Mining Embodied Emotions: A Comparative Analysis of Sentiment and Emotion in Dutch Texts, 1600-1800.

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Abstract

This article presents a new model for emotion mining, resulting from the research project "Embodied Emotions". This project aims: 1. to trace historical changes in emotion expression and in the embodiment of emotions, and 2. to develop methods to trace these changes in sizeable corpuses of digitized texts. Up to now, the mining of sentiments or emotions has mainly been restricted to modern, or even very recent text corpora, such as social media. Sentiment mining techniques are often based on relatively simple emotion models of binary (positive/negative) oppositions, or limited sets of 'basic' emotions and are not yet able to deal adequately with the complexity and the historical contingency of emotions and their expression. To meet these challenges, we have developed the Historic Embodied Emotion Model (HEEM), built on a test case of 29 Dutch language theatre plays written between 1600 and 1800 and annotated manually with HEEM labels for emotions and body terms. In this article, we present this model and compare it with other sentiment mining techniques: 1) off the shelf linguistic analysis software LIWC (Linguistic Inquiry and Word Count), 2) a version of LIWC that has been adapted for the analysis of Dutch historical texts, 3) a new Dutch translation of WordNetAffect. We conclude that, although different forms of sentiment mining have their value and use, HEEM provides new opportunities for emotion mining and analysis of embodied emotions in historical texts.

1. Introduction: combining the affective and digital turns

Over the last decade, sentiment and opinion mining have become important fields of research, both within academia and for companies and organizations that have started to utilize this information for reputation management and marketing purposes. Many techniques and resources, e.g. Sentiwordnet [Baccianella et al. 2010], Harvard General Inquirer Database [Stone et al. 1996], Liu's Opinion Lexicon [Liu 2015], focus on single word mining of overall sentiment (thumbs up/down) or coarse-grained opinions in contemporary language. Research conducted with these lexicons tends to suffer from "short-termism": the data analyzed is often limited to recent, short time periods, with a bias towards social media. [1]

Historians are interested in long-term developments, e.g. in opinion and emotion expressions across time. Historians stress that the experience and expression of emotions is subject to social and cultural changes [Frevert 2014]. However, to date, sentiment mining techniques are not able to deal adequately with the complexity and the historical contingency of emotions and their expression. They focus on explicit utterances of emotions (I am angry), and ignore the fact that the body is an important vessel for emotion communication. Human emotions are a complex of neuro-physical, social and cultural actions and reactions. They are expressed not only in words but also in gestures, facial expressions and physical reactions. [2]

Over the last years, emotions and their history have become a focus point for research [Rosenwein 2002] [Boddice 2014] [Frevert 2014] [Matt and Stearns 2013] [Plamper 2015]. Centers for emotion studies were founded in Berlin, London, Australia, France, and Amsterdam, specialized journals (e.g. *Emotion Review*) and discussion forums provide platforms for emotion researchers (e.g. H-EMOTIONS, EMONET-L, HIST-EMOTION). The cultural and historical complexity of emotions has been analyzed in a multitude of studies, providing insight in the complex relations between mind and body, in the constantly changing vocabularies used to address emotions, and in the changeable appraisal of emotions. However, up to now, most of the (historical) research in emotion studies relies mainly on traditional hermeneutical methods of research [Leemans 2017] (for examples of historical sentiment mining see e.g. [Sprugnoli et al. 2016]).

In our project, we aim to test existing sentiment mining techniques for their capacity to analyze emotion expression in previous ages, and to develop an enriched form of sentiment mining based on an "embodied emotions model" that is capable of tracing historical changes in the verbal and bodily expression of emotions over time.

To analyze the emotional practices of the past, we chose to focus on Dutch language theater texts of the early modern period (1600-1800). Theatre texts are rich sources for emotion research since staging emotions is one of the main goals of this genre. Characters tend to be very explicit in indicating their feelings, while stage directions and speech lines give us information about the bodily enactment of emotions. Although the communication on stage seems to have little in common with daily speech, the way emotions were described, expressed and enacted nonetheless appealed to a very large audience that apparently recognized and immersed itself in the tribulations and emotions of the characters.

Theater texts offer an excellent case to explore the possibilities of historical emotion mining over a longer period as it is one of the oldest literary genres that remained popular over centuries. Moreover, the two hundred years between 1600 and 1800 witnessed fundamental changes in emotional culture and the enactment of emotions on stage. During the 18th century, the classic view on "passions" as highly embodied, strong and threatening impulses waned and a more positive appreciation of the senses and sensibility as source of human knowledge and morality came to the fore. New theatre forms, e.g. the bourgeois tragedy or the "Comédie Larmoyante", replaced the traditional fierce passions from the tragedy – such as anger, revenge, remorse, shame and despair with "smaller" emotions or "sentiments" such as sadness, infatuation, bliss and sensibility [Leemans and Johannes 2013]. The medical conception of the humoral system considered the condition of the blood, phlegm, yellow bile and black bile as of great influence on emotional health [Plamper 2015]. This view remained dominant throughout the seventeenth and eighteenth centuries but at the same time new medical theories came to the fore. The presumed physical determinants of emotional wellbeing seem to have shifted gradually from the bodily fluids to the nerves, the muscles and the skin [Plamper 2015] [Frevert 2014] [Dixon 2003]. Although we expect that with these migrations, the bodily expressions of emotions changed as well, systematic research into this change is still lacking.

Within the Dutch language area, hardly any digital research has been conducted into the history of emotions, nor into early modern theatrical or literary culture. Current text, concept or sentiment mining projects tend to focus on 20th- and 21st-century data sets, e.g. social media, newspapers, journals, or novels (see e.g. [Wevers 2017] [Eijnatten et al. 2014] [Pander Maat et al. 2014] [Dalen-Oskam 2013] [Vossen et al. 2013]. For the 19th century, Dutch biographical datasets have been sources for digital textual research that extracted biographical information and conceptualizing "events" from these datasets [Braake and Fokkens 2015].

