Universiteit Leiden
The Netherlands

The Emotions of a Painted Face: Analyzing British Portraiture Art from The Tudors to The Victorian Era

Veneta V. Andersen[1], Fons J. Verbeek[2]
[1]Media Technology, Leiden University, [2]Leiden Institute of Computer Science

Abstract: This study uses an emotion face recognition algorithm to detect and measure the six basic human emotions (anger, disgust, fear, happiness, sadness, and surprise, and contempt, where contempt is experimental), and neutral, as defined by an Ekman classifier, in British portraiture art between 1500 and 1910. Only single-sitter portraits are considered for the analysis, and the images are taken from the collection of The National Portrait Gallery in London. The analyzed images include examples from Tudor and Elizabethan period, Stuart Portraits and the Civil War, Georgian and Regency Portraits, up to the Victorian and Edwardian portraits (1910). The research examines how the measured emotion recognition values are distributed throughout the periods, in which they were painted, and seeks a dominant emotion by historical period, by sitter's gender, and by sitter's class status. Only single sitter, oil painted portraits are considered, as a study by Karolina Nurzynska has shown that the texture of an image might affect the emotion measurements obtained by an emotion face recognition algorithm. [1]
Keywords: British portraiture, cloud-based emotion recognition algorithm, meta-method classifier

1. Introduction

1.1. The Art of the Face

In fine art, the artistic representation of a person's face is the portrait. There are various portrait types and sub-genres – the *full-length* portrait, usually reserved for ruling royalty or nobility, the *three-quarter length* portrait, and the *head-and shoulder* portrait, which is the dominating kind of portrait in art history, as it presents the image on the face in all angles, in which the sitter is positioned towards the viewer (spectator).

Portrait art brings forth the characteristic of the period, in which it was painted. In early Egypt, for example, portraits only showed the subject in profile. The Baroque portrait offers sharp lighting and dramatic interaction, compared to the Impressionist portrait, which pairs silence with melancholy. The Romantic portrait is often described as higher-spirited and uplifting, yet it is not nearly as colorful as the Expressionist portrait. The Italian portrait carries the extravaganza of the Italian landscape. The British portrait offers "the sobriety of the Commonwealth" with its "delicate, yet supple style."[2]

[1] "Emotion Recognition: The Influence of Texture's Descriptors on Classification Accuracy", BDAS 2017: Beyond Databases, Architectures and Structures. Towards Efficient Solutions for Data Analysis and Knowledge Representation, pp 427-438

[2] "Portrait Painting in England, 1600–1800", Katharine Baetjer, Department of European Paintings, The Metropolitan Museum of Art, 2003

Universiteit Leiden
The Netherlands

Portraiture art has a complicated relationship with emotion. In portraiture art before the 19th Century (before the invention of the camera), it is considered that the more neutral a face appeared, the higher in society his owner ranked. According to Nicholas Jeeves from the Cambridge School of Art, by the 17th century in Europe "it was a well-established fact that the only people who smiled broadly, in life and in art, were the poor, the lewd, the drunk, the innocent, and the entertainment. Showing the teeth was for the upper classes a more-or-less formal breach of etiquette." [4] He referred to *The Rules of Christian Decorum and Civility* of 1703, by St. Jean-Baptiste De La Salle, to signify the importance of the lip to the teeth: "[T]here are some people who raise their upper lip so high… that their teeth are almost entirely visible. This is entirely contradictory to decorum, which forbids you to allow your teeth to be uncovered, since nature gave us lips to conceal them."[3] Hence, portraiture art has strived to deliver a neutral image of the sitter: the individual is stripped of emotion, not to distract from his social status, personal wealth, skill set, and individual distinguished qualities. It is a testament to his sense of self-control, where there is no place for any temporary lapse into an emotional outburst. Also, it is just overwhelmingly difficult to pose with a natural smile for a long-painted portrait, and it is not until the early 19th century, when photographs could be produced successfully, that fleeting emotions became a part of the portraiture genre.

Depending on the number of individuals portrayed in an image, portraits can be defined as *individual*, *family* and *group* ones. The *individual* or (as referred to in this paper) *single sitter* portraits adhere to the rules to appear unemotional. On contrary, however, *group* and *family* portraits are partial to emotion, as they strive to present complex family relations. Their role is to depict the rules of behavior, and the hierarchies within the pictured group, and interactions and gaze are necessary to validate those hierarchies. The family and group portraits will not be included in this research.

The images we selected are only single sitter examples of British portraiture art from the collection of the National Portrait Gallery in London. The study focuses only on oil portraits, produced from 1500 until 1910, as it is considered that in the late Middle Ages portraiture painting became a genre of its own, while several factors in the Victorian era (mainly the rise of photography) brought about a decline in British portrait art. Additionally, it is in the fifteenth century (with the invention of the canvas), that portraiture art became more inclusive, as commissions became available "not only princes, the high clergy and noblemen, but members of other social groups - merchants, craftsmen, bankers, humanist scholars and artists - sat for their portraits, keeping themselves, quite literally, in the public eye." [2] This diversity allows us to derive measurements for different social categories of sitters, as well as for both genders. The portraits we selected have three common features:

- They all have **one face** in them;
- They all carry the characteristics of the **period** in which they were painted;
- They all strive to appear **neutral**.

Posing in an unemotional and naturally neutral appearance for an extended period, however, seems just as impossible as keeping a natural smile for long. So, does some emotion leak through the neutral portrait? And does that emotion offer an insight into the period, in which it was painted? Does it differ by sitter? Is it affected by gender or to social status?

[3] "The Rules of Christian Decorum and Civility, divided into two parts, for use in the Christian Schools," St. Jean-Baptiste De La Salle, 1703 (https://lasallian.info/wp-content/uploads/2012/12/Christian-Decorum-reprint-2007.pdf) , Accessed August 25, 2017

This research offers an answer to these questions by applying an emotion face recognition algorithm to images of single sitter portraits from the collection of the National Portrait Gallery in London. It takes a sample of images 976, which belong to The Tudor and Elizabethan period, up until The Victorian era (1500 – 1910) of British art history, and offers an insight into a new way of art historical analysis, pairing contemporary emotion face recognition tools, with brute force analysis of the results. It is unique, as it combines the fields of art history, emotion face recognition, and machine learning, in a way, which has not been done before.

1.2. The Science of the Face

In affective computing, the facial expression is one of the most widely acknowledged forms of scientific modulation, which makes any the scientific representation of the face subjected to the effects of emotion. Emotions are elusive, ephemeral, ambiguous, and misleading. In 1862, however, Duchenne de Boulogne (1806–1875), a French physician who pioneered modern neurology, identified independent expressive muscles in the face. Based on his work, the American psychologist Paul Ekman and his team have developed the "Facial Action Coding System," which provides mapping between the muscle and the emotion space. Ekman is a pioneer in researching facial emotion recognition from face analysis. His research helped divide the human emotion in four categories: *full emotion* (standard emotion without suppression), *micro expression* (expression of concealed emotion, which happens within less than 1/5th of a second), *restricted emotion* (concealed emotion), and *slight emotion* (a failed emotion). A person's 80 facial muscular contractions, and their combinations, give rise to thousands of expressions. A major class of expressions are categorized into seven basic emotions *happiness, surprise, contempt, sadness, fear, disgust* and *anger*. Ekman's research has shown that expressions of emotion are identical across all cultures; moreover, blind people display the same facial expressions as people who can see when exhibiting emotion. Presently, most attempts to automate emotion face recognition are based on Ekman's classifier, as the principles of The Facial Action Coding Systems are used in combination with powerful Artificial Neuron Networks (ANNs), analytics, data mining and machine learning to create modern day facial emotion recognition software. [1]

2. Method

This study uses one such facial emotion recognition platform - Microsoft's Azure Cognitive Services Emotion API beta - to detect and measure the six (and contempt) basic emotions, and neutral, in examples of British portraiture art between 1500 and 1910. Asure's Emotion API is a cloud-based emotion recognition algorithm, which "takes an image as an input, and returns the confidence across a set of emotions for each face in the image, as well as bounding box for the face, from the Face API. The emotions detected are happiness, sadness, surprise, anger, fear, contempt, disgust or neutral. These emotions are communicated cross-culturally and universally via the same basic facial expressions, where are identified by Emotion API."[4] It recognizes the faces of up to 64 persons in an image, computes the face rectangles, and returns an array of face entries and their associated emotion scores. It provides a score between 0 and 1 for each of Ekman's emotions. The results provide a numerical value to the confidence, with which an emotion is detected by the algorithm. The *neutral* emotion is the result of *1-Sum(All.Emotions)*. Azure's Emotion API supports all JPEG, PNG, GIF, and BMP image formats, and best

[4] Emotion API Overview, Microsoft Docs: https://docs.microsoft.com/en-us/azure/cognitive-services/emotion/home, Accessed August 25, 2017

performs with frontal to near frontal faces. Its algorithms have been trained mainly on photographic images of the face with diverse quality.

The images for this research have been selected from the database of The National Portrait Gallery in London, which offers the largest collection of images of portrait paintings in the world. The images were selected using the ***Advanced Search*** option of the Primary Collection using the following steps:

- ➔ **Primary Collection of National Portrait Gallery in London**
  - **Advanced Search**
    - **Portrait**
      - **Made Between (1500 and 1910); Medium Type (painting)**
        - **Subjects and Themes (Medium …Oil)**

The output was sorted using the **Gallery Recommended** option, displaying 20 results per page in 119 pages.

All images are in the same file format (JPEG), and dimensions, as downloaded by the ***Larger Image*** option for each image on the website of The National Portrait Gallery.

The role of emotion in single sitter portrait differs from that of family and group portraits. The purpose of the single sitter's portrait is to attest to the individual's riches, social status, profession, and ability to remain in control, by remaining neutral. Family and group portraits, however, relied on emotion and gaze to provide the connection and hierarchy among their members, and they do not adhere to the "neutrality" rule, by which single sitter portraits were painted. Thus, for this research, only single sitter portraits were selected from the search results. Family and group portraits, which appeared in the search results, obtained as described above, were ignored, and only single sitter portraits or all lengths and head angles were selected for emotion measurement evaluation.

The images were then downloaded and organized in folders in the order of their appearance on the search page, each image's name consisting of the full name of the sitter.

2367 portraits matching these criteria were found. Of them **1065 single sitter portraits** were downloaded in the order they appeared in the search. The saved images were then input into Azure's Emotion API for evaluation, one at a time. Only images, in which a single bounding box was found by Azure, and it belonged to the face of the sitter (and not to a "ghost" image in the background), were used for evaluation. The others were discarded.

The resultant Emotion API evaluation yielded **976 images of oil portraits**, containing only single sitters and displaying only a single "bounding box" of the sitter's face per image, which were compiled in an MS Excel file for evaluations on emotion measurements for all six emotions (contempt), and neutral.

It has often taken artists a period of several years to complete a painting. It is also common for the paintings from 16th and 17th centuries, that art historians assign an estimated period, in which a portrait was created. Thus, in the ***Year*** column of the data file, the last assigned year for the painting was noted: for example, in the portrait of **Thomas Wentworth** (1st Baron Wentworth, Tudor and Jacobean Portraits database entry, by Unknown Anglo-Netherlandish artist, oil on panel, circa 1547-50, NPG 1851) the year 1550 was considered as the year of painting, and the portrait was then assigned to the historical period of that year. The ***Period* column** of the data file categorizes the selected images by the final year per their descriptions, and assigned to the period in British art history, to which that year belonged - *Tudor, Stuart, Georgian*, or *Victorian* period.

A ***Gender*** column was created, keeping track of the sitter's gender, noting whether they were *male* or *female*.

