

# Oscillation between Contemplation and Revelation – Recurrence and Change in the Life History of Teresa of Ávila

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## Abstract

Advancements in language technology and applied mathematics offer a plethora of tools that can enrich textual cultural heritage research. Using an information-theoretical approach to author profiling, this paper tries to leverage some of these tools to reconstruct mental states in the Early Modern Spanish author Teresa of Ávila. We shift away from traditional static textual feature analysis and instead approach author profiling as a dynamic problem, requiring a representation of the author's life history. Teresa of Ávila was an Early Modern Spanish mystic and Carmelite nun whose authorship offers a unique dataset due to her prolific output and well-preserved, digitized writings. We model Teresa's letter corpus as a complex system with multiple states and try to track her mental and socio-cultural dynamics through lexical co-occurrence structures and affective valences in her letters. We find that Teresa's letters reflect a life history of state switching between contemplation and revelation. This relatively new approach offers a more robust and dynamic perspective on author profiling in cultural heritage research.

## Keywords

author profiling, cultural heritage data, information theory, change detection

## 1. Introduction

Over the last decade, we have witnessed an accelerated development and democratization of language technologies and applied mathematics that impacts a range of domains in textual cultural heritage research [28]. Technologies for representation learning and generative modeling not only allow researchers to automate systematic analysis of large collections of linguistic data but also enable researchers to query and model those data aided by mathematical theories [12, 22, 3]. The field of cultural heritage research is abundant with unresolved questions and challenges that can benefit from *operational research* interventions, that is, applications of advanced

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CHR 2023: Computational Humanities Research Conference, December 6 – 8, 2023, Paris, France

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CEUR Workshop Proceedings (CEUR-WS.org)

mathematical methods to improve domain experts' analytical assessment. One such area is a text-based automatic reconstruction of an author's psychological traits and development, often referred to as author profiling [31]. Profiling an author is a complex and multidimensional problem that is typically approached as a text prediction problem, that is, given a set of *static* textual features (e.g. word counts) from a collection of documents, predict the prevalent demographic traits of the documents' author (e.g. gender, age, native language or sexual orientation). More challenging is a developmental characterization of the author in question, which requires a *dynamic* representation of the author's life history based on textual features [27, 44]. We will engage with this paper's latter task, specifically the detection and characterization of change in the information space of Early Modern Spanish mystic and Carmelite nun Teresa of Ávila (1515-1582), also known as Saint Teresa of Jesus, born Teresa Sanches de Capeda Dávila y Ahumada. Teresa of Ávila's authorship is particularly interesting for several reasons. First, we have very few women authors from the period that were both highly productive and whose writings are well-preserved and digitized. Second, Teresa of Ávila lived an unusually eventful life, where both internal events (e.g., ecstasy, mystical raptures, and asceticism) and external events (e.g., extensive traveling, the founding of 17 convents and numerous priories, and convent confinement) had profound effects on her thinking and behavior [9]. Third, and more pragmatically, due to its age, Teresa of Ávila's letter corpus is not subject to copyright, which allows us to share data and results openly.

### 1.1. Teresa of Ávila and the Emotional Intensification of Early Modern Christianity

An influential figure of the turbulent Catholic Reformation, the life and work of Spanish mystic and renewer of the Discalced Carmelite order, Teresa of Ávila illustrates an overall, cross-denominational emotional intensification, 'subjectivation' or 'individualization' of Early Modern Christianity [33]. This is not least due to the fact that she deftly drew upon and creatively reworked the Catholic mystical tradition of 'bridal theology' promoting marriage as the social model for an ideal inner religious life molded as a relationship with Jesus Christ as a spiritual husband [39]. This inspiration led to an erotic, intimate tone in her writings, which mostly fall under the category of self-scrutinizing religious *ego-documents* – the autobiography, the confession, and the letter being the most dominant genres [39, 7, 36].

In more than one respect, Teresa's biography is typical for a religious mystic and reformer. One important feature is that she suffered from recurrent illnesses from an early age, and as a result hereof, she became accustomed to social isolation. She was born into the social elite of Spain. Her family was counted among the so-called *converso* – among Jews converted to Catholicism in Spain and Portugal during the 14th and 15th centuries. Background of this nature automatically made her suspect in the eyes of the Catholic officialdom. This, but more importantly, her remarkable success as an active monastic reformer led her confinement by the Inquisitional Tribunal of Valladolid to a Castillian convent in 1575-1579. In a time immediately following the Council of Trent (a series of meetings held in Trent between 1545-1563 for Catholic church officials seeking to make the Catholic Church adaptive in the post-reformatory climate) that mandated claustration for all nuns, Teresa's active engagement in secular, 'public' matters might also have raised concern among the local officials. In passing, we have to add

that Teresa's part-taking in the social, financial, and institutional life of her community was by no means unique; Elisabeth A. Leffeldt has made the case that a line of Spanish Early Modern nuns led an active life in the religious as well as the secular sphere [19].

The Discalced Carmelites were rooted in the Christian eremitic tradition, so self-confinement was integral in the order's religious practice – a circumstance driven by the wish to reach favorable contemplative conditions. By way of a lay order, the ascetic-hermetic lifestyle was not reserved for the monastics alone; in Late-Medieval times and throughout the Early Modern period, it became available to the general population to an accelerating degree. In Spain, the Carmelites and their ascetic ethos grew highly popular among the top-level of society; this is one cultural background for the designation of Teresa as co-patron of Spain in 1618, only a few years after her death [20].

Though one can only speak of a 'feminization' of Catholic and Protestant Christianities taking hold of mainstream religious life in 19th century [48], Teresa's work and writings forecast this development. It did so despite the misogyny flourishing in the (predominantly male) elites of the Catholic (as well as of the Protestant) Reformation [45].

The work of the prominent Carmelite nun was part of a general individualization trend. One way of approaching the subject is to view her life story as indicative of the rise of an interest in 'sources of the self' within the Western-Christian, philosophical traditions. This development entailed a distribution of a general propensity for 'inwardness', consisting in a radical reflexivity that allows the mind to objectify itself as a "punctual self" [42]. Another way of framing her position in Christian traditions is by viewing her work as part of a general dispersal of an ascetic, 'world-denying love' and lifestyle [4]. This was a significant aspect of so-called Axial Age religiosity with a 'miserabilist' and anti-materialist outlook, inviting believers to deem a given spiritual world more real than the physical, tangible one, and, further, to conceive of life in the physical realm as defined by pain and distress. This outlook took hold of world religions as they developed from the centuries leading up to the Common Era's beginning and into the Early Medieval period. Monastic movements were the trend's epitome, but the 'tragic mentality' gradually spread among the lay populations. Ideas of life on earth as suffering and a ranking of the inner life of the soul (closer to Heaven) over the outer life of the body (bound to the World), became unmistakably mainstream in European, late-medieval Christian penitence practices and pious aesthetics still vibrant into Teresa's Early Modern era [40].