For the early modern period, the ePistolarium project is one of the few projects researching textual culture in the Dutch language with computational tools. ePistolarium provides a web application that allows users to browse through 20.000 digitized letters from Dutch scholars and from scientists who stayed in the Dutch Republic during the 17th century. This letter collection has been the base for exploratory topic modeling [Wittek and Ravenek 2011]. So, while digital research into Dutch language texts is developing rapidly, our work on early modern Dutch literary texts opens up fresh territory.

One of the reasons for the delayed employment of digital research tools by researchers of early modern history is that current text mining tools developed for modern language texts do not work well for older texts as vocabulary, meaning and spelling altered importantly over time. Moreover, spelling in early modern texts is highly inconsistent. For early

modern texts, lexicons or classification schemes of emotions are not available.

2. Development of Historical Embodied Emotions Model (HEEM)

For the corpus selection of this project, we collaborated with DBNL (Digital Library of Dutch Literature) and with Nederlab - a project that aims to provide online access to all digitized Dutch language texts since the Middle Ages. We selected 280 theatre texts from the period 1600-1800, representing different periods (Renaissance 1600-1669, Classicism 1670-1749, Enlightenment 1750-1800) and different genres (tragedies, comedies and farces). Most of the theatre texts were xml represented according to TEI standards (http://www.tei-c.org), so we could differentiate between scenes, characters, speaker turns, and stage directions.

We selected 29 texts from our corpus of 280 plays to annotate manually. The selection ensured coverage of different theatre genres (tragedy, comedy, farce), and different periods. We converted the TEI XML files into Folia and used the KAF annotator for our annotation process.[1]

This set of annotated files is employed in different ways. First of all, as it is a representative sample of the entire HEEM-corpus, it provides preliminary answers for our research questions concerning the changes in emotion expression over time. Furthermore, it serves as a test and training set for the development of machine learning methods aiming at automatically annotating the entire corpus of 280 plays. The results of this process will be the subject of a later publication. In this article, we present the results of the model development on the basis of the 29-corpus. We will use this model and corpus as a test set for comparisons with other sentiment mining methods.

2.1. HEEM annotation guidelines

In our project we distinguished emotions from related categories such as mood, trait, cognitive state, physical state, edonic state, attitude and sensation (cf. WordNet-Affect - [Strapparava and Valitutti 2004]). We decided to focus on emotions proper, although the adjacent category of "moods" turned out to be hardly distinguishable from emotions in some cases. Additionally, we adopted the definition of emotions by Klaus Scherer who defines an emotion as a strong feeling deriving from one's circumstances or relationships with others involving cognitive appraisal, bodily symptoms, (a readiness for) action, motoric expression (for instance in face or voice) and subjective awareness [Scherer 2005, 697, 703–5]. Besides emotions we are also interested in the simultaneous occurrence of bodily reactions. In total, we developed five annotation categories (Table 1).

In the annotation guidelines we further defined the five categories and provided lists of examples (see HEEM-Github for more detailed information). Starting from these definitions and after a preliminary exploration of a subset of corpus texts, we composed a list of 37 emotions relevant for the interpretation of early modern theatre texts (Table 2).

CONCEPT TYPE	EXPLANATION	ILLUSTRATION
Emotion	Strong feeling deriving from one's circumstances or relationships with others involving cognitive appraisal, bodily symptoms, (a readiness for) action, motorical expression and subjective awareness	weerzin (*aversion*), haten (*to loathe*), verliefd (*in love*), verdrietig (*sad*)
Body part	Internal and external parts of the body	gezicht (*face*), spieren (*muscles*), bloed (*blood*), geest (*mind*), ogen (*eyes*)
Bodily process	(uncontrollable) reactions of the body coinciding with emotions	huilen (*cry*), zuchten (*sigh, moan*), blozen (*blush*), rillen (*tremble*)
Emotional action	(controllable) human action triggered by an emotion	schelden (*scold*), in de armen sluiten (*embrace*), honen (*scorn*), smeken (*beg*)
Body sensation	Sensations and perception of temperatures, tastes, smells, vibrations and movements in the body associated with emotional experience	warm (*warm*), koud (*cold*), bitter (*bitter*), droog (*dry*), samentrekkend (*contracting*)

Table 1. HEEM Emotional Concepts

Anger (Woede); Annoyance (Wrevel); Acquiescence (Berusting); Awe (Ontzag); Benevolence (Welwillendheid); Compassion (Mededogen); Dedication (Toewijding); Desire (Verlangen); Despair (Wanhoop); Disappointment (Teleurstelling); Disgust (Walging); Envy (Jaloezie); Fear (Angst); Feeling of loss (Gemis); Greed (Hebzucht); Happiness (Geluk); Hatred (Haat); Heavy-heartedness (Bedruktheid); Honor (Eergevoel); Hope (Hoop); Joy (Blijdschap); Love (Liefde); Loyalty (Trouw); Moved (Ontroerd); Offended (Beledigd); Pride (Trots); Relief (Opluchting); Remorse (Wroeging); Sadness (Verdriet); Shame (Schaamte); Spitefulness (Wrok); Suspicion (Achterdocht); Trust (Vertrouwen); Unhappiness (Ongelukkig); Vindictiveness (Wraakzucht); Wonder (Verwondering); Worry (Bezorgheid);

Table 2. HEEM emotion categories (37)

Words were annotated and interpreted in context, which means that a polysemous word like the Dutch noun "hoop" which has two meanings (*heap* and *hope*) will only be identified if it is used in its second meaning. Likewise, body related concepts, i.e. body parts, bodily processes and body sensations, are only identified if they are involved in an emotion expressed in the text. In the case of bodily processes, for instance, the reaction must be triggered by an emotion and not by any other phenomenon. For example, *trembling* is annotated in a sentence such as *she trembles with anger*, but is not annotated in: *she trembles from the cold*.

