Quantum Semantic Correlations in Hate and Non-Hate Speeches

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This paper aims to apply the notions of quantum geometry and correlation to the typification of semantic relations between couples of keywords in different documents. In particular we analysed texts classified as hate / non hate speeches, containing the keywords women, white, and black. The paper compares this approach to cosine similarity a classical methodology, to cast light on the notion of “similar meaning”.

1 Corpus

The Online Hate Index[1], a joint initiative of Anti Defamation LeagueFLs Center for Technology and Society and UC BerkeleyFLs D-Lab, consists of 7619 comments from the platform Reddit, collected in 2016 during the USA Presidential campaign. While the corpus has been funded by ADL, no research activities are conducted by ADL or directed based on their personal goals: research design and testing has been conducted entirely by Berkeley D-Lab, an interdisciplinary academic unit. The comments were labelled by a team of undergraduates under the supervision and using methods developed by D-Lab. ADL had no involvement in the selection of comments, development of methods, and labels applied to comments. 7184 comments have been manually labelled “non-hate”, whereas 411 have been considered as “hate” speeches with the purpose of stimulating further machine learning researches. The five most used words in the collected hate speeches are Jews, white, hate, black, and women. Hate speeches present also some peculiar features: the average number of words, the average number of all caps, and the average sentence length is higher. Among the five most used words in hate speeches, white and black are interesting because they can be considered an antonymic couple from the point of view of lexical semantics. For this reason, we decided to analyse the semantic relations between the terms white, black, and women.

1.1 Sub-corpora

As the corpus is subdivided into hate (see table [1] and non-hate speeches (see table [2]), we identified six sub-corpora:
The logical formalism we used to represent elementary semantic relations corresponds both to Boole algebra and to the one proposed by Greimas and Rastier in their well-known semiotic square and suggests a strong connection to Dubois and ToffanoFLs eigenlogic which could provide a formal description of the semantic relations immanent to the text, thus allowing the formulation of semantic queries.

1.2 Note on the formalism

The logical formalism we used to represent elementary semantic relations corresponds both to Boole algebra and to the one proposed by Greimas and Rastier in their well-known semiotic square and suggests a strong connection to Dubois and ToffanoFLs eigenlogic which could provide a formal description of the semantic relations immanent to the text, thus allowing the formulation of semantic queries.

| Query: | black + white + women |
|--------|------------------------|
| H.WBWh.1 - Did you ever notice how these anti-white racist blacks always pick on the old, the weak or the infirm? Old ladies. Children. Young women. Teenage geeks. And they almost never do it alone, but run in packs, like jackals or hyenas. |
| H.WBWh.2 - Eastern Europe will likely be the most reliable backup plan for most whites. And while most of western Europe is cucked out right now, I have higher long term hopes for there than America. Most Americans are satisfied with only going so far as civic nationalism. Nationalism is intertwined with ethnicity in Europe and so ethnonationalism is the inevitable result from the resurgence of the right there. I expect that America’s nationalism will never again become attached to race, unfortunately. The elites in all western countries are banking on a multicultural future and in many cases are mating accordingly. This girl has mostly white features and in all likelihood is 75% white (given that most American blacks are 20-40% white themselves), but the media will play up her blackness in order to make it seem that black women are desirable. |
| H.WBWh.3. - It was always a lot like this. There were always elements of it. For example it was immediately anti-male from the word go. It was just easier to campaign that way because society was so anti-male / pro-female already. Hence the saying that feminism is just the other side of the coin from traditional conservatism. For example feminists went on and on about drunk husbands beating their poor wives the way they go on about rape today. A good false accusation makes for fine propaganda and feeds into what everyone likes to think about men anyway. Feminists could have taken the high road. They didn’t. They took the easy screw men over, sex war men and women are enemies and men are all evil road. So the rot was there from the beginning. So was the narcissism. The victimry. The “we rich white women are worse off than black slaves” crap. Reality was they were treated better than anyone else. but that doesn’t sell well. Victimry does (for women). They shamelessly used their power to get more. Sure some wanted equal responsibilities and duties too at first but those voices, never a majority, got fewer and fewer. Getting more privileges was just the easy path. So yes to the vote, but no to conscription that went with it. And you can see how close to a hate movement all that already was even back in the day when they had some issues that were actually worth fixing (even if they were not a matter of equality because men’s issues were not being addressed too). But since they got all their issues dealt with by around 1890 (except the vote because most women still opposed the vote for women until the 1910s) they became a movement without a cause and just wnet off the deep end of anti-male hate. |
| H.WBWh.4 - Sometimes I feel like those movements became obsolete the moment women got equal rights with men and people stopped thinking about blacks as of inferior race. Now they just keep momentum, turning women and minorities into privileged classes. If they keep this up in a few decades we would *need* MRA and white rights activists. |