Whichever story-line one prefers, it is incontestable that rigorous, world-denying religious movements took root in groups among Europe's educated classes and colonies during the Early Modern period and that Teresa of Ávila's life and work is highly indicative hereof – not least when turning to the informational and affective structures in her body of letters.

## **1.2. Novelty and Resonance in Teresa's Letters**

In this paper, we analyze Teresa's letter corpus as a system of indicators of Teresa's mental state. The letters, in particular, are interesting because of their relatively frequent and homogeneous nature, both beneficial for dynamic author profiling. For reconstruction, we use an information-theoretical approach to event detection and characterization in noisy and complex textual data [46, 26]. This approach takes its inspiration from the embedding theorem of chaos

theory [34, 41, 37], which allows us to approximate the dynamics of a complex system. Rather than measuring author traits through word counts, we approach an author as a complex system with many states, which switch between attractors, i.e., a value or set of values toward which variables in a dynamical system tend to evolve. Some of these attractors may be associated with dynamics of psychological information and captured in low-dimensional indicator variables [32, 11]. In our case, these simple indicator variables are expressed through *novelty* and *resonance* in both the lexical co-occurrence structure and the affective valence of Teresa’s letter corpus.

Recent developments and applications of information theory have provided robust measures for tracking the states and dynamics of psychological and socio-cultural systems as reflected in textual data, [22, 3, 14, 30, 24]. One paradigmatic study applied relative entropy to study the development of Darwin’s thinking in his cultural context [22]. Both Shannon and relative entropy have similarly been used in studies to detect changes in the prevalent psychological states due to the sociocultural context (e.g., state censorship, degree of recognition, religious observation) [30, 27]. One specific information theoretic approach applies windowed relative entropy to dense low-dimensional text representations to generate signals that model *novelty*,  $\mathcal{N}$ , a document’s reliable content-difference from the past; *transience*,  $\mathcal{T}$ , the document’s content difference from future documents; and persistence is modeled as information *resonance*,  $\mathcal{R}$ , the difference between *novelty* and *transience*, or conceptually, the degree to which future information conforms to a documents *novelty* [3, 24]. Taking a more dynamic perspective on this approach, one study has shown that discussion boards on social media where the novelty signal displays both short-range correlations and a particularly strong association with resonance are more likely to contain trending content, [25]. Using the same approach combined with event detection has also been shown to reliably predict major change points in historical and contemporary data, [44, 26].

## 2. Methods

### 2.1. Data and Normalization

The corpus  $\mathcal{D}$  contains a collection of 690 distinct writings authored by Teresa of Ávila between the years 1546 and 1582, covering the span of the author’s age from 31 to 67 (death). This collection encompasses diverse literary genres, such as letters, books, spiritual testimonies, poetry, and soliloquies. All writings were translated into English by Kieran Kavanaugh.

Furthermore, corpus  $\mathcal{D}$  was divided into two subsets:  $\mathcal{D}_{\text{train}}$  and  $\mathcal{D}_{\text{analysis}}$ . The first subset,  $\mathcal{D}_{\text{train}}$ , was used for training a topic model and includes all available texts. However, since the texts vary considerably in length, each text was further divided into paragraphs (denoted by a new line character). The second subset  $\mathcal{D}_{\text{analysis}}$  consists exclusively of letters. To obtain a dynamic representation of the author’s life history on a timeline, letters should contain information about day, month, and year. For this reason, we removed letters lacking a month (N=10) and assigned a random number between 1 and 28 for those without a day (about 25% of the total number of letters).

Both subsets underwent the same preprocessing procedure, which included the following steps: 1) removal of characters and words, including punctuation marks, numerical characters,

high frequency and closed class words, as well as proper nouns. The removal of proper nouns was motivated by their relatively high frequency in letters, resulting in latent variables that create spurious correlations between documents. 2) case-folding of all characters, 3) lemmatization. After preprocessing,  $\mathcal{D}_{\text{train}}$  contains 215,059 lemmas across 5680 paragraphs. In comparison,  $\mathcal{D}_{\text{analysis}}$  contains 78,118 lemmas across 2703 paragraphs, which translates to 459 unique letters. Note that all letters were authored by Teresa of Ávila and responses were not considered.

## 2.2. Document Representations

To model Teresa’s associative states in the letters, we used the lexical co-occurrence structure of documents from a Latent Dirichlet Allocation (LDA) model of the letter corpus [5]. First, we trained an LDA model on  $\mathcal{D}_{\text{train}}$  using coherence sweep to optimize the representation dimensions (i.e., the  $k$ -number of latent variables). Second, the final model ( $k = 8$ )<sup>1</sup> was used to infer the representation of each document in the  $\mathcal{D}_{\text{analysis}}$  resulting in a document-by-latent variable matrix  $D \times T$ , where  $D$  is the column of documents belonging to  $\mathcal{D}_{\text{analysis}}$ ,  $T$  is the row of latent variable  $T = \{t_1, t_2, t_3, \dots, t_k\}$ . Each cell  $ij$  is the probability  $p$  of a latent variable  $t_j$  occurring in a document  $d_i$ ,  $p(t_j|d_i)$ . The document representations were normalized so that  $p$  values sum to 1.

To capture indicators of Teresa’s emotional states, we utilized sentiment classification to model the affective valence of each document as a distribution over a small inventory of emotions. The classifier is based on the BERTweet [35, 23] language model pre-trained on the EmoEvent corpus [1]. Given a document, the model outputs  $p$  scores for Ekman’s six basic emotions (anger, disgust, fear, joy, sadness, surprise) [10] and a neutral case. First, we run the emotion classifier on raw documents from  $\mathcal{D}_{\text{analysis}}$ . Second, we created a similar to LDA document-by-latent variable matrix but with each  $ij$  representing  $p$  of an emotion  $e_j$  occurring in  $d_i$ ,  $p(e_j|d_i)$ .

## 2.3. Design and Analysis

The study modified the pipeline suggested in [29] by adding recurrence quantification analysis: 1) Extract indicator variables (novelty and resonance) from document representations, 2) estimate possible change points in the novelty variable, and finally, 3) characterize the change in resonance variable by inspecting the recurrence structure.