Finally, a ***Status*** column was added, where notes of the sitter's social status were made, assigning them to *Royal & Noble* (Kings, Queens, Dukes, etc.) or *Non-Royal* (merchants, artists, scientist, etc.) category for evaluation.

The emotion values for all sitters were then evaluated in both an Excel spreadsheet, and in Weka, and results were produced for all *Period*, *Gender* and *Royals vs. Non-Royal* categories. The results for all six (and contempt) emotions measured reflect what Ekman would consider restricted emotions, or slight emotions, as the rules, by which single sitter portraits in the times between the Tudor, and the Victorian eras were painted, call for neutral expressions.

3. Period Highlights and Emotion Measurements

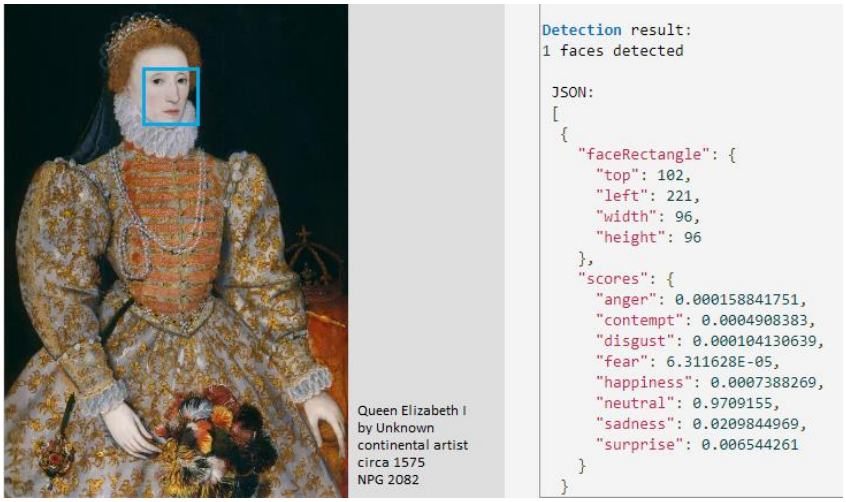
3.1. Early English Kings – Tudor and Elizabethan Era (1485 – 1603)

The Tudor and Elizabethan period covers the Tudor dynasty from the defeat of Richard III at Bosworth Field by Henry Tudor, later crowned Henry VII, in 1485; the reign of Henry VIII to his death in 1547; through the long reign of Elizabeth I from 1558 to 1603.[5] This period is noted as the one of healing, population growth, economic upheaval, and optimism, following the dark days of the Black Death and the agricultural depression. The increase in population, however, brought about an increase in migration, land shortage, low wages, and widening of the gap between the rich and the poor. The Reformation transformed English religion during the Tudors, with Henry the VIII replacing the pope as the head of the Church, maintaining the Catholic doctrines, but opening the path to Protestantism. "The Tudors embraced portraiture and its political applications. Henry VIII commissioned from Holbein a larger than life-size mural so realistic that visitors trembled before it. For Elizabeth I, portraits helped create the myth of a perpetually youthful Virgin Queen. And once the Tudors had also extinguished, via the Reformation, any British tradition of religious art, there was no turning back. Unable to paint God, we painted ourselves."[6]

Many portraits of monarchs during this period were not painted from life, but from "established patterns of facial likeness that circulated among artists' workshops instead. Many portraits of Elizabeth I were produced throughout her long reign, but she rarely sat for portraits from life. Rather, sketches of her face (or pattern drawings) were used to transfer and traced her features onto the primed wooden panel, and then painted in. Picture 1 shows emotion measurements for the portrait of Elizabeth I, known as the 'Darnley Portrait,' named after one of its previous owners, and is one of the most accomplished portraits of Queen Elizabeth in existence. "This portrait was almost certainly painted from life, and the resulting pattern for the queen's face was to be repeated for the remainder of her reign. It

[5] Genealogy of the Tudors: http://www.npg.org.uk/assets/files/pdf/collections/pickups/genealogy.pdf
[6] Art History News: A too brief history of British portraiture, September 23 2015, http://www.arthistorynews.com/articles/3560_A_too_brief_history_of_British_portraiture, Accessed August 25, 2017

was an image that was much reproduced, and is more lifelike than some of her later portraits, which created the idea of an ageless Virgin Queen." [7]



Picture 1: Azure's Emotion API measurements for the "Darnley" portrait

Although the Elizabethan period (1558-1603) is noted as the Golden Age of British history, its last two decades were marked by wars against Spain and the Irish, socio-economic distress, and open criticism of her government and its failures,[8] leaving the Stuarts with numerous problems to solve.

165 image samples of Tudor and Elizabethan portraits were downloaded from the collection of the National Portrait Gallery in London for emotion measurements and evaluation. Table 1 shows the *mean*. the *standard deviation,* and the *coefficient of variation* per emotion measurements. Highlighted are the mean values for happiness and sadness. Diagram 1 provides a visualization of the moving average (of the previous 10 data points) per emotion, where "neutral" is placed on a Secondary Vertical Axis, to allow for better visibility.

Emotion	Mean	Standard deviation	Coefficient of Variation
Anger	0.008716	0.034528	396%
Contempt	0.003641	0.006668	183%
Disgust	0.001133	0.004761	420%
Fear	0.000430	0.001200	279%
Happiness	**0.019053**	**0.074168**	389%
Sadness	**0.014800**	**0.029357**	198%
Surprise	0.006590	0.024860	377%
1 – neutral	0.054364	0.093665	172%

Table 1: Mean and St. Dev Emotion Measurements: **Tudor and Elizabethan Period**

[7] The National Portrait Gallery, The Queen's Likeness: Portraits of Elizabeth I: http://www.npg.org.uk/research/programmes/making-art-in-tudor-britain/case-studies/the-queens-likeness-portraits-of-elizabeth-i#darnleyportrait, Accessed August 25, 2017

[8] John Cramsie, "The Changing Reputations of Elizabeth I and James VI & I," Reviews and History: Covering books and digital resources across all fields of history (review no. 334 June 2003)

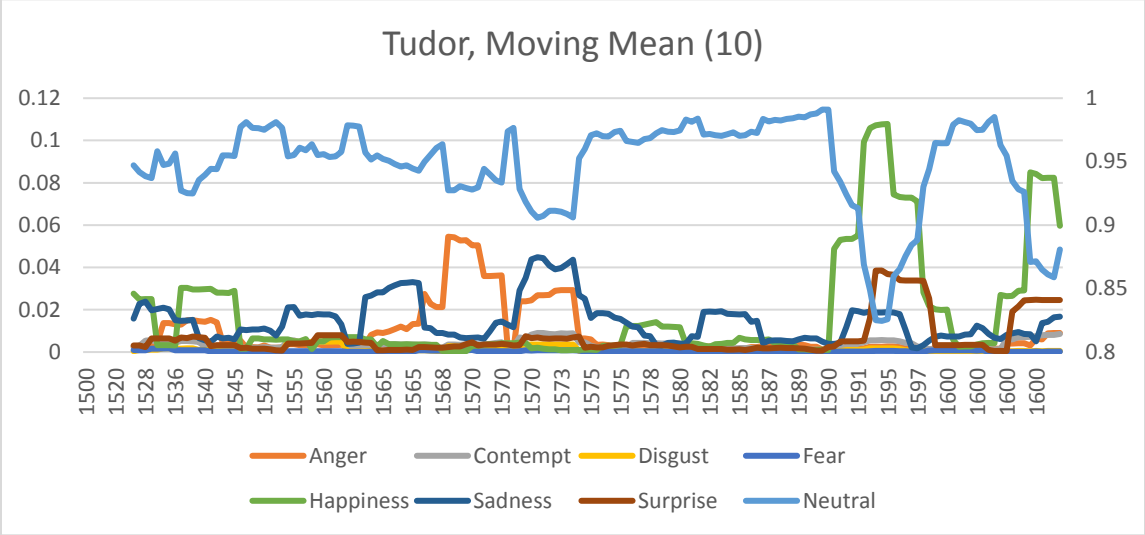


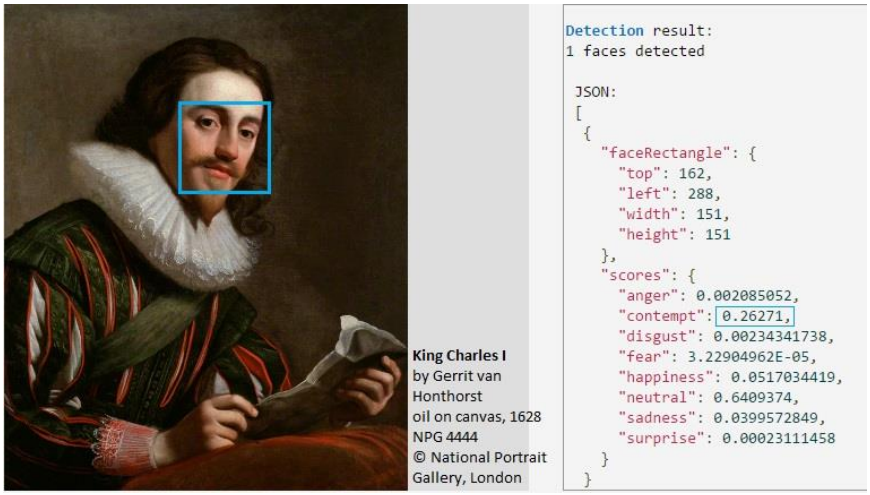
Diagram 1: Shows the moving mean (MM) of emotions for the Tudor and Elizabethan period (averaged by 10). The neutral value is placed on a secondary vertical axis, so that it the trend of the other emotions can be visible

Even though *neutral* is the dominant value for this period*, happiness, sadness*, *anger* and *surprise* were also detected. Overall, however, the evaluated images from this period exhibited the lowest levels of restricted (per Ekman) emotions.

3.2. Stuart and Civil War (1603 – 1714)

This is the period ruled by the House of Stuart, and a time, punctuated by the English Civil War, Commonwealth and Protectorate. Six monarchs ruled in this period, which was highlighted by betrayal and executions, by parliament dismemberment and religious strife, by debt and protests, and by stagnation in population growth. This portrait of King Charles I (Picture 2) is noted for its unusual for The Stuart period intimacy, and is an interesting example of an image, which measured high on *contempt*, one of the dominating emotion measurement for the Stuart Period. King Charles I "inherited his father's belief in the 'Divine Right of Kings' and became the greatest of all British royal art patrons and collectors. His dismissal of Parliament and personal rule, however, along with his imposition of taxes and attempts to impose religious uniformity led eventually to civil war. He was defeated and tried on the charge that he 'traitorously and maliciously levied war against the present Parliament and the people therein represented.'"[9] He was executed in 1649.

[9] Portraiture, West, Shearer. Oxford : Oxford University Press, UK 2004 Accessed August 26, 2017



Picture 2: Azure's Emotion API measurements for the portrait of Charles I

312 images of oil portraits from the collection of the NPG were evaluated for this period. Table 2 shows the emotion *mean,* the *standard deviation,* and the *CV* measurements for the emotion measurements obtained by Azure's Emotion API for the Stuart period, highlighting the values for *happiness*, *sadness* and *contempt.* It is important to note that the standard deviation for all three emotion measurements is also high, indicating a high disperse of the data points from the mean.

Emotion	Mean	Standard Deviation	Coefficient of Variation
Anger	0.002033	0.007773	382%
Contempt	**0.006605**	**0.027895**	422%
Disgust	0.000484	0.001903	393%
Fear	0.000124	0.000714	578%
Happiness	**0.025865**	**0.072189**	279%
Sadness	**0.008787**	**0.020838**	237%
Surprise	0.001674	0.009712	580%
1 – neutral	0.045572	0.083774	184%

Table 2: Mean and St. Dev Emotion Measurements: **Stuart Period**

Diagram 2 offers a visualization of the moving mean (MM) values for the period, averaged by 20, and that the spike in average *happiness* value for the Stuart era is noteworthy, because it coincides with the time of King Charles I's execution.