Table 1: Hate speeches. Italic underlines the occurences of the keywords.
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so yeah, teach slavery all you want, but also include the fact that these ideas were not constitutional and mostly pushed by democrats.

and

women

think it’s ANTI SEMITIC to PROTECT YOUR CHILDREN FROM THEM). [Israel’s $1 billion a year sex slave trade of white women](http://www.jewlicious.com/2006/04/because-we-were-slaves-israels-sex-trade/)

Query: black *women – white

Table 2: Non-hate speeches. Italic underlines the occurrences of the keywords.

| Query: black + white + women |
|--------------------------------|
| **NH.WBWh.1** - I think manliness might be a real thing. Explaining done by a man is a real thing. But why make it gendered? women explain things to men all the time, at times also using a patronizing tone. Anecdotally, I’ve experience more women explaining something in a patronizing way than I have men. Even if there would be statistics that show men do it more often in a patronizing way (which there aren’t), it’s still hard to argue for making it gendered. To put it in an analogy: we know that black people in the USA commit more burglary than white people (in relative terms). Should we call it “blackburgling”? I don’t think so: I think it implies that committing burglary is somewhat characteristic of black people, which isn’t the case since it’s only a minority of black people today and women only make 70 cents to a man. These are both lies, and there is nothing taught about how we spread ideas of individual freedom across the western world and gave more rights to women, minorities, plants and animals than any other, all thanks to “racist slave holders” so yeah, teach slavery all you want, but also include the fact that these ideas were not constitutional and mostly pushed by democrats. |

| Query: black + white + women |
|--------------------------------|
| **NH.WBWh.2** - Well, you’re not wrong. blacks, men and women, are of significantly lower intelligence than all other races on the planet, with the single exception of the aborigines of Australia, who are just as limited, mentally, as black Africans. I’m talking about a BIG difference in intelligence, not a small difference. The average IQ of whites is around 100. Hispanics come in at around 89. American blacks, who have mangled their genetics with whites for generations of interbreeding, come in at an average of 85. African blacks have an average IQ of 70! That’s right, 70. By normal white standards, the average negro in Africa is mentally retarded. These IQ tests have been done many different times, many different ways, all around the globe, and they all show the same thing. They are not wrong. Since you are black yourself, I should point out that a general or average IQ for a race has no bearing on the IQ of any individual in that race. By that I mean you yourself may be a genius. There are many black geniuses. I am talking here about average intelligence. Why is average intelligence important? Because it dictates what a race, as a whole, is able to accomplish. If you look at Africa, blacks were able to build almost nothing. No roads. No wagons to drive on those non-roads. They didn’t even learn to domesticate horses to ride by themselves. Everything African negroes have, they learned from other races. And please don’t talk about Egypt. The peoples of northern Africa were not negroes in ancient times, and to a large extent are still not negroes. They were Mediterranean peoples, like the Greeks, Etruscans and Romans. Why is the lack of accomplishment of African blacks in history important today? Because blacks still cannot create or build anything of importance, as a race. Their low intelligence, coupled with other negative factors that have been less well-demonstrated, prevent them from achieving anything. Just look at any black city in America. Any black city, take your pick. As soon as a city goes black, it goes to ruin and decay. Always. |