### 2.3.1. Indicator Variables

Two related information signals are extracted from temporally sorted low-rank dense vector representations of documents: *Novelty* as an article  $s^{(j)}$ ’s reliable difference from past articles  $s^{(j-1)}, s^{(j-2)}, \dots, s^{(j-w)}$  in window  $w$ :

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<sup>1</sup>The number of topics is similarly low when using other methods, such as BERTopic [13]

$$\mathcal{N}_w(j) = \frac{1}{w} \sum_{d=1}^w JSD(s^{(j)} | s^{(j-d)}) \quad (1)$$

and *resonance* as the degree to which future articles  $s^{(j+1)}, s^{(j+2)}, \dots, s^{(j+w)}$  conforms to article  $s^{(j)}$ 's novelty:

$$\mathcal{R}_w(j) = \mathcal{N}_w(j) - \mathcal{T}_w(j) \quad (2)$$

where  $\mathcal{T}$  is the *transience* of  $s^{(j)}$ :

$$\mathcal{T}_w(j) = \frac{1}{w} \sum_{d=1}^w JSD(s^{(j)} | s^{(j+d)}) \quad (3)$$

The novelty-resonance model was originally proposed in [3], but here we use a symmetrized and smooth version by using the Jensen-Shannon divergence (*JSD*):

$$JSD(s^{(j)} | s^{(k)}) = \frac{1}{2}D(s^{(j)} | M) + \frac{1}{2}D(s^{(k)} | M) \quad (4)$$

with  $M = \frac{1}{2}(s^{(j)} + s^{(k)})$  and  $D$  is the Kullback-Leibler divergence:

$$D(s^{(j)} | s^{(k)}) = \sum_{i=1}^K s_i^{(j)} \times \log_2 \frac{s_i^{(j)}}{s_i^{(k)}} \quad (5)$$

### 2.3.2. Change Detection

We search for multiple change points in the Novelty signal, which delimit segments with a reliable difference in mean. For this, we used the PELT search method proposed by [17, 43]. Given a time series  $y$ , we aim to find  $m$  change points  $(t_1, \dots, t_m)$ , which segment the time series into  $y_{(t_{i-1}+1): t_i}$ . Formally, we minimize:

$$\sum_{i=1}^{m+1} [C(y_{(t_{i-1}+1): t_i})] + \beta f(m) \quad (6)$$

where the first term is the sum of cost of individual segments, measured by a cost function  $C(\cdot)$ . The second term  $\beta f(m)$  is the complexity penalty, which is included to balance the first term and prevent over-fitting (with higher penalty values, a higher goodness-of-fit improvement is needed to add a change point). In our application, we use the Least squared deviation ( $c_{L_2}$ ) cost function:

$$c_{L_2}(y_{a,\dots,b}) = \sum_{t=a+1}^b \|y_t - \bar{y}_{a,\dots,b}\|_2^2 \quad (7)$$

where  $\bar{y}$  is the mean of the sub-signal  $y_{a,\dots,b}$ . The found change points were also consistently detected using different cost functions (we tested  $C_{L_1}$  and  $C_{rbf}$ , see [43] for a review). Among the tested cost functions, the  $C_{L_2}$  appeared to yield the most conservative segmentation of our signal while maintaining the same penalty parameter settings.

### 2.3.3. Recurrence Plots

This study uses recurrence plots (RP) to characterize the change in recurrence of Teresa of Ávila's letters' information dynamics. An RP represents the recurrence of an  $m$ -dimensional, read 'high-dimensional', dynamical systems, that is, their phase space trajectories, in two dimensions. The recurrence of a state  $x$  and times  $i$  at a different time  $j$  is represented in a 2D squared matrix  $R$  with dots (both axes are time axes) [webber\_recurrence\_2015]:

$$R_{i,j}^{m,\epsilon_i} = \Theta(\epsilon_i - \|x_i - x_j\|), \quad x_i \in \mathbb{R}^m, \quad i, j = 1 \dots N \quad (8)$$

where  $N$  is the number of considered states  $x_i$ ;  $\epsilon_i$  is a threshold distance,  $\|\cdot\|$  a norm, and  $\Theta$  the Heaviside function [webber\_recurrence\_2015]:

$$\Theta(x) = \begin{cases} 1, & x > 0 \\ 0, & x \leq 0 \end{cases} \quad (9)$$

In this specific application, we use auto-RP such that  $x_i = x_j$  if  $i = j$ .

### 2.3.4. Indicator Smoothing

A Gaussian kernel smoother was used for the visualization of novelty and resonance variables to reduce noise and make oscillations more apparent. The Gaussian kernel function is:

$$K_h(x) = \frac{1}{\sqrt{2\pi h^2}} \exp\left(\frac{-x^2}{2h^2}\right) \quad (10)$$

Where  $h$  is the bandwidth set to  $5 \leq h \leq 20$  to illustrate trends at multiple scales. For RPs  $h = 2$  to retain sufficient variation for an informative visualization, observed patterns persist quantitatively at higher bandwidths. For a Gaussian kernel smoother, the smoothed value,  $S(x)$ , at each point  $x$ , is calculated as follows:

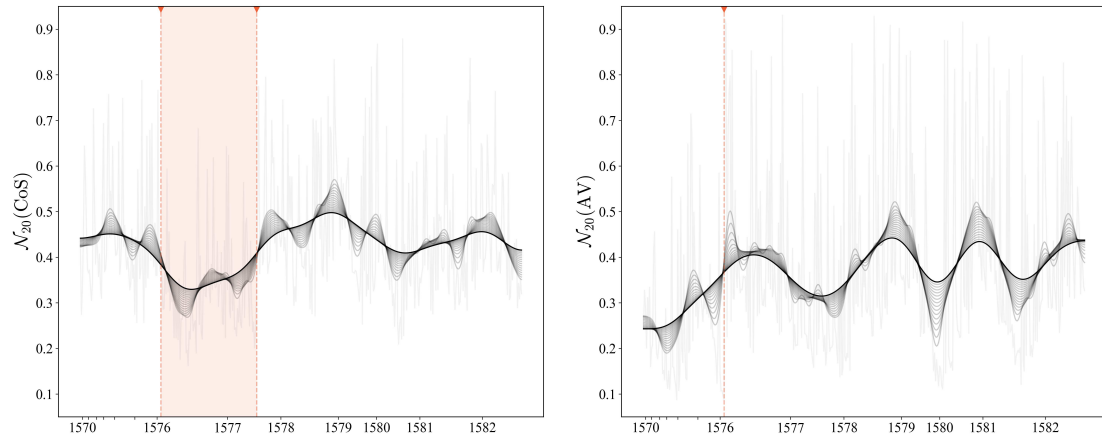
$$S(x) = \frac{\sum_{i=1}^n K_h(x - x_i) \cdot y_i}{\sum_{i=1}^n K_h(x - x_i)} \quad (11)$$

Where  $y_i$  is the original novelty or resonance values at  $x_i$ .

## 3. Results

### 3.1. Temporary Confinement and State-switching

The dynamic evolution of novelty in Teresa's letters can be observed in Fig. 1. The co-occurrence structure (left) and the affective valence (right) show irregular oscillations at multiple scales.



