pages

Because our analysis suggested that grids decreased across eras, with an increase in other ECS features, we considered these findings as possibly indicative of a change from more conventional to more decorative and productive layouts (e.g., Peeters 1998 [1991]). We therefore asked to what degree these changes affected the layout of *whole pages* rather than just component parts of pages. Though they remained the most used layout, whole pages using *only* grid-type layouts significantly decreased over time, $r(37)=-.446$, $p<.001$, while pages with at least one variant ECS feature (blockage, staggering, etc.) increased over time, $r(37)=.434$, $p<.01$ (Figure 4).

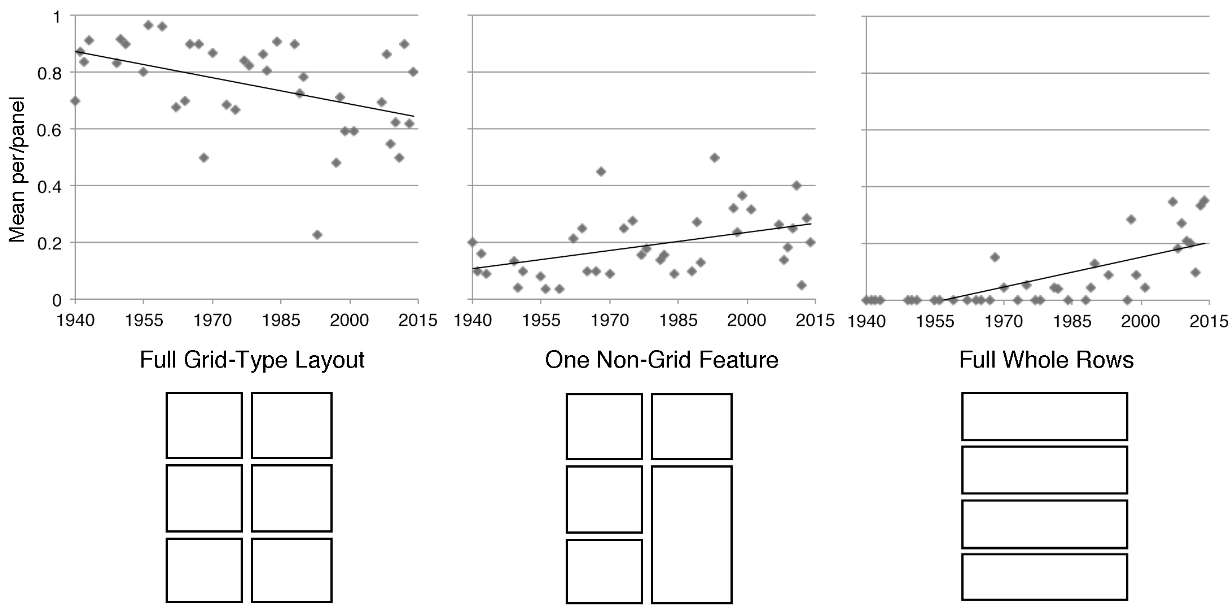

Figure 4. Changes over time for properties of whole pages: whole pages using only grid-type layouts, pages with at least one non-grid layout feature (blockage, staggering, etc.), and pages using only whole horizontal rows.

Given our finding above that whole rows increased in usage over time—which were included in grid-type layouts—we also asked about the rates of whole pages featuring only vertically stacked whole rows. These layouts also increased in usage over time, $r(37)=.736$, $p<.001$.

Gutter

We next examined variations in the spacing of the gutter between panels. Gutters perceived to have a "normal" width did not change significantly over time (p=.224), nor did the use of no gutter at all, i.e., panels completely touching each other (p=.467). However, we did find an increase in the use of panels with wide separation or panels overlapping each other (all rs > .406, all ps < .001).