| Query: white + women – black |
|--------------------------------|
| **NH.WBWh.1** - 8chan trolls are using it to abuse women, children, minorities, and gays heterosexual white men can’t be abused, folks. If the very same thing happens to them it’s... well... irrelevant. |
| **NH.WBWh.2** - Many white women voted for Trump not because they were concerned about their income, but because they are the ?Ivanka voters?. Their vote was for Ivanka instead of Donald. They love her style and success story. I can’t imagine this being true at all. |
| **NH.WBWh.3** - Then there’s white ribbon day. With posters saying ‘Are you man enough to stop violence against women?’ [http://whiteribbon.org.nz/](http://whiteribbon.org.nz/) |
| **NH.WBWh.4** - It’s become a sort of cliche that Hispanic women apparently urge their daughters to seek out white men (or at the very least, lighter skinned men) in order to “improve the race”. There is about a 10 point IQ difference between whites and most mestizos, and fairer skin is usually seen as more attractive regardless of political beliefs, so their efforts aren’t misguided. The last time I was in Corpus Christi, as well as when I visited Phoenix and San Diego, it seemed like every single young white male had a mestizo girlfriend. And in their minds “why not?” An average white guy can get a high end mestizo girl easier than an average white girl, and chances are that she is eager to please because she is happy just to have a white guy. The rate of WM/HF mixing in the southwest is every bit as bad as WM/AF mixing on the West Coast. Here in the Midwest the most commonly seen mixed couple is BM/WF so I was rather shocked when I’ve gone out west and seen the extent of what is happening out there.
2 State-of-the-art

A geometric approach to semantic space studies has been proposed first by Jean Petitot, in terms of catastrophe theory [14]. As quantum geometry is concerned, it is used by scholars in Information Retrieval for the purpose of unifying vector, logic, and statistical approaches [19] [12]. Among others, Bruza and Woods [3], applied it to the semantic representation of polysemic words as a superposition state. Barros, Toffano, Meguebli and Doan [2] proposed to interpret the notion of entanglement as a measure of the strength of the semantic relation between two query-words, both present in a certain document. To this purpose, using the Hyperspace Analogue to Language (HAL) method [11], the authors formalised the semantic space of a document as a square matrix, as we will explain hereafter. Many quantum information retrieval scholars prefer this technique because it is Hermitian and it allows the implementation of a density matrix [19] [12]. Instead of measuring cosine similarity between two keywords, the work in [2] makes use of the Gram-Schmidt orthogonalisation method to measure the degree of correlation between the words, characterized by the violation of a CSHS inequality [4]. Pushing forward this idea, Galofaro, Toffano, and Doan [8] proposed a theoretical paper in which observables are interpreted as semantic features. The Born rule is used to find the expectation values associated to the application of a specific observable to two word-vectors in order to measure the degree of correlation/anticorrelation between them [18]. The present paper aims to test this method, and to compare it with the classical cosine similarity measure.

3 Relevance to language processing

It is possible to ask how are we going to interpret the correlation value in terms of linguistic features. According to Umberto Eco [7], the terms “semantics” has been used in five different acceptations:
1. Lexicology: a study of meaning outside every context (dictionary);
2. Structural Semantics: interested in semantic fields considered as systems;
3. Study of the relation between the meaning and the referent;
4. Truth-conditional logic;
5. Textual semantics: a study of the peculiar meaning assumed by terms and words in their context;

Though the five levels are obviously related, the text and the context have the last word in defining the meaning of terms. For example, according to any thesaurus, black and white are antonyms (if black, then not white and vice versa). Having a look at our corpus, we find: “most American blacks are 20-40% white” (H.WBWh.2), weakening the antonymy. The HAL method allows us to work on semantics in sense of 5 because we formalise the semantic relations between terms that constitute a given context. These become the characteristics of a semantic space.

### 3.1 Commutation test and quantum correlation

With measuring the degree of quantum correlation we are searching for a semantic equivalent to HjelmslevΦL commutation test. Commutation of elements of the expression plan aims to search for linguistic units. If we substitute “black” with “Afro-American” in blacks, men and women are of significantly lower intelligence than all other races on the planet, we notice how meaning is unaltered, while if we substitute it with “Afghan hound”, the meaning changes. We could even suggest that this is why the original sentence is actually racist: we speak about men as they were dogs. However, *Afghan hounds, men and women* is not correct in English because of structural reasons related to semantics in sense 2: “men” and “women” carry a structural classeme (an element of meaning) (human → −animal) [10].

What if we were able to commute meanings, and not signifiers? For example, what if we were able to change the meaning unit “human” in “dog” while preserving “male” and “female” all along the sentence? This is what we mean by “commutation test on the content plan”. As a result of the test, such an abstract machine as a computer could probably generate, on the expression plan, a sentence like Afghan hounds, sires and bitches. The Born rule provides a tool to measure the expectation values for these commutations.