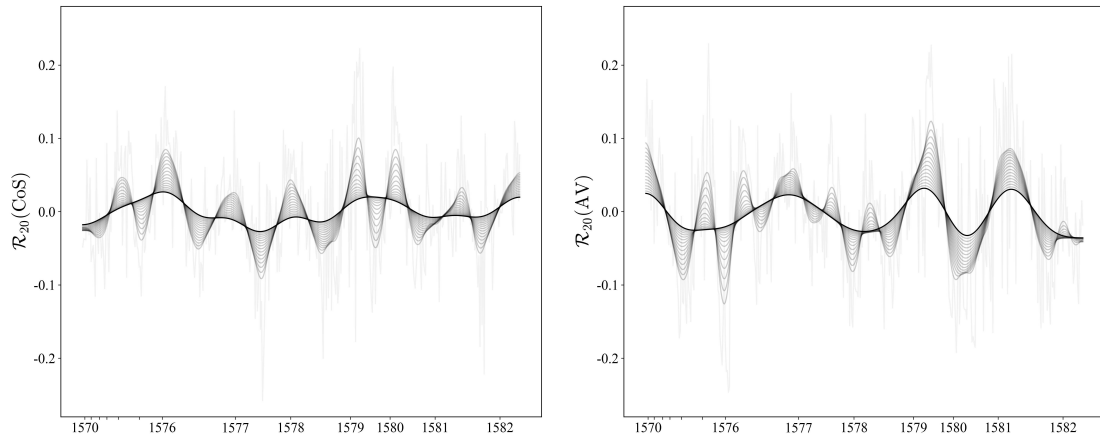
**Figure 1:** Novelty signals for the letters’ co-occurrence structure (left) and affective valence (right). Vertical dotted lines indicate reliable change points and shaded regions signify a persistent event.

From 1570 to late 1576, the two novelty series are anti-correlated with a decrease in the production of new associations, while Teresa’s emotional expressions are diversifying. This dynamic mirrors a decoupling of information flow observed during crises in social information systems [26]. After 1577 both series show more regular oscillations but with a higher frequency in the change of affective states. Teresa seems to have been switching between high and low associative states and concurrently high and low states of emotional arousal – albeit at a faster rate of change.

Returning to the observed decoupling between change in the co-occurrence structure and affective valence. To further investigate the matter, we estimated possible change points using a mean shift model, see Fig. 1. Both series’ oscillation patterns are perturbed by a particular event, as evidenced by two event boundaries (1576 and 1577) in the co-occurrence structure that moves from global high to low to high (left) and one change point in affective valence (1575) from global low to high (right). This period (1575 to 1577) describes the beginning of Teresa’s confinement at the Castilian convent after several inquisitional tribunals. The tribunals date back to 1570 and end in 1575 when the inquisitional tribunal of Valladolid assigns Domingo Báñez to review Teresa’s autobiographical work *Life*<sup>2</sup> leading to her subsequent confinement. A low associative state characterizes the confinement, yet a progressive diversification in her affective state. Affective valence exhibits its global maximum leading up to her release. The co-occurrence structure, conversely, finds its global minimum during the confinement and its global maximum at her release from confinement in 1579. Towards the end of this confinement, Teresa establishes her more regular state-switching dynamic, which continues as she resumes her travels in Spain.

<sup>2</sup> *The Life of the Holy Mother Teresa of Jesus (La Vida de la Santa Madre Teresa de Jesús)*, colloquially referred to as *Life*, was Teresa’s autobiography, written between 1562-64 and published posthumously.



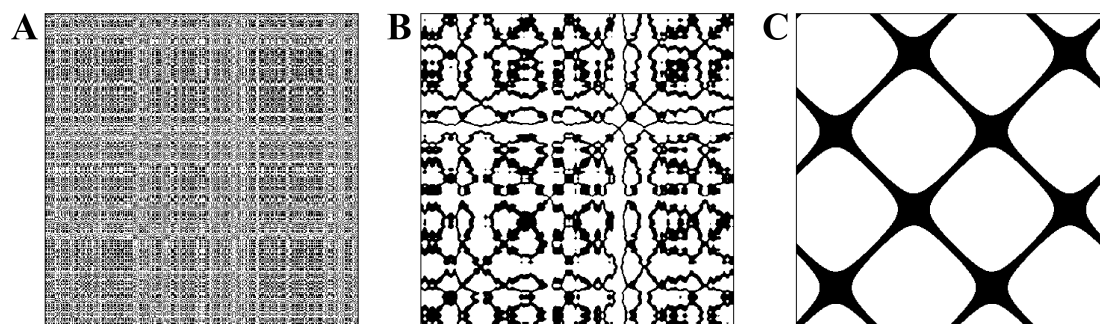


**Figure 2:** Resonance signals for the letters' co-occurrence structure (left) and affective valence (right).

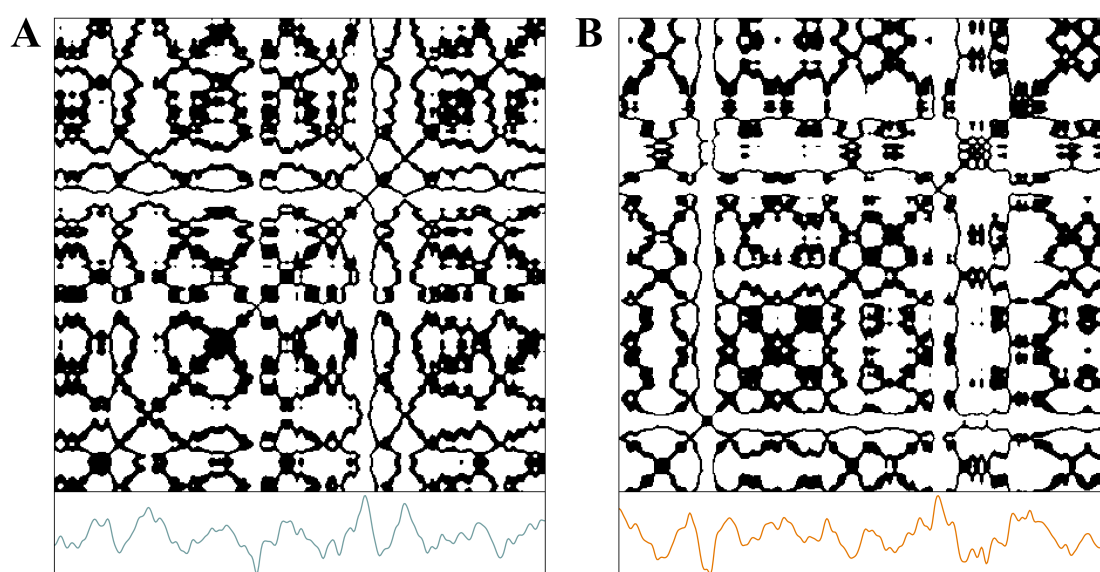
### 3.2. Resonant Recurrence and a Leaky-Bucket

Multi-scale state switching seems to be the general rule for resonance both in Teresa's co-occurrence structure and her affective valence; see Fig. 2. As with novelty, we find a higher frequency of affective state-switching after Teresa's release from confinement. The resonance decreases during the early confinement for her associative states and increases upon her release, but the dynamic is not robust enough to support an aforementioned crisis-driven decoupling from novelty [26]. This can be confirmed by the observation that neither resonance dynamic show statistically reliable change points. This is because corresponding transience increases or decreases balance increases and decreases in both novelty signals. In the case of Teresa's letters, we can think of their information flow using an analogy to the adaptive leaky bucket mechanism [38]. The leaky bucket parameter(s) dynamically changes, letting information out (transience) proportionally to the information that enters (novelty). The mechanism does, however, display a temporal delay, which can be observed in the oscillatory patterns of resonance. Periods of high resonance, when new information is more likely to persist, are interspersed with periods of low resonance, when less new information enters the system, in more or less regular intervals. Notice that this resonance pattern seems to occur at multiple time scales and, by extension, that the raw signal displays self-similarity over multiple time scales.