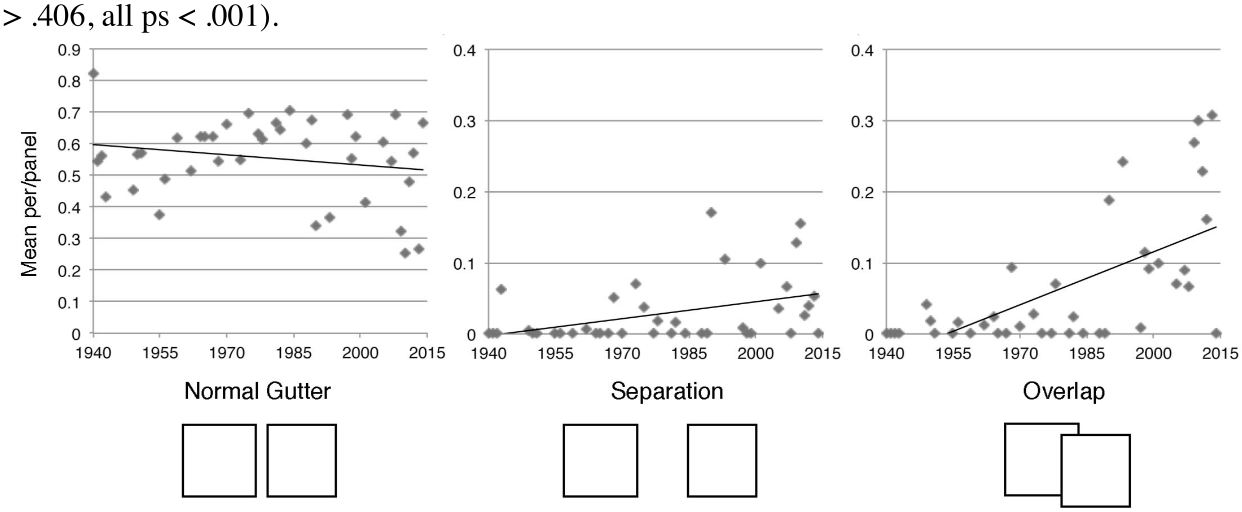

Figure 5. Change over time for distance between panels (i.e., the gutter). Normal gutters showed no significant change. Note the difference in scale between the graph for normal gutters and those for separation and overlap.

Normal gutters were positively correlated with the use of grid-type layouts, $r(38)=.638$, $p<.001$, but negatively correlated with inset panels, panels spanning whole rows, whole columns, or full splash pages, and horizontally staggered panels (all rs < -.436, all ps < .05). The opposite pattern emerged for separated or overlapping panels, which had a negative correlation with grid layouts (all rs < -.595, all ps < .001), but positive correlations with inset panels, panels spanning whole rows, whole columns, or full splash pages, and horizontally staggered panels (all rs < -.331, all ps < .05).

Panel shape

Finally, we observed several ways that the shape of panels changed from the 1940s through the 2010s. Negative correlations suggested a significant decrease in usage of circular and square shaped panels (all rs < -.339, all ps < .05), and a trending decrease in triangular panels, $r(38)=-.287$, $p=.072$. Only rectangular shaped panels appeared to increase in their usage over time, $r(38)=.529$, $p<.001$. No significant correlations occurred between publication date and quadrilateral or irregularly shaped panels (all ps > .391). The increase in usage of rectangular shaped panels is also consistent with the increase in panels spanning a whole row, and they were positively correlated, $r(38)=.437$, $p<.001$.

We also found changes in the usage of borderless and bleeding panels. Borderless panels showed a slight decrease in usage over time, $r(38)=-.373$, $p<.05$, while bleeding panels showed a strong positive correlation with publication date, $r(38)=.605$, $p<.001$, suggesting a massive increase in their usage over time, apparently starting around the 1990s (Figure 6).

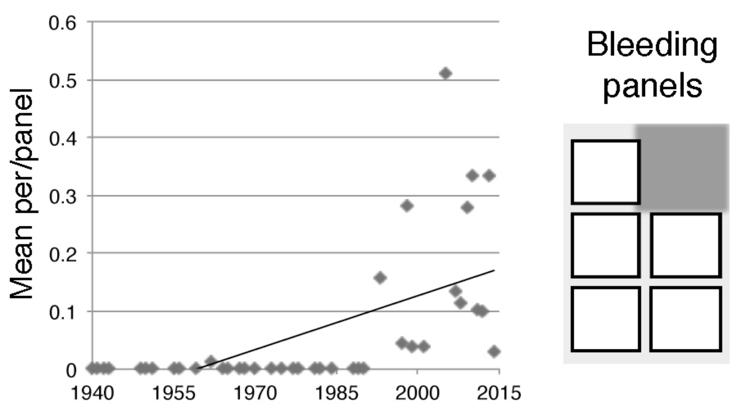

Figure 6. Use of bleeding panels—panels with no borders that extend to the edge of the page—over time.