### 4 Design

In synthesis, we prepared the corpus reducing each word to its stem; we then applied the HAL method to obtain two word vectors representing the keywords we are interested in, and a document vector; finally, we measured the the cosine similarity of the keywords and their (anti)correlation value.

#### 4.1 Cleaning the corpus

Since we are interested in every kind of semantic information not manifested by morphology or syntax, we used the Python library nltk Lancaster stem to reduce different tokens to the same type (e.g. black, blacks, blackness). The Lancaster stemmer is more aggressive than the alternative nltk Porter stemmer, which can distinguish between woman and women. Obviously, a stem is not necessarily identical to its morphological root: our purpose is only to reconstruct the immanent net of relations underlying the manifest words. For a similar reason, we used nltk stopwords list to eliminate syncategorematic terms. We also used regex to eliminate all not relevant signs such as punctuation [20].
4.2 The matrix

We applied the HAL method to each document of each sub-corpus to formalise it. Given $k$ roots occurring in the document, we calculate a $k \times k$ matrix which represents the semantic space of the document. For example, table 3 shows the HAL matrix of the document:

NH.BW-Wh.5: That’s probably because 30 years ago they were not bashing blacks or women. Well, women only got bashed if they mouthed off

|   | 30 ago | bash | because | black | got | if | mouth | not | off | onli | or | probabl | s | that | they | well | were | women | year |
|---|--------|------|---------|-------|-----|----|-------|-----|-----|------|----|----------|--|------|------|------|------|-------|------|
| 30 ago | 10     | 0    | 0       | 9     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 8| 7    | 0    | 0    | 0    | 0     | 0    |
| bash   | 8      | 10   | 0       | 0     | 7   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 5| 4    | 0    | 0    | 0    | 0     | 9    |
| because| 0      | 0    | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 9    | 0    | 0    | 0    | 0     | 0    |
| black  | 4      | 10   | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 8| 7    | 0    | 0    | 0    | 0     | 0    |
| got    | 3      | 9    | 3       | 2     | 10  | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 1| 0    | 0    | 0    | 0    | 0     | 0    |
| if     | 0      | 3    | 10      | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 0    | 0    | 0    | 0    | 0     | 0    |
| mouth  | 0      | 0    | 0       | 7     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 5| 0    | 0    | 0    | 0    | 0     | 0    |
| not    | 0      | 0    | 10      | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 0    | 0    | 0    | 0    | 0     | 0    |
| off    | 5      | 7    | 0       | 0     | 4   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 3    | 2    | 1    | 0    | 0     | 0    |
| onli   | 0      | 0    | 0       | 5     | 7   | 9  | 0     | 0   | 0   | 0    | 0  | 0        | 1| 0    | 0    | 0    | 0    | 0     | 0    |
| or     | 0      | 4    | 0       | 5     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 8    | 2    | 0    | 0    | 4     | 0    |
| probabl| 0      | 0    | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 0    | 0    | 0    | 0    | 0     | 0    |
| s      | 0      | 0    | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 0    | 0    | 0    | 0    | 0     | 0    |
| that   | 0      | 0    | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 0    | 0    | 0    | 0    | 0     | 0    |
| they   | 0      | 0    | 0       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 0| 1    | 0    | 0    | 0    | 0     | 0    |
| well   | 9      | 8    | 6       | 1     | 7   | 9  | 0     | 0   | 0   | 0    | 0  | 0        | 6| 2    | 5    | 4    | 3    | 20    | 4    |
| were   | 0      | 2    | 6       | 0     | 7   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 8| 0    | 0    | 0    | 0    | 3     | 10   |
| women  | 8      | 0    | 5       | 0     | 0   | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 4| 3    | 2    | 9    | 0    | 10    | 0    |
| year   | 1      | 4    | 12      | 0     | 14  | 0  | 0     | 0   | 0   | 0    | 0  | 0        | 16| 0   | 0    | 0    | 6    | 9    | 8     |

Each square matrix is calculated moving a window, representing the considered context, over the document, stem by stem. All stems within the window co-occur with the last stem with a strength which is inversely proportional to the distance between the stems. We finally sum the different occurrences of stems: for example, women occurs two times in our document.