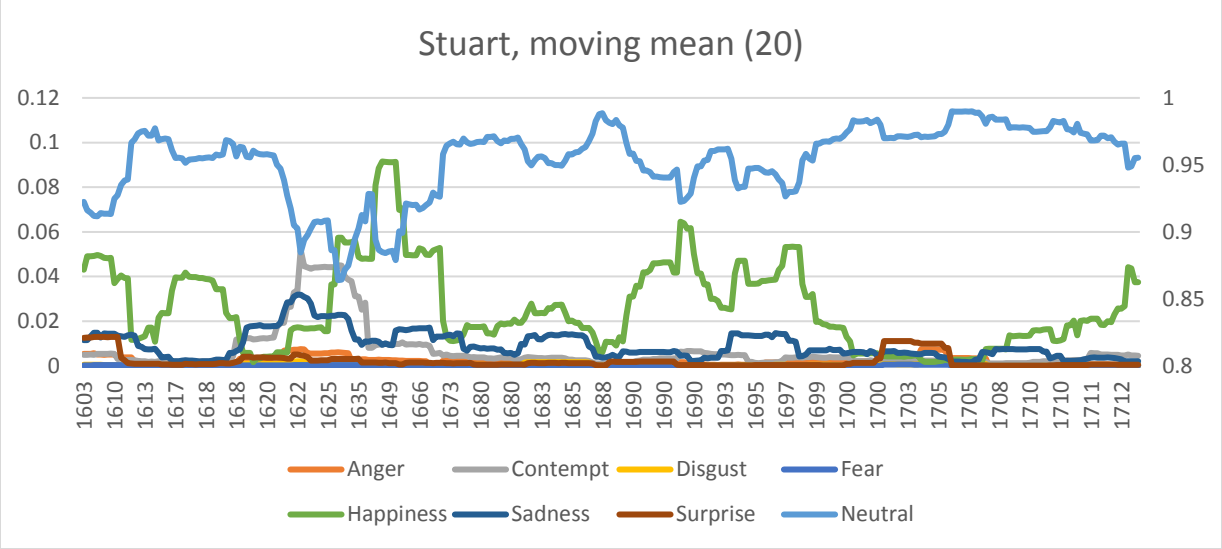


Diagram 2: Shows the moving mean (MM) of emotions for the Stuart period (averaged by 20). The neutral value is placed on a separate axis, so that it the trend of emotions can be visible.

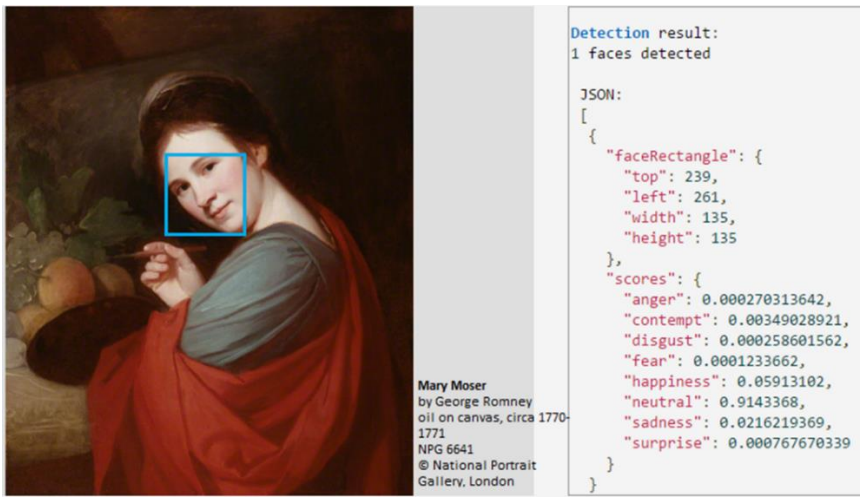
The later years of the Stuart period are noted for the time, when private and university education in England and Scotland, became widely available to the young male of the upper class. The time of the Glorious Revolution (1688), was "a decisive break in English history, especially as it made the Parliament of England supreme over the King."[10] It had paved a way, away from contempt, and to distinct emotion measurement values for this research. The Georgian period to follow offers a cornerstone of emotional values.

3.3. Georgian and Regency (1714 – 1837)

This period encompasses the Hanoverian age from 1714 with the reigns of King George I, King George II and King George III, as well as the Regency under King George IV and up to the death of King William IV in 1837. It is defined in the emergence of Romantic poetry, in revival of the Gothic style in architecture, and by the birth of the Industrial Revolution. The period was both dynamic and prosperous, as cities grew, trade expanded, and popular culture blossomed. The Georgians displayed the lowest approval in monarchy in British history, and witnessed the abolition of the slave trade in 1807, followed by the total abolition of slavery in 1833. The first photographic technologies were produced in the 1830s. "Portraits of royalty and other celebrities (far more accurate than paintings) allowed members of the public to feel they were viewing these people 'in the flesh'. The dead could be remembered, the fleeting could be fixed."[11] The smile had made its way into portraiture.

Women artists also make their debut into portraiture in this period, and it is refreshing to find two women among the founding Members at the Royal Academy: Angelica Kauffman and Mary Moser (Picture 3). Both were very gifted artists, who struggled to make their voices heard, yet remained active and influential in a male-dominated society.

[10] England's Glorious Revolution 1688–1689: A Brief History with Documents, Steven C. A. Pincus, 2005
[11] British Library Catalogue: http://www.bl.uk/learning/timeline/item106980.html



Picture 3: Azure's Emotion API measurements for Mary Moser

374 instances were evaluated in this period, making the image sample the largest per period in this research. Table 3 shows the *mean*, *standard deviation*, and *CV* values per emotion for the Georgian period, and it is important to note that this is the period, which exhibits the highest average values for *happiness* of all four periods measured.

Emotion	Mean	Standard deviation	Coefficient of Variation
Anger	0.002986	0.015760	530%
Contempt	0.002900	0.006426	221%
Disgust	0.000533	0.003232	608%
Fear	0.000092	0.000589	640%
Happiness	**0.048962**	**0.129390**	265%
Sadness	**0.012330**	**0.049363**	402%
Surprise	0.001583	0.008747	554%
1 - neutral	0.069389	0.140185	203%

Table 3: Mean and St. Dev Emotion Measurements: **Georgian Period**

Diagram 3 offers a visualization of the moving mean (MM) average of 20 of the emotion values for the Georgian period. There are two peaks in the happiness values in Diagram 3. The first peak coincides with the Jacobite rising of 1745; the second peak in 1793 mark the beginning of the French Revolutionary Wars, which dragged for nearly a quarter century, till 1815.

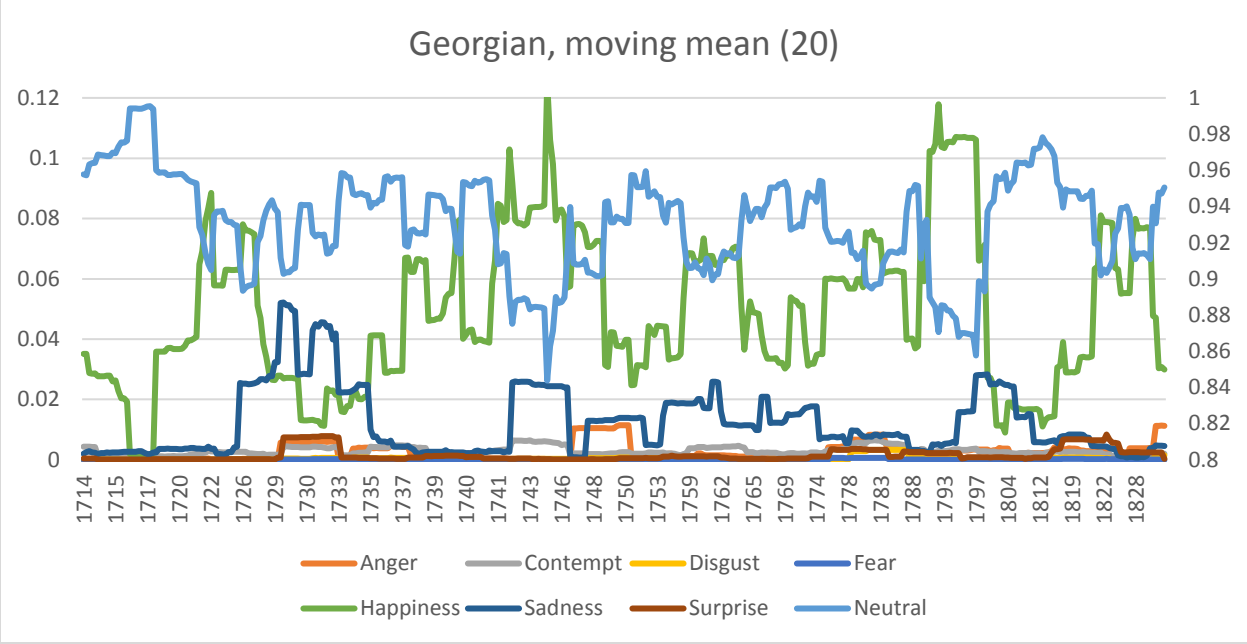


Diagram 3: Shows the moving mean (MM) of emotions for the Georgian period (averaged by 20). The neutral value is placed on a separate axis, so that it the trend of the other emotions can be visible.

On June 20 1837, Victoria became Queen of the United Kingdom, after the death of her uncle, William IV. The average happiness value is seen to decline.

3.4. Victorian and Edwardian (1837 – 1910)

The Victorian Era incorporates the long reign of Queen Victoria from 1837 to 1901, with the reign of King Edward VII to 1910. During Queen Victoria's reign, Britain was the most powerful trading nation in the world. Science and progress made a great impression on them, and it felt that they could improve society in the same way, they were improving technology. Britain was the leading world center for advanced engineering and technology. Its engineering firms were in worldwide demand for designing and constructing railways. The Victorian advances in transport and communications sparked a social, cultural and economic revolution. Ideologically, however, they witnessed resistance to the rationalism, which grounded the Georgians, and an increasing turn towards romanticism and mysticism in all areas of social life.

There are two cholera epidemics between 1832 and 1853. Few upper-class women breast-fed their children, weakening the immune systems of their offspring, and Victorian nurseries were infested with mumps, diphtheria, measles, and rubella. Middle class men might celebrate their 45th birthday, but children were lucky to have lived to 5.

The English historian Liza Picard writes, "No matter how poor people were, they could usually raise a penny or so for some light entertainment." These were the days of the Elephant man, of Jack the Ripper, of the circus, the street artist, and the zoos.

Two developments began to affect the slow death of the painted British portrait from the mid-19th Century onwards. "The first was *Victorian fashion*, and the desire to cover everything up; all those

frocks, long coats and beards left little of interest to paint. The second was *photography*, which not only encouraged [us] to see people caught in a single moment,"[12] but also made portraiture art available to all social classes.

Picture 4: Emotion measurements in Azure for Sydney Smith

Sydney Smith (Picture 4) was an English writer, most famous for his "rhyming recipe for salad dressing," but also known for his wit, among which strikes his observation of looking upon "Switzerland as an inferior sort of Scotland." His portrait, however, is exceptionally positive for the Victorian days, from the sweet satisfaction on his face, to the ease in his posture.

Only ***125 instances*** were evaluated for this period. Their measurements for *mean*, *standard deviation*, and *CV* are shown in Table 4.