Finally, we inspect the auto-and cross-recurrence pattern in resonance for the co-occurrence structure and affective valence. Recurrence plots provide a descriptive technique to explore further the regularity of the observable oscillations in resonance (i.e., the state switching). Fig 3 is included for comparison and shows the recurrence patterns of two well-known signals: A) white noise and (C) a sinusoid at a given frequency. We observe a fine scale pattern in the sinusoid, while the white noise signal displays no apparent fine patterns. In the middle (B), we observe the recurrence pattern of resonance for the letters' co-occurrence structure. Notice how the maximum in the associative resonance series around Teresa's release in 1579 breaks the recurrence pattern.



**Figure 3:** Illustration of the resonance recurrence of the letters' co-occurrence structure when compared to recurrences observed in white noise and a sinusoid signal. From left to right: (a) White noise signal, (b) resonance signal, (c) a sinusoid signal.



**Figure 4:** From left to right: (a) resonance recurrence for the letters' co-occurrence structure, (b) recurrence of resonance based on affective valence.

The same pattern can be observed in Fig. 4 A, but compared to affective valence in B. Both A and B show a lacy pattern of recurrence, where resonance state-switching, a resonance landscape where minima and maxima are interchanging, is repeated persistently throughout the letter corpus at more or less regular intervals. From B, it can also be observed that in the latter part of the letters, Teresa increases the frequency and amplitude of the affective states, indicating more pronounced and well-demarcated states.

In summary, we first observe state-switching in novelty and resonance indicator variables in the letter's co-occurrence structure and affective valence from 1570 to 1582. After 1578-79 state-switching increased in frequency for affective valence. Second, information flow, as

measured by resonance, in the letter corpus is comparable to an adaptive leaky bucket with a time delay. Third, one particular event seems to perturb novelty, Teresa's confinement in 1575 and subsequent release in 1579. For most of the period, Teresa's associative state, as modeled on the letter's co-occurrence structure, decreased and returned to an all-time high upon her release. Conversely, Teresa's affective state, as modeled on the letter's affective valence, diversified throughout the confinement. Fourth, we find an associative and affective state decoupling during her imprisonment, especially in the early half.

## 4. Discussion

Teresa's letter corpus embodies a bistable author profile, as evidenced by the co-occurrence structure and affective valence. Indicator variables estimated on these text properties identify a switching dynamic between two attractor states in both associative and affective states. This switching dynamic is nicely mirrored in Teresa's paradoxical historical profile: As a nun and mystic, she practiced the Axial Age ascetic ideal through self-reflection, seclusion, and careful monitoring of internal states; but as a religious reformer, she *promoted* that very same emphasis on the private, inner-worldly experience as the ideal spiritual mode. From a certain perspective, Teresa's life and work here forecast 20<sup>th</sup>-century feminist theory's challenge to the public/private dichotomy [2]. The comparison to 20<sup>th</sup>-century feminist theory is not haphazard: though the public/private dichotomy was only (fully) articulated throughout the 19<sup>th</sup> century [15], and the application of the pair to an Early Modern context is anachronistic, the tension between the passive, en-cloistered, inner, spiritual ('private') life associated with women and the female experience, on the one hand, and the active, out-going, secular life associated with the male experience, so dominant in the Victorian period [8], was prevalent in the Early Modern period [47]. Teresa foreshadowed a strategy to ease the tension between the poles that came to flourish in the 19<sup>th</sup> century – a strategy often over-looked in 20<sup>th</sup>-century feminist theory: she used a religious platform to expand an inwardly defined agenda to encompass the outer world [6].

### 4.1. Contemplation and Revelation

The most striking finding is Teresa's switching between high and low information resonance states. In the first, she develops and diversifies ideas and emotions that resonate throughout her letters; in the second, she is in (self-)confinement and focuses on her inner life. In a terminology imported from Catholic/Christian discourse, we suggest that this pendulous alternation reflects states of *revelation* with high resonance and *contemplation* with low resonance; *insight* and *rumination* would be non-religious alternatives.

Following the Early Modern logic of and concern for 'sources of the self' [42], we notice how her state switching becomes more regular with time; this behavior will likely reflect the self-calibration or 'professionalization' of a mystic training herself through contemplative practices [21]. Especially her increased frequency of affective state switching seems similar to affective self-calibration seen in other mystical and ascetic practices [6]. In author profiling the self-similarity of information states, as exhibited by Teresa's letter corpus, has been linked to the burstiness of creative and inspirational states [27]. Returning to the leaky bucket metaphor of

the letter's information flow: when Teresa is in a state of revelation, bursts of new information are smoothed to keep a steady flow of states from revelation to contemplation regardless of the sometimes erratic information burstiness from external events (e.g. churchly sanctions) or internal events (e.g. mystical raptures).

#### 4.2. Confinement and Self-monitoring

Teresa's life history was characterized by confinement in more than one sense. She was confined to the Castilian convent after several inquisitional tribunals deemed it necessary, but self-confinement was also part of her monastic order, i.e., the Carmelites, ascetic practices as reflected in the cycles of contemplation and revelation. In addition, the Council of Trent's mandate for the claustration of nuns in 1563 was a part of the official religious backdrop of her day. And externally driven confinement (i.e., confinement on the initiative of the churchly officialdom) did impact her. In her letter, it translates into the information dynamics; we find a disproportionate decrease in the variation of associative states that lasted until her release but also an increased heterogeneity of her affective states. A possible interpretation is that while the forced convent confinement somewhat muted Teresa's revelatory experiences, it introduced a situation of spiritual urgency that amplified her awareness of fluctuations in her emotions and spiritual states. Spiritual exercises of self-evaluation inducing heightened religious self-awareness were in fashion in 16<sup>th</sup>-century Catholicism. The epitome of the trend was the manual *Exercitia spiritualia* or *Spiritual Exercises* published in 1548 and written by the Spanish priest and theologian Ignatius of Loyola (1491-1556), who founded the religious order *Societas Iesu*, the Society of Jesus better known as The Jesuits. They grew instrumental in the Catholic Church's response to the challenges posed in the post-Reformation period. The main point here is that, in her spiritual 'self-absorption,' Teresa followed a mainstream Catholic tendency.

