An Application of Authorship Attribution by Intertextual Distance in English

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1. Introduction

1 Several months ago I received a copy of 'Inter-Textual Distance and Authorship Attribution : Corneille and Molière' by Cyril and Dominique Labbé, kindness of the latter[1]. With great interest I studied the article and asked myself the question, 'Could the Labbés' technique, so extensively tested in oral and written French, be applied in English ?'

2 An initial trial, using the 36 Shakespeare *First Folio* plays and several works by other contemporary playwrights, proved encouraging in the light of previous work done with non-traditional methods of authorship discrimination. In particular, the intertextual distance between the verse parts of Shakespeare's *Henry V* and the body of the 36 Shakespeare plays was greater than generally expected, and in accordance with testing I had done previously.

3 Besides the difference in language, there was a methodological divergence in my using a shorter preparation of texts than the Labbés'. I had available modern English spelling electronic texts of dramatic works originally written in the variable orthography of the 16th and 17th centuries. In the case of the 36 Shakespeare plays, these were edited texts in the public domain that were no longer protected by copyright. These dramatic texts would not have met the standards of modern textual study. Their use was thus conditional. All speech headings and stage directions were stripped from the texts to avoid repetitions of names and directions like 'Exit' and 'Enter'.

4 Secondly, and more importantly, I did not lemmatize the texts. The past participle of 'have', 'had', would, for example, be counted as a word on its own, distinct from its lemma[2]. Modern spelling of all the texts was essential for standardization ; otherwise, one word, spelled differently, would be counted as two or three or more words.

5   Thirdly, I chose to truncate plays to a standardized length of 11,371 words – commonly the first half, or a little more, of the plays used, excepting *Henry V* (verse) and *Henry V* (prose). This obviated the need to scale down larger texts to the size of smaller ones in order to give equal weight to their word distributions. But it meant that I could not use texts smaller than the length dictated by the key text with which I was originally most concerned, the verse parts of *Henry V*. Problems might arise in the case of a play with a first half written by one author and a second by another[3].

2. The Purpose of the Present Investigation

6   Some years ago I received through the good offices of Robert Matthews a set of electronic plays by Thomas Middleton, prepared for Gary Taylor in his capacity as editor of the Oxford Middleton. These plays are modern-spelling texts.

7   Both Middleton (1580-1627) and Shakespeare (1564-1616) were contemporaries[4]. Would the Middleton plays, with intertextual distances, effectively distinguish themselves from the Shakespeare plays of the *First Folio* ? This was the essential question, and it turned out to be relatively simple to answer, as seen below.

8   More complex was the question of how comparable my simplified methods in English were with those of the Labbés in French. To what degree did they harmonize ? It is to this that I turn first, as the related matter is dealt with in the opening two sections of 'Qui a écrit quoi ?' in this journal.

3. The Index

9   In comparing 50 French literary texts, Dominique Labbé employed a data matrix of 50 rows and 50 columns. The number of separate distances between points is $n*(n\text{-}1)/2$ or 1225. The indices were found to range between 0.195 and 0.536. With an assumption of normality, the mean of 0.377 and standard deviation of 0.053 produced distribution tails (minus or plus two standard deviations) containing 32 and 43 indices respectively.

10   Because there are four factors that govern the distancing of texts from each other (authorship, chronology, genre and content), it is possible to make a confident authorship identification or exclusion only with extreme index values, 0.2 for identification or inclusion and 0.5 for exclusion.

