

What six decades of medical research tell us about social movements? Evidence from word embeddings on menstruation

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This article presents an analysis of a corpus of 85,777 abstracts of articles from the PubMed platform, known for its huge database of health articles. By applying Natural Language Processing techniques, my goal is to analyze which associations are made to the term ‘menstruation’ and how they have changed over time. Particularly, the generation of word embeddings is key to capturing the similar terms and surrounding themes to ‘menstruation’. In addition to the generation of word embeddings, a bootstrap resampling analysis is added to the methodology to ensure robustness. Results point to the changes in meaning over the years, and the association with themes more related to public health and social movements today.

Keywords: natural language processing; word embeddings; menstruation; health communication

Introduction

Menstruation is still seen as an embarrassment by societies, despite feminist activism and constant claims for ending menstrual taboos (Gottlieb, 2020). The publication of ‘Our Bodies Ourselves’ in the 1970s, following the feminists urge for equality was historical for the popular knowledge of women’s health (Bobel, 2008). However, five decades later, research emphasizes that nowadays menstruation is still regarded as ‘shameful’ or to be ‘hidden’ (Johnston-Robledo & Chrisler, 2020). In the medical arena, menstruation is still understudied, and requires more efforts toward related diseases, society education, and a more patient-centric approach (Critchley et. al 2020). This idea converges with social studies, that also claim that medical views of women’s health are

based on “medicalization” (Purdy, 2001) and “pathologizing” (Ussher et al., 2007). In the first case, studies are driven by interests of establishing medical procedures or treatments for issues once seen as normal. In the second case, studies focus only on diseases, and not in other aspects of the theme (such as a holistic idea of well-being or public health).

Drawing on the understanding that medical research aims to address the patients’ agenda, the objective of this paper is to analyze how the medical community historically researched menstruation, and to what extent the research covered societal claims. Since health journals are the major source of knowledge in medical communities, my research focuses on examining abstracts from papers over a period of six decades (from 1960 to 2019). To collect the articles in structured data, I built a script that consults PubMed’s API to gather the data, in a total of 85,777 articles. I chose to use abstracts in this paper because they are author-curated expressions of the central topics and discoveries of each article. I hypothesize that the theme has become more complex along the decades, attempting to address society’s needs.

To capture the changes in the attitudes of health researchers about menstruation, I applied the theoretical framework of word embeddings, whose property is to detect word meanings and similarities. According to the work from Garg et al. (2018), the comparison of word embeddings through time can capture a change in semantics that reflects a change in behavior toward subjects. In their work, the authors examined attitudes concerning gender and race in the United States, capturing meaning variation over a century, and assessing specific lexicon for measuring changes.

For defining which lexicon are the focus of my analysis, I considered the most prominent topics of ‘Our Bodies, Ourselves’. Since its conception, this book was a cultural mark, and it is still a health empowerment symbol. I retrieved the main terms

from the book to measure their meanings and similarities in my quantitative analysis. For historical comprehension, the 1971 and the 2011 editions have their chapters and related terms compared to those generated by the word embeddings in the correspondent decades. In addition to the word embeddings generation, I ran a bootstrap resampling analysis, to ensure the validity of the similarity metrics. Results point that the meanings of menstruation dislocated from general concerns about symptoms (1970s) to a broader spectrum of topics (2010). Menstruation is still studied by its symptoms and related diseases; however, it is now addressed as a broader topic, with terms that characterize a public health problem (2010s).

The article is organized as follows: Section 2 brings the theoretical framework on how word embeddings are applied in historical studies of meaning, and a brief review on both gender studies and NLP and medical studies and NLP; Section 3 details the corpus retrieval, and techniques employed for text processing and quantitative analysis; Section 4 discusses the results from the word embeddings. Finally, I present the conclusions and the limitations of the study.

Theoretical Framework

Word embeddings are representations of words in a low-dimensional continuous space. Deriving from Vectorial Semantics as linguists like Harris (1954) defined, it determines a meaning of a word according to its neighbors on a text. Through this technique, it is possible to represent the context of words. In the last decade, (Mikolov, Le, et al., 2013; Mikolov, Sutskever, et al., 2013) and Pennington et al. (2014) developed respectively Word2Vec and GloVe, algorithms that generate word embeddings. Since then, researchers from multiple areas developed studies using word embeddings as a tool to quantify changes in word meaning. Also, studies have applied word embeddings as a theoretical framework to quantify changes in societal behavior toward issues, using

historical corpora to assess such changes.