#### 4.3. Limitations

From a methodological perspective, the analysis of Teresa's letter corpus provides a detailed example of how attention to the dynamic properties of single-author corpora can provide a handle on the underlying data-generating mechanisms of historical persons. To fully understand Teresa of Ávila, we would ideally have to monitor all intrinsic variables related to her psychological states and traits. This strategy, however, is clearly not possible for historical persons that are dead, but even for the living, it is not feasible; instead, we have reconstructed a limited set of scalar time series that capture critical states of Teresa's life history. These time series are, however, indicator variables that describe the state of the system, with temperature being the paradigmatic example. A limitation is that they do not allow for direct causal inference.

Another limitation of the current study is the reliance on English translations of Teresa's Spanish writings. While this choice was partly taken out of convenience due to data and tool availability, authoritative studies of Teresa use this data set [45]. In addition, we have conducted additional analysis to ensure that trends and artifacts that could originate in the translation process are not present, see Appendix A.

Finally, we know that "the map is not the territory," [18] and when mapping out the infor-

mational and affective flow in Teresa's letters, we do not assume any straightforward correspondence to her underlying mental states. The letters are ego documents ripe with rhetorical concerns and 'political' agendas, blurring their status as sources to her mental state. But (functional) maps do, nevertheless, retain certain relevant properties of the territory it seeks to represent. Here we trust that the proof of the pudding is in the eating – that our findings prove convincing.

## References

- [1] F. M. P. del Arco, C. Strapparava, L. A. U. Lopez, and M. T. Martín-Valdivia. “EmoEvent: A multilingual emotion corpus based on different events”. In: *Proceedings of the 12th Language Resources and Evaluation Conference*. Marseille, 2020, pp. 1492–1498. URL: <http://aclanthology.org/2020.lrec-1.186>.
- [2] D. Bair. “Simone de Beauvoir: Politics, Language, and Feminist Identity”. In: *Yale French Studies* 72 (1986), pp. 149–162. URL: <https://www.jstor.org/stable/2930232>.
- [3] A. T. J. Barron, J. Huang, R. L. Spang, and S. DeDeo. “Individuals, institutions, and innovation in the debates of the French Revolution”. In: *Proceedings of the National Academy of Sciences* 115.18 (2018), pp. 4607–4612. URL: <https://doi.org/10.1073/pnas.1717729115>.
- [4] R. N. Bellah. *Religion in Human Evolution: From the Paleolithic to the Axial Age*. First Edition. Cambridge, Mass: Belknap Press, 2011.
- [5] D. M. Blei, A. Y. Ng, and M. I. Jordan. “Latent Dirichlet Allocation”. In: *Journal of Machine Learning Research* 3 (2003), pp. 993–1022. URL: <http://dx.doi.org/10.1162/jmlr.2003.3.4-5.993>.
- [6] D. T. Bradford. “Emotion in mystical experience”. In: *Religion, Brain & Behavior* 3.2 (2013), pp. 103–118. URL: <http://www.tandfonline.com/doi/abs/10.1080/2153599X.2012.703004>.
- [7] E. Carrera. *Emotions and health, 1200-1700*. Studies in medieval and Reformation traditions ; v. 168. Leiden; Boston: Brill, 2013.
- [8] L. Davidoff. “Class and Gender in Victorian England”. In: *Sex and Class in Women’s History*. London: Routledge, 2012, pp. 27–81.
- [9] C. Eire. *The Life of Saint Teresa of Avila: A Biography*. Illustrated edition. Princeton: Princeton University Press, 2019.
- [10] P. Ekman. “An argument for basic emotions”. In: *Cognition and Emotion* 6.3-4 (1992), pp. 169–200. URL: <https://doi.org/10.1080/02699939208411068>.
- [11] J. Gao, Y. Cao, W.-w. Tung, and J. Hu. *Multiscale Analysis of Complex Time Series: Integration of Chaos and Random Fractal Theory, and Beyond*. 1 edition. Hoboken, N.J: Wiley-Interscience, 2007.
- [12] J. Gao, J. Hu, X. Mao, and M. Perc. “Culturomics meets random fractal theory: insights into long-range correlations of social and natural phenomena over the past two centuries”. In: *Journal of The Royal Society Interface* 9.73 (2012), pp. 1956–1964. URL: <https://doi.org/10.1098/rsif.2011.0846>.
- [13] M. Grootendorst. *BERTopic: Neural topic modeling with a class-based TF-IDF procedure*. 2022. arXiv: 2203.05794 [cs.CL].
- [14] J. Guldi. “The Measures of Modernity: The New Quantitative Metrics of Historical Change Over Time and Their Critical Interpretation”. In: *International Journal for History, Culture and Modernity* 7.1 (2019), pp. 899–939. URL: <http://doi.org/10.18352/hcm.589>.
- [15] J. Habermas. *Strukturwandel der Öffentlichkeit: Untersuchungen zu einer Kategorie der bürgerlichen Gesellschaft*. 1. Aufl edition. Frankfurt am Main: Suhrkamp, 1990.

- [16] L. Hansen, L. R. Olsen, and K. Enevoldsen. “TextDescriptives: A Python package for calculating a large variety of metrics from text”. In: *Journal of Open Source Software* 8.84 (2023), p. 5153. URL: <https://doi.org/10.21105/joss.05153>.
- [17] R. Killick, P. Fearnhead, and I. A. Eckley. “Optimal detection of changepoints with a linear computational cost”. In: *Journal of the American Statistical Association* 107.500 (2012), pp. 1590–1598.
- [18] A. Korzybski. *Science and Sanity. An Introduction to Non-Aristotelian Systems and General Semantics*. New York City: The International Non-Aristotelian Library Pub Co., 1933.
- [19] E. A. Lefffeldt. *Religious Women in Golden Age Spain: The Permeable Cloister*. 1st edition. Aldershot, Hamps., England Burlington, VT: Routledge, 2005. 252 pp.
- [20] D. MacCulloch. *Reformation: Europe’s House Divided 1490-1700*. 38831st edition. London New York, NY Toronto: Penguin UK, 2004.
- [21] B. Morgan. *On Becoming God: Late Medieval Mysticism and the Modern Western Self*. 1st edition. New York: Fordham University Press, 2012.
- [22] J. Murdock, C. Allen, and S. DeDeo. “Exploration and exploitation of Victorian science in Darwin’s reading notebooks”. In: *Cognition* 159 (2017), pp. 117–126. URL: <https://doi.org/10.1016/j.cognition.2016.11.012>.
- [23] D. Q. Nguyen, T. Vu, and A. Tuan Nguyen. “BERTweet: A pre-trained language model for English Tweets”. In: *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: System Demonstrations*. Online: Association for Computational Linguistics, 2020, pp. 9–14. URL: <https://aclanthology.org/2020.emnlp-demos.2>.
- [24] D. Nguyen, M. Liakata, S. DeDeo, J. Eisenstein, D. Mimno, R. Tromble, and J. Winters. “How we do things with words: Analyzing text as social and cultural data”. In: *Frontiers in Artificial Intelligence* 3 (2020), p. 62. URL: <https://doi.org/10.3389/frai.2020.00062>.
- [25] K. Nielbo, P. Vahlstrup, and A. Bechmann. “Trend Reservoir Detection: Minimal Persistence and Resonant Behavior of Trends in Social Media”. In: *Proceedings of the Workshop on Computational Humanities Research (CHR 2020)*. Vol. 1. Amsterdam, the Netherlands, 2021, pp. 290–297. URL: <https://ceur-ws.org/Vol-2723/short3.pdf>.
- [26] K. Nielbo, K. Enevoldsen, R. Baglini, E. Fano, A. Roepstorff, and J. Gao. “Pandemic news information uncertainty—News dynamics mirror differential response strategies to COVID-19”. In: *Plos One* 18.1 (2023), pp. 1–16. URL: <https://doi.org/10.1371/journal.pone.0278098>.
- [27] K. L. Nielbo, K. F. Baunvig, B. Liu, and J. Gao. “A curious case of entropic decay: Persistent complexity in textual cultural heritage”. In: *Digital Scholarship in the Humanities* 34 (2019). URL: <https://doi.org/10.1093/lc/fqy054>.
- [28] K. L. Nielbo, R. Nichols, and E. Slingerland. “Mining the Past – Data-Intensive Knowledge Discovery in the Study of Historical Textual Traditions”. In: *Journal of Cognitive Historiography* 3.1-2 (2017), pp. 93–118. URL: <https://doi.org/10.1558/jch.31662>.
- [29] K. L. Nielbo, F. Hastrup, K. C. Enevoldsen, P. B. Vahlstrup, R. B. Baglini, and A. Roepstorff. *When no news is bad news – Detection of negative events from news media content*. 2021. arXiv: 2102.06505 [cs.CY]. URL: <https://arxiv.org/abs/2102.06505>.