4.3 Cosine similarity

In a HAL matrix, rows and columns differ. A word-vector is then represented by the concatenation between the corresponding row and column vectors. In this way we obtain the word-vectors of the keywords we are interested in (white, black, women): $|w_{white}⟩, |w_{black}⟩, |w_{women}⟩$. We can now calculate the angle between any two word-vectors as well as their cosine similarity ($cs$), since “cosine has the nice property that it is 1.0 for identical vectors and 0.0 for orthogonal vectors” [16]. Usually, cosine similarity measures the similarity between the query vector and the document vector. For this reason, the way we use it, measuring cosine similarity between the keywords in each document, and obtaining each time a different measure, could seem rather unorthodox. However, since the two keywords are just vectors, their angle can be used to measure their similarity in the particular semantic space corresponding to a certain document. For example, as Song, Bruza, and Cole wrote, “nurse and doctor are similar in semantics to each other, as they always experience the same contexts, i.e., hospital, patients, etc.” [17]. The reason why we choose to compare cosine similarity to the expectation degree measured through the Born rule is perhaps not intuitive. In both case we deal with many-dimensional vectors, and not with punctiform
events. For this reason we will not consider the euclidean distance to calculate similarity or different methods to calculate frequency, such as pointwise mutual information (PPMI).

### 4.4 Gram-Schmidt orthogonalisation

In order to measure correlation between two keyword-vectors, let us say *black* and *women*, we first obtain a document vector \( |\Psi\rangle \) summing all word-vectors. The next step is to apply the Gram-Schmidt orthogonalisation process to \( |w_{\text{black}}\rangle, |w_{\text{women}}\rangle \) in order to obtain two pairs of orthonormal bases \( \{ |u_{\text{black}}\rangle, |u_{\text{black}}\perp\rangle \} \) and \( \{ |u_{\text{women}}\rangle, |u_{\text{women}}\perp\rangle \} \). If we project and normalise the document-vector \( |\Psi\rangle \) onto each couple of bases we obtain a vector \( |\phi\rangle \):

\[
|\phi\rangle = \alpha |u_{\text{black}}\rangle + \alpha_\perp |u_{\text{black}}\perp\rangle = \beta |u_{\text{women}}\rangle + \beta_\perp |u_{\text{women}}\perp\rangle
\]  

(1)

We want to emphasize that we represented the document vector through its components on the two bases provided by each keyword-vector.

### 4.5 Abstract machines

The notion of abstract machine links quantum theory\(^{[18]}\) to post-structuralist perspectives on meaning\(^{[5]}\). To typify the semantic relation between *black* and *women* in our corpus, we design two abstract machines: \( \sigma \) and \( \tau \), two linear operators. Their input vector is \( |\phi\rangle \) (representing the document. The \( \sigma \)-machine operates on each context, and returns the output \(+1\) when it acts on the vector \(|u_{\text{black}}\rangle\) (representing the meaning of the stem *black*), \(-1\) in the other case. In a similar way, the \( \tau \)-machine applies the same transformation on the meaning of the stem *women*. Now let us imagine what happens when we apply both the machines to the document: \( \sigma \tau |\phi\rangle \). Principally, we deal with three situations:

1. the two outcomes are correlated in every context, when the first output is \(+1\) and the second is \(+1\), and when the first is \(-1\), the second is \(-1\). If we multiply the two numbers we always score \(+1\);

2. the two outcomes are anti-correlated: in every context where the first output is \(+1\), the second will be \(-1\) and also the other way round. If we multiply the two numbers, we will always score \(-1\);

3. the two outcomes are not correlated. in some contexts the output of the two machines will be \(\{+1,+1\}\), while in others it will be \(\{+1,-1\}, \{-1,+1\}, \{-1,-1\}\). The average of the outcomes in the different contexts of the considered document will be 0.

The three considered cases are extreme situations: we will also find weak correlations, in which the score will tend to 1, weak anti-correlation, where the score will tend to \(-1\), and also absence of correlation, giving results near 0. The outcome of a generic machine can be a transformation or not, \(+\) or \(-\). Since we have two machines, we deal with a four-state semantic space \( \sigma \tau = \{++,-+,+-,-\} \). To construct an example of a general machine, we use the following Pauli spin matrix:

\[
\hat{\sigma}_z = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}
\]  

(2)

The effect of this matrix is to switch the components of the state-vector to which it is applied. It is the equivalent of the logical gate *negation* in Quantum Computation\(^{[13]}\). In this way we define an operator \( \hat{B}_z \) in the *black-base* \( \{ |u_{\text{black}}\rangle, |u_{\text{black}}\perp\rangle \} \), and an operator \( \hat{W}_x \) in the *women-base* \( \{ |u_{\text{women}}\rangle, |u_{\text{women}}\perp\rangle \} \).

