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A quantitative study of non-linearity in storytelling

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ABSTRACT

In this paper, we present a study of non-linearity in storytelling in a collection of 2,348 books published since 2001 that are divided among 10 different categories. We employ word embeddings to capture the semantic non-linearity of a book, along with three associated measures called speed, volume, and distance. We find that narrative non-linearity is strongly associated with the communication of non-instrumental (imaginary) information, but only very weakly negatively associated with a book's success. When we decompose non-linearity, we observe that reader preferences for books favor greater narrative distance with lower speed, i.e. books that take readers further but do so more parsimoniously are more successful. Our work aims to contribute to a growing body of studies that use computational methods to better understand human narrative behavior.

1. Introduction

There are many ways that we may not tell a story in a strictly linear way. We may jump from one person's perspective to another (focalization); we may jump from one place to another (setting); or we may jump from one time frame to another (anachrony), moving either forward (prolepsis) or backward (analepsis). In each of these cases, instead of moving to the next logical step in a sequence, our attention is focused on a different, non-linear direction: sideways, backwards, or elsewhere. Narrative theory refers to this discrepancy – the discrepancy between the ordering of the events in the storyworld and the way they are recounted – as the difference between "story" and "discourse" (Bal & Van Boheemen, 2009; Brewer & Lichtenstein, 1981, 1982; Tomashevsky, 1965). Human beings have a remarkable capacity not only to narrate events, to explain through language "what happened," but also to manipulate the sequencing or connectedness of those events in their telling.

The presence of non-linearity within human storytelling is near universal. We can find examples of it in all cultures and time periods. Indeed, it would be challenging to find a narrative work of substantial length in any medium that did not at some point employ at least one of the practices described above to some degree. While narrative non-linearity is often implicitly associated with the category of time (Genette, 1983), this need not be the case. Non-linearity can encompass a range of narrative practices that interrupt the sequential flow of events. This may entail a movement in time, either forward or backward, but it also may entail a movement in space (from one setting to another), perspective (from one character's telling to another), or diegetic level (as when a story is included inside of another story (cf. *1001 Nights*)). In each of these cases, readers do not move straightforwardly through narrative events but non-linearly through a more complex telling of those events.

The widespread presence of non-linearity in human storytelling thus raises the question of its cognitive and social value. Why

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would a narrator depart from the most linear, sequential and efficient means possible to convey information to a recipient? Under what conditions are storytellers more likely to depart from this sequentialist assumption? And are there optimal levels of non-sequentiality that align most successfully with particular audience expectations? Given that there are obvious costs imposed on audiences when stories are told out of order, it is important to understand when, where, and to what extent these tactics are employed and to what effect. Why do people indulge in such communicative inefficiency and what is gained by it?

A sizable body of research using laboratory studies has produced insights into the different cognitive states associated with non-linear storytelling (Brewer & Lichtenstein, 1981, 1982; Hoeken and van Vliet, 2000; Knobloch et al., 2004; Bermejo-Berros et al., 2022). However, only two works to date (Sobchuk & Tinits, 2020; Toubia et al., 2021) have studied this practice using quantitative measures outside the laboratory among existing cultural products. This work represents an important precedent as part of a research program that attempts to complement laboratory-based work with large-scale studies of cultural behavior (Mesoudi et al., 2006; Dubourg & Baumard, 2021). By being able to capture the audiences, contexts, and informational goals associated with existing narrative practices, we can potentially learn more about the role that non-linearity plays in human communication and cognition.

In this paper, we present a study of the non-linearity of narrative using the CONLIT dataset (Piper, 2022), a collection of 2348 books published between 2001 and 2021 that are divided among 10 categories, including age-level, cultural capital (prize-winners/bestsellers), thematic association (memoir, science fiction, etc.), and instrumentality (fiction/non-fiction). We utilize a measure called *circuitousness*, introduced by Toubia et al. (2021), which employs machine learning and natural language processing to capture the semantic linearity of a book, along with three associated measures called *speed, volume*, and *distance*. In addition to these primary dependent variables, we observe their association with measures of success, audience type, and the instrumentality of the information being conveyed (whether the story is true or fabulated). Utilizing the methods of Toubia et al. (2021), our work extends their findings in three significant ways: we focus on an additional, culturally significant medium (books rather than movies, TV shows, and academic papers); further validate the connection between circuitousness and narrative non-linearity; and thirdly, we highlight the linkage between non-linearity and instrumentality while controlling for narrative communication. While Toubia et al. (2021) show a meaningful difference with respect to circuitousness between academic writing and televisual scripts, the divide may have been due to the stronger narrativity of the visual media explored rather than the instrumentality of the information. Here we show how even when controlling for narrativity, fictional storytelling engages in far higher levels of non-linearity as captured by our measures.

Our work contributes to a growing body of computational studies of culture to better understand human narrative behavior. We provide the first-ever estimates of non-linear storytelling in a large and diverse sample of contemporary books. Doing so we find support for the hedonic basis of non-linear storytelling, i.e., that non-linearity is strongly associated with the communication of non-instrumental (imaginary) information. At the same time, while we observe a slight negative association between non-linearity and reader enjoyment (contrary to prior research), these results are statistically weak and thus leave open the question of this relationship for future work. Even though levels of non-linearity are strongly predictive of a book's instrumentality, they do not appear to reliably predict its success. However, we do find that when we decompose non-linearity into the relationship between narrative speed and narrative distance, i.e., how far a narrative travels versus how fast it travels that distance, we can observe reader preferences for greater narrative distance with lower narrative speed and not the other way around. These findings provide important insights both for authors and publishers seeking to maximize their success as well for building further understanding of human preferences with respect to narrative form.

1.1. Prior work

Prior research on the psychological effects of non-linear storytelling is largely informed by the idea of "structural affect theory" first developed by Brewer and Lichtenstein (1981,1982). Structural affect theory suggests that discourse structure – the ordering and omission of events in a narrative – will be associated with different affective responses. Brewer and Lichtenstein (1981, 1982) posit three primary reader response states associated with a text's (non)linearity, which they label "suspense," "curiosity," and "surprise," further theoretically developed by Sternberg (1990). Knobloch et al. (2004) have confirmed that different discourse structures induce their predicted affective states (e.g., non-linear stories cause readers to express higher levels of curiosity) independent of the instrumentality of the information communicated (i.e., fact or fiction). Bermejo-Berros et al. (2022) also confirm the association between discourse structure and affective state and additionally identify more granular cognitive states associated with the different discourse structures, where for example, experiences of "retrospection" and "diagnosis" are associated with non-linear storytelling. Thus we see fairly consistent results when measuring the association between modulations in discourse structure and affective states of readers.