Discussion

In this study, we analyzed the comic page layouts of American superhero comics from the 1940s through the 2010s, with the broad hypothesis that layouts have moved away from using a basic grid structure (e.g., Duncan, et al. 2015: 119). Overall, we found that many elements changed: Of the 36 ECS features statistically analyzed in our study, 64% (23/36) were found to have increased or decreased over time. The most salient changes seemed to be a shift from generally less systematic grid-type layouts (e.g., lots of staggering, diverse panel shapes) to a more systematic style that uses more variant features of layouts (e.g., several full rows, varying distances between panels, bleeds). Altogether, we interpret these findings as suggesting that layouts have indeed moved away from "conventional" grid-type layouts towards "decorative" or "productive" types of layouts (Groensteen 2007, Peeters 1998 [1991]) that treat the page as more of a "canvas" than a stream of panels (Fresnault-Deruelle 1976, Molotiu 2012).

Our first piece of evidence that layouts have changed over time is that pages have decreased in the number of panels that they contain. This indicates that comics creators are accomplishing their intended message for a page using fewer panels. This might also be a way to let panels "breathe" more on the page; rather than squeezing many smaller panels into a page, fewer panels would allow for bigger representations with more visible content. Such a shift may have been spurred by industry changes made in the 1960s, when art boards shrunk so significantly as to limit the number of panels that could comfortably fit on the page (Verano 2006: 380). We can also speculate that this might reflect a shift towards the aesthetics of the visual content and their function for conveying the story (for example, a shift away from text conveying more information); however, our data does not inform this directly.

A more salient change appeared in our observation of the directionality between panels. We found a decrease of rightward and down-left directions, which are indicative of the "left-to-right and down" Z-path order of reading panels, inherited from the order of written text. The decrease in both of these directions suggests deviation from this Z-path in favor of other page layouts. Support for this interpretation also comes from the decrease in usage of grid-type layouts over time, as these layouts commonly employ the Z-path. Grid-type layouts involve rows of panels stacked one on top of the other, usually surfacing as horizontal staggering, which showed a dramatic decrease in usage over time, and pure grids, which remained constant. Together, these findings about panel directionality and arrangements suggest that the use of grid layouts using a Z-path has decreased over time.

In place of grids, we found an increase in the occurrence of ECS features per page, which included blockage, vertical and horizontal staggering, and inset panels. In particular, we found a moderate, but ultimately not statistically significant, increase in the use of vertical stagger and blockage, and a significant increase in the use of inset panels. We also found an increase in the use of whole rows, whole columns, and splash pages. These latter findings also connect to our findings of fewer panels per page: Panels that span across the page horizontally or vertically will naturally take up more space.

In addition to single panel occurrences within pages, we also found a significant increase in pages made of *only* whole row panels. This appeared to start in the 1990s, and became most prevalent in the 2000-2010s. This usage of whole pages consisting of wide rectangular panels aligns with the observation of a movement towards "widescreen" panels in American superhero comics starting in the late 1990s (Mazur, et al. 2014). Indeed, while panels spanning a whole row steadily increased through all eight decades, whole pages using only these types of panels clearly showed a jump in the 1990s. In more contemporary comics, wide vertical panels also facilitate technological shifts for reading comics on digital devices. Downward scrolling or swiping through vertically stacked panels that conform to the size of a screen would be easier than navigating through a complex page layout. While this layout has been employed before the advent of reading comics on digital devices, such technology could only serve to encourage its proliferation.

More subtle aspects of page layouts appeared in our results related to gutters. While the use of normal gutters and no gutters remained constant over time, we observed an increase in separation and overlap, seemingly starting around the late 1980s. This speaks to our conclusion that pages have become more decorative, as these gutters would allow for more creative panel arrangements. This change would also impact the Z-path, as separating and overlapping gutters could potentially eschew canonical page navigation, as suggested by experimental studies showing that these factors can alter the Z-path (Cohn 2013a, Cohn, et al. 2015).