Emotion Victorian	Mean	Standard deviation	Coefficient of Variation
Anger	**0.0117298**	0.0446565	381%
Contempt	0.0040560	0.0096154	237%
Disgust	0.0007732	0.0016394	212%
Fear	0.0003648	0.0014299	392%
Happiness	**0.0349816**	**0.1034278**	296%
Sadness	0.0097926	0.0210765	215%
Surprise	0.0040992	0.0190747	465%
1 - neutral	0.0657971	0.1148603	175%

Table 4: Mean and St. Dev Emotion Measurements: **Victorian Era**

[12] A too Brief History of British Portraiture, September 2003 http://www.arthistorynews.com/articles/3560_A_too_brief_history_of_British_portraiture , Accessed August 26, 2017

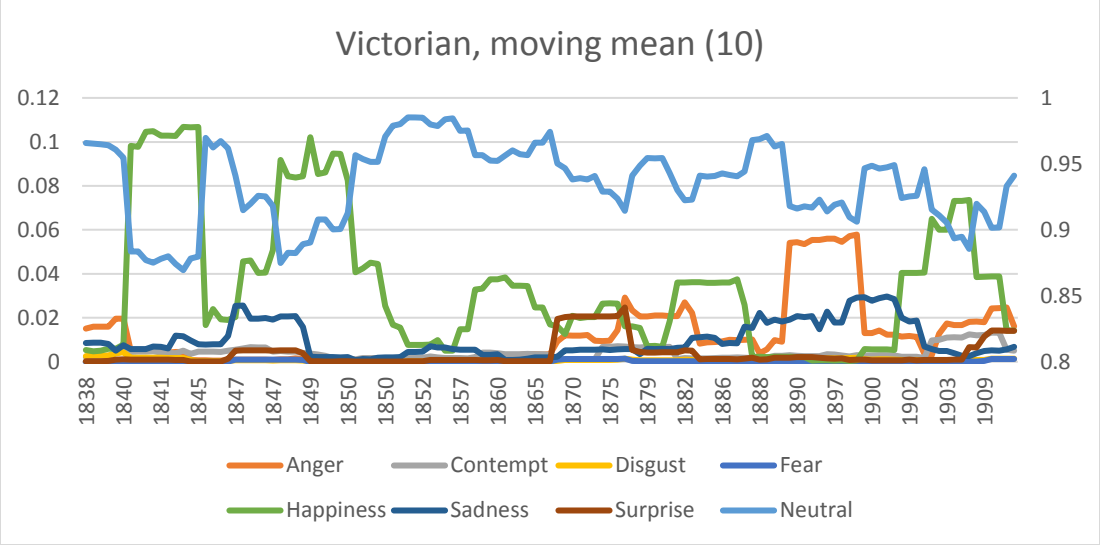


Diagram 4: Shows the moving mean (MM) of emotions for the Victorian period (averaged by 10). The neutral value is placed on a separate axis, so that it the trend of the other emotions can be visible.

Diagram 4 provides a visualization of the moving mean for the Victorian period, and it is indicative of the declining values of happiness, to be replaced by higher valued of anger.

4. Results per Gender

Females are underrepresented, compared to males both in our sample, and in British portraiture art in the selected period from 1500 to 1910. In the entire collection of the National Portrait Gallery in London, an advance search by Sitter/ Gender returns an overwhelming 46,619 male sitter portraits, in contrast to only 16,302 female sitter portraits (only 34.97% female sitters). The ratio between male and female artists is even more staggering 7,485 male to 899 female artists in the entire collection (only 12.01% female artists). In our data sample, the female sitters are represented by only 140 instances, compared to 837 males, or 16.73%. Even with that underrepresentation, however, the results of this research show, that females exhibit higher average happiness values, and measure lower on sadness, compared to the male sitters. The males, who dominate the sample, also dominated by sadness, anger, contempt over the female gender. (see Table 5)

Emotion	Male			Female			Overall		
	Mean	St.Dev	CV	Mean	St.Dev	CV	Mean	St.Dev	CV
Anger	**0.005344**	0.025820	483%	0.001345	0.008717	648%	0.004770	0.024164	507%
Contempt	**0.004667**	0.018196	390%	0.002509	0.003992	159%	0.004358	0.016925	388%
Disgust	0.000724	0.003293	455%	0.000205	0.000719	351%	0.000650	0.003065	472%
Fear	0.000200	0.000926	463%	0.000163	0.000774	476%	0.000194	0.000906	466%
Happiness	0.028890	0.092002	318%	**0.069619**	0.146332	210%	**0.034732**	0.102595	295%
Sadness	**0.012386**	0.038165	308%	0.004746	0.013235	279%	0.011291	0.035776	317%
Surprise	0.002147	0.011078	516%	0.006567	0.027267	415%	0.002781	0.014635	526%
1 - neutral	0.054358	0.106849	197%	0.085154	0.148421	174%	0.058775	0.11426	194%

Table 5: Emotion Measurements – **Gender**

It is important to note, that the standard deviation values for all emotions are also high, showing the great variety in measurements.

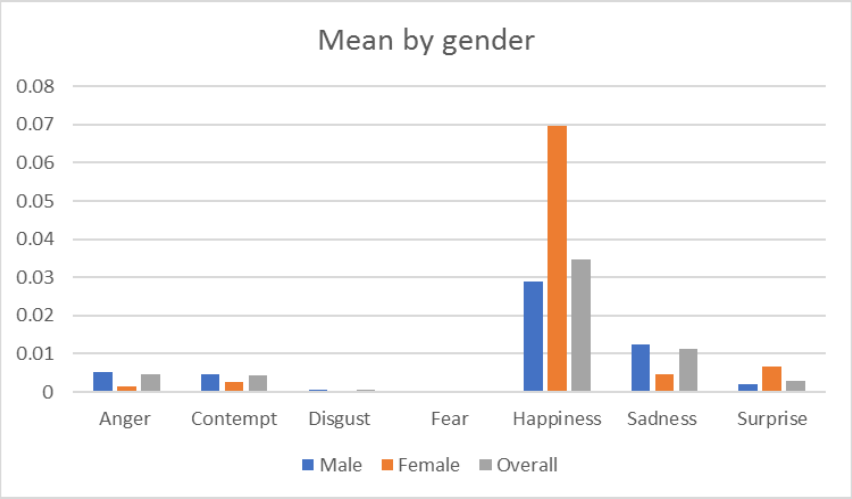


Diagram 5: Average of the emotions per gender

Diagram 5 shows the average emotion per gender for 140 female and 837 male instances for all four periods studied.

5. Results for 'Royalty, Rulers and Aristocracy'

An advanced search for 'Royalty, Rulers and Aristocracy' in the NPG portrait database results in 3,190 returns for sitters, who were tagged as royal. Of them only 1,008 were male, and images were available only to 2,154 instances. ***499 royals*** and ***477 non-royal*** sitters have made it into our sample of images selected from the period between 1500-1910. The high number of royals is due to the fact, that before the 17th century, before the invention of the canvas, portraits were painted on wooden panels, which were expensive, and reserved only for the ones, who can afford it. Portrait art in the Tudor and Stuart

periods were dominated by the wealthy. The Post-Georgian times saw a rise in the non-royal samples. Table 6 shows the average mean and the standard deviation values for both categories. The results support the concept, that average emotion measurements in British portrait art for the representatives of the Royal class are lower, that those of the non-royals. Hence, the research supports the theory that emotion in British portraiture in the periods evaluated, was reserved for the "lewd and the entertainment." Scientists, merchants, people of trade, philosophers, were portrayed less neutrally that the members of the British royal families. The values of the standard deviation for the non-royals also attests to the greater diversity of measured emotions in non-royals.

Emotion	**Noble**			**Non-noble**			**Overall**		
	Mean	St.Dev	CV	Mean	St.Dev	CV	Mean	St.Dev	CV
Anger	0.003263	0.017326	531%	0.006347	0.029595	466%	0.004770	0.024164	507%
Contempt	0.003792	0.012521	330%	0.004950	0.020529	415%	0.004358	0.016925	388%
Disgust	0.000536	0.002743	512%	0.000768	0.003365	438%	0.000650	0.003065	472%
Fear	0.000208	0.000863	414%	0.000180	0.000948	527%	0.000194	0.000906	466%
Happiness	**0.027206**	0.080799	297%	**0.042605**	0.120772	283%	**0.034732**	0.102595	295%
Sadness	0.010198	0.031031	304%	0.012433	0.040113	323%	0.011291	0.035776	317%
Surprise	0.002245	0.011527	513%	0.003342	0.017280	517%	0.002781	0.014635	526%
1- neutral	0.047448	0.090406	191%	0.070626	0.133747	189%	0.058775	0.114260	194%

Table 6. Emotion measurements – **Royalty, Rulers and Aristocracy**

Diagram 6 offers a visualization of the results in Table 6 for the average emotion measurements per emotion for 499 royals and 477 non-royals.

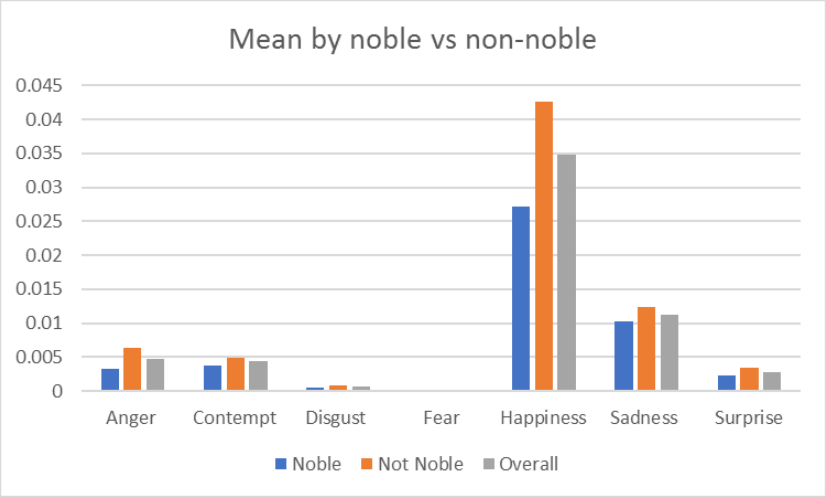


Diagram 6: Mean measurements – **Royalty, Rulers and Aristocracy**

6. Results Analysis in Weka

6.1. Weka, Auto-Weka, and SMOTE

Weka is widely used open-source collection of machine learning algorithms for data mining tasks. It contains tools for data pre-processing, classification, regression, clustering, association and visualizations. This research uses a number of those tools, both directly – via the EM unsupervised clustering algorithm for clustering and visualization; and indirectly - through Auto-Weka for classification of the dataset.

Data classification is just one of many kinds of supervised learning, which Weka can perform. The goal of a classifier is "to build a concise model of the distribution of class labels in terms of predictor features. The resulting classifier is then used to assign class labels to the testing instances where the values of the predictor features are known, but the value of the class label is unknown."[13] For its classification algorithms, Weka uses inductive machine learning: the process of learning, a set of rules from instances (examples in a training set), or more generally speaking, creating a classifier that can be used to generalize from new instances.

Auto-Weka is a meta-classifier – a system designed to automatically search through "the joint space of WEKA's learning algorithms and their respective hyperparameter settings to maximize performance, using a state-of-the-art Bayesian optimization."[14] It studies the input data, and selects the optimal algorithm to analyze it. Auto-Weka 2.0 was built to make data analysis easy for users with little data mining experience, and when given a dataset, it automatically selects the optimal classification algorithm.