11   I made use of a data matrix consisting of 36+1 Shakespeare texts *(Henry V* (verse) *and Henry V* (prose) split one of the 36 *Folio* plays in two.) and 9 Middleton plays. This matrix may be schematized thus :
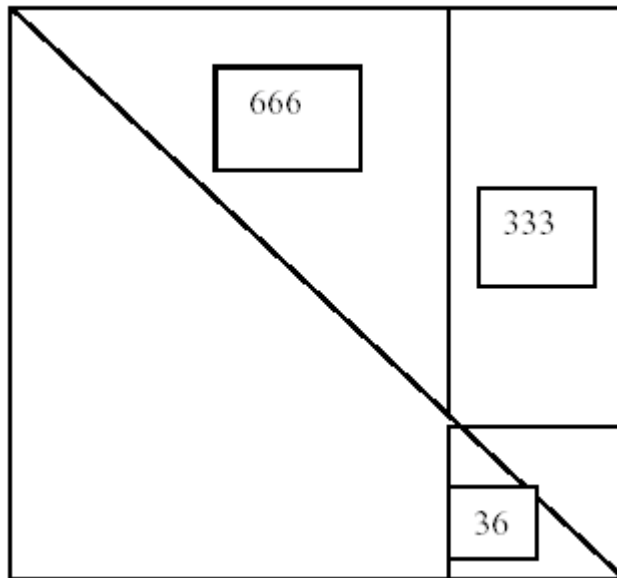
12   As the data matrix is square and symmetrical, the intertextual distances are duplicated, e.g., A to B = B to A, and so on. All cells along the diagonal are empty as A = A, B = B, and so on. The comparisons form three blocks, a Shakespeare within-set group - 666 comparisons, a Middleton within-set group – 36 comparisons, and a Shakespeare-Middleton between-sets group - 333 comparisons. The 46 texts are named in Appendix I.

13   The mean of all 1035 distances ($n*(n$-1$)/2$) is 0.370, an index similar to that of the 1225 comparisons in 'Qui a écrit quoi', 0.377. Bearing in mind differences of language and chronology, the closeness of the two means, 0.007, is remarkable. The standard deviations are understandably more divergent, 0.031 for comparisons involving two contemporary playwrights Shakespeare and Middleton on the one hand, and 0.053 for the comparisons involving 11 French authors and 22 works over at least one hundred years on the other.

14   The histogram below shows the overall distribution of the 1035 intertextual differences in the schema above. Although the configuration has the general appearance of statistical normality, the right-hand tail (with more greater-than-average intertextual distances than theoretically expected) is too extensive to fit a symmetric Gaussian bell curve.

Histogram of Intertextual Distances

Index
All Texts
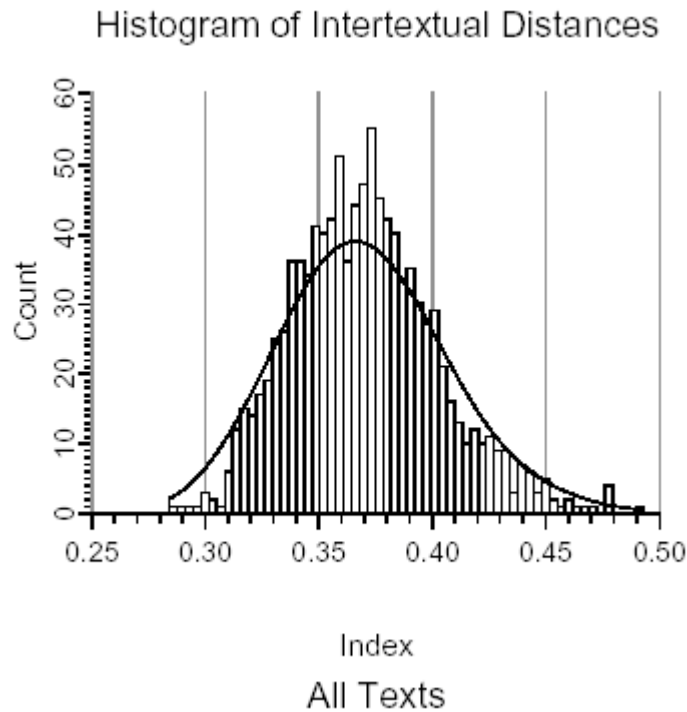
15 In addition, the overall mean > 0.035, suggests heterogeneity rather than a single statistical population.

16 Of particular interest in assessing the comparability of my application with the Labbés', is the rectangle with 333 intertextual distances. As Middleton and Shakespeare are established as separate authors, the 333 distances should theoretically be distributed in a way agreeable with a pre-determined index, > 0.35, indicating different authors (or different registers).

17 The mean of the 333 distances, 0.387, approaches the value of 0.40, the maximum index for texts by a single author with widely different genres and topics[5]. The distribution is notable because of its extended right-hand tail. If the 333 comparisons were between two authors only, the aggregate of intertextual distances should be roughly symmetrical. This is not the case in the histogram below.