Finally, we also looked at panel shapes that were used in comics over time. Square panels significantly decreased over time, and irregular panel shapes decreased, though not significantly. Rectangular panels increased, again consistent with the findings supporting greater usage of "widescreen" panels spanning a whole row.

Perhaps our most noteworthy finding related to panel shape was that of bleeding panels, which extend without a border to the edge of the page. Bleeds increased dramatically, especially in the last few decades. We also observed that in older comics, oddly shaped panels were more prevalent, perhaps to break up the monotony of the grid-type layouts (e.g. angled borders with no functional purpose). Over time, this trend disappeared or was possibly replaced by bleeding panel borders, which seemed to assume the role that oddly shaped panels once held in allowing the page to breathe. Such change could also relate to the overall reduction in panels per page over time by bringing focus to the content of panels, as discussed above. The increase in bleeds may also be connected with an advance in printing technology seen in the 1980s, which allowed for panels to be printed beyond the page boundaries rather than being constrained to an "active" print area within the given margins of a page (Verano 2006).

Overall, we take these findings to suggest that layouts and their structures have become more systematic in American superhero comics, while at the same time being more decorative. In earlier years, grid-type layouts appeared more often, but were punctuated by unusual features. This reliance on the grid could possibly be due to artists assuming the need for a Z-path because readers may not have known where to go, or because the popularity of comic strips in the early history of superhero comics lead comic artists to default to a more recognized layout, i.e. square panels lined up one after the other. The appearance of more variant features is thus a reflection of a generally less systematized structure of layouts. In later years, authors could assume that rules of navigation were systematic and implicit, as shown by the consistent preferences for reading order of panels shown in experimental findings, even in the absence of content (Cohn 2013a, Cohn, et al. 2015). The implicit knowledge that readers (and artists) grew to have particular rules of navigating pages then allowed artists to explore decorative features that were also more systematic—less irregular—at the same time. These findings may also suggest that artists are treating the page as a canvas, while at the same time being cognizant of a reader's need to move through the page in an intuitive way that obeys their principles of navigation. Lastly, such changes may be connected to the development of advanced printing technology, which could allow for more variability in page layout (e.g., bleeds).

These findings may suggest that the notions of "conventional" and "decorative" types of layouts may be more complex than the theories have set them up, and may possibly be graded. As discussed above, we interpret our data as suggesting that pages have become more decorative while at the same time have become more systematic in their features over time. This may warrant a reconsideration of these top-down categories, in Peeters (1998 [1991]) as a gradient, or in Groensteen (2007) as a graded quadrant space. However, it is unclear how one might fully quantify pages as decorative or rhetorical, (ir)regular, discrete, or ostentatious. Perhaps these notions could be characterized by variant ECS features (bleeds, overlap, etc.) and/or by relations to content, similar to how conventional layouts could be characterized by grid-type layouts? How these descriptive categories might be quantified in a way that can fuse with empirical approaches, like ours, could be a fruitful challenge for future theorizing.

Overall, our study found several changes across the external compositional structure in superhero comics from the United States over time. In that "visual language theory" has outlined that comics are written in visual languages of graphics combined with verbal languages of text (Cohn 2013b), it is worth remembering that *all* languages change over time. Page layout may simply be one element within the visual language used in comics that has the potential for change. It is noteworthy that most of these changes seemed gradual over time, suggesting that each generation was building on the prior generation's established conventions (or deviations from conventions). In only a few cases, we found rapid changes begin at a particular time (mostly starting in the late 1980s). Such examples perhaps marked more of a conscious attempt to deviate from predecessors rather than the successive development of a system. In addition (or alternatively), such examples may also reflect the influence of another visual language—such as via the influx of Japanese manga into the United States during the 1980s and 1990s (Goldberg 2010, McCloud 1996), though additional coding of manga would be required to substantiate such a relationship. However, these sudden changes then appeared to become growing trends of their own, as they consistently increased in usage (e.g. "widescreen" panels). Language change will, inevitably, keep what is most useful and shed what might be extraneous. In the case of ECS—at least in this visual language—though features may persist that were salient when they first emerged, the evolving system retains features conducive to the key aspects of layout and, likely, conveying the narrative content.