Addressing the matter of how word-meaning variation reflects changes in societal behavior, some Computational Social Science works have been developed. Among them, the work from Garg et al. (2018) studies how stereotypes associated with gender and race changed over the course of 100 years; similarly, Kozłowski et al. (2019) assess how the understanding of “class” changed in 100 years. More recently, Card et al. (2022) studied how attitudes toward immigration changed through congress speeches, also analyzing how Republicans and Democrats differ in opinions on this subject.

Regarding gender studies, NLP methods and word meaning variation are broadly applied to detect gender biases in language; Mihalcea and Garimella (2016) studied the particularities in which women and men express themselves differently, working in a discourse disambiguation project. Another line of research is on hate speech and Violence Against Women (VAW), with the development of algorithms that detect and classify texts with misogynistic vocabulary (Fortuna & Nunes, 2018; Fulper et al., 2014; García-Díaz et al., 2021).

In the medical arena, the application of NLP toward word meaning is growing. One example is the study of symptoms: according to Koleck et al. (2019), ‘pain’ and ‘sleep disturbance’ are the most studied symptoms by NLP methods. In PubMed, around 100 NLP works are published annually (Wang et al., 2020). However, works using PubMed’s database, considering specific lexicon and word meaning variation, are still rare. One example is from Tighe et al. (2015), where the authors analyze different manners of describing pain. In this paper, I address how the medical approaches to a concept varied through decades. As far as I know, this is a novelty in studies with PubMed’s corpora.

Contributing to the works mentioned in this Section, the present study aims to apply the study of how the meanings over six decades indicate changes in society, combining the techniques from previous Computational Social Science, gender studies, and the database from PubMed.

Materials and methods

Data was collected from PubMed's proprietary API, using a Python script to organize information in data frames; the keywords used to retrieve articles were 'menstruation' and its variants, 'menstruations,' 'menses,' and 'menarche.' After the collection, the data was preprocessed with tokenization and cleaning using nltk and spaCy packages for Python¹.

The preprocess resulted in 85,777 articles, with approximately 69 million tokens. For improving the precision of my embedding estimates, I randomly selected 30 bootstrapped samples for each decade and averaged them, as recommended by Antoniak and Mimno (2018). These authors observed that bootstrap is particularly desirable for small corpora. The previously cited article from Kozłowski et al. (2019) also use bootstrap to generate word embeddings. The word embeddings were trained with Word2Vec and GloVe for the sake of robustness. To detect similar terms, the cosine similarity between specific lexicon and 'menstruation' was calculated in the data analysis process.

¹ Both are open software, respectively available on <https://www.nltk.org/> and <https://spacy.io/>

Besides the techniques for capturing semantical contexts, the specific lexicon was based on two editions of ‘Our Bodies, Ourselves’. The first edition is from 1971 (Boston Women's Health Course Collective and New England Free Press 1971), and the second one is from 2011 (Norsigian et al., 2011). One of the most striking features is that the latest edition is almost 900 pages long while the 1971’s edition has approximately 200 pages. By analyzing the editions, it is possible to see the topics concerning women’s health became more complex. In 1971, there was already an idea of facing social issues, however, the 2011 edition has advances on this direction, featuring stories from women of different origins, and dedicating chapters for body image, identity, violence against women, public health system, and environmental issues.

Taking the changes on the book into account, the Table 1 was filled with the lexicon to analyze the word embeddings, using the parts from the 2011’s book as a guideline.

Table 1. Terms from OBOS

Parts from the book	Terms
Bodies and Identities*	Body, identity
Relationships and Sexuality	Relationship, sexuality
Sexual Health and Reproductive Choices	Pregnancy
Childbearing	Pregnancy
Post reproductive Years*	Perimenopause
Medical Problems and Navigating the Health Care System*	Politics, Activism
Major Forces Affecting Women’s Sexuality and Reproductive Health*	Politics, Activism

*Parts that most chapters are not addressed in the first edition

From Table 1, we can imply that the most recent edition of OBOS addresses beyond general concerns of symptoms and physiological characteristics of menstruation. This edition also brings information regarding women’s health and its intersections with public health — vital issues for economic development and equity in