In addition to the study of affective states, Brewer and Lichtenstein (1982) have also shown that for non-fictional texts narrative comprehension declines with increased non-linearity. Modulating the order of events in fact-based communication makes recall more challenging. When it comes to measures of reader enjoyment, prior research suggests that enjoyment, at least with respect to fictional texts, is independent of narrative linearity (Hoeken and van Vliet, 2000). However, more recent research has suggested that one can observe a positive association between non-linearity and audience enjoyment with respect to film in a laboratory setting (Bermejo--Berros et al., 2022). While modulating the order of events makes recall more challenging, it may also create an "information gap" that heightens audience curiosity and thus attention and interest (Loewenstein, 1994; Kidd & Hayden, 2015).

A growing body of research in the field of natural language processing and computational narrative understanding (Clark, Brahman & Iyyer, 2022) has focused on the task of computationally modeling discourse structure towards the large-scale study of cultural behavior (known as "cultural analytics"). Reagan et al. (2016) and Jockers (2017) were the first to model "plot arcs" as theorized by Freytag (1895), using sentiment detection as a proxy for narrative fortune in a collection of 1300 stories from Project Gutenberg. Schmidt (2015) modeled narrative sequence as changes in topic distributions in a collection of 80,000 television episodes. Other work

has attempted to model narrative sequence through "scene" changes (Zehe et al., 2021) as well as narrative "levels," i.e., when stories are imbedded inside of other stories (Gius et al., 2019). Ouyang and McKeown (2015) and Piper (2015) have modeled narrative "turning points," i.e. the idea that narratives are defined by a sense of transformation, change of state or temporal "breach" (Bruner, 1991) in collections of online stories (Reddit) and canonical novels respectively.

In addition to Toubia et al. (2021) to date only one other work has studied the practice of non-linear storytelling among real-world cultural outputs using quantitative methods. Sobchuk and Tinits (2020) observe the practice of temporally non-linear narratives in eighty popular Hollywood mystery films produced between 1970 and 2009, where popularity is measured by average IMDb ratings and non-linearity as the number of flashback or flashforward scenes per hour (i.e., "anachrony"), which were hand-annotated. They find that the overall average rate of anachrony has increased over time, driven most prominently by a small group of outliers, though mean increases can be observed for multiple quantiles. The authors suggest this may be an indication of cultural attraction theory, which argues that cultural behavior converges on universal human cognitive preferences, in this case experiences of non-linear storytelling. Given that their data was selected to only include popular films, they do not discuss the association between non-linearity and success, only that it increases in some films over time.

Central to all of this work is an understanding of the concept of narrative non-linearity. Building on the foundational theoretical distinction between story and discourse (Tomashevsky, 1965), recent work on "sequentiality" in narrative theory (Baroni & Revaz, 2016) has attempted to expand our understanding of discourse structure to extend beyond notions of time and chronology to encompass other facets of representation. Building on this prior work, we define narrative non-linearity here as the *non-sequentiality of one or more foundational narrative elements, which can include features of setting, time, events or perspective*. We explicitly do not limit our definition of non-linearity to temporal sequencing (i.e. anachrony). Rather, we include multiple ways in which a narrative may not move forward to the next logical event in a sequence but instead move orthogonally to another narrative frame.

If we think of "story" as a pathway through a series of events, there are multiple ways that the narrative "discourse" may diverge at a given point from the expected next event in that sequence, whether it means moving adjacently to another character's perspective of the same events, another setting that is unconnected to the current one, or a different timeframe where characters and events are continuous but time is disjointed. In our framework, time is thus a subset of a larger range of non-sequential narrative practices, which, it is important to note, may overlap (change of perspective may also imply change of time). Additionally, our definition does not focus on a single turning point or narrative pivot as in prior computational work, but allows for an understanding of non-linearity to be enacted at multiple moments throughout a narrative according to different degrees of non-sequentiality. In other words, non-linearity for our purposes is not a binary category, but can be understood as one of degree (more/less). Books can engage in greater or lesser degrees of non-linearity depending on how frequently the discourse structure is modulated.

Given this definition of narrative non-linearity and the findings of prior research, we organize our inquiry according to three overarching hypotheses, which we label as follows:

H1. *The non-instrumentality hypothesis*. We expect to see levels of non-linearity negatively associated with a narrative's instrumentality, i.e., its intended truth content. Given prior research suggesting that non-linearity is associated with lower levels of reader comprehension (Brewer & Lichtenstein, 1982), we expect that when the primary goal of a story is to inform readers of real-world information we should observe lower levels of non-linearity. On a secondary level, we expect non-linearity to be associated with a book's genre or category, though less strongly than with instrumentality. Given prior research on the power of genre to impact style, we expect that authorial aims of aligning a book with a given genre will affect the level of non-linearity. Finally, given non-linearity is associated with more challenging comprehension on the part of readers we should observe lower levels of non-linearity in books targeting younger readers, even for fiction.

H2. *The success independence hypothesis*. Given that prior work on reading fiction has shown no relationship between non-linearity and audience enjoyment (though this has been shown for film), we expect to see no association between measures of success and levels of non-linearity in our book data. While levels of non-linearity may help predict a book's instrumentality, we hypothesize that it will not help predict a book's success within its given category.

H3. *The optimization hypothesis*. We can think of non-linearity reflecting two creative decisions: the amount of information covered (i.e., the overall narrative distance traveled) and how the sequencing of this information is optimized (i.e., the average semantic distance between consecutive passages in the narrative, or narrative *speed*). Large jumps with too little information risk unduly taxing the reader. Short leaps with too much information risk boring the reader. Non-linearity can thus be thought of as reflecting how the sequencing of information is optimized given the information covered. While no prior work exists on this problem, research suggests that the rate at which stories enter and exit public attention has been accelerating in the past few decades (Lorenz-Spreen et al., 2019) and that within visual culture there is a demonstrable preference for "faster" narrative forms, i.e., shorter shot durations and greater number of cuts (Cutting et al., 2011). We hypothesize that books will mirror these larger cultural trends and thus speed rather than overall distance will be the stronger variable for predicting success.

2. Materials and methods

2.1. Data

Our data is drawn from the CONLIT dataset (Piper, 2022), which includes a sample of 2348 books drawn from 10 categories summarized in Table 1. All books were selected using various popularity filters, including number of weeks on a bestseller list, winning a literary prize, being selected for a Goodreads choice award, or filtering by "bestsellers" on Amazon or "best of" on Goodreads. The

categories included in the dataset cover different forms of stylistic distinction: cultural capital (elite consecration versus market-based popularity (Bourdieu, 1987)), stylistic affinity (i.e. genres such as science fiction, memoir, mystery, etc.), reading level (middle school, young adult), and instrumentality (fiction/non-fiction). Prior research has shown that genre, audience, and instrumentality play significant roles in impacting literary behavior (Piper & Portelance, 2016; Underwood, 2016; Wilkens, 2016) and thus this data allows us to assess the effects of non-linearity on highly differentiated audience categories drawn from different reader platforms. Note we remove the non-fiction category "MIX" from the original dataset because it includes non-narrative books and we also remove Romances because of their stylistic outlier status (Piper & Portelance, 2016).