For the dataset in this research, Auto-Weka was used to build three classification models, which can accurately classify the dataset. The first model classified the dataset by gender of the sitter, based on the six emotions (and contempt), and neutral values it was provided. The second model also used the emotion values for all 976 sitters to build a classification model for all four periods. The third, successfully classified the data by royal and noble vs. non-royal and noble.

In this study, as the dataset is imbalanced for both *gender* and *period*, SMOTE: Synthetic Minority Oversampling Technique (found under Weka's filter category) – a popular oversampling method is used. SMOTE is an oversampling approach that creates synthetic samples which can be used for data classification of instances for imbalanced datasets. A dataset is imbalanced, if the classification categories are not approximately equally represented. The SMOTE filter can be found in the ***Preprocessing*** tab of Weka, and was used in combination with Auto-Weka to build classification models, which performed with higher accuracy. This research uses and oversampling technique for both *gender* and *period* classifications, to optimize empirical performance in constructing the classifiers.

---

[13] Supervised Machine Learning: A Review of Classification Techniques, S. B. Kotsiantis, Informatica 31 (2007) 249-268

[14] Auto-WEKA 2.0: Automatic model selection and hyperparameter optimization in WEKA
Lars Kotthoff, Chris Thornton, Holger Hoos, Frank Hutter, and Kevin Leyton-Brown.
In JMLR. 18(25):1–5, 2017

6.2. Classification Results Output per Gender in Auto-Weka with/without SMOTE

Classification using class-imbalanced data is biased in favor of the majority class. The problem can be attenuated by undersampling or oversampling, which produce class-balanced data.[15]

The dataset for this research is imbalanced for female instances – 140 females to 837 males. Females are also underrepresented, however, in British portraiture art in the periods between Tudor and Victorian eras, and the obtained data sample reflects this underrepresentation. To use the data for classification in Auto-Weka without a preprocessing for the minority class was a challenge, as the underrepresentation of females confused the classifier and led to inaccurate classification results.

When given the raw data in .CSV file for all six (and contempt) emotions, and neutral, and for gender, the Auto-Weka classifier returned a success rate of correctly classified instances at 85.7%, but a closer look at the confusion matrix, revealed that the classification was unsuccessful, and the classifier could not distinguish between the genders, based on the emotion values provided. (see Figure 1)

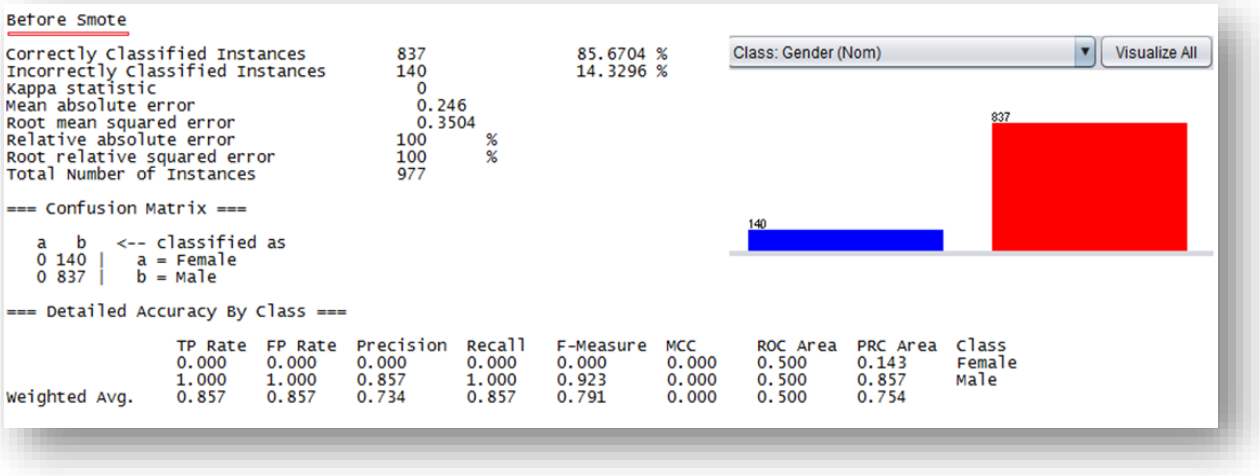
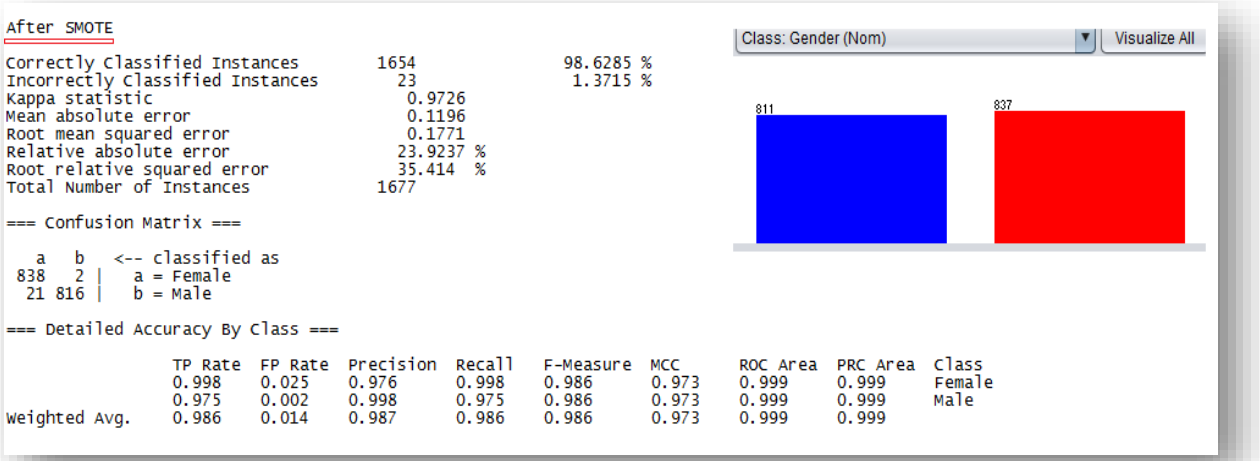


Figure 1: Auto-Weka Classification Output for **Gender** with **SMOTE**

To correct the class-imbalance, the SMOTE (Synthetic Minority Over-sampling Technique) filter in the *Preprocessing tab* of Weka, was used.

[15] SMOTE for high-dimensional class-imbalanced data, Rok Blagus and Lara Lusa, BMC Bioinformatics201314:106 https://doi.org/10.1186/1471-2105-14-106



After SMOTE

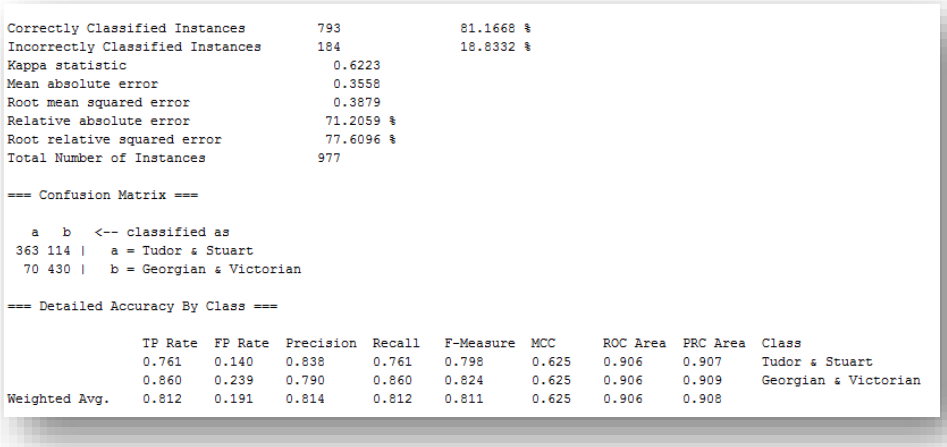
```
Correctly Classified Instances        1654               98.6285 %
Incorrectly Classified Instances        23                1.3715 %
Kappa statistic                          0.9726
Mean absolute error                      0.1196
Root mean squared error                  0.1771
Relative absolute error                 23.9237 %
Root relative squared error             35.414  %
Total Number of Instances             1677

=== Confusion Matrix ===

   a   b   <-- classified as
 838   2 |   a = Female
  21 816 |   b = Male

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.998    0.025    0.976      0.998    0.986      0.973    0.999     0.999     Female
                 0.975    0.002    0.998      0.975    0.986      0.973    0.999     0.999     Male
Weighted Avg.    0.986    0.014    0.987      0.986    0.986      0.973    0.999     0.999
```


Figure 2: Auto-Weka Classification output for **Gender** with **SMOTE**

The success rate of the classification increased to 98.62 %, and the confusion matrix shows that 838 instances were classified as *female* under class **a**, and 816 *male* instances were placed in class **b**. Results are shown in Figure 2.

6.3. Classification Results Output per Period in Auto-Weka with and without SMOTE

Auto-Weka correctly classified the dataset by period for all six (and contempt) emotions, and neutral, only when the dataset was divided in Pre-Georgian (including and instances before 1714) and Post-Georgian (all instances after 1714). In Figure 3, the classification results were obtained without any preprocessing in Weka. Classifying for emotion by all four periods, however, was only successful after SMOTE for each imbalanced class – class c (Georgian) was used as a reference class, and the other classes were synthetically over-sampled.



```
Correctly Classified Instances         793               81.1668 %
Incorrectly Classified Instances       184               18.8332 %
Kappa statistic                          0.6223
Mean absolute error                      0.3558
Root mean squared error                  0.3879
Relative absolute error                 71.2059 %
Root relative squared error             77.6096 %
Total Number of Instances              977

=== Confusion Matrix ===

   a   b   <-- classified as
 363 114 |   a = Tudor & Stuart
  70 430 |   b = Georgian & Victorian

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.761    0.140    0.838      0.761    0.798      0.625    0.906     0.907     Tudor & Stuart
                 0.860    0.239    0.790      0.860    0.824      0.625    0.906     0.909     Georgian & Victorian
Weighted Avg.    0.812    0.191    0.814      0.812    0.811      0.625    0.906     0.908
```

Figure 3: Auto-Weka Classification output for **Pre-** and **Post-Georgian Period**

Figure 4 shows the confusion matrix for the classification of instances for all six + contempt emotions, and neutral, before SMOTE. The correctly classified instances were only 42.57%.

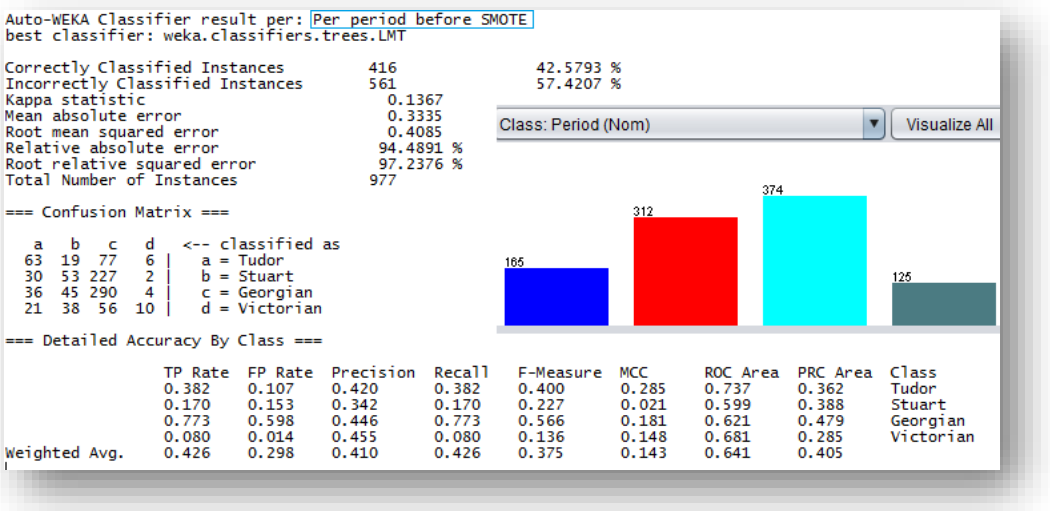


Figure 4: Shows the Auto-Weka Classification output for **All Four Periods** without **SMOTE**

After SMOTE for each under-sampled period, the percentage of correctly classified instances based on the measurements all six emotions (and contempt), and neutral, per period increased to 96.05%, shown on Figure 5.