Histogram of Intertextual Distances
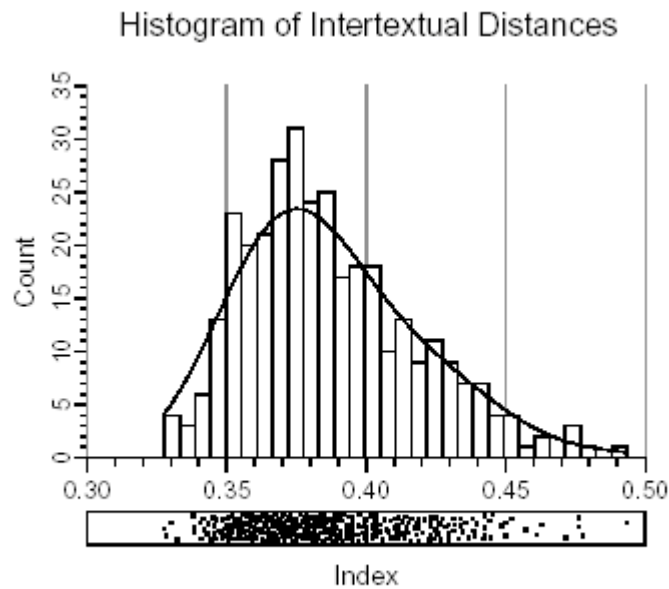
9 Middleton Plays vs. 37 Shakespeare Texts

18   Suspicion arises that the 37 Shakespeare texts are heterogeneous. Bimodality may be checked for by separating eight Shakespeare texts previously suspected of part-Marlovian authorship from the remaining 29[6]. The 333 intertextual distances are thus divided into two sets, one with 72 intertextual distances and the other with 261.

19   The histogram below shows the distribution of distances between the Middleton plays and the bulk of the Shakespeare *First Folio*. Note that reasonable symmetry has been restored to the distribution with a mean between 0.37 and 0.38. We may provisionally assume that the pattern is that of the dispersion of intertextual distances between Middleton and one other author.
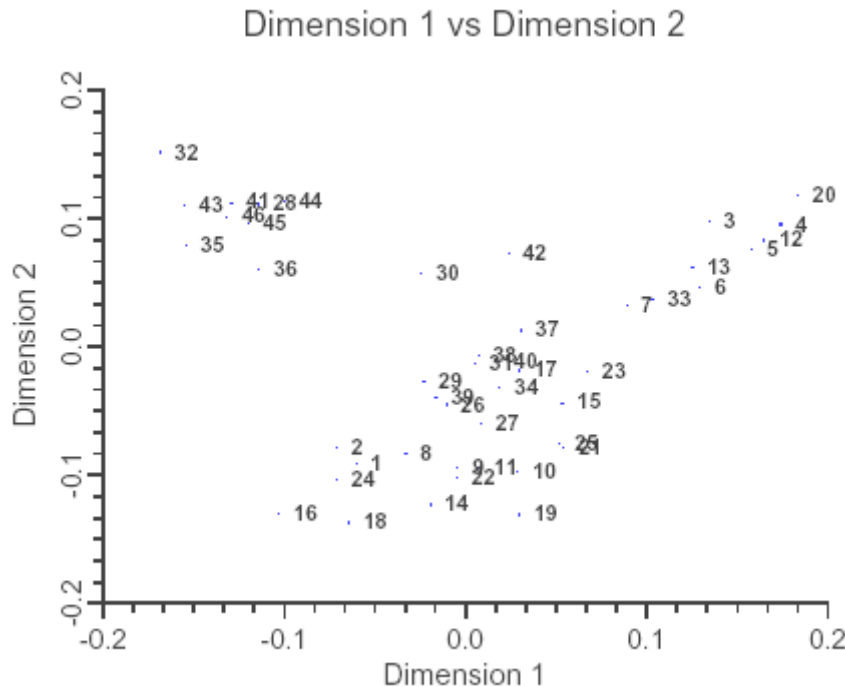