In order to measure "success," we use two measures collected from the reading platform Goodreads.com: average user ratings and the total number of ratings (Kousha et al., 2017). Following Kousha et al. (2017), we use average ratings as a proxy for *reader enjoyment* of a given book, while we use the total number of ratings to estimate *book popularity* in terms of readership size. In Figs. 1, 2 and 3 we provide distributions of the year of publication of our data along with our two success measures. While alternative measures of success would be desirable, book sales data remains closely guarded industry data and is prohibitively expensive. Finally, in addition to category and success, the CONLIT data includes a number of measures that we use as variables to control for other stylistic differences, including text difficulty, word and sentence length, text length, authorial gender, and number of characters.

2.2. Methods

We operationalize the concept of narrative non-linearity using the measure of *circuitousness* first proposed by Toubia et al. (2021), along with two related measures described in their paper and schematically represented in Fig. 4. As described in Toubia et al. (2021), texts are first represented as a progression of points in a latent (i.e., unobserved) semantic space. Texts (avg length = 102,278 words) are broken into 1500-word chunks,[1] with each chunk represented as a point in a 300-dimensional semantic space, using the Word2vec model (Mikolov et al., 2013, 2018). That is, each chunk of text t is represented by a 300-dimensional vector x_t, which captures its location in the semantic space. Points that are closer in the semantic space reflect content that is more semantically related (i.e., more likely to appear in the same context). Each text is therefore represented by a path in the semantic space, i.e., a sequence of points $\{x_1,\ldots x_T\}$ where each point x_t reflects the position of one chunk of text, and T is the number of points in the path.

Circuitousness is then calculated as the ratio between the length of the actual path of a text in the semantic space and the shortest path that starts and ends at the same point and visits all the same points in between. As can be seen in Fig. 4, the more a narrative diverges from the shortest path between points in its actual path, the more it can be thought of as engaging in non-linear storytelling.

Circuitousness can additionally be decomposed into two component measures defined by Toubia et al. (2021). The first is *speed*, which is the average Euclidean distance (in the semantic space) between adjoining chunks of text. Toubia et al. (2021) argue that speed can be interpreted as the amount of effort required for the audience to cover the narrative distance between individual portions of text. Lower (respectively, greater) speed indicates that the events featured in any given sequence of text tend to be more semantically related (respectively, unrelated). The second measure is *distance*, which captures the total semantic distance covered by a given narrative, or more precisely the minimum distance required to cover all the points in the narrative (holding the first and last points fixed), referred to as the length of the shortest path in Toubia et al. (2021). Thus *circuitousness* can be measured as:

$$Circuitousness\ (C) = \frac{Speed\ (S)}{Distance\ (D)}$$

In order to validate our measure beyond the validation exercises already reported by Toubia et al. (2021-see Supplemental Information), we first illustrate the effect of differing pathways on circuitousness using four sets of word types that each illustrate one possible type of non-linearity (Fig. 5). For each pair we illustrate the change in circuitousness when we move through the semantic space in less sequential ways.[2] In each panel the path on the left (right) is the shortest (longest) path connecting the first and last points. We see that it is more circuitous to go from Paris -> Boston -> London -> New York than Paris -> London -> Boston -> New York as semantic space reflects geographic distance. We can see the same effect for time (morning -> evening -> afternoon - > night is more circuitous than morning -> afternoon -> evening - > night) as well as the causal connections between narrative topics. It is less circuitous to go from the concept of "revenge" to "murder" to "investigation" to "justice" than if one were to put the murder after the investigation. Finally, it is less circuitous to go from “myself” to “yourself” by first going to “ourselves” (moving from singular to plural) and then “yourselves” (moving from self to others) and finally “yourself” (plural to singular), than to move from “myself” to “yourselves” (self, singular to others, plural) then “ourselves” (others to self) and then “yourself” (self, plural to other, singular). In this sense, the word embedding model is able to capture different aspects of non-linearity.

Second, we inspect individual works that score significantly high / low on our measure of circuitousness (i.e., 2SD above/below the mean). As shown in Table 2, we find that for highly circuitous books our models capture all three aspects of narrative non-linearity, including setting, time and perspective. Indeed the most non-linear book in the data is Ali Smith’s *How To Be Both* (2014), a critically acclaimed novel famous for its shifting perspectives and time frames. The novel moves between the perspective of George, a 16-year-old girl living in contemporary Cambridge, and Francesco del Cossa, an Italian renaissance artist. As one critic wrote, "The Francesco

[1] We do not break up sentences, hence some chunks may have more than 1,500 words.

[2] In order to illustrate semantic paths between 4 points in 2 dimensions, we apply Principal Component Analysis on the set of vectors corresponding to the four points, and plot the first two components. However, the measures of speed and circuitousness reported in Figure 5 are based on the original, 300-dimensional vectors.

Table 1
Overview of the CONLIT data included in this study.

Code	Category	Instrumentality	Platform	Selection Citeria	# Docs
BIO	Biography	non-fiction	Goodreads	"Best memoir / biography / autobiography" list	190
BS	Bestseller	fiction	New York Times	fiction published since 2001 with the longest aggregate time on the New York Times bestseller list	249
HIST	History	non-fiction	Amazon	books listed under "history" under the "bestsellers" tag	206
MEM	Memoir	non-fiction	Amazon	books listed under "memoir" under the "bestsellers" tag	229
MID	Middle-school	fiction	Goodreads	Goodreads Choice awards for "Middle Grade" books	166
MY	Mystery	fiction	Amazon	books listed under "Mystery, Thriller, Suspense" under the "bestsellers" tag	234
NYT	New York Times Reviewed	fiction	New York Times	fiction reviewed in the New York Times Book Review	418
PW	Prizelists	fiction	5 Prizelists (US, UK, Canada)	works shortlisted for the National Book Award (US), PEN/Faulkner Award (US), Governor General's Award (Canada), Giller Prize (Canada), and the Man Booker Prize (UK)	258
SF	Science-Fiction	fiction	Amazon	books listed under "Science Fiction & Fantasy" under the "bestsellers" tag	223
YA	Young Adult	fiction	Goodreads	Goodreads Choice Awards for Young Adult Fiction	175