Each annotated concept is classified into one of the 37 classes of the HEEM emotion classification. Consider, for example, the following sentence and its annotations: Ex. (1) "Ik kreeg van haar daar zulk gekyf; / Dat noch het hart beefd in me lyf" ("She scolded at me so terribly that my heart is still trembling in my body"). The word "gekyf" (*scolding*) can be identified as an emotional action and linked to the emotion class Anger. "Hart" (*heart*) is annotated as a body part and, in this case, linked to the emotion class Fear. Likewise, "beefd in me lyf" (*tremble in my body / breast*) is identified as Bodily Process and also linked to the emotion class Fear. In the annotations, no distinction was made between the references to body parts or bodily processes in a literal and a metaphorical sense. The reason for this decision was that such a distinction is often quite difficult to make in early modern texts, where expressions which we now consider to be metaphorical often had a quite material basis in humoral theories of the passions.

2.2. Inter-annotator study

The annotation was performed by a group of experienced readers of early modern Dutch (theatre) texts. An inter-

annotator study was carried out to check the consistency and reliability of the annotations. Five annotators annotated independently 2 documents with a total of approx. 1100 sentences. Agreement is calculated following the metric *agr* as proposed by [Wiebe et al. 2005] and [Read and Carroll 2010], who calculate agreement on similar data. This metric calculates pair-wise agreement by first measuring precision of annotator A's annotations on B's annotations, and then measuring precision of annotator B's annotations on annotator A's annotations. Agreement between 2 annotators is the mean of the 2 scores. We only report overall agreement (Table 3 and 4), which is the mean of the pair-wise scores.

One of the problems of these kinds of annotations is that different annotators are likely to choose different unit lengths while marking up what is essentially the same. If we consider again example (1), we cannot know whether an annotator identifies only the word "beefd" (*trembles*) or whether he considers the whole sentence ("het hart beefd in me lyf") as a Bodily Process. We took a lenient approach and considered an overlap of one word as matching.

	OVERALL
Emotion	.73
Body part	.73
Bodily process	.47
Emotional action	.30
Sensation	.61

Table 3. Overall agreement on HEEM concepts in percentages

We first measured agreement on the identification of the different concept types in text. Table 3 shows that the concept types Emotion, Body Part and to a lesser extent Sensation are reliably identifiable, with overall scores of 73, 73 and 61%, respectively. Bodily Processes and Emotional Actions, however, have low agreement scores, which do not allow for definite conclusions. On the basis of these results we decided to drop the categories Emotional Action and Bodily Process for our model development. The lack of agreement in these two categories is caused by the fact that some annotators tended to include more expressions than others. Plays are literary texts that artistically play with words and that are larded with metaphors. In the following sentence body part and emotion are easy to identify: "Wat nevel van verdriet bezwalkte uw blinckende ogen" (*What haze of sorrow drapes your gleaming eyes*). There is sorrow connected to the eyes, but what exactly happens to the eyes? And should that be taken literally? We agreed to take metaphors and expressions literally even though it could be a literary construction and thus that a phrase like this should be tagged as the description of a bodily process. Nonetheless this type of "bodily processes" could be easily overlooked.

We also measured agreement on the classifications of emotions into one of the specific HEEM emotion categories. On this task the annotators achieved an agreement of 85%. The numbers show that the identification of emotions (0.73) is harder than their classification into subcategories once the expressions are identified (0.85).

3. Adapting LIWC and WordNetAffect for historical emotion mining

3.1. LIWC

While we were developing HEEM, we also started experimenting with off-the-shelf sentiment mining tools. We chose Linguistic Inquiry and Word Count (LIWC) as the most promising sentiment and embodiment mining technique for further exploration. LIWC is a text analysis software program, which provides a simple but effective way of measuring tendency and strength of emotions (and other psychological properties) in text [Pennebaker et al. 2001] [Pennebaker et al. 2015]. The LIWC dictionary was translated into Dutch and tested by Dutch social scientists [Zijlstra et al. 2004].[2]

The LIWC software processes each word of a text by searching for matches with a categorized dictionary, including around 4,500 words and word stems. As the software is developed by and for psychologists, it provides lists of words on wellbeing, affect, cognition, biological processes, social practices, and some specific emotions, e.g. anger, anxiety, sadness [Tausczik and Pennebaker 2010] [Kahn et al. 2007].[3] The categories Posemo and Negemo cover a broad

range of terms that express positive and negative appreciations and sentiments including adjectives and adverbs like *nice* or *edgy*, as well as states or situations that could allude to moods or indicate positive or negative appraisal such as *alone* or *gloomy*. See Table 4 for an example of some of the calculations of LIWC on an early modern Dutch theatre text: *Achilles* by Balthazar Huydecoper (1719). We will analyze the results of this table later in this paper. But first, we need to discuss the reliability of LIWC for researching early modern texts.

Category	LIWC		HD-LIWC	
	%	Freq.	%	Freq.
We	0.56	98	0.91	161
You	2.55	449	2.98	525
I	1.64	290	4.86	856
Negemo	2.67	470	4.78	843
Posemo	2.23	394	3.51	618
Posfeel	0.39	69	0.59	104
Anger	0.75	132	1.93	341
Anxiety	0.64	113	0.90	159
Sad	0.90	159	1.36	240
Physical	1,33	235	3,05	538
Body	1.33	235	2.38	420
Death	0.38	67	0.48	84
Social	6.17	1087	10.00	1763
Sports	0.01	1	0.01	2
Swear	0.00	0	0.00	0
TV	0.01	2	0.02	4

Table 4. Examples of LIWC weighted categories of B. Huydecoper, *Achilles* (1719). Total # of words = 17,631

LIWC has been previously applied on historical data sets, without an evaluation of the performance of the software [Borowiecki 2013] [Leemans and Johannes 2013]. As LIWC is designed for modern texts, it underperforms in historical texts. To diminish this problem, we extended the Dutch LIWC dictionary with historical data by linking it to GiGaNT, a lexicon service provided by the INL (INL Lexicon Service). GiGaNT offers spelling and word variants of Dutch language, from the 15th to the 20th century. We used a subset covering the period from 1600-1800. The "historical Dutch LIWC" (HD-LIWC) was created by adding spelling variants for all words to the original Dutch LIWC (cf. the spelling normalization procedure applied in [Zwaan et al. 2015]). The original Dutch LIWC dictionary contains 6,512 terms, while the HD-LIWC contains 8,757 terms. Table 5 shows that most historical terms map unambiguously to a single modern variant (96%). For historical terms that mapped to multiple modern variants, a single variant was selected randomly.