As a result, for example, \( \hat{W}_x \) switches all the \( |u_{\text{women}}\rangle \)-related components of \( |\phi\rangle \):

\[
\hat{W}_x (\beta |u_{\text{women}}\rangle + \beta_\perp |u_{\text{women}}\perp\rangle) = \beta_\perp |u_{\text{women}}\rangle + \beta |u_{\text{women}}\perp\rangle
\]  

(3)
\(\hat{B}_x\) acts in the same manner on the \(|u_{\text{black}}\rangle\)-related values of \(|\phi\rangle\). To calculate the expected score of the application of both machines to the document-vector, we apply the Born rule, whose output will be a number between \(-1\) and 1.

\[
r = \langle \phi | \hat{B}_x \hat{W}_x | \phi \rangle
\]

The more the two layers of meaning are connected, the more the two independent abstract machines will return similar outputs: thus we interpret \(r\) as the immanent correlation between the respective meanings expressed by the \textit{black} and the \textit{women} stems.

5 Comparing data

We measured cosine similarity and correlation in our corpus of hate and non-hate speeches corresponding to the logical query \textit{black*white*women}. We measured similarity and correlation between \textit{black}, \textit{women} and \textit{white}, \textit{women} respectively. The window length varies from 4 to 10. The results are displayed in fig. 1 referring to hate speeches, and fig. 2 referring to non-hate speeches. Then we calculated the graphs corresponding to cosine similarity and correlation between \textit{white}, \textit{women} in the corpora of both hate and non-hate speeches where the term \textit{black} is absent - see figures 3 and 4. Finally, we applied the same procedure to \textit{black}, \textit{women} in the corpora of both hate and non-hate speeches where the term \textit{white} is absent - see figures 5 and 6. To compare the results we focus on window lengths of 8-10, which seem associated to more stable values.

5.1 \textit{black} * \textit{white} * \textit{women}

Both hate and non-hate speeches present strong anticorrelation \textit{black} vs. \textit{women} and \textit{white} vs. \textit{women}. Looking at the document H.BWhW.4, it is not surprising to see that both \textit{black/women} and \textit{white/women} are anticorrelated, since the text draws a comparison between \textit{women’s rights} and \textit{black’s rights}. We notice also the correspondence between a \(r \simeq 0\) correlation score and a \(cs \simeq 0.7\) value of similarity: two word-vectors can be geometrically close without being correlated. Another interesting problem is the \textit{black/white} opposition. Generally speaking, their anticorrelation is weaker than for the other two, and it tends to disappear in H.WBWh.1. Provided that lexical semantics would describe them as antonyms, it could seem strange that they are not anti-correlated in H.WBWh.1. According to textual semantics \[10\] semantic relations are modulated and transformed by their co-occurrence in contexts. In our document, \textit{anti-}, \textit{white}, and \textit{racist} give a fundamental contribution to establish the contextual part of the meaning of \textit{black}, providing it of contextual classemic values - Rastier calls them \textit{afferent semes}, and distinguishes them from the \textit{inherent semes}, which characterize the semantic nucleus of a \textit{lexeme} \[15\]. In a similar way, H.WBWh.3 is also interesting, since it shows how two terms can be weakly similar (0.5 \(\leq cs \leq 0.7\)) and still weakly anticorrelated \((-0.5 \leq r \leq 0\)).

5.2 \textit{white} * \textit{women} − \textit{black}

Five out of six non-hate speeches present a strong anticorrelation \textit{white} vs. \textit{women}, whereas hate speeches are featured by a weaker anticorrelation; in one case, NH.WhW-B.2, we have a positive correlation, since the document focuses on \textit{white women} voting for D. Trump. If we look at the other documents, they oppose \textit{women} to white men, voters. We must point out how NH.WhW-B.4 could be considered a hate speech from a semantic point of view. In this text, \textit{hispanic women} are opposed to \textit{white girl}, \textit{men}, \textit{guys} and this explains the strong anticorrelation.
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Figure 1: Hate speeches H.WBWh.1-4. In H.WBWh.1, black and white show a high similarity score though they are not correlated. In the text, the meaning of “white” is modified both by the prefix anti- and by the presence of black.