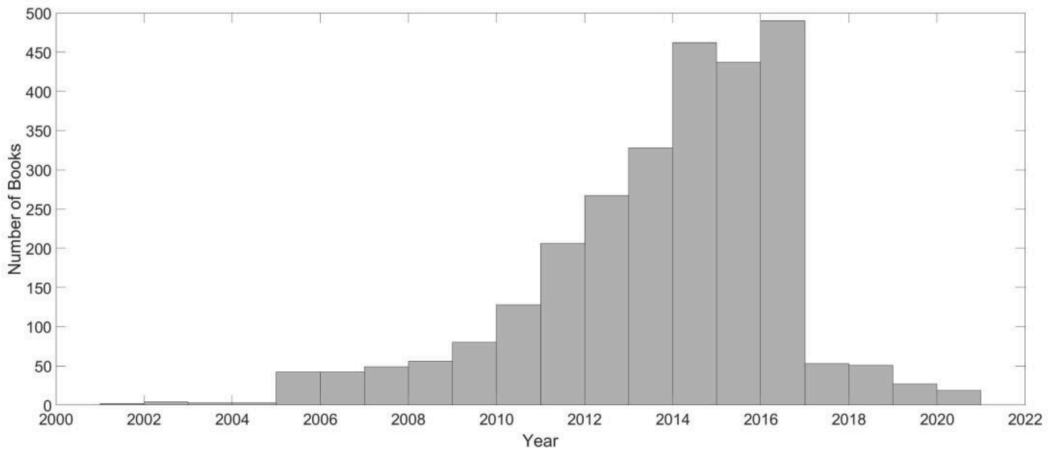


Fig. 1. Distribution of publication year of books in our sample.

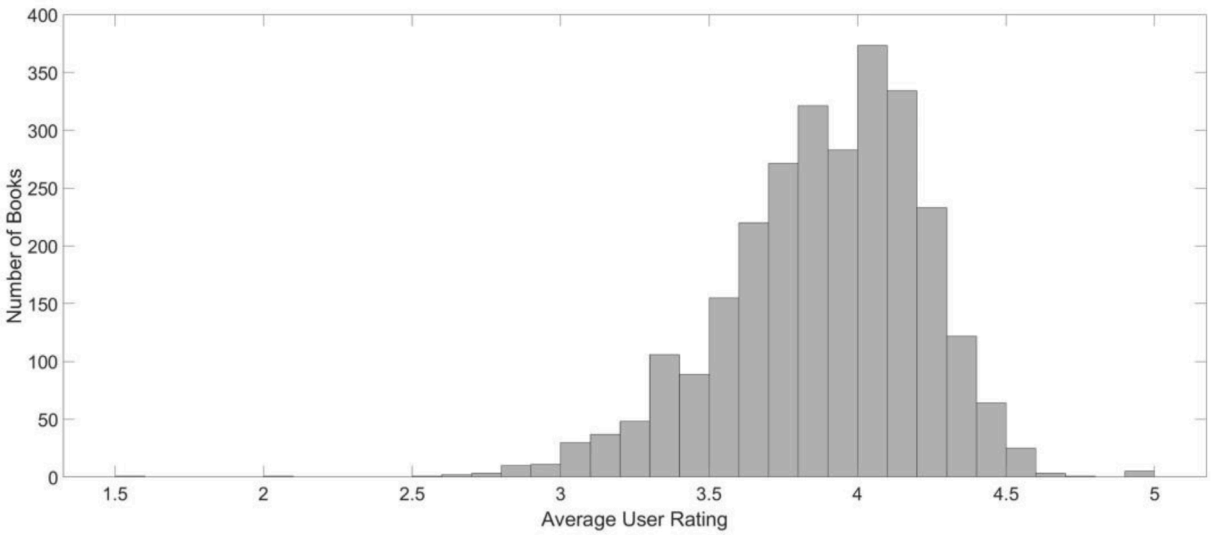


Fig. 2. Distribution of the average user rating on Goodreads for books in our sample.

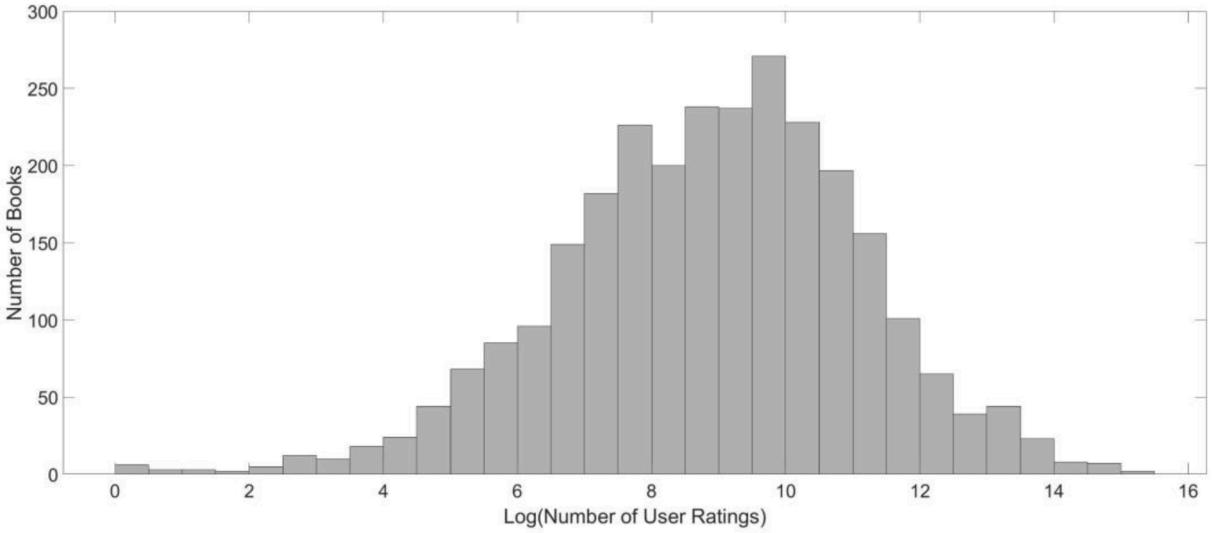


Fig. 3. Distribution of the log-transformed number of ratings on Goodreads.