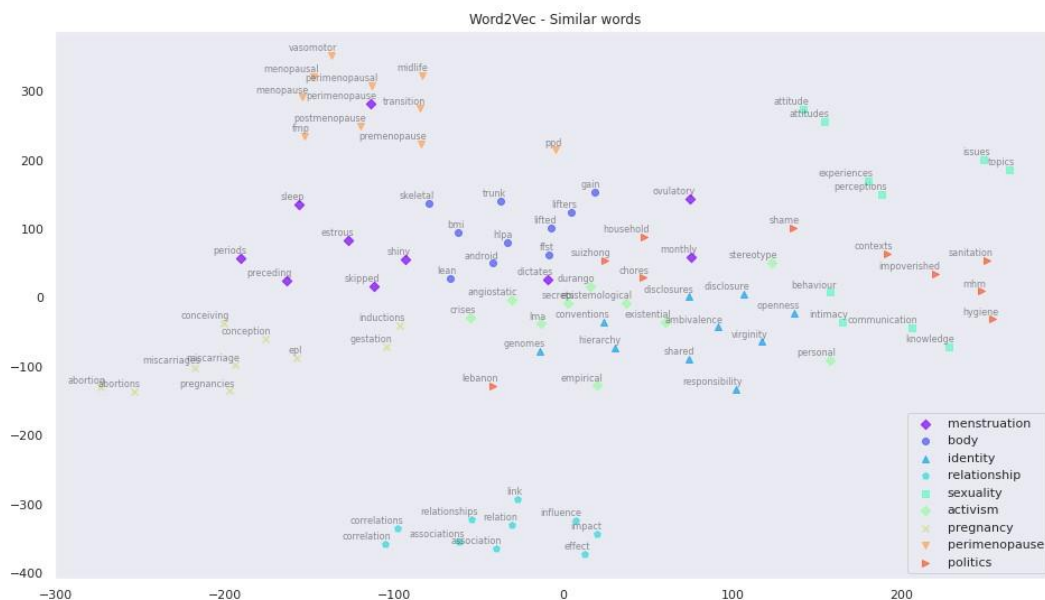
society. Medical conditions (cancer, abnormal uterine bleeding, endometriosis), reproductive choices, and parenting were not considered in the study. Such themes require a vast and specific lexicon, which is not the focus of this article, instead, the aim to verify if the themes contained in ‘Our Bodies, Ourselves’ (OBOS) became more addressed in health studies over the past six decades.

Findings and discussion

1960 to 2019 aggregated data

In this first part of the analysis, the word embeddings from the whole corpus of 85,777 abstracts were generated by Word2Vec and GloVe. Figure 1 and Figure 2 concentrate on the results reported by term from OBOS, respectively by Word2Vec and GloVe.

Figure 1. The 10 most similar words from OBOS terms — Word2Vec



Concerning medical dimensions, four terms are clearly located in this segment.

Beginning with ‘menstruation,’ the most similar terms usually have a relation with the

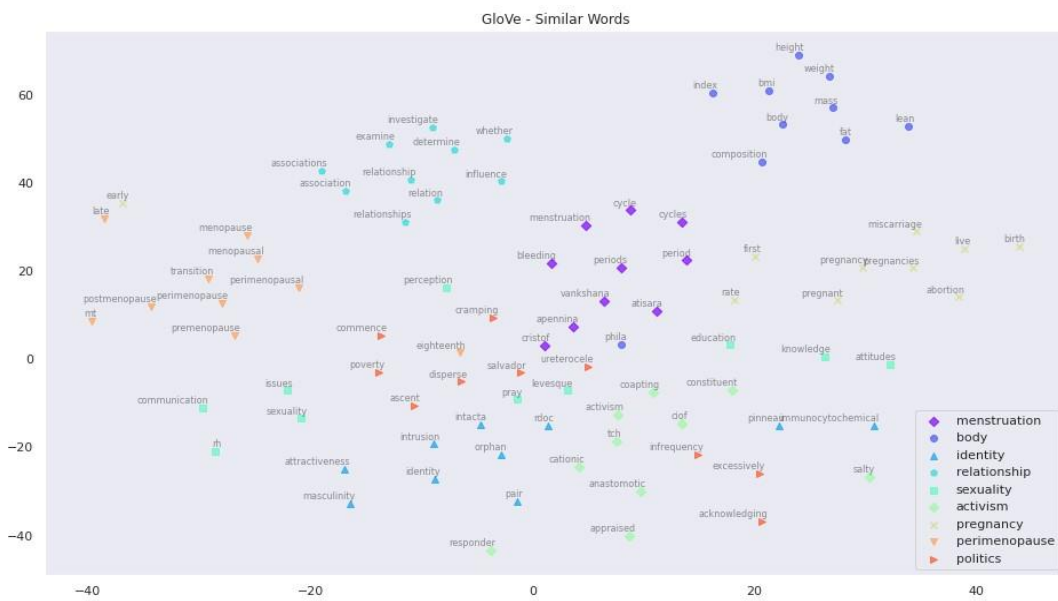
cycle, regularity, and symptoms (such as ‘monthly,’ ‘skipped,’ and ‘ovulatory’). Considering ‘body,’ ‘BMI’ (body mass index) and ‘lean’ indicate their association with weight. ‘Perimenopause’ and ‘pregnancy’ are other terms that are undeniably on the medical dimension: the representations of these terms concentrate on the left side of the chart.