Histogram of Intertextual Distances
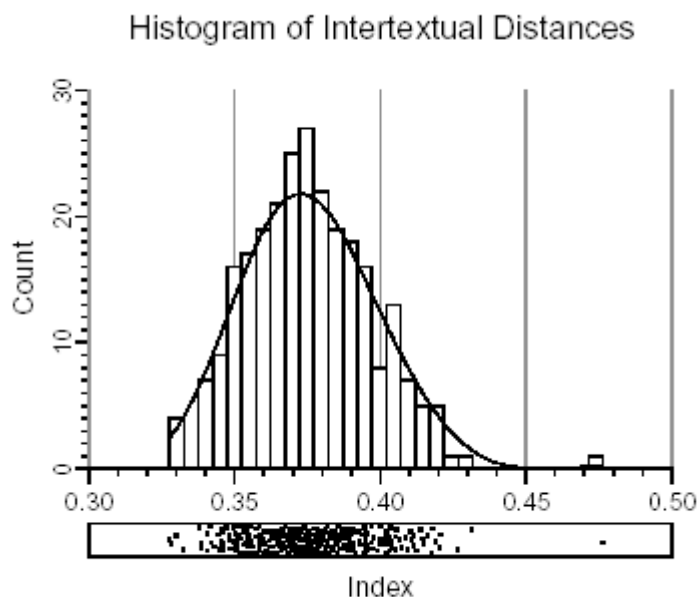
9 Middleton Plays vs. 29 Shakespeare Texts

20　This hypothesis of a heterogeneous Shakespeare body of plays is confirmed by examination of the histogram created by the 72 remaining distances.

21　The distribution is not perfectly symmetrical due to the small number of distances concerned. What is revealing is the presence of a central clustering between indices 0.42 and 0.44, well in excess of the limit of 0.40 cited above, and quite distinct from the clustering between 0.37 and 0.38 in the previous histogram.

22　Either the eight texts abstracted from the 37 Shakespeare *Folio* texts are significantly different from the remaining 29 plays with respect to date of composition, genre or topic, or they differ *authorially* from the bulk of the Shakespeare plays. Possibly two or more mutually reinforcing factors are at work[7].

23　Such considerations, however, are not central to the investigation at hand. The focus of interest is the limiting value of textual homogeneity. Are the indices derived from the examination of the 1035 intertextual distances in English at all comparable to those derived from extensive testing in French ? I believe that there are reasons for thinking that they are. Nevertheless, there are even better reasons for believing that the method of intertexual distances is transferable from French to English.

4. Multidimensional Scaling

24　The entire square 46 by 46 matrix may be transformed into a two-dimensional best-fit 'map' by multidimensional scaling[8]. Imagine a mileage/kilometer chart of the sort shown in regional road atlases. The miles/kilometers are distances between geographical locations of towns on a limited spherical section of the globe. A two-dimensional map can be re-constructed from the matrix of distances to show the town locations as they would appear on a geographical map.

25　The same technique may be applied to the matrix of intertextual, as opposed to geographical, distances. For the 'map' to be intelligible, two dimensions out of the potential 46 can be represented on flat paper. Multidimensional scaling mathematically orders the dimensionality of the matrix into a hierarchy of which the first two dimensions (Dimensions 1 and 2) account for more information than any other two dimensions combined. In effect, the remaining 44 dimensions are superfluous 'noise'.

26　In the case at hand of the 46 by 46 matrix, the resulting 'map', if intelligible with regard to the four factors (authorship, chronology, genre and content) will indicate which one or two or three of these account for the lion's share of variation within the data matrix.

27　I have assigned the 46 texts code numbers which indicate their chronological sequence. See Appendix I. If date of composition is the outstanding feature of the multidimensional scaling 'map', the visual clustering will reflect the numerical ordering of the plotted points. If, on the other hand, authorship is the major factor in the matrix, clustering will gather together texts by Shakespeare and texts by Middleton in distinct and separate clusters.