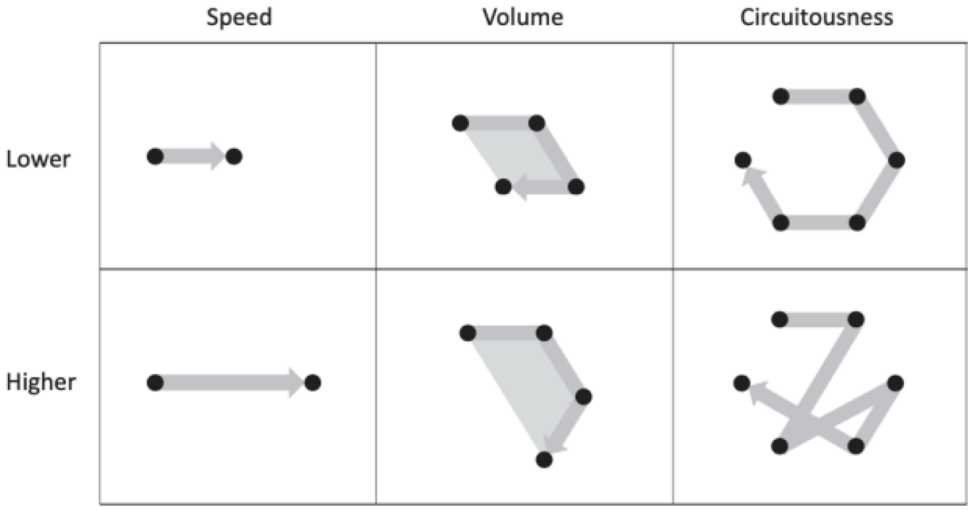


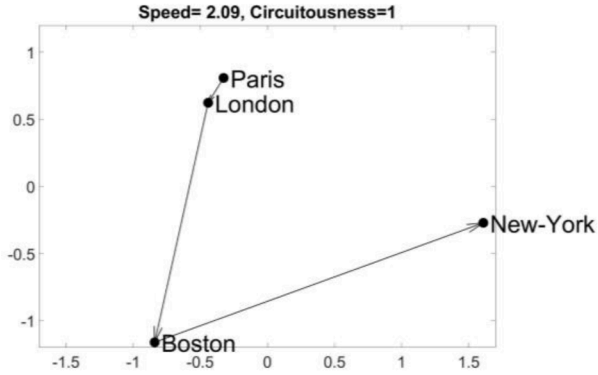
Fig. 4. Schematic representation of the three proposed measures in Toubia et al. (2021).

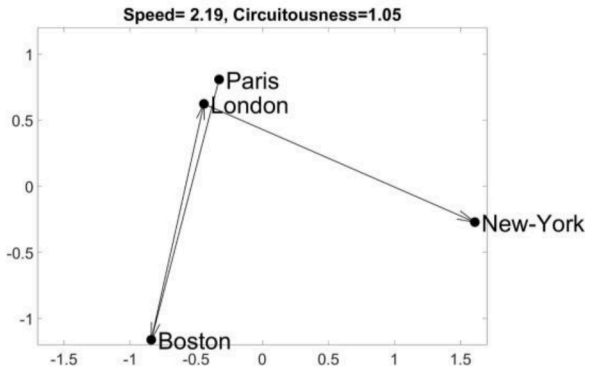
passages are littered with poetic fragments that pull the chronology forward and back and so out-of-shape that sometimes, it is difficult to know what is happening" (Day, 2014).

On the negative side (i.e., < 2SD below the mean) we find that many of the least circuitous works are on the shorter end in terms of length (the correlation between the number of tokens and circuitousness is $r = 0.235$). We find that low circuitous books are marked as much by a sense of continuity as the absence of bifurcation that we see in our highly circuitous books. For example, Julie Otsuka's *The Buddha in the Attic* (2.38 SD below the mean of circuitousness) is a novel that tells the story of a group of young women brought from Japan to San Francisco as "picture brides" in the early twentieth century. Rather than follow a single character, it offers a series of vignettes told in the plural first person that follow different women through different stages of the experience. As one reviewer wrote, "Though the publisher classifies the book as a novel, it is more like a beautifully rendered emakimono, hand-painted horizontal scrolls that depict a series of scenes, telling a story in frozen moments" (Stephens, 2011). In a similar vein, *The Dept. Of Speculation* by Jenny Offil (2.23 SD below the mean of circuitousness) is comprised of a series of disconnected reflections on a woman's unhappy marriage, where there is a unifying theme but little association between any of the parts. The narrative essentially focuses on "one thing after another" with respect to a single character's inner life.

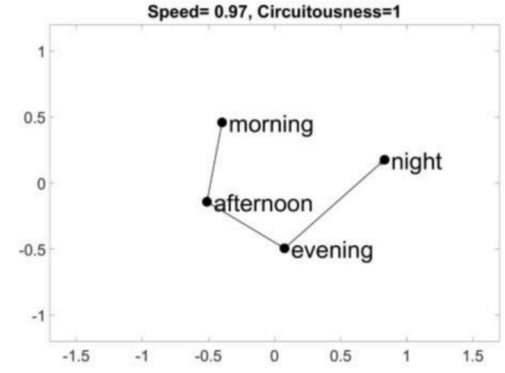
What appears to define a circuitous book then is not simply the concept of narrative discontinuity, but rather the act of *connecting disconnected worlds*. In strongly circuitous books there is a clear sense of distinct diegetic worlds that are then integrated in non-sequential ways, where such diegetic worlds may be a text-within-the-text, different characters' experiences, actual physical spaces, or some combination of each. Weakly circuitous books, on the other hand, are marked by the absence of such strongly

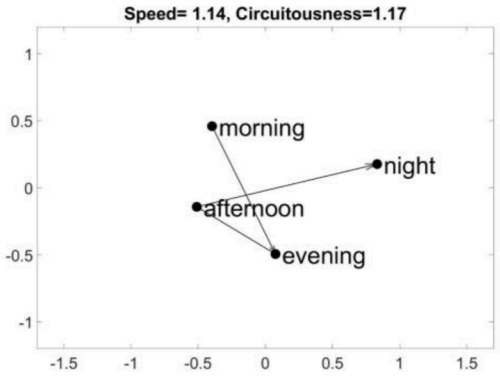
(a) setting



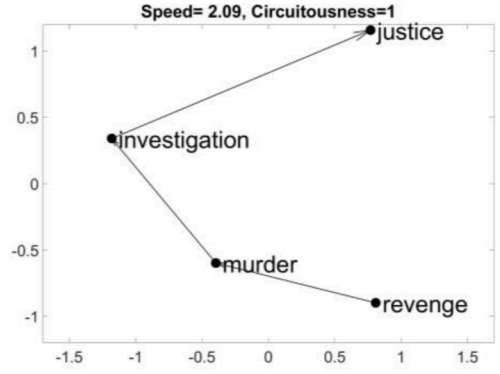


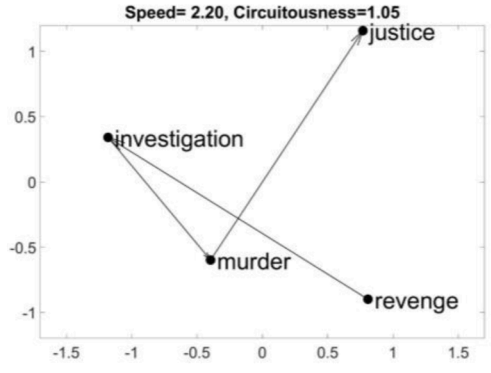
(b) time



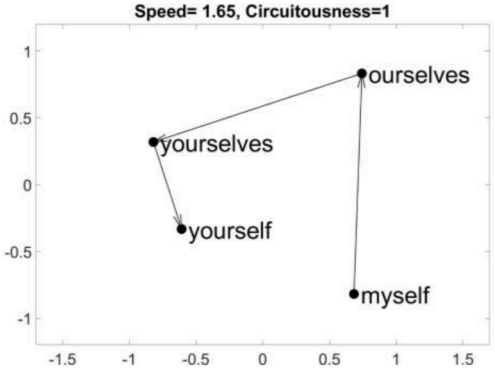


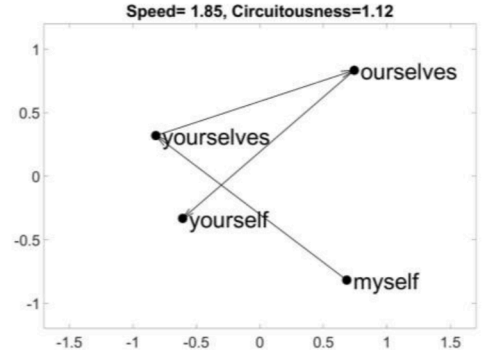
(c) events





(d) perspective





(caption on next page)

Fig. 5. Illustration of circuitousness in (a) setting, (b) time, (c) events, (d) perspective.