#Mappings	#Historical terms	Percentage
1	8021	96,08
2	706	3,76
3	27	0,14
4	3	0,02

Table 5. The number of mappings to modern term in the historical Dutch LIWC dictionary.

Applying the "historical Dutch LIWC" (HD-LIWC) to our corpus resulted in higher coverage as more words were labeled with one or more LIWC categories. Table 4 shows percentages of words found for the positive emotions (Posemo),

Negative emotions (Negemo), and Body categories using the original Dutch LIWC and HD-LIWC in one selected play: *Achilles* by Balthasar Huydecoper (1719). However, the higher percentages achieved by HD-LIWC must be interpreted with care, because our method of developing HD-LIWC introduced noise into the list. We identified three types of noise that were introduced. First, for historical words that map to multiple modern alternatives, one alternative was selected at random. For example, the historical term "vreed" is a spelling variant of both "vrede" (*peace*) and "wreed" (*cruel*). In the historical LIWC, "vreed" only maps to "vrede", the meaning of "vreed" as "wreed" is missed. The second source of noise is caused by the way in which the LexiconService returns spelling variants for verbs. Regardless of the tense of the verb entered, the LexiconService returns spelling variants in all tenses. This means that LIWC categories Present and Past are unreliable and should not be used. The third source of noise is introduced by inconsistencies in GiGaNT/the LexiconService. For example, the term "gehoond" (*mocked*) is retrieved as a spelling variant of "gezond" (*healthy*) and counted in the LIWC category Body, where it obviously does not belong.

3.2. WordNetAffect

As an experiment, we also compiled another emotion wordlist for Dutch based on the English resource WordNetAffect [Strapparava and Valitutti 2004]. WordNetAffect is built as an extra layer on the Princeton WordNet [Fellbaum 1998] semi-automatically labeling each set of synonyms with a so-called affect type (such as mood, trait, emotion, behavior, etc.). Part of these synsets is additionally labeled with a set of fine-grained emotion classes such as anger, fear, disgust, etc. We transferred these labels from the Princeton WordNet to the Dutch WordNet [Vossen et al. 2008] using the equivalent links between the two WordNets. We then selected the words labeled with the affect type "emotion" and expanded the set with historic variants adopting the same strategy as followed for the historical version of LIWC. For the tests presented in this paper we did not take into consideration the fine-grained emotion classification. [25]

The result in numbers are presented in Table 6. As this resource is automatically generated it includes also incorrect labels or omissions mainly due to erroneous or missing equivalent links or even to the fact that the original English resource has been built also in a partly automatic way. [26]

Dutch WNAffect	Flectional variants	Historical variants
2315	5215	15618

Table 6. The number entries Dutch D-WNaffect (modern and historical)

4. Comparing HEEM with D-LIWC and D-WNAffect

In this section, we will present a quantitative comparison between HEEM annotations and the four wordlists: the Dutch version of LIWC (D-LIWC), the historical Dutch version of LIWC (HD-LIWC), the Dutch version of WordNetAffect (D-WNAffect) and the historical Dutch version of WordNetAffet (HD-WNAffect). To be able to perform the comparisons, we merged the LIWC classes 'posemo' and 'negemo' into one single class 'emotion' and compared the result with the HEEM emotion classes. Additionally, we compared the LIWC class 'Body' with the HEEM class 'Lichaamsdeel' (Emotion related Body part). [27]

The results in absolute numbers can be seen in Table 7. The numbers of HEEM entities differ considerably from the numbers identified by both D-LIWC and HD-LIWC, which is caused by the broad definition of the LIWC categories of emotions and body related terms compared to the corresponding HEEM classes. We also see that HD-LIWC has higher coverage than LIWC. [28]

	HEEM	D-LIWC	HD-LIWC	D-WNAffect	HD-WNAffect
Emotions	3730	11550	22349	9694	17948
Body parts	826	3369	6714	-	-

Table 7. Number of entities found in the 29 HEEM texts

		LIWC	HD-LIWC	D-WNAffect	HD-WNAffect
Emotions	precision	0.13	0.10	0.19	0.13
	recall	0.41	0.60	0.49	0.64
	F-measure	0.20	0.17	0.27	0.22
Body parts	precision	0.11	0.74	-	-
	recall	0.44	0.60	-	-
	F-measure				

Table 8. Precision and recall of HD-LIWC and D-LIWC on HEEM

We established the precision of D-LIWC in finding emotions and body parts when compared to the manual annotations of HEEM. Here precision indicates how many entities found by D-LIWC and HD-LIWC are also identified as emotions or body parts by HEEM. Table 8 shows that only 13,5% and 10.1% of the words identified as emotions by D-LIWC and HD-LIWC, respectively, are labeled as emotions by HEEM. Likewise, only 10.9% and 7.4% of the body terms identified by D-LIWC and HD-LIWC are listed by HEEM as emotion related body parts.

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The low precision score is illustrative for the difference between sentiment mining (LIWC), which returns a wide variety of opinions and affective expressions and the manual expert annotations according to the model developed for HEEM, which is very precise and more restrictive in its identification of emotion words and terms for body parts involved in the embodiment and expression of emotions.

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Recall scores measure how many words have not been found by D-LIWC and HD-LIWC when compared to HEEM. The score of 60,2% for the recall on emotions implies that still 40% of the emotion words in the 29 plays were not found by the historicized LIWC. HD-LIWC gives higher recall than the D-LIWC but its lower precision scores uncover that the noise introduced by the extra words is substantial.