Figure 2: Non-hate speeches NH.WBWh.1-2. In NH.WBWh.1, a 0.5 similarity score between black and white corresponds to a -0.5 value of anticorrelation, since the text is between black and women. NH.WBWh.1 - a pseudo-scientific argument on IQ, opposes black and white.
Figure 3: Hate speeches H.WWh-B.1-3. In particular, in H.WWh-B.1-2 the keywords occur without a strong relation, whereas H.WWh-B.3 is explicitly on white women.

Figure 4: Non-hate speeches NH.WWh-B.1-6. Five out of six documents show a maximal anticorrelation and a 0 similarity score. NH.WWh-B.2 is about white women ("Ivanka Voters").

5.3 black * women – white

H.WB-Wh.1 presents a positive correlation between black and women: in fact the document opposes black women to black men without reference to white women (women → black). On the contrary, H.WB-Wh.2 present a strong anticorrelation black vs. women, since women and blacks are considered as two distinct minorities. Most non-hate speeches present a weak anticorrelation or a weak correlation, except for NH.WB-Wh.2, in which a maximal anticorrelation value is justified because the document is composed of two different sections, the first about black color and the second about women. In NH.BW-Wh.5 we can see again how a high score of similarity does not necessarily correspond to a correlation of a given type: in this text, we have a first close co-occurrence of women and black; the second occurrence of women is free and it weakens the value of the first relation.
Figure 5: Hate speeches H.WB-Wh.1-2. H.WB-Wh.1 is about *black women*, opposed to *black men*; H.WB-Wh.2 carries on an analogy between *blacks’ rights* and *women’s rights*.

Figure 6: Non-hate speeches NH.WB-Wh.1-5 show a great differentiation. In these cases, correlation is helpful to characterise more explicitly what does “similarity” mean.
6 Conclusion

The paper shows how quantum correlation can clarify the less clear notion of similarity. The terms black and women can occur in hate-speeches with different relations, individuating black women, or opposing women and blacks. In particular:

- Low similarity values (0 ≤ cs ≤ 0.5) correspond to a maximum of anticorrelation (−1 ≤ r ≤ −0.5) between the two stems. We have a double privative semantic opposition −(A ∗ B);
- Weak similarity (0.5 ≤ cs ≤ 0.7) correspond to weak anticorrelation or no correlation (−0.5 ≤ r ≤ 0);
- Higher similarity value (0.7 < cs ≤ 1) corresponds to weak or strong correlations (0 ≤ r ≤ 1): (A ↔ B);

The method seems promising as it concerns Digital Humanities and Machine Learning. Many machine learning techniques make use of human beings to label the corpus to avoid to define the involved labels, at the risk of mistakes and ambiguity. Quantum semantics offers a different perspective on meaning, which can be useful to re-classify the corpus. For example, many hate speeches present strong anti-correlations between terms no matter of the width of the window. Furthermore, similar semantic profiles such as NH.WhW-B.2, H.WhW-B.3, NH.BW-Wh.4, H.BW-Wh.1 reveal a similar topic (black or white women) and show a sexist connotation, no matter how they have been labelled.

6.1 Semantics and information

As we wrote, the method we described applies to Semantics only in a narrow sense (see paragraph 3). Actually, the algorithm does not understand meaning: its task is not to translate texts; the algorithm provides information on meaning: on textual semantic structure, on some functions of the semantic system that produces the text (in our case: a ∨ b; c → d) in the light of the semiotic square [9]. For example, the algorithm could be applied to a document written in a previously unknown language such as Minoan linear A script, or to an encrypted one. As long as we can distinguish its words, the algorithm would not decode the document, but it would provide information on what lexemes can be considered similar, implied or opposed as meaning is regarded, mining information from their co-occurrence in the text and measuring the expectations related to some simple transformations operated on the coherent distributions of meaning - isotopies [10] - along the text.