It is worth considering the implications on such change related to cognition, given that this "system" of page layout emerge from artists' minds and are comprehended by those of readers. Thus, in order to adapt to changes in layout over time, the structures in readers' minds must likewise change. In this case, grid-type layouts as a whole decreased, but the changes that we observed did not necessarily challenge the standard Z-path reading order except perhaps the potential for variation in separation and overlapping panels, and a trending, though non-significant, increase in blockage. Thus, these changes remain in concert with the basic preferences of a Z-path system for standard grids (such as downward directionality for whole rows), and would not radically alter readers' assumptions about reading order. Nevertheless, if a system becomes more decorative, readers must adapt to those changes. Such is the case even in examples of separation or overlap, which may force the reader out of their typical navigation through the page. Indeed, though American superhero comics have largely retained layouts supporting the Z-path, readers are still systematic in their treatment of various *non*-Z-path arrangements (Cohn 2013a, Cohn, et al. 2015).

Note also that this orientation helps explain why some readers may feel strongly about certain features of page layouts. Readers may be habituated towards the patterns from the time period when they began reading or most read comics (i.e., when their cognitive patterns were established). As layouts change, deviations from their familiar structures may be looked upon judgmentally. However, contrary to the idea that certain artists—or artists from a particular era—may be "less talented" or somehow "deficient" in visual storytelling, such changes are simply part of the natural progression of the visual language. Similar statements could apply to cross-cultural differences in layouts (or any other structures in these visual languages): deviations are not deficiencies, but such judgments reflect readers' reactions to differences in light of their own habituated patterns.

Along these lines, we believe that this empirical approach to layouts can ground expectations for the principles various readers carry about navigating page layouts. Indeed, our approach to layouts could also be applied to visual languages found in other comics, both from other countries (manga, manhwa, bande dessinée, etc.) and other genres within the United States (indie and underground comics, kids' comics, etc.). If corpus analyses show differences in the patterns of page layouts between these types of comics, we may expect that readers of those works would have different preferences for navigating comic pages as a whole. For example, a fairly recognizable surface difference is that comics from the United States and Europe are typically ordered left-to-right, while Japanese manga are ordered right-to-left, and indeed these typological differences have informed variations in readers' navigational orders (Cohn 2013a). Whether corpus studies can inform preferences of more complex variations in external compositional structure is an open question.

We would also hope that our approach could connect these ECS structures to other aspects of panel content that can be measured empirically (Cohn, 2011; Cohn et al., 2012; Forceville, 2005, 2011), especially their narrative and semantic structures (Cohn, 2014). Such work could aid in better understanding how page layouts interact with the content of panels, as has been speculated on in prior work (Groensteen 2007, Peeters 1998 [1991]).

Altogether, our study provides an initial foray into the empirical investigation of page layouts in comics. Such work therefore reinforces the usefulness of empirical evidence for substantiating theoretical claims about structure in comics more generally. These methods allow us to directly measure the validity of various claims, and also to make observations that may not be overtly apparent. We hope that such work reflects a growing movement of using scientific methods to study the visual languages used in comics.

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Appendix: Works Analyzed

The following books were used in the corpus analysis. Because this study examined properties of these works over time, they are listed chronologically by publication date.

1. Berold, B. and Eisner, W. (1940). *The Flame*. 3: 1-20. Fox Comics.
2. Kirby, J. and Wellman, M. W. (1941). *Captain Marvel Adventures*. 1: 1-31. Fawcett Comics.
3. Binder, J. (1942). *Captain Midnight*. 1: 1-34. Fawcett Comics.
4. Vagoda, B. and Weisbecker, C. (1943). *Black Hood*. 9: 1-23. MLJ Magazine
5. Nordling, K. (1949). *Lady Luck*. 86: 1-32. Quality Comics.
6. Quackenbush, B and Eisner, W. (1950). *Doll Man*. 30: 1-32.Comic Favorites, Inc.
7. Anderson, M and Siegel, J. (1951). *Lars of Mars*. 11: 1-16 & 28-31. Approved Comics.
8. Ferstadt, L, Fago, A., & Fox, V. (1955). *Blue Beetle*. 18: 1-25. Charlton Comics.
9. Cole, J. and Woolfolk, B. (1956). *Plastic Man*. 64: 1-31. Comic Magazines.