- [30] K. Nielbo, M. Perner, C. Larsen, J. Nielsen, and D. Laursen. “Automated compositional change detection in Saxo Grammaticus’ *Gesta Danorum*”. In: *Digital Humanities in the Nordic Countries, 4th Conference, DHN2019*. Vol. 2364. Copenhagen, Denmark: ceur workshop proceedings, 2019, pp. 321–332. URL: <https://cst.dk/DHN2019/DHN2019.html>.
- [31] M. P. Oakes. “Author Profiling and Related Applications”. In: *The Oxford Handbook of Computational Linguistics*. Oxford: Oxford University Press, 2022, pp. 1165–1197. URL: <https://doi.org/10.1093/oxfordhb/9780199573691.013.53>.
- [32] E. Ott. *Chaos in Dynamical Systems*. 2nd ed. Cambridge: Cambridge University Press, 2002. URL: <https://www.cambridge.org/core/books/chaos-in-dynamical-systems/7A0749AE3FBBF4312A54D7573C2DAAB5>.
- [33] B.-C. Otto. “Magic and religious individualization : on the construction and deconstruction of analytical categories in the Study of Religion”. In: *Historia religionum : an international Journal* : 9, 2017 9 (2017), pp. 29–52. URL: <https://doi.org/10.19272/201704901003>.
- [34] N. H. Packard, J. P. Crutchfield, J. D. Farmer, and R. S. Shaw. “Geometry from a Time Series”. In: *Phys. Rev. Lett.* 45.9 (1980), pp. 712–716. URL: <https://link.aps.org/doi/10.1103/PhysRevLett.45.712>.
- [35] J. M. Pérez, J. C. Giudici, and F. Luque. *pysentimiento: A Python Toolkit for Sentiment Analysis and SocialNLP tasks*. 2021. arXiv: 2106.09462 [cs.CL]. URL: <https://doi.org/10.48550/arXiv.2106.09462>.
- [36] L. Perfetti, ed. *The Representation of Women’s Emotions in Medieval and Early Modern Culture*. First Edition. Gainesville: University Press of Florida, 2005.
- [37] T. Sauer, J. A. Yorke, and M. Casdagli. “Embedology”. In: *Journal of Statistical Physics* 65.3 (1991), pp. 579–616. URL: <https://doi.org/10.1007/BF01053745>.
- [38] M. Shrivastav and S. Gonnade. “An Adaptive Leaky-Bucket Mechanism for Traffic Management in OBS Networks”. In: *International Journal of Engineering Sciences & Research Technology* 3.2 (2014), pp. 949–955.
- [39] C. Slade. *St. Teresa of Avila: Author of a Heroic Life*. First Edition. Berkeley: University of California Press, 1995. 238 pp.
- [40] P. Sloterdijk. *God’s zeal : the battle of the three monotheisms*. English. Cambridge: Polity, 2009.
- [41] F. Takens. “Detecting strange attractors in turbulence”. In: *Dynamical Systems and Turbulence, Warwick 1980*. Ed. by D. Rand and L.-S. Young. Berlin, Heidelberg: Springer Berlin Heidelberg, 1981, pp. 366–381.
- [42] C. Taylor. *Sources of the self: the making of the modern identity*. Cambridge, MA: Harvard University Press, 1989. 601 pp.
- [43] C. Truong, L. Oudre, and N. Vayatis. “Selective review of offline change point detection methods”. In: *Signal Processing* 167 (2020), p. 107299. URL: <https://doi.org/10.1016/j.sigpro.2019.107299>.



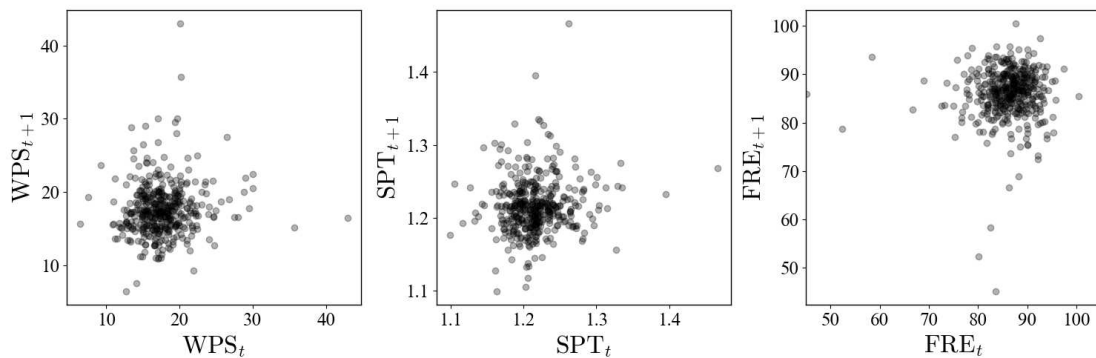
- [44] E. Vrangbæk and K. Nielbo. “Composition and Change in De Ciuitate Dei: A Case Study of Computationally Assisted Methods”. In: *Papers presented at the Eighteenth International Conference on Patristic Studies held in Oxford 2019*. Vol. 14: Augustine of Hippo’s De ciuitate Dei: Content, Transmission, and Interpretations. Studia Patristica. Leuven: Peeters, 2021, pp. 149–164. URL: <https://doi.org/10.2307/j.ctv27vt566.14>.
- [45] A. Weber. *Teresa of Avila and the Rhetoric of Femininity*. Princeton: Princeton University Press, 1990. URL: <https://chooser.crossref.org/?doi=10.2307%5C%2Fj.ctv15r5dsh>.
- [46] M. Wevers, J. Kostkan, and K. L. Nielbo. “Event Flow - How Events Shaped the Flow of the News, 1950-1995”. In: *Proceedings of the Conference on Computational Humanities Research 2021*. Vol. 2989. CEUR Workshop Proceedings. Amsterdam, the Netherlands: CEUR-WS.org, 2021, pp. 62–76. URL: <https://ceur-ws.org/Vol-2989/long%5C%5Fpaper16.pdf>.
- [47] M. E. Wiesner. *Women and Gender in Early Modern Europe*. Cambridge England ; New York, NY, USA: Cambridge University Press, 1993.
- [48] L. Woodhead, ed. *Reinventing Christianity: Nineteenth-Century Contexts*. 1st edition. London New York (N.Y.): Routledge, 2019.