Table 2
Selection of most circuitous books and the type of non-linear narrative technique employed.

Author	Title	Category	Circuitousness (Standardized)	Non-Linear Type
Ali Smith	How To Be Both	Prizewinner	8.61	Perspective Time
Joanne Fluke	Christmas Caramel Murder	Bestseller	3.76	Perspective Setting
Erica Swyler	The Book of Speculation	Mystery	3.70	Time
Julie Myerson	The Stopped Heart	New York Times	3.52	Time
Clare Mackintosh	I Let You Go	Mystery	3.25	Perspective
Gary Shteyngart	Super Sad True Love Story	Science Fiction	3.06	Perspective
Taylor Stevens	The Informationist	New York Times	2.95	Setting Time
Susan Rieger	The Divorce Papers	New York Times	2.88	Perspective

associated multiple worlds and instead rely on the stringing together of less differentiated parts. As another point of confirmation, we note that the genre with the highest levels of circuitousness are Mysteries, while the genre with the lowest levels are Histories, which aligns with expectations we would have about the stylistic tendencies of these genres (see Table 6).

Third, we conduct an experiment using GPT-3 (Brown et al., 2020), a state-of-the art language model, to generate short stories using different prompts that should impact circuitousness, if circuitousness is a valid measure of non-linearity. Though validation is on-going, prior research has shown that GPT-3 is able to approximate human-generated text and be logically responsive to natural language prompts (Wang et al., 2021; Dou et al., 2022; Dale, 2021). Using GPT-3, we artificially generate 500 stories according to the five conditions listed in Table 3 with their associated prompts. Results, reported in the Appendix, confirm our prediction that the non-linear story conditions exhibit significantly higher circuitousness on average. While GPT-3 is still an experimental tool for validating human text, we note that this exercise provides further convergent evidence for the validity of our nonlinearity measure.

Finally, we also include a third measure used by Toubia et al. (2021) which they refer to as *volume*. Volume is computed by finding the smallest (i.e., minimum volume) ellipsoid containing all of the points that make up the path of a book in the semantic space. That is, the points that represent a book are enclosed (or "shrink wrapped") by the smallest possible ellipsoid, and the volume of the set of points is measured as the volume of that ellipsoid. Toubia et al. (2021) interpret volume as the semantic "space covered" by a text, noting that "covering a lot of [semantic] space allows audiences to see and connect a wide range of topics." Volume is thus related to the "multi-dimensionality" of the text in distinction to the distance-based measures used above and is potentially aligned with theories of "heteroglossia" thought to underpin the modern novel (Bakhtin, 2010). In a 300-dimensional semantic space such as the ones employed by Word2vec, each new point (i.e., chunk of text) adds a new dimension (as long as the number of points is less than or equal to 300). The more orthogonal a new point is from the subspace spanned by the previous points, the more it increases the volume of the text by adding a *distinct* new dimension.

Following Toubia et al. (2021), to account for the skewness of the distributions we log transform these semantic features and standardize them for ease of interpretation. We standardize all other variables for which we report regression coefficients. Note also that all measures are normalized to account for the number of points T (e.g., *distance* is really the length of the shortest path divided by T-1). The original matlab code used for calculating the measures and book metadata is available at the following repository: https://doi.org/10.6084/m9.figshare.22211914. A Python version of the code is available at: https://github.com/smoorjani/word_embedding_measures/.

3. Results

H1. *The non-instrumentality hypothesis*. We expect to see levels of non-linearity negatively associated with A.) a narrative's instrumentality, B.) the intended audience age level, and C.) to show some effect with respect to a book's genre.

Table 3
List of prompts used in our five conditions for testing GPT-3 generated stories.

Condition	Type	Prompt
Control	Linear	Tell a story that is no longer than 250 words where the events happen in order.
Non-linear	Setting	Tell a story that is no longer than 250 words that moves back and forth between different settings.
Non-linear	Time	Tell a story that is no longer than 250 words that moves back and forth between different timeframes.
Non-linear	Events	Tell a story that is no longer than 250 words that moves back and forth between different events.
Non-linear	Perspective	Tell a story that is no longer than 250 words told in the third person but moves back and forth between the perspective of different characters. Do not include the words 'from this character's perspective.'

A. Our first analysis compares fiction books to non-fiction books. We begin by conditioning only on adult fiction books by removing MID & YA in both the primary and secondary classifications of books. We classify non-fiction books as those with codes BIO, MEM or HIST. We create a dummy variable for fiction books. Then, to understand how semantic features vary across fiction and non-fiction, while controlling for length, we separately regress each standardized semantic feature on the fiction dummy, as well as 4 different variables that capture the length of the text: the total number of tokens (i.e., instances of words), the number of tokens that are words from the Word2vec dictionary, the number of sentences, and the number of chunks of text. We log transform all length variables, given their skewness.

Results, reported in Table 4, indicate that, controlling for length, fiction books tend to have considerably higher circuitousness ($\beta =$ 0.733, $p < 0.05$) with lower volume ($\beta =$ -0.530, $p < 0.05$). Recall that the dependent variable is standardized, hence, the results indicate that Fiction books have a Log(circuitousness) that is on average 0.733 SD higher than that of other books, controlling for length. Fictional storytelling thus distinguishes itself by modulating the ordering and revelation of more compact amounts of information, rather than on the presentation of more semantically diverse information.

B. As part of H1, we also compare youth fiction to adult fiction. We expect that because non-linearity is associated with more challenging reader comprehension (Brewer & Lichtenstein, 1982), authors will employ lower levels when trying to reach younger readers. Results, reported in Table 5, indicate that, controlling for length, youth books have lower levels of circuitousness ($\beta =$ -0.311, $p < 0.05$) and volume ($\beta =$ -0.229, $p < 0.05$). In other words, youth books behave more like non-fiction when it comes to non-linearity, emphasizing the clear communication of information over narrative disjunction.