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4.1. Emotions or sentiments

The tables 9, 10 and 11 present correctly found, and missed emotion words, and words that HD-LIWC counts, but HEEM ignores. These lists provide insight into the way HEEM works in comparison to D-LIWC and HD-LIWC. Table 9 shows the most frequent words correctly found by HD-LIWC. The words in bold such as "vreezen" (*fear*), "vreugd" (*joy*) and "spyt" (*reget*) are historical variants of emotion words that are correctly found by HD-LIWC, and that are missed by D-LIWC. Table 10 shows the most frequent words that are still missed by HD-LIWC. Many words such as "gramschap" (*anger*), "toorn" (*anger*) "min" (*love*), "minnen" (*to love*), and "mededogen" (*compassion*) are archaic emotion words that are no longer in everyday use or even obsolete. These words are not included in the HD-LIWC as they are not variants of contemporaneous words with an affective meaning. It also shows that some historical form variants are still lacking in HD-LIWC (e.g. "jalouzij" (*envy*), "lijefd" (*love*), "liefd" (*love*), "haaten" (*hate*) etc.) although their modern counterparts (i.e. "jaloezie", "liefde" and "haten") are present in D-LIWC.

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liefde	love	160
vrees	fear	128
haat	hate	94
hoop	hope	91
wraak	revenge	72
vreugd	**joy**	71
verdriet	sadness	58
schrik	fear/shock	56
vreezen	**fear**	52
wanhoop	despair	45
eer	honour	42
geluk	happiness	39
vreugde	joy	37
spyt	**remorse**	36
droefheid	sadness	31
wraeck	**revenge**	30
vreest	fears	26
woede	anger	26
trouw	fidelity	25
angst	fear	23
lust	desire	22
bemint	loves	21
haet	**hate**	21
bang	afraid/fear	19
vreugt	**joy**	18
vreesen	**fear**	18
verlangen	desire/longing	18
beminnen	love	18
schrick	**fear**	17
gelukkig	happiness	17
rouw	grief/feeling of loss	16
blydschap	**joy**	15
wrock	**spitefulness**	14
genoegen	satisfaction/happiness	13
vermaak	joy	12
spijt	regret	12
wraakzucht	revengefulness	11
vreeze	**fear**	11

Table 9. Words correctly found by HD-LIWC. Words in bold are historical variants of emotion words that are missed by D-LIWC, but that are correctly found by HD-LIWC.

min	love	128
smart	grief	98
gramschap	anger	60
toorn	anger	30
minnen	love	27
liefd	love	26
mint	love	24
minne	love	21
droeve	grief	19
mededoogen	compassion	15
smert	grief	14
tooren	anger	14
begeert	desire	11
haaten	hate	11
jalouzy	envy	11
verbaast	wonder	10
achterdocht	fear	9
bevreest	fear	9
schroomen	shame	9
verschrikt	fear	9
begeeren	desire	8
lijefd	love	8
smarte	grief	8
verblyd	joy	7

Table 10. Words missed by HD-LIWC

moet	must/courage	767
eer	before/honour	568
alleen	alone	381
groot	large	241
vry	free	218
goed	good	195
ernst	seriousness	160
wij	we	160
deugd	virtue	152
gaet	to go	150
lieve	dear	147
hoop	hope	146
ryk	rich	141
hemel	heaven	134
nood	need	134
gunst	grace/goodwill	131
beter	better	129
moed	courage	129
lief	dear	128
held	heroe	125
best	best	124
straf	punishment	123
vyand	enemy	123
lust	lust	119
trouw	faithful	115

Table 11. Words found by HD-LIWC, ignored by HEEM

Table 11 constains the words that are found by HD-LIWC, but are ignored by HEEM. It includes words such as "goed" (*good*), "ryk" (*rich*), "held" (*hero*) which are appraisals and judgments rather than emotions in the stricter sense. In HEEM only descriptions of emotions as defined by Scherer (see paragraph IV) are annotated while LIWC includes all kinds of sentiment words including emotions, attitudes, appraisals and beliefs as well as concepts that are strongly associated with positive or negative feelings such as "hemel" (*heaven*) or "straf" (*punishment*). | 33

A second set of highly frequent errors comes from incorrectly found form variants. The verb form "moet" (*must*) and the adverb "eer" (*before*) are wrongly considered as historic form variants of the noun "moed" (*courage*) and the noun "eer" (*honor*), respectively. It seems worth trying to solve these confusions by filtering on part-of-speech, but this is currently not an option as well-performing NLP tools are not yet available for historical Dutch. | 34

Finally, LIWC does not take into account polysemy or context. LIWC overestimates the sentiment value of texts since it classifies ambiguous words like "alleen" (*alone*) and "vry" (*free*) as negemo and posemo, and lists "social" pronouns such as "we" as positive sentiments. The polysemous noun "hoop" has an affective meaning (*hope*) and a non-affective meaning (*heap*). The theater texts include both usages as in "van alle hoop ontbloot" (*deprived from all hope*) and "een hoop geboeyde slaven" (*a lot of chained slaves*). In HEEM the former usage is annotated as an emotion and the latter is not, whereas LIWC is not able to distinguish between them. Likewise, we can see that a word like "lust" (*desire*) appears both on the list of correctly found words (cf. Table 9) and on that of the incorrectly found words (cf. Table 11). It will therefore be difficult to achieve high scores with a word counting method like LIWC on an early modern literary corpus. | 35

4.2. Bodies and physical states

The LIWC category "Physical" will return body parts such as *hands*, *eyes*, *womb* or *ears*, and bodily processes or reactions such as *trembling*, *bleeding* or *blushing*, but also general physical states such as *awake*, *sleepy*, *wounded*, or illnesses (*anorexia*, *angina*, *AIDS*), and even loosely related body words such as *alcohol*, *bathroom*, *bathrobe*, *cook*, *kitchen* and *dishes*. HD-LIWC even broadens this category including words like "schoon", which can mean *clean* and *beautiful*, but in early modern Dutch is in many cases used for *however* ("(of)schoon"). Also, the indicated problem that HD-LIWC introduces noise in spelling variants in verb tenses, is visible in the returns HD-LIWC gives on the historical corpus. One of the words with the highest recall rates in the category physical is *was*. This past tense of the verb to be, is indicated as physical since LexiconService has *was* listed as a verbal conjugation of "washing". The broad range of the LIWC category Physical, and the noise created by HD-LIWC therefore renders this category as not very indicative for research into physical states or reactions to emotions.