In relation to social and cultural dimensions, ‘identity’ is linked to aspects that are divergent. On one hand, there are terms such as ‘conventions,’ ‘openness,’ and ‘hierarchy’ that seem rooted in social aspects. On the other hand, the term ‘genomes’ indicates a medical dimension to the word: identity being in the genes. For another ambiguous term, ‘relationship,’ the word embeddings captured relations with terms such as ‘association’ and ‘correlation’. Social and cultural dimensions (such as friendships) were not present on the map. ‘Sexuality’ is related to ‘attitudes,’ ‘experiences,’ but also with ‘communication’ and ‘knowledge’. Also, ‘activism’ is related to knowledge in ‘epistemological.’

The most revealing feature is ‘politics,’ which is similar to many terms that include social and cultural experiences. ‘Impoverished,’ ‘sanitation,’ ‘household,’ and ‘hygiene’ are examples of terms related to public health. An important cultural aspect is ‘shame’: the association of this negative feeling with menstruation is constantly regarded as the reason why women do not want to share their experiences with their periods. ‘Chores’ locate women and menstruation at home, with domestic obligations.

Moving forward, word embeddings were trained with GloVe algorithm and plotted in a chart (Figure 2) with the same layout for comparison.

Figure 2. The 10 most similar words from OBOS terms — GloVe



Although some plotted terms on the map differ from one model to another, some contexts are similar. Differently from Word2Vec, the medical-related terms are located specifically on the top part of the chart, whereas the cultural and social dimensions are mostly at the bottom part. ‘Menstruation’, ‘pregnancy’, and ‘menopause’ are related mostly to medical related terms. One difference is that the GloVe method also captured some substances such as ‘atisara’, which is used in ayurvedic medicine.

In ‘identity’, ‘attractiveness’ and ‘masculinity’ are two aspects not in Word2Vec and that might indicate cultural dimensions of menstruation (usually associated with femininity). ‘Sexuality’ is associated with ‘communication’, similarly to the result of Word2Vec. Also, ‘politics’ indicates a relation with ‘poverty’, that has the same root as ‘impoverished’, detected by Word2Vec.

According to both models, ‘menstruation’, ‘pregnancy’ and ‘perimenopause’ are deeply connected with ‘medical’ aspects, almost opposed to public health terms. In both charts, the location of more ‘medicalized’ terms is clearly apart from

‘social’ terms. Although this overview offered a broad perspective on the subject, a more in-depth analysis is required for understanding each decade. Since Word2Vec and GloVe captured similar contexts, I proceed to the next round of analysis with Word2Vec and bootstrap analysis.

Data per decade: from 1960 to 2019

For the analysis of the decades, first, I isolated the 5 more similar terms to ‘menstruation’ as can be verified in Table 2. Menstruation patterns, such as cycle length, incidence, and regularity, are the most observed similar terms even across decades. As in the overview analysis, menstruation seems to still be thought of a set of symptoms.

Table 2. Five most similar terms to ‘menstruation’

1960	1970	1980	1990	2000	2010
ovulatory	cycle	latency	first	ovulatory	ovulatory
periods	woman	cycle	last	cycle	skipped
bleeding	days	woman	period	subsequent	ovulation
monthly	treatment	experienced	abortion	length	perimenopause
sleep	cycles	cycles	incidence	woman	regularity

When trying another approach, I analyzed the selected terms from OBOS, splitting them in two charts. The first one, in Figure 3, contains the word embeddings from the 1970s, and the second one, in Figure 4, contains the word embeddings from the 2010s.