## Appendix: A

### Translation artifacts and descriptive statistics of the letter corpus

We calculated a range of readability metrics on the letter corpus. Namely, Flesch reading ease, which ranges from 0 (most difficult to read) to 100 (easiest to read). Scores are based on the average number of words per sentence and the average number of syllables per word in a document, which are the other two metrics plotted in Figure A1. The metrics were calculated automatically [16] from raw texts and so relied on accurate English tokenization. The model utilized for this task was spaCy’s `en_core_web_lg 3.6.0`<sup>3</sup>.

If the reading ease of either Teresa’s original letters, or their English translations increases or decreases over time, one would expect the readability scores to be auto-correlated (indicated by a linear pattern, when a variable is plotted against a lagged version of itself). The points in our lag plots (Figure A1) do not seem to form a linear pattern at lag=1. Based solely on a visual examination of the plot, it appears that there is no discernible trend (strong increase or decrease over time) pertaining to letter readability.

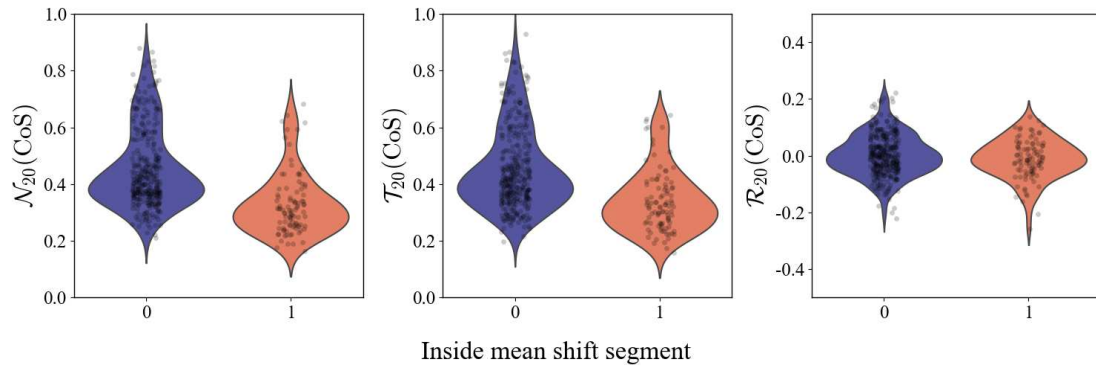


**Figure A1:** Lag plot of selected text statistics (on the x-axis are values at time  $t$ , while on the y-axis are values at the following time point,  $t + 1$ ). Text statistics are, from left to right: WPS, the average number of words per sentence across a document, SPT, the average number of syllables per token across a document, and FRE, Flesch reading ease. Calculated on raw texts. See also Figure A3 for densities.

### Mean shift in Novelty during Teresa of Avila’s confinement

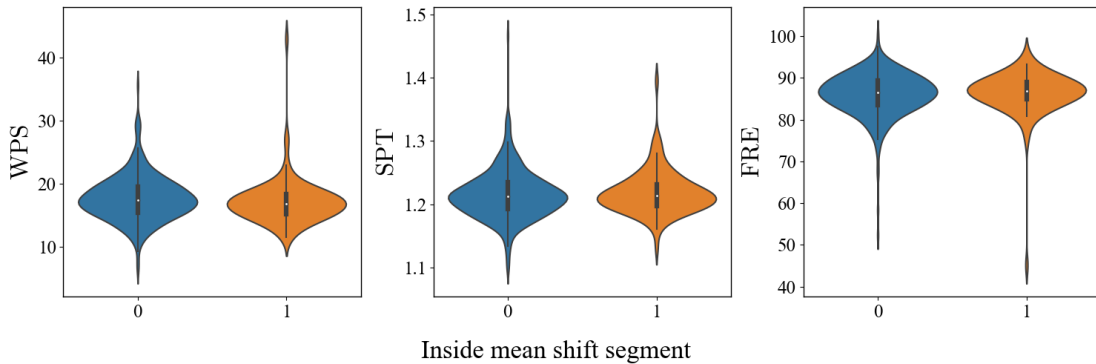
As an additional illustration of the change point detection results we reported in Figure 1, we plot probability distribution densities of the indicator variables (in Figure A2). This comparison entails examining the distributions of indicator variables for letters located within the mean shift segment (between the two identified change points in CoS novelty) and contrasting them with the remaining scores. For resonance, the density is highest around 0, both for letters inside and outside of the mean shift segment (see the oscillation pattern in Figure 2). On the other hand, the averages of novelty and transience seem lower during the mean shift segment. Note that this visualization illustrates the predictions of a change point detection model, and it should not be interpreted as a significance test.

<sup>3</sup>[https://spacy.io/models/en/#en\\_core\\_web\\_lg](https://spacy.io/models/en/#en_core_web_lg)



**Figure A2:** Densities of novelty, transience, and resonance scores based on co-occurrence structure in text. Mean shift=1 indicates data points falling into the intermediate segment between the two found change points (highlighted in orange in Figure 1, N=96). Mean shift=0 corresponds to the remaining data points (N=323).

As a sanity check of the reliability of the reported mean shift segment, Figure A3 compares the densities of readability scores. The densities do not seem to differ very much, having a similar mode and median for all metrics inside or outside of the mean shift segment. The exception to this are the outliers falling inside the mean shift segment. There seem to be a few hard-to-read letters (based on FRE), likely due to containing long sentences (contrast the long tails of the mean shift=1 distribution in the WPS and FRE subplots).



**Figure A3:** Densities of readability scores, from left to right: WPS, the average number of words per sentence across a document, SPT, the average number of syllables per token across a document, and FRE, Flesch reading ease. Calculated on raw texts. Box plots inside the violins indicate quartiles.