The LIWC category Body is more precise and concise (400 words) than Physical (648 words). But again, noise is introduced by HD-LIWC. "zich" (*his*) is indicated as a body term, as a spelling variant of *sight* ("zicht"), just as "vry" (*free*), as a conjugation of "vrijen" (*making love*), "tien" as a variant of "teen" (*toe*), and "arme" (*poor*) as spelling variant of "arm" (*arm*). Altogether 25% of the indicated body terms is incorrect. Although this is a high percentage, it is quite easy to correct, since the same noise words keep coming back and their percentage is quite high (of the 25% of noise 75% is caused by the word "zich").[4] For future use HD-LIWC could be cleared of these easily traceable mistakes. Apart from these apparent over-interpretations, HD-LIWC indicated many words as body terms that are ambiguous. "Vryen" can mean *to make love*, but in most instances it is an inflection of "vrij" (*free*). As long as LIWC only counts single words, without taking context in consideration, this will remain a problem.

5. The performance of heem and hd-liwc in a few practical examples

In the last section of this article, we will dive deeper into the texts and provide some examples as to how applying LIWC and HEEM can help us to analyze early modern texts. In Table 4 we presented the (HD)-LIWC analysis of an 18th-century Dutch tragedy by Balthazar Huydecoper. Table 12 draws a comparison between this tragedy and a comedy from around the same period by Jacob Campo Weyerman.

Category	D-LIWC %	D-LIWC Freq.	HD-LIWC %	HD-LIWC Freq.	D-LIWC %	D-LIWC Freq.	HD-LIWC %	HD-LIWC Freq.
We	0.56	98	0.91	161	0,30	29	0,10	45
I	1.64	290	4.86	856	1,93	186	3,58	345
Negemo	2.67	470	4.78	843	1,01	97	1,97	190
Posemo	2.23	394	3.51	618	0,90	87	2,06	199
Posfeel	0.39	69	0.59	104	0,29	28	0,66	64
Anger	0.75	132	1.93	341	0,27	26	0,52	50
Anxiety	0.64	113	0.90	159	0,16	15	0,32	31
Sad	0.90	159	1.36	240	0,19	18	0,36	35
Physical	1,33	235	3,05	538	1,37	132	2,73	263
Body	1.33	235	2.38	420	0,70	68	1,39	134
Death	0.38	67	0.48	84	0,23	22	0,34	33
Social	6.17	1087	10.00	1763	4,18	403	4,21	406
Sports	0.01	1	0.01	2	0,04	4	0,08	8
Swear	0.00	0	0.00	0	0	0	0	0
TV	0.01	2	0.02	4	0,18	17	0,19	18

Table 12. Comparison of D-LIWC and HD-LIWC analysis of a tragedy (*Achilles* by B. Huydecoper, 1719) and a comedy (*De Hollandsche sinnelykheid* by J.W. Weyerman (1713). Total # words: Huydecoper–17,631; Weyerman-9,647.

The comparison leads to some interesting observations. Firstly, the comedy seems to be far less joyful than the tragedy as the relative frequency of positive emotions (Posemo) is lower (0.90 / 2.06%) in Weyerman than in Huydecoper (2.23 / 3.51%). Secondly, the tragedy seems to be more emotional over all, whereas the comedy seems to stage less emotional scenes. As expected, emotions like sadness, anger and anxiety are far more dominant in Huydecoper's tragedy. Also, death is addressed more often in the tragedy. Body terms are used less in the comedy - a fact that may be connected to the lower degree of emotional expressions. However, since LIWC does not interconnect these categories (as HEEM does), we cannot verify this hypothesis. [39]

What puzzled us at first is that exclusive modern-day categories such as TV also returned results in the early modern texts. A check of the dictionary showed us that this is due to the fact that this category also includes words like "vermaak" (*entertainment*), which is a rather common description of being amused in early modern Dutch. We can conclude that (HD)-LIWC shows interesting results when comparing individual texts. Comparing these two texts with the overall results of (HD)-LIWC analysis of 29 Dutch theatre texts, taught us that they follow main trends. Overall, modern categories such as Sports, School and TV return low results (between 0,03 and 0,2% - and most of the 0,2% depended upon the word "vermaak"). The category Swearing is even almost completely absent (0,01%). This can be due to the civilizing zeal of the playhouse (swearing was hardly tolerated on Dutch stages), and to the fact that swear words are cultural and time sensitive. The Dutch are famous for swearing with diseases [Sanders 1998]. As the most threatening diseases change over time, so do the swear words. Religious swear words (e.g. devil, holy) have gone out of fashion. [40]

Religion does show up as a category of interest for Dutch plays (around 0,70%). This is striking since the Amsterdam theatre did not admit biblical plays on stage, and frankly discouraged play writers from addressing matters religious on stage [Leemans and Johannes 2013, 267–8]. That early modern plays were meant to arouse and temper the passions is quite clear from the data: both tragedies and comedies show high results for physical and emotional categories: Early modern Dutch comedies present a posemo percentage of 2,7% and a negemo of 1,75%, and tragedies 3,30% posemo and 3,54% negemo. This is overall significantly higher than the average pos/negemo percentages of English language novels (2.67% posemo, 2.09% negemo), or of the New York Times (2.32% posemo, 1.35% negemo). Current social media, however score much higher on the sentiment scale than early modern Dutch drama (LIWC 2015). [41]

To compare the performance of (HD)-LIWC and HEEM we can also check the results in distinguishing between different genres over 29 Dutch theatre plays. Figure 1 shows that HEEM seems to be better in distinguishing comedies and tragedies. Quite astonishing is the fact that LIWC hardly seems to be able to distinguish between tragedy and comedy on the basis of their sentiments: positive and negative sentiments in both genres score around 50%. HD-LIWC has similar results for tragedies, but finds comedies more positive than negative. According to HEEM tragedies are far more negative than positive, and although HEEM does not seem to find comedies significantly more positive, it does show that in percentage, comedies are much merrier than tragedies.[5]

	D-LIWC total# words		HD-LIWC		HEEM	
	Total # words	%	Total # words	%	Total # words	%
Comedy Neg	1988	46	3377	39	1788	54
Comedy Pos	2368	54	5201	61	1552	46
Tragedy Neg	3811	54	6967	52	3702	68
Tragedy Pos	3244	46	6496	48	1758	32

Table 13. Comparison of sentiment analysis of 13 comedies and 14 tragedies between D-LIWC, HD-LIWC and HEEM. First columns give total amount of words in texts, second columns % of total for that genre.