Figure 3. Similar terms to OBOS topics in the 1970s

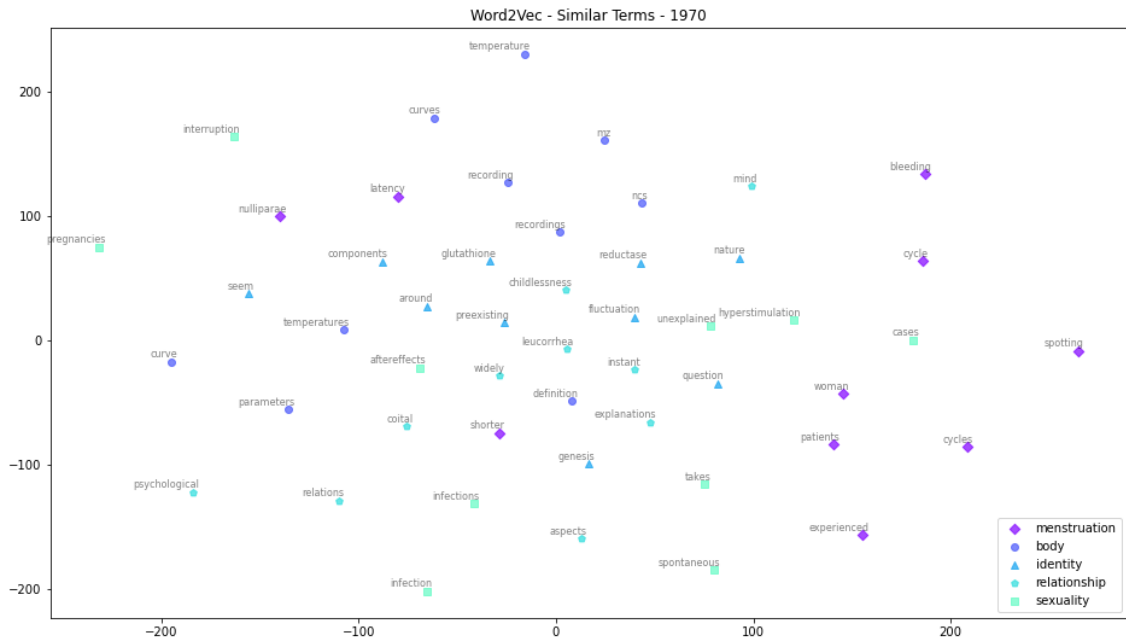
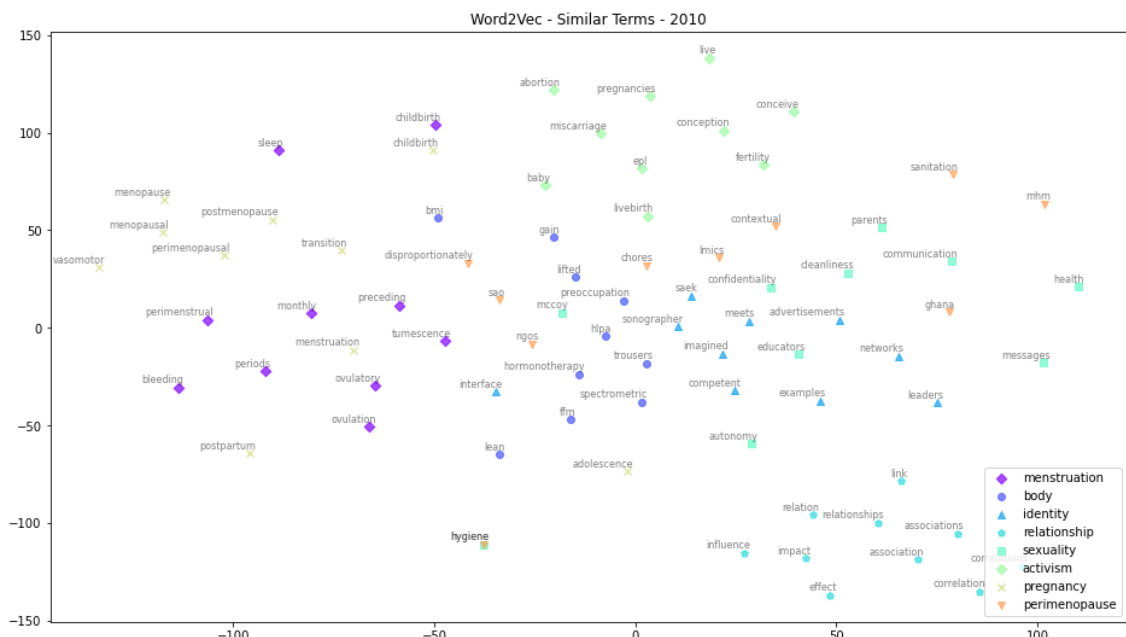