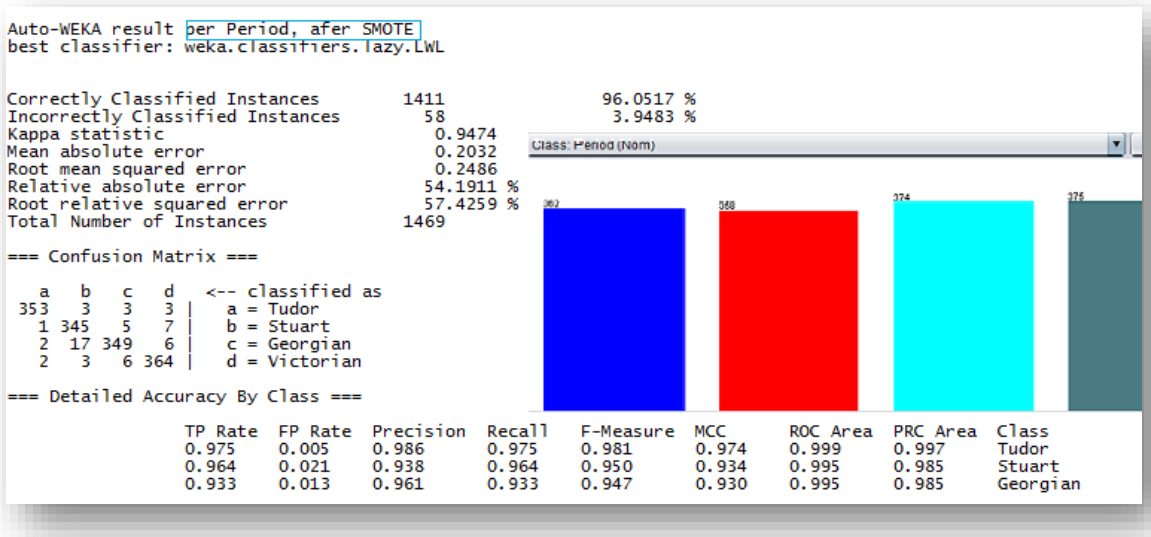
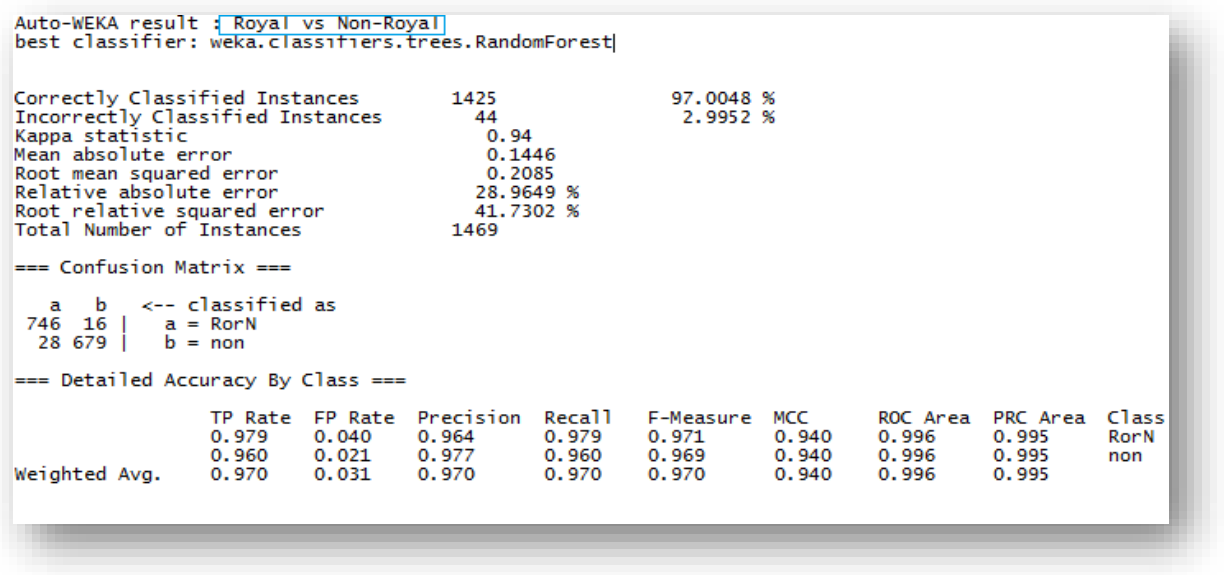


Figure 5: Results of Auto-Weka for Royals to Nobles

With the SMOTE filter per period added to the classification model, a successful classification for all six (and contempt) emotions, and the neutral value was possible for royal vs non-royal classes, shown on Figure 6.



```
Auto-WEKA result : Royal vs Non-Royal
best classifier: weka.classifiers.trees.RandomForest

Correctly Classified Instances        1425               97.0048 %
Incorrectly Classified Instances        44                2.9952 %
Kappa statistic                          0.94
Mean absolute error                      0.1446
Root mean squared error                  0.2085
Relative absolute error                 28.9649 %
Root relative squared error             41.7302 %
Total Number of Instances             1469

=== Confusion Matrix ===

   a   b   <-- classified as
 746  16 |   a = RorN
  28 679 |   b = non

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.979    0.040    0.964      0.979    0.971      0.940    0.996     0.995     RorN
                 0.960    0.021    0.977      0.960    0.969      0.940    0.996     0.995     non
Weighted Avg.    0.970    0.031    0.970      0.970    0.970      0.940    0.996     0.995
```

Figure 6: Result Auto-Weka Classification for Social Status after SMOTE per period

6.4. Result Cluster Visualizations with WEKA

The EM (Expectation – Maximization) clustering algorithm of Weka uses statistical methods to produce probabilistic clusters, relying on inferred (latent) variables.[16] The EM Clustering generates probabilistic descriptions of the clusters by *mean* and *standard deviation* for numeric attributes, and *value counts* for nominal attributes. In the *Training Set, Percentage Split* (66% of the dataset for training) cluster mode option, the EM clustering method trains itself on 66% of the dataset provided, and uses the rest 33% for training. In the *Classes to clusters* evaluation mode, the EM algorithm outputs the log-likelihood, assigns classes to the clusters, and prints the confusion matrix and the error rate.

An EM Clustering model for male vs female clusters for all six (plus contempt) emotions and neutral was built in the *Classes to clusters evaluation on training data* method. The results are shown in Table 7.

[16] The EM Clustering Algorithm in Weka, Matthew Mayo, Jan 3, 2017
https://mmmayo13.github.io/2017/01/03/em-clustering-algorithm-weka/, Accessed August 26, 2017

Attribute	Cluster 0 (0.6)	Cluster 1 (0.4)
Neutral		
mean	0.9759	0.8718
std. dev.	0.0467	0.1702
Anger		
mean	0.0001	0.0079
std. dev.	0.0002	0.0295
Contempt		
mean	0.0013	0.0068
std. dev.	0.0015	0.0203
Disgust		
mean	0	0.0011
std. dev.	0	0.0037
Fear		
mean	0	0.0004
std. dev.	0	0.0011
Happiness		
mean	0.0209	0.0846
std. dev.	0.0459	0.1692
Sadness		
mean	0.0014	0.0182
std. dev.	0.0021	0.0425
Surprise		
mean	0.0002	0.0084
std. dev.	0.0004	0.0252

Table 7: EM Clustering Model (Classes to clusters evaluation on training data) values by all six (and contempt) emotions, and neutral for male and female instances

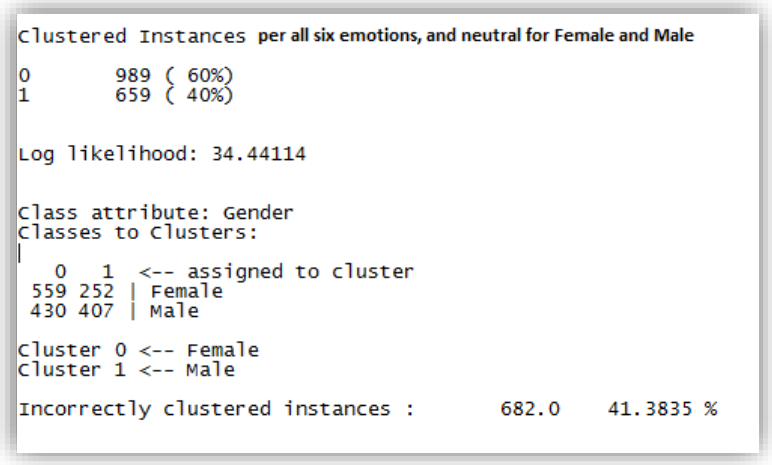


Figure 7: Confusion matrix and Incorrectly clustered instances for female and male on all six (and contempt) emotions and neutral

This EM clustering method was the only one in Weka, which produced results for correctly classified instances of over 55%. Visualizations for happiness and sadness per period, gender and royal vs non-royal were made, shown in Figures 8 -12.

6.4.1. Clustering for Gender and Period In Weka

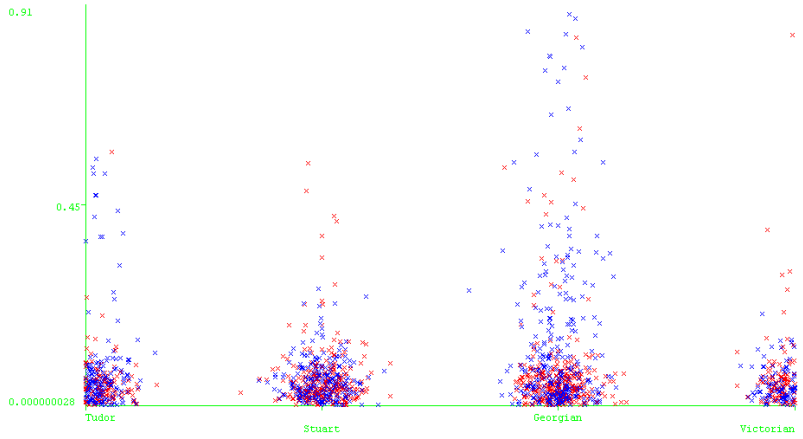


Figure 8: Weka FOUR Cluster EM (Neural Network) Visualization for Happiness (Y) over all four Periods (X) after SMOTE filter for Gender was applied (color blue is for Female and red for Male)

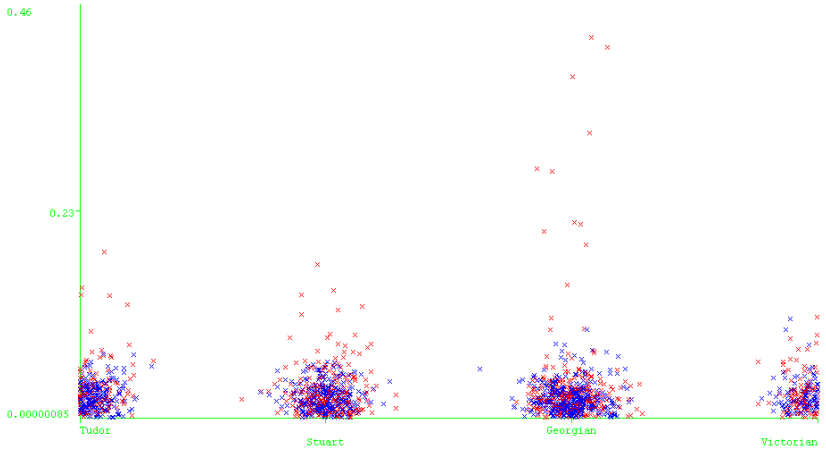


Figure 9: Weka FOUR Cluster EM (Neural Network) Visualization for Sadness (Y) over all four Periods (X) after SMOTE filter for Gender was applied (colored blue for Female and red for Male)