C. Finally, we also test our circuitousness measure with respect to genre differences across all fiction and non-fictional narratives. As we can see in Table 6, we observe meaningful differences between different categories, differences which also align with expectations. Consistent with Table 4, the non-fiction categories (BIO, MEM, HIST) have lower circuitousness (ranging from 0.772 to 0.439 SD below the mean) and higher volume (ranging from 0.271 to 0.852 SD above the mean). Within the fiction categories, MID and YA tend to have lower circuitousness (0.077 and 0.027 SD below the mean) and lower volume (0.198 and 0.546 SD below the mean). Histories appear the most linear of all categories (0.772 SD below the mean on average, controlling for length) while mysteries the least (0.564 SD above the mean on average, controlling for length). The latter category is well-known for relying on modulated discourse structures.

H2. *The success independence hypothesis*. Given prior research, we expect to see no association between measures of success and levels of non-linearity.

Next, we quantify the link between narrative features and success. We measure success using both the average rating of the book according to Goodreads, and the number of ratings on Goodreads (log-transformed, to account for skewness). We run separate regressions for each success measure. For ease of interpretation, we do not standardize the success measures. In addition to the semantic features, we include a host of control variables: the year of publication (controlled for with one fixed effect per calendar year in our data), the category (one fixed effect per category), a dummy for the gender of the author (1 for male), the total number of characters in the book, measures of reading difficulty (Tuldava score, average word length, average sentence length), and the length of the book (same four measures as above). Our aim is to understand the association of non-linearity with success independent of a book's length, its difficulty, the number of characters it contains, the author's gender or the year it was published, all of which we assume may have some relationship with a book's success.

We first use *circuitousness* as our main independent variable. We include volume as an additional control variable, but not speed or distance as circuitousness is the ratio of these latter measures (hence, we include either circuitousness or both speed and distance in our regressions). We find a negative coefficient for circuitousness both with the average rating (β=-0.014, p<0.06) and the number of ratings (β=-0.057, $p = 0.26$) as dependent variables, but only average rating approaches significance (Table 7). When we decompose our data into the fiction and non-fiction subsets (see Appendix), we see that while directionally similar in both cases the level of significance declines further (more strongly for non-fiction). We also note the small values of the coefficients themselves, where an increase in one standard-deviation of circuitousness results in a decrease of 0.014 average rating (so a book that is 2SD higher in circuitousness than average should see a ratings reduction of just under 0.03, e.g., ~4.03 to 4.0).

H3. *The optimization hypothesis*. What is the optimal relationship between narrative speed and distance? Given prior research on cultural acceleration, we expect books to emphasize speed (i.e., narrative pacing) over narrative distance.

To understand the importance of trade-offs with respect to non-linearity, we decompose log(*circuitousness*) into its two components, log(*speed*) and log(*distance*) (recall that log(*circuitousness*)=log(*speed*)-log(*distance*)). In Table 8, we see that this decomposition yields a

Table 4
Comparison of fiction and non-fiction.

	Log(circuitousness)	Log(volume)
Fiction dummy	0.733**	-0.530**
Log(number of tokens)	yes	yes
Log(number of words)	yes	yes
Log(number of sentences)	yes	yes
Log(number of chunks)	yes	yes
Number of observations	1960	1960
R^2	0.356	0.683

Observations excluded MID, YA.
*: $p < 0.1$; **: $p < 0.05$.

Table 5
Comparison of youth fiction with adult fiction.

	Log(circuitousness)	Log(volume)
(MID+YA) dummy	-0.311**	-0.229**
Log(number of tokens)	yes	yes
Log(number of words)	yes	yes
Log(number of sentences)	yes	yes
Log(number of chunks)	yes	yes
Number of observations	1723	1723
R^2	0.269	0.637

Observations limited to MID+YA+NYT+SF+MY+PW+BS.
*: $p < 0.1$; **: $p < 0.05$.

Table 6
Comparison of circuitousness and volume across all categories.

	Log(circuitousness)	Log(volume)
HIST	-0.772 [-0.927, -0.618]	0.852 [0.743, 0.960]
BIO	-0.581 [-0.735, -0.427]	0.271 [0.163, 0.378]
MEM	-0.439 [-0.563, -0.316]	0.344 [0.257, 0.430]
MID	-0.077 [-0.228, 0.075]	-0.198 [-0.304, -0.091]
YA	-0.027 [-0.173, 0.118]	-0.546 [-0.648, -0.443]
PW	0.002 [-0.109, 0.114]	-0.069 [-0.147, 0.010]
NYT	0.261 [0.173, 0.348]	-0.159 [-0.221, -0.098]
SF	0.282 [0.159, 0.405]	0.016 [-0.070, 0.103]
BS	0.373 [0.254, 0.493]	-0.158 [-0.242, -0.074]
MY	0.564 [0.441, 0.687]	-0.198 [-0.285, -0.112]
Log(number of tokens)	yes	yes
Log(number of words)	yes	yes
Log(number of sentences)	yes	yes
Log(number of chunks)	yes	yes
Number of observations	2348	2348
R^2	0.366	0.689

Note: We include one dummy variable for each category in the data. Because the relevant information is the differences between genres, rather than whether coefficients for specific genres are significantly different from 0, we report 95% confidence intervals rather than significance levels for the coefficients.

Table 7
Effect of circuitousness on average rating and total number of ratings on Goodreads controlling for other stylistic effects.

	average rating	log(number of ratings)
Log(circuitousness)	-0.014*	-0.056
Log(volume)	0.012	-0.045
Year fixed effects	yes	yes
Category fixed effects	yes	yes
Gender dummy	yes	yes
tuldava_score	yes	yes
total_characters	yes	yes
avg_sentence_length	yes	yes
avg_word_length	yes	yes
Log(number of tokens)	yes	yes
Log(number of words)	yes	yes
Log(number of sentences)	yes	yes
Log(number of chunks)	yes	yes
Number of parameters	41	41
Number of observations	2348	2348
R^2	0.333	0.295

Note: All variables for which coefficients are reported are standardized. *: $p < 0.1$; **: $p < 0.05$.

more nuanced view of the effect of circuitousness, as the combination of two effects: a positive effect of log(*distance*) ($\beta = 0.072$ for average rating, $\beta = 0.454$ for log(number of ratings), $p < 0.05$ in both cases) and a negative effect of log(*speed*) (β = -0.026 for average rating, $p < 0.05$, β = -0.112 for log(number of ratings), $p = 0.13$). That is, contrary to our hypothesis success is related to covering content that requires more distance to cover (positive effect of distance), but doing so in a way that is efficient and parsimonious (negative effect of speed).

Table 8
Effect of speed and distance on average rating and total number of ratings on Goodreads, controlling for other stylistic effects.