6.2 Future work

In this paper we measured the correlation with reference to the single Pauli operator σₓ. To improve the method, we will measure the expectations of Pauli’s operators σₓ and σ₃ to get an alternative way to measure entanglement [18], to be compared to Bell inequalities used by Barros et al. [2]. On a similar line, the Born rule allows us to work on density matrices. Thus we hope to get further insights on the relation between Von Neumann information and meaning.

References

[1] (2018): The Online Hate Index. Available at http://www.adl.org/resources/reports/the-online-hate-index
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[2] João Barros, Zeno Toffano, Youssef Megueblí & Bich-Liên Doan (2014): *Contextual Query Using Bell Tests*. In Harald Atmanspacher, Emmanuel Haven, Kirsty Kitto & Derek Raine, editors: *Quantum Interaction*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 110–121, doi:10.1007/978-3-642-54943-4_10.

[3] Peter Bruza & John Woods (2008): *Quantum collapse in semantic space: interpreting natural language argumentation*. In: *Proceedings of the Second Quantum Interaction Symposium (QI-2008)*, College Publications, pp. 141–147.

[4] John F Clauser, Michael A Horne, Abner Shimony & Richard A Holt (1969): *Proposed experiment to test local hidden-variable theories*. Physical review letters 23(15), p. 880, doi:10.1103/PhysRevLett.23.880.

[5] Gilles Deleuze & Félix Guattari (1988): *A thousand plateaus: Capitalism and schizophrenia*. Bloomsbury Publishing.

[6] François Dubois & Zeno Toffano (2017): *Eigenlogic: A Quantum View for Multiple-Valued and Fuzzy Systems*. In Jose Acacio de Barros, Bob Coecke & Emmanuel Pothos, editors: *Quantum Interaction*, Springer International Publishing, Cham, pp. 239–251, doi:10.1007/978-3-642-54943-4_10.

[7] Umberto Eco (2014): *From the tree to the labyrinth*. Harvard University Press, doi:10.4159/9780674728165.

[8] Francesco Galofaro, Zeno Toffano & Bich-Liên Doan (2018): *A quantum-based semiotic model for textual semantics*. Kybernetes 47(2), pp. 307–320, doi:10.1108/K-05-2017-0187.

[9] A. J. Greimas & François Rastier (1968): *The Interaction of Semiotic Constraints*. Yale French Studies (41), pp. 86–105, doi:10.2307/2929667 Available at http://www.jstor.org/stable/2929667.

[10] Algirdas Julien Greimas (1983): *Structural semantics: An attempt at a method*. University of Nebraska Press.

[11] Kevin Lund & Curt Burgess (1996): *Producing high-dimensional semantic spaces from lexical co-occurrence*. Behavior Research Methods, Instruments, & Computers 28(2), pp. 203–208, doi:10.3758/BF03204766.

[12] Massimo Melucci (2015): *Introduction to information retrieval and quantum mechanics*. Springer, Berlin, Heidelberg, doi:10.1007/978-3-662-48313-8.

[13] Michael A Nielsen & Isaac L Chuang (2004): *Quantum Computation and Quantum Information (Cambridge Series on Information and the Natural Sciences)*. Cambridge university press.

[14] Jean Petitot (2004): *Morphogenesis of meaning*. P. Lang.

[15] François Rastier (2009): *Sémantique interprétative*. Presses universitaires de France, doi:10.3917/puf.rast.2009.01.

[16] Amit Singhal (2001): *Modern Information Retrieval: A Brief Overview*. IEEE Data Eng. Bull. 24(4), pp. 35–43. Available at http://sites.computer.org/debull/A01DEC-CD.pdf.

[17] Dawei Song, Dawei Song, Peter Bruza & Richard Cole (2004): *Concept Learning and Information Inferencing on a High Dimensional Semantic Space*. In: *ACM SIGIR 2004 Workshop on Mathematical/Formal Methods in Information Retrieval (MF/IR2004)*. Sheffield, United Kingdom, 25-29 July 2004., doi:10.1.1.370.4676.

[18] Leonard Susskind & Art Friedman (2014): *Quantum mechanics: the theoretical minimum*. Basic Books (AZ).

[19] Cornelis Joost Van Rijsbergen (2004): *The geometry of information retrieval*. Cambridge University Press, doi:10.1017/CBO9780511543333.

[20] Dmitry Zinoviev (2016): *Data Science Essentials in Python: Collect-Organize-Explore-Predict-Value*. Pragmatic Bookshelf.