10. Plastino, A. and Bernstein, R. (1959). *Action Comics*. 252: 1-27. DC Comics.
11. Springer, F. and Kastle, H. (1962). *Brain Boy*. 2: 1-28. Dell Comics/Western Publishing.
12. Wood, W. and Lee, S. (1964). *Daredevil*. 5: 1-20. Marvel Comics.
13. Ditko, S. and Gill, J. (1965). *Captain Atom*. 78: 1-20. Charlton Comics.
14. Ditko, S. and Glanzman, D.C. (1967). *The Blue Beetle*. 3: 1-20. Charlton Comics.
15. Steranko, J. (1968). *Nick Fury Agent of S.H.I.E.L.D*. 1: 1-20. Marvel Comics.
16. Adams, N. and O'Neil, D. (1970). *Green Lantern*. 76: 1-23. DC Comics.
17. Novick, I. and Bates, C. (1973). *The Flash*. 211: 1-16. DC Comics.
18. Dillion, D. and Pasko, M. (1975). *Justice League of America*. 122: 1-18. DC Comics.
19. Tuska, G. and Mantlo, B. (1977). *The Invincible Iron Man*. 100: 1-19. Marvel Comics.
20. Rogers, M. and Englehart, S. (1978). *Detective Comics*. 475: 1-17. DC Comics.
21. Colan, G. and Mantlo, B. (1981). *The Avengers*. 210: 1-22. Marvel Comics.
22. Colan, G. and Thomas, R. (1982). *Wonder Woman*. 289: 1-26. DC Comics.
23. Byrne, J. (1984). *Fantastic Four*. 269: 1-22. DC Comics.
24. Bolland, B. and Moore, A. (1988). *Batman: The Killing Joke*. 1: 1-20. DC Comics.
25. Dwyer, K. and Gruenwald, M. (1989). *Captain America*. 358: 1-22. Marvel Comics.
26. McFarlane, T. and Michelinie, D. (1990). *The Amazing Spider-Man*. 328: 1-23. Marvel Comics.
27. Lyle, T. and Potts, C. (1993). *Venom: Funeral Pyre*. 2: 1-22. Marvel Comics.
28. Kubert, A. and David, P. (1997). *The Incredible Hulk*. 454: 1-25. Marvel Comics.
29. Yu, L. F. and Ellis, W. (1998). *Wolverine*. 121: 1-21. Marvel Comics.
30. Quesada, J. and Smith, K. (1999). *Daredevil*. 8: 1-22. Marvel Comics.
31. Dillon, S. and Ennis, G. (2001). *The Punisher*. 6: 1-22. Marvel Comics.
32. Sciver, E. V. and Johns, G. (2005). *Green Lantern: Rebirth*. 5: 1-21. DC Comics.
33. Garney, R. and Straczynski, J. M. (2007). *Amazing Spider-Man*. 539: 1-23. Marvel Comics.
34. Romita Jr., J. and Hudlin, R. (2008). *Black Panther*. 35: 1-22. Marvel Comics.
35. Medina, P. and Way, D. (2009). *Deadpool*. 11: 1-22. Marvel Comics.
36. Gleason, P. and Tomasi, P. (2010). *Green Lantern Corps*. 42: 1-24. DC Comics.
37. Finch, D. and Jenkins, P. (2011). *Batman The Dark Knight*. 2: 1-20. DC Comics.
38. Pacheco, C., Diaz, P., and Gillen, K. (2012). *Uncanny X-men*. 10: 1-20. Marvel Comics.
39. Guedes, R., Fawkes, R. & Lemire, J. (2013). *Constantine*. 1: 1-21. DC Comics.
40. Gerads, M. and Edmondson, N. (2014). *The Punisher*. 5: 1-20. Marvel Comics.

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