28　In the diagram below, nine Middleton plays {28,32,25,36,41,43,44,45,46} are located in the upper left-hand corner. The majority of plays by Shakespeare form an irregular shape from lower left to upper right, while two plays 'float between' the Middleton and Shakespeare clusters. They are *Timon of Athens* {30} and *Henry VIII* {42}, both collaborative plays and recognized as such by a considerable number of scholars[9]. In addition, 3H6 {4}, 1H6 {5}, Tit {6}, are the *First Folio* plays seen as collaborative by Ward Elliott and Robert Valenza, and Gary Taylor[10].

Dimension 1 vs Dimension 2

29   The fact that the 9 Middleton plays form a cluster in the upper left-hand separate from the Shakespeare plays confirms that the intertextual distances are sensitive to the authorship difference between Shakespeare and Middleton. The 37 designated Shakespeare texts have an elongated shape with a semi-detached 'handle' of 9 plays to the right. This peculiar feature of the *First Folio* plays strengthens the impression received above that the aggregate distances between the Middleton plays and the Shakespeare plays are bimodal, bimodality being a feature of the Shakespeare corpus[11].

30   Although the plays in the 'handle' of the Shakespeare cluster are generally of early composition {3, 4, 5, 6, 7, 12, 13}, *Macbeth* 1606 {33} and *Henry V* (verse) 1598-99 {20} are not so. Two early Shakespeare plays, *The Two Gentlemen of Verona* 1590-91 {1} and *The Taming of the Shrew* 1590-91 {2} are relatively close to the Middleton plays, of which the earliest, *The Phoenix* 1603-04 {28}, was written some 12 years later. Chronology is not the predominant factor.

31   Seven of the nine 'handle' plays are history plays {3, 4, 5, 7, 12, 13, 20}, the exceptions being *Titus Andronicus* {6} and *Macbeth* {33}. One history play, *Henry VIII* {42} stands by itself, and two other history plays, *Henry IV, Part 1* {15} and *Henry IV, Part 2* {17} lie within the main part of the Shakespeare cluster. Genre is not the predominant factor.

32   Although unobtrusive, the positioning of *Timon of Athens* {30} is the strongest evidential support for the discriminating power of intertextual distances.

   Developing a conjecture by Wells (1920) and Sykes (1924), Lake (1975), Jackson (1979), and Holdsworth have provided extensive, independent, and compelling evidence that approximately a third of the play was written by Thomas Middleton.[12]

33   *Timon of Athens* is found between the Shakespeare and Middleton clusters ; it is the nearest Shakespeare play to the Middleton plays.

34   The generally accepted collaboration of John Fletcher and William Shakespeare in *Henry VIII* (*All is True*) {42} stands by itself outside the cluster of Shakespeare plays[13].

35 My previously arrived at view is that the eight of the plays in the 'handle', {3, 4, 5, 6, 7, 12, 13}, are partly the work of Christopher Marlowe[14].

Appendix I			
Shakespeare Texts	Date	Code No.	Abbreviations
The Two Gentlemen of Verona	1590-01	1	TGV
The Taming of the Shrew	1590-01	2	Shr
Henry VI, Part Two	1591	3	2H6
Henry VI, Part Three	1591	4	3H6
Henry VI, Part One	1592	5	1H6
Titus Andronicus	1592	6	Tit
Richard III	1592-93	7	R3
The Comedy of Errors	1594	8	CE
Love's Labour's Lost	1594-95	9	LLL
A Midsummer Night's Dream	1595	10	MND
Romeo and Juliet	1595	11	Rom
Richard II	1595	12	R2
King John	1596	13	Jn
The Merchant of Venice	1596-97	14	MV
Henry IV, Part One	1596-97	15	1H4
The Merry Wives of Windsor	1597-98	16	Wiv
Henry IV, Part Two	1597-98	17	2H4
Much Ado About Nothing	1598	18	Ado
Henry V (prose)	1598-99	19	H5p
Henry V (verse)	1598-99	20	H5v
Julius Caesar	1599	21	JC
As You Like It	1599-1600	22	AYL
Hamlet	1600-01	23	Ham
Twelfth Night	1601	24	TN
Troilus and Cressida	1602	25	Tro
Measure for Measure	1603	26	MM
Othello	1603-04	27	Oth
All's Well That Ends Well	1604-05	29	AWW
Timon of Athens	1605	30	Tim

King Lear	1605-06	31	KL
Macbeth	1606	