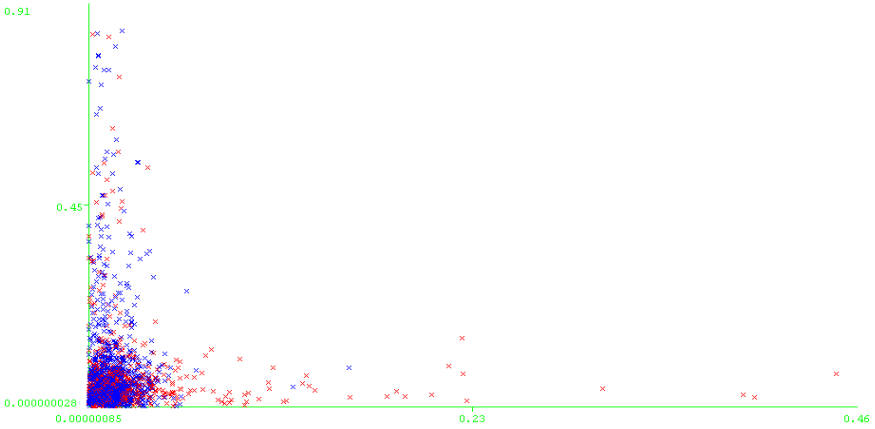


Figure 10: Unsupervised clustering with Weka for Happiness (Y) to Sadness (X) per Gender for all Four Periods after SMOTE for Female (colored blue for Female and red for Male)

6.4.2. Clustering for Royal vs. non-Royal in Weka

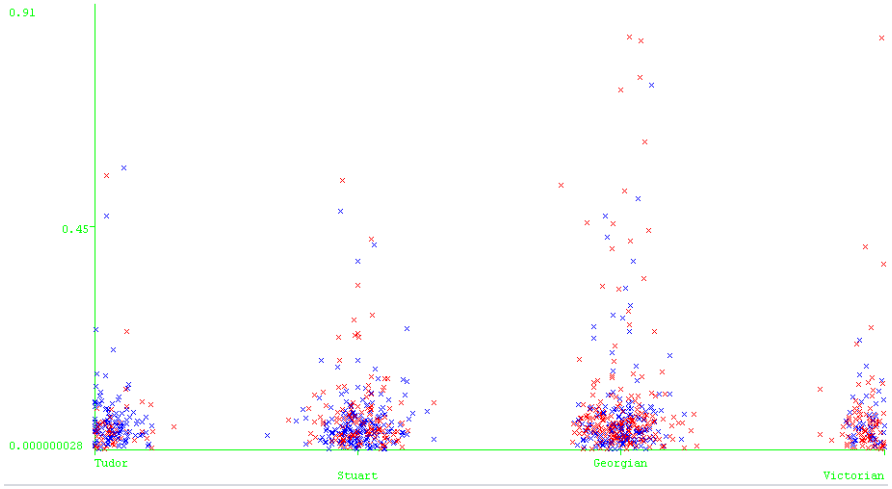


Figure 11: Weka FOUR Cluster EM (Neural Network) Visualization for Happiness (Y) over all four Periods (X) after SMOTE filter for Period was applied (color blue is for Royal and red for Non-Royal)

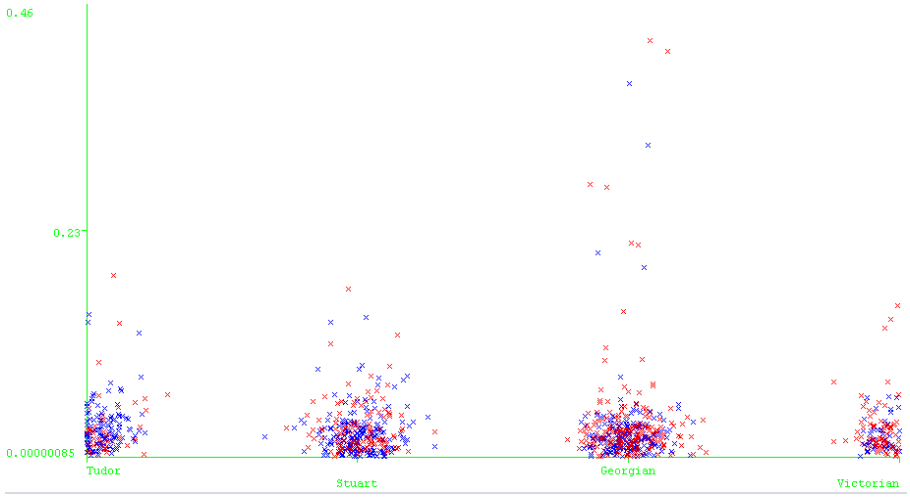


Figure 12: Weka FOUR Cluster EM (Neural Network) Visualization for Sadness (Y) over all four Periods (X) after SMOTE filter for Period was applied (color blue is for Royal and red for Non-Royal)

7. Conclusion

In conclusion, this research offers a new way of looking at portraiture paintings, bringing emotion recognition and machine learning algorithms to portrait analysis. Although the idea that single sitter portraits should be painted neutral has been known to both artists and art historians for centuries, this study provides a numerical value to the degree of neutrality in British portraiture painting between 1500 and 1910, as detected by the algorithm. For all the 976 single sitter portraits evaluated, the results of the emotion face recognition measurements taken from Azure's Emotion API for this data sample, show that the portraits were painted with neutrality of emotion in mind, as *neutral* is the dominating value for all four periods: the mean of *neutral* = 0.941225, and *CV* = 12%. (seen in Table 7)

Measurements for	Neutral	Anger	Contempt	Disgust	Fear	Happiness	Sadness	Surprise	1 -neutral
mean	0.941225	0.004770	0.004358	0.000650	0.000194	0.034732	0.011291	0.002781	0.058775
stdev	0.114257	0.024164	0.016925	0.003065	0.000906	0.102595	0.035776	0.014635	0.114260
cv	12%	507%	388%	472%	466%	295%	317%	526%	194%

Table 7

Some emotions do leak through the paint, however, and it is possible to measure their values, and to analyze them within the parameters of the periods, in which the portraits were painted. These emotions differ per gender and social status of the sitters, and our results showed that females on average are happier than males; that male sadness values are higher than those of the females for the same period; that royals exhibit higher neutral values than non-royals.

The results show that female sitters do measure higher on happiness, compared to males, while male sitters measure higher on sadness, compared to females. The royal instances present a higher degree of

neutrality, compared to the non-royals (merchants, scientists, artists etc.), and the overall display of emotion increase from Tudor to Victorian portraits. (see Appendix, Graphs 1 and 2 for mean and standard deviation of all emotions per all four periods studied)

These results are consistent in evaluating the dataset both in Excel, and in Weka.

This study depends on four parameters – portrait format; periods selected, emotion face recognition algorithm chosen, and data evaluation methods used. It would be fair to assume, that since the images were taken from a public source, they were with a relatively low resolution, yet further research could investigate whether higher resolution images (where the size of the bounding box would be with a higher pixel resolution), would provide a higher certainty values for the emotion values measured. It would be also fair to assume, that Italian portraits for the same periods, might yield a different emotion curve from that of British portraits, as portrait art is influenced by the place in which it was painted. MS Azure Cognitive Service Emotion API is the tool we used in this research, and it is publicly available for use. Using a different emotion face recognition algorithm – one, that can output additional information like gender confidence, ethnicity confidence, and age, can bring other parameters to the research.

This research is unique, as it presents guidelines for data selection, methods and evaluation, which could be applied to obtain better insight into portrait art, and the emotional states of its subjects. It offers possible tools and directions to art historians to analyze their collections differently. It is assumed that the greater the sample, within the smaller the period, more accurate results could be derived.