	Average rating	log(number of ratings)
Log(circuitousness)	–	–
Log(speed)	-0.026**	-0.112
Log(distance)	0.072**	0.454**
Log(volume)	-0.050**	-0.496**
Year fixed effects	yes	yes
Category fixed effects	yes	yes
Gender dummy	yes	yes
tuldava_score	yes	yes
total_characters	yes	yes
avg_sentence_length	yes	yes
avg_word_length	yes	yes
Log(number of tokens)	yes	yes
Log(number of words)	yes	yes
Log(number of sentences)	yes	yes
Log(number of chunks)	yes	yes
Number of parameters	42	42
Number of observations	2348	2348
R^2	0.337	0.299

Note: All variables for which coefficients are reported are standardized. *: $p<0.1$; **: $p<0.05$.

More popular books are more likely to engage in covering more distance regardless of the instrumentality of the information. However, we note a difference with respect to volume when it comes to instrumentality (see Appendix). Fiction's popularity (total ratings) has a highly significant negative relationship with volume (β = -0.571, $p < 0.05$), while non-fiction's is less statistically meaningful though directionally similar (β = -0.414, $p = 0.12$). Fiction's success appears to be associated with covering more semantically *related* ground rather than more orthogonally associated information (see Appendix). Fiction books that cover more narrative distance but less semantic space ultimately do better according to our measures of success.

4. Discussion

In this paper we have shown that when writers are conveying fictional stories (i.e., non-instrumental) they are more likely to rely on higher levels of non-linearity than when conveying true stories, confirming assumptions of prior experimental research about the hedonic nature of non-linear storytelling. We have also shown that non-linearity is weakly *negatively* associated with reader enjoyment and popularity regardless of the instrumentality of the information. However, because these results are less statistically robust, we cannot conclusively reject the hypothesis of the independence of linearity and reader preferences. Further research is warranted to better understand this relationship, which we discuss below. When we decompose non-linearity into the dimensions of *speed* and *distance*, we show that readers prefer works with greater overall narrative distance while exhibiting more parsimony when taking steps between points (i.e. lower speed). Narratives that travel further through semantic space but do so more economically are more strongly preferred. Finally, we show that readers show a strong preference for works of fiction that exhibit less semantic volume, which can be understood as information that is less orthogonal to prior information, which runs counter to prior theory (Bakhtin, 2010). Readers appear to exhibit a preference for more semantic focus (length, not breadth) when it comes to fictional stories.

Our work thus seeks to make several novel contributions. First and foremost, we illustrate the value of using large samples of real-world cultural products to test theories developed in laboratory settings. Understanding audience and reader preferences based on large samples of already produced content can help those in creative industries more appropriately tailor their work to the cognitive preferences of audiences. While some work has suggested that cultural success is either unpredictable or tied to social influences (Salganik et al., 2006), our work joins emerging research that suggests there may be predictable narrative qualities that help inform success with reading or viewing audiences (Archer & Jockers, 2016; Berger & Packard, 2018; Toubia et al., 2021).

One distinguishing feature of our data is the sampling method used, which conditions largely on popular writing. While our success measures exhibit normal distributions, we would expect a random sample of professionally published writing to exhibit a non-normal distribution of success, with few works accruing most of the success, which may impact the predictive power of our measures and their effects. Also, while we have relied on a large-scale crowd-sourced reader platform for our measure of audience response, future work could explore potential biases inherent in this platform (Kousha et al., 2017) as well as other ways of capturing audience response, although book sales data remains prohibitively expensive. Readers could also be disambiguated into more nuanced sub-groups. We expect there to be preferences that are indicated by sub-communities of readers, captured either by genre selection, age or other demographic features.

Second, our work contributes to research in the growing field of cultural analytics and natural language processing applied to the problem of "narrative understanding" (Piper et al., 2021; Clark et al., 2022). While validating large numbers of entire books remains a challenging task, we observe important insights derived from our models as they relate to narrative communication. Globally, our work contributes to the further understanding of the way the communication of non-instrumental information (i.e., fiction) differs considerably from instrumental information (Brewer & Lichtenstein, 1981; Ely et al., 2015; Piper, 2016; Sap et al., 2022). When the

goal is to convey something imaginary or unreal, human narrators engage in very different communicative practices. Chief among these, as we have been able to show, is a stronger reliance on non-linearity with less semantic volume.

At a more granular level, we see how our measure of circuitousness captures an important aspect of non-linearity as the connection of disconnected worlds. In other words, strongly circuitous books are those that build *multiple* robust worlds that may belong to different settings, time periods or characters' world views. Future work will want to further disambiguate the different forms of non-linearity discussed here as well as explore alternative, potentially non-geometric ways to model them (Chang & Dedeo 2020).

5. Conclusion

Narrative is an essential form of human communication and is seen by many research communities as a foundation of human cognition, identity and behavior (Adler et al., 2016; Bushell et al. 2017; Shiller, 2020). Our work aims to initiate a research program focused on the computational modeling of narrative forms that can help us better understand cognitive preferences with respect to the myriad narrative forms that populate human cultures.

There are a number of avenues for future work that can address the limitations of current models. First, further work can be undertaken to disambiguate the different types of non-linearity our models have identified. We expect there may be more subtle relationships between genres and types of non-linearity (i.e. a greater reliance on spatial, temporal, or perspectival non-linearity) along with reader preferences. Perhaps the weak effects of non-linearity we are seeing on reader enjoyment would become more pronounced if we were able to condition on more granular types of non-linearity.

A second area for future research is in the concept of reader enjoyment. While online reader reviews represent a valuable way of gaining insights into broad trends in reader preferences they also have strong limitations when it comes to capturing the construct of "enjoyment" with respect to reading (for a more robust discussion of the concept of enjoyment see Bermejo-Berros et al., 2022). Future work should continue to explore more nuanced ways of understanding how readers enjoy books (potentially through related concepts of immersion, transportation, recall, etc.) and how these experiences relate to discourse structure in general and non-linearity in particular.

Finally, future work will want to continue to explore more diverse samples of book data and continue to explore intermedial differences (reading versus viewing). While the CONLIT dataset is valuable to assess a variety of different kinds of audience-level effects (instrumentality, age, cultural prestige, genre), there may be other kinds of sampling bias impacting the effects we have observed here. Two areas in particular worth further consideration are, first, the popularity bias of this dataset, i.e. what might happen if we condition on a random sample of writing produced in a given year rather than focus on those books that have passed through a popularity filter? Second, it is important to study these effects beyond English-language documents to better understand the cultural effects on reader preferences. Do we see broader global trends or stark regional differences? Finally, there are some indications in the literature that viewing and reading may lead to differing responses when it comes to non-linearity (Bermejo-Berros et al., 2022), which suggests the need for more work in this area. These are all promising avenues for further understanding the relationship between the rich tapestry of narrative discourse structure that storytellers engage in and audience preferences.

Declaration of Competing Interest

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.poetic.2023.101793.

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