Figure 4. Similar terms to OBOS topics in the 2010s



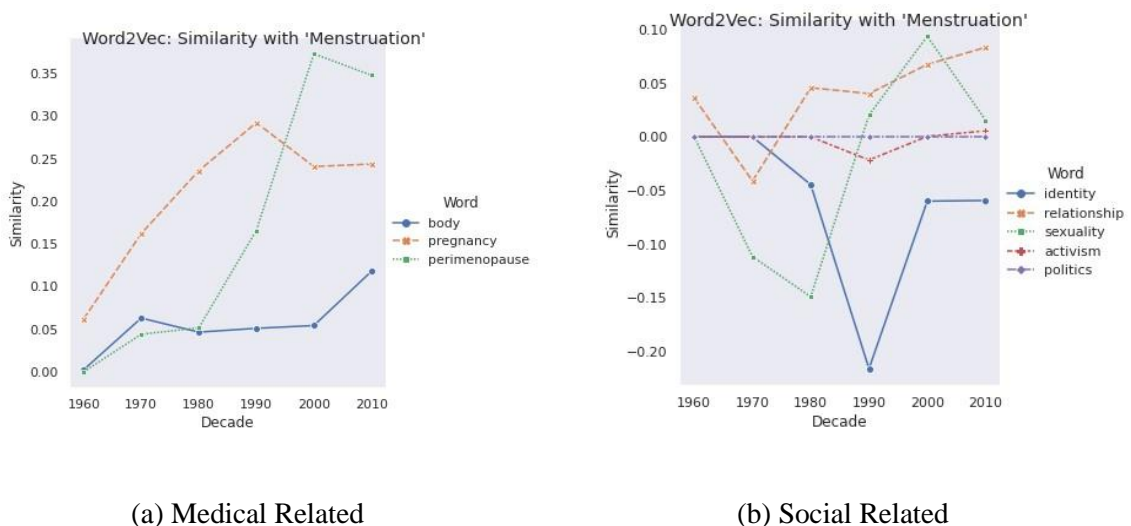
Three terms were not considered in the 1970s: ‘activism’, ‘pregnancy’, and ‘perimenopause’. Regarding their meanings in the 2010s, ‘activism’ is close to ‘abortion’, ‘fertility’, and ‘hygiene’, which are flags that social activists usually defend.

‘Pregnancy’ is related to ‘childbirth’, but also to ‘menopause’ and ‘postmenopause’, two phases that comprise older women. ‘Perimenopause’ is related to ‘sanitation’, ‘chores’, and ‘Ghana’, probably referring to the country where a study was realized.

Despite having new topics emerging in the 2010s, some terms had their meaning changed. For example, ‘identity’ is now related to ‘advertisement’, while ‘sexuality’ refers to ‘parents’, ‘autonomy’, and ‘health’. Also, body is associated with “preoccupation”. Those are all aspects that are in accordance with the new views of menstruation as a broader health topic, not only summarized by the explanation of the cycles and the ‘medical’ aspects.

By isolating the terms and comparing how similar to ‘menstruation’ they are through the decades, I constructed two charts. Chart (a) illustrates the terms more related to ‘medical’ views (‘body’, ‘pregnancy’, and ‘perimenopause’).