For scholars who work on historical texts HEEM is an interesting tool not only for its preciseness in measuring positive and negative emotions, but even more for its ability to trace the relative dominance of certain emotions in a specific period of time, and the chronological development of "emotions lost and found" [Frevert 2011]. Moreover, HEEM can analyze where in the body emotions such as wrath are located and how that changes over time (Figure 1). In general, HEEM can trace trends in the locations of emotions in the body, finding for instance the rise of the heart as an important seat for emotions over the early modern period (Figure 2). The data presented in these graphs are the results of the machine learning process that we carried out on the basis of the HEEM model we discussed so far in this article (see for a discussion of the development of the machine learning: [Zwaan et al. 2015]). We have used the HEEM model to analyze a significant larger set of theatre texts (N = 280). The results of this analysis will be presented in a following publication. In the meantime, the HEEM tool is already made available in open access (HEEM-Github).
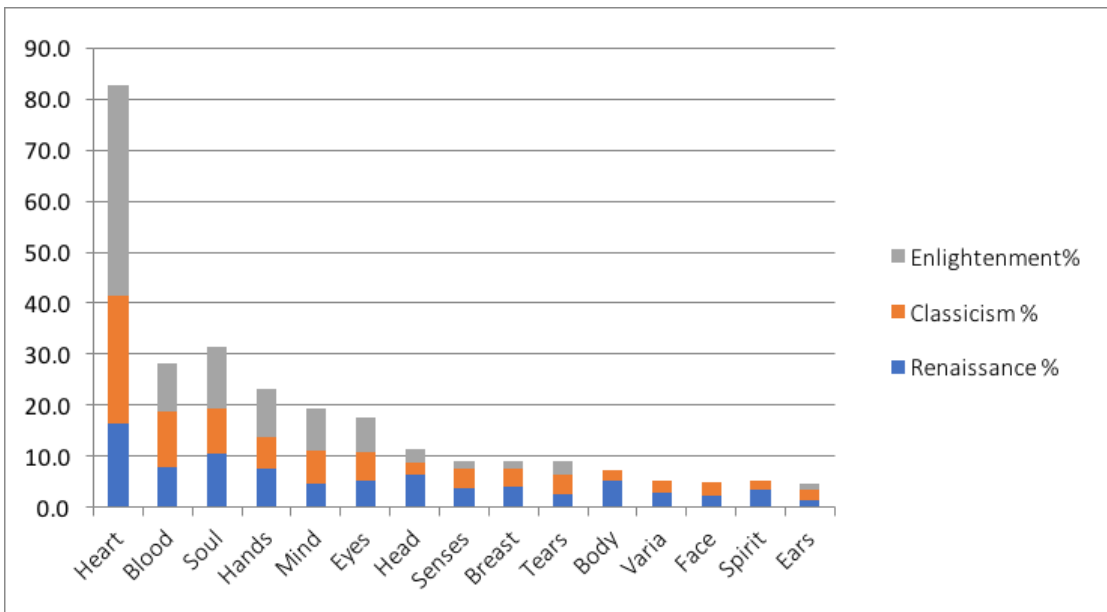

Figure 1. Embodiment of wrath (HEEM+: N=- 280 texts)
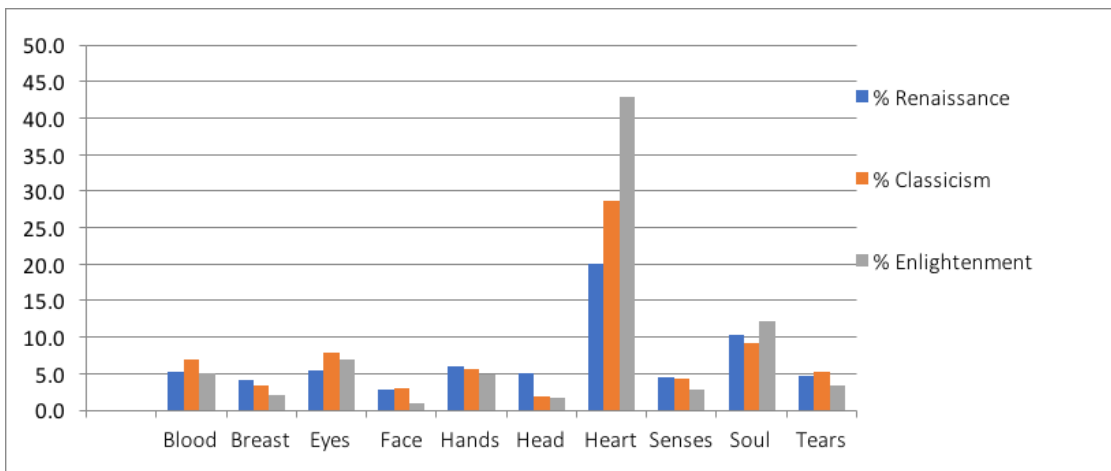
Figure 2. Changes over time in embodied location of emotions (HEEM+: N = 280 texts)

HEEM and HD-LIWC can also be applied on single plays in order to explore sentiment dynamics over time. Figure 3 presents a visualization of positive and negative sentiments in the course of one Dutch theater play. The 'sentimental' development can be visualized per character and per speaker turn. The visualization shows that the two main male characters (Achilles and Patroclus - blue and red lines) are overall in despair, although Achilles seems to temporarily brighten up by the presence of Brizeïs (orange line).

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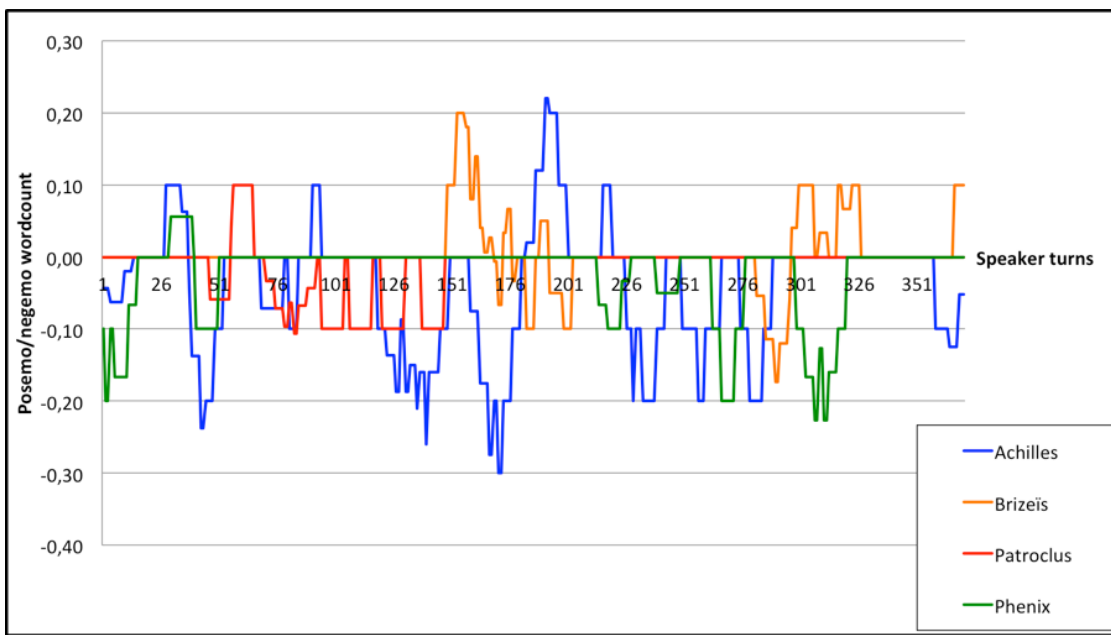
Figure 3. Visualization of positive and negative sentiments (using HEEM) of different characters in 18th century Dutch play: Huydecoper, *Achilles* (1719).

These single play analysis and visualizations can be of interest for literary historians, e.g. to study the narrative structure of texts, or to compare the plot-sentiment development in different genres. In a follow-up project, we are developing new narrative-driven visualization tools for HEEM [Zwaan et al. 2016].

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6. Conclusion

This article presents a new model for historical emotion mining in Dutch language texts: HEEM. We have described why and how we developed HEEM for the mining of embodied emotions in historical Dutch language texts. We have presented our evaluation data of HEEM development, and compared HEEM performance with the off the shelf

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sentiment mining tool LIWC, and with a historicized version of Dutch language LIWC.

We conclude that especially a historicized version of Dutch language LIWC (HD-LIWC) could be apt for sentiment mining in historical texts. Some of the "non-emotion" categories LIWC registers also seem relevant for historical texts (topics such as "death" or "religion", usage of we/I/you), whereas some categories are too time specific to be of any use (TV, sports, school, swearing). 47

Overall, LIWC is a text analysis program based on single word recall. Although LIWC offers some classifications of specific emotions, these are biased towards negative emotions (sadness, anger, anxiety). Researchers interested in emotions, as opposed to a larger category of sentiments, seem to be better off with HEEM. 48

HEEM also has a more fine-grained vocabulary for the detection of body terms in historical texts and relating those to emotions. It allows us to map changes in the embodiment of emotions on the Dutch Stage over a long period of time. For the future, improvements could be made to HD-LIWC by developing stricter spelling variants and including part of speech tags, to diminish noise. Together with the Dutch LIWC team, we are exploring possibilities to improve HD-LIWC, and apply it on the Dutch translation of LIWC2015. 49

Combining LIWC and HEEM could bring new perspectives to future research: it could give an indication of the physicality of a text (how many body terms are used in general?) and of the percentage of emotional physicality: what percentage of the physical terms is indicated as emotionally charged? 50

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Cornetto Project: http://www2.let.vu.nl/oz/cltl/cornetto/

DBNL (Digital Library of Dutch Literature): http://www.dbnl.org

ePistolarium: http://ckcc.huygens.knaw.nl

INL Lexicon Service: http://sk.taalbanknederlands.inl.nl/LexiconService/

LIWC2015: https://liwc.wpengine.com

Nederlab: http://www.nederlab.nl

HEEM: https://github.com/NLeSC/HEEM-dataset

Notes

[1] FOLIA: http://proycon.github.io/folia; KAF: http://www.cltl.nl/results/software/kafnafannotator/

[2] LIWC has been updated and expanded in 2015 (LIWC2015, see [Pennebaker et al. 2015]). However, since the Dutch translation of LIWC2015 has not yet been published and integrated in LIWC2015, we have made use of the previous version (LIWC2007)

[3] The LIWC output consists of: 1. General descriptor categories (total word count, words per sentence, punctuation etc), 2. Standard linguistic dimensions (percentage of pronouns, articles, etc.), 3. Word categories indicating psychological constructs (e.g., affect, cognition, biological processes), 4. Personal concern categories (e.g., work, home, leisure activities) [Pennebaker et al. 2001]

[4] Of 420 HD-LIWC indicated body terms in 1 theatre play, 98 were obviously noise: zich (77), gehoond (10), vry (4), hoog (3), hangt (2), schede (2).

[5] Although HEEM does not have specific categories for positive and negative sentiments, we clustered the emotions in these two categories for this analysis. (see also [Zwaan et al. 2015]).

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