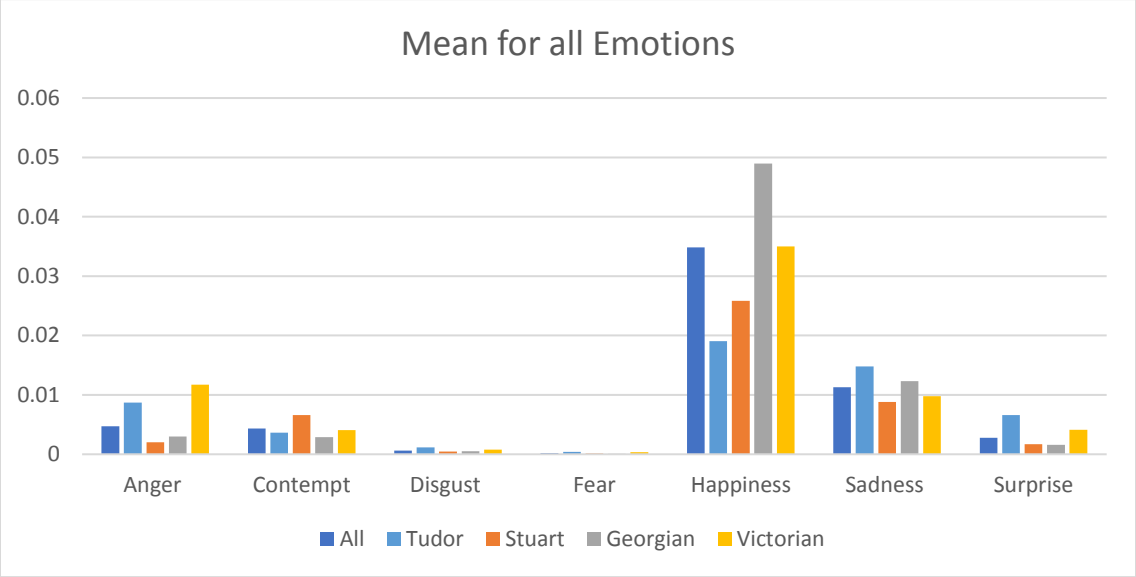
Universiteit Leiden
The Netherlands

Bibliography

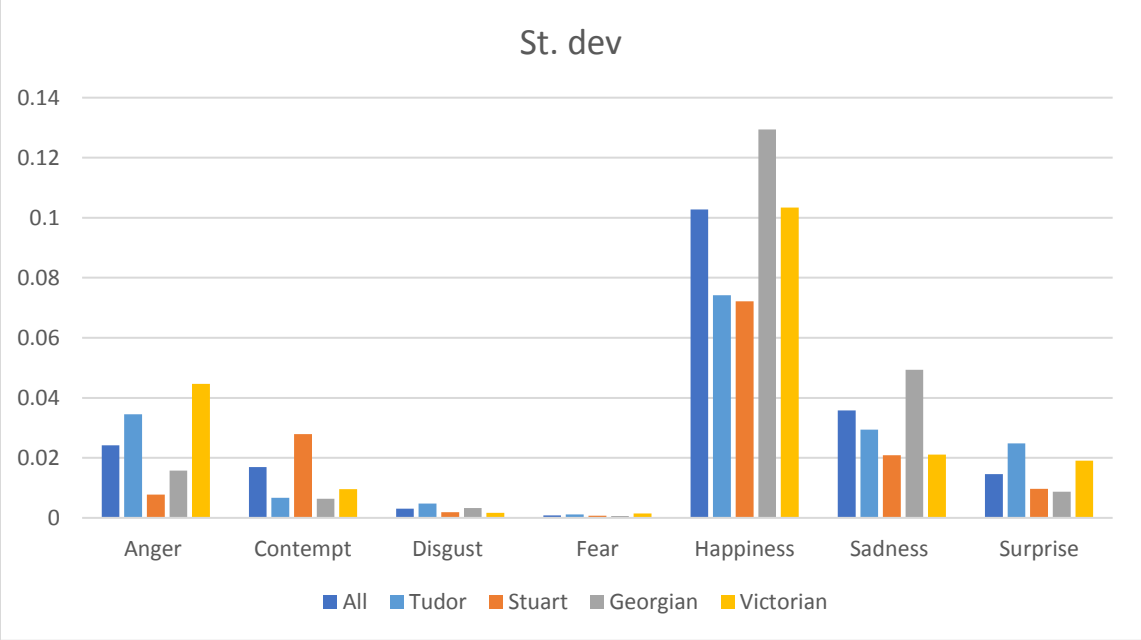
1. P. Ekman & Friesen, W. V. (2003). Unmasking the Face. Cambridge: Malor Books., p.12
2. N. Schneider, The Art of the Portrait (Masterpieces of European Portrait Painting 1420-1670), 1994
3. Microsoft Cognitive Services Azure Emotion API https://docs.microsoft.com/en-us/azure/cognitive-services/emotion/home, Accessed August 26, 2017
4. N. Jeeves, The Serious and the Smirk, https://publicdomainreview.org/2013/09/18/the-serious-and-the-smirk-the-smile-in-portraiture/ Accessed August 13, 2017
5. National Portrait Gallery, Online Collection August 2016 http://www.npg.org.uk/collections.php, Accessed August 22, 2016
6. R. Picard, Affective Computing. MIT Press, 1997
7. S. Porter and L. ten Brinke, Reading Between the Lies: Identifying Concealed and Falsified Emotions in Universal Facial Expressions, Psychological Science, vol. 19, no. 5, pp. 508–514, 2008.
8. Weka 3 - Data Mining with Open Source Machine Learning Software, http://www.cs.waikato.ac.nz/ml/weka/documentation.html , Accessed August 23, 2017

Universiteit Leiden
The Netherlands

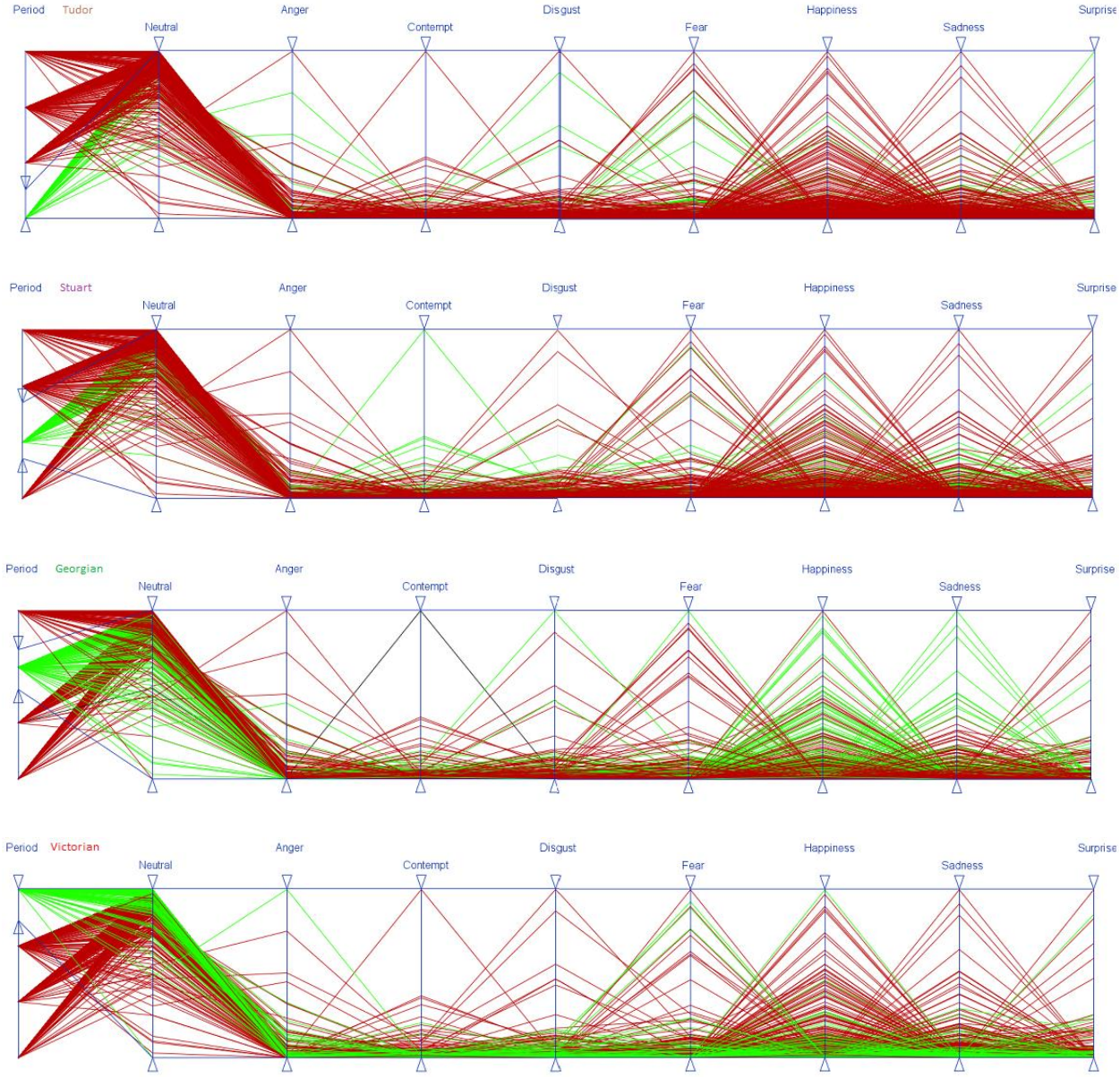
Appendix



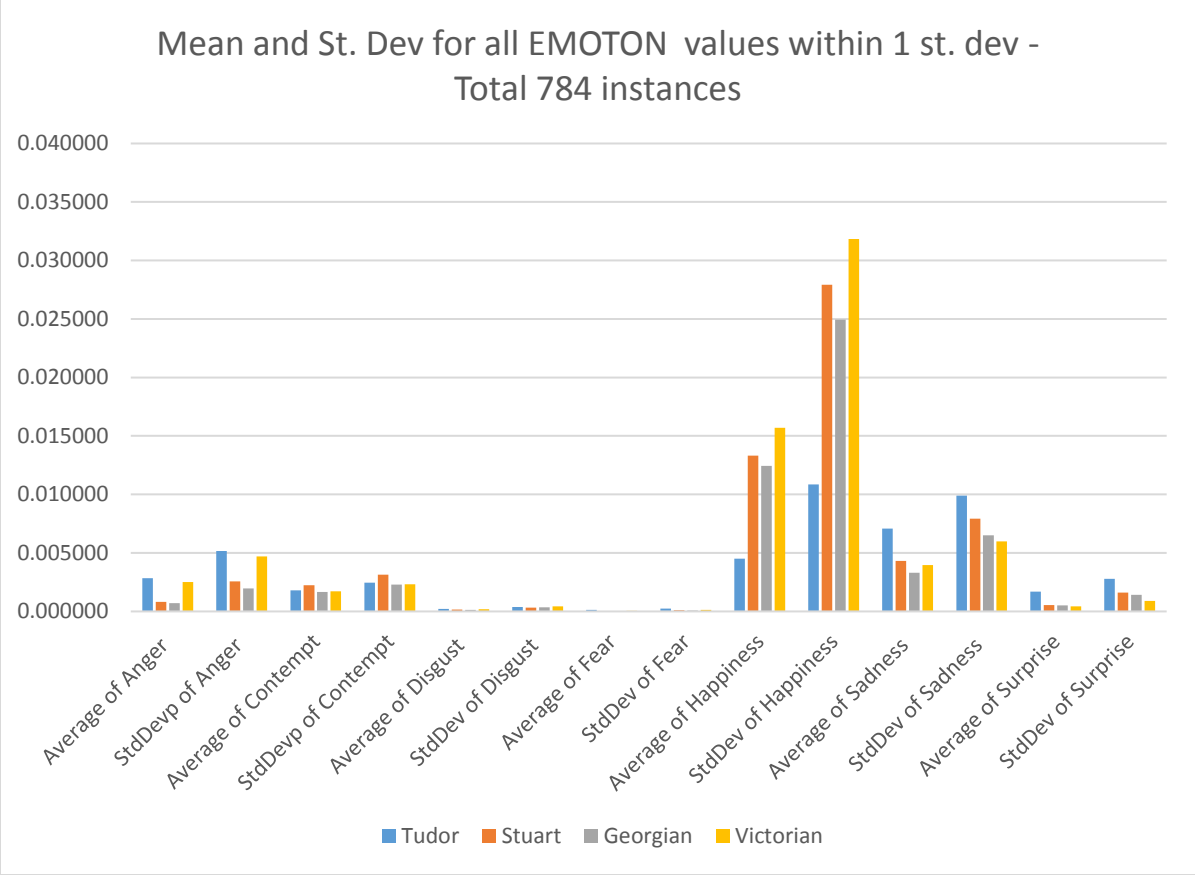
Graph 1: **Shows the mean of emotions for all FOUR period**



Graph 2 – Standard Deviation for all FOUR period



Graphs 3, 4, 5 and 6: Interactive Visualization Produced by Weka for the emotions per period



Graph 7: Mean and Standard Deviation for all emotion values within 1 standard deviation

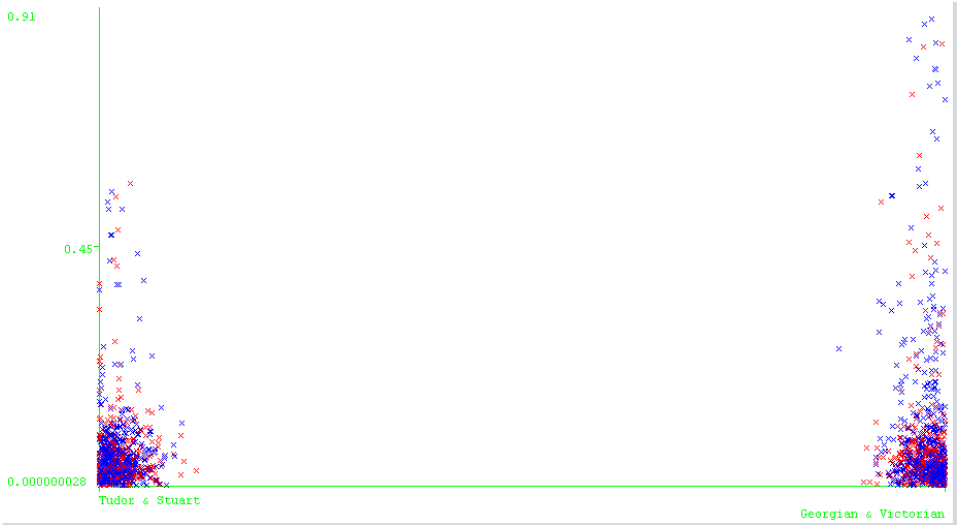


Figure 15: Cluster for Happiness (Y) for male and female in Pre- and Post- Georgian