Figure 5. Similarity with Menstruation through Decades

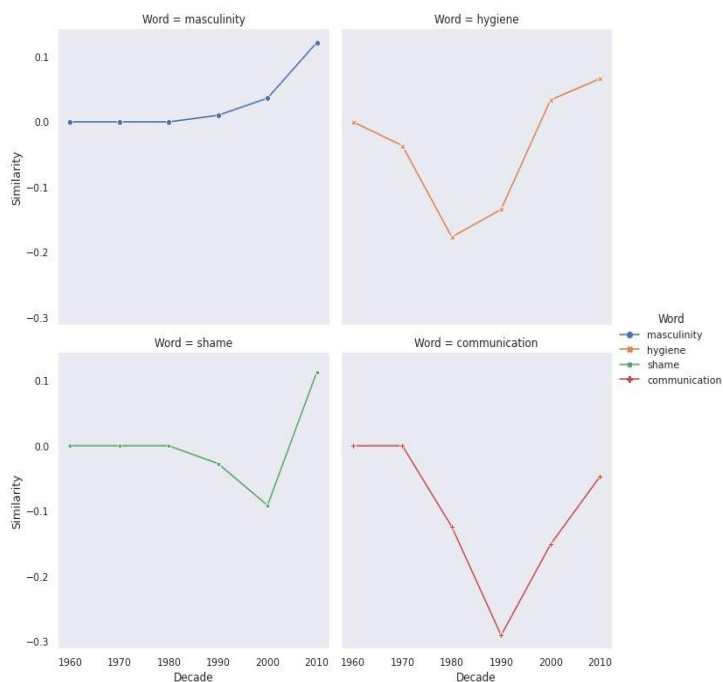


On one hand, ‘pregnancy’ rises from 1960s to 1990s, registering a reduction in the 2000s. On the other hand, ‘perimenopause’ has the more expressive growth from 1990s to 2000s. ‘Pregnancy’ reaches 0.30 of similarity in the 1990s, while ‘perimenopause’ surpasses 0.35 in the 2000s. Terms related to social issues are plotted

in (b). All terms have low similarity to ‘menstruation’, except from ‘sexuality’ that is slightly more similar in the 2000s.

A further selection of social and political terms, based on the chart from Figure 1, showed more insightful results in Figure 6.

Figure 6. Similarity with Menstruation through Decades



When plotting ‘masculinity’, ‘hygiene’, ‘shame’, and ‘communication’, there is a movement upwards from the last couple of decades. These subjects, all related to social issues, rise in similarity to ‘menstruation’, following the trend of increasingly social concerned studies.

‘Masculinity’ rises especially in the last decade, with a similarity of 0.10, the same measure of ‘shame’. However, ‘masculinity’ has always presented stable metrics, while the interest in ‘shame’ had a downward point in the 2000s and gained relevance again in he 2010s.

‘Hygiene’ had higher similarities in the 1960s and 1970s, plummeting in the 1980s. Since the 1990s, the term has increased in similarity, surpassing its past higher results. ‘Communication’ decreased only in the 1990s, and now it is again trending upwards.

Despite having the tendency of growth, the social terms still have less similarity than the symptoms and other descriptions related to menstruation. Possibly, even in studies that tackle social issues, research is directed to understand its effects on menstruation symptoms and other related diseases.

Conclusion

From the study, there is a clear division of understanding menstruation as ‘medical’ or ‘social’ issue as captured by the models of word embeddings. Both Word2Vec and GloVe models captured the relations of ‘menstruation’ to terms from medical and social aspects. ‘Politics’ is a highlighted term, which was close to issues such as ‘poverty’ and ‘sanitation’. The term dialogues with recent concerns of understanding ‘menstruation’ as a public health issue, not exclusively a medical aspect of women.

By comparing word embeddings from 1960s to 2010s, the most common associations to menstruation are still those describing particularities from the cycle and symptoms (therefore, ‘medical’). However, when comparing the word embeddings from 1970s and 2010s with selected lexicon from OBOS, we could see the addition of subjects through time. The growing number of similar terms represents how ‘menstruation’ has become a complex theme, with diverse matters to address. In this regard, ‘activism’ is a term that emerged, associated with ‘abortion’ and ‘fertility’, themes that are currently part of activists’ agendas. Other words had their similar terms changed, like ‘identity’, which is now related to ‘advertisement’.

Interest in ‘social’ aspects are higher in the last couple of decades, which can be verified by the higher similarity of ‘menstruation’ to terms such as ‘shame’ and ‘hygiene’. Parallel to the social interest, the medical aspects also expand. The similarity of ‘pregnancy’ and ‘perimenopause’ to ‘menstruation’ increased over the last 60 years. Moreover, both terms had peaks of more than 0.30 of similarity with ‘menstruation’.

This study shows that the concerns from 70 years in medical research on menstruation were focused on symptoms and diseases related to the theme. However, there is a change in the subject, which is evident by how the word embeddings associations were also altered.

For future studies, other various lexicon analysis can be performed using the same database. For example, a specific analysis of a set of diseases would be a great complement to this article, or in-depth yearly analysis of specific decades. Moreover, a qualitative approach, focusing on analyzing the discourses from the abstracts would be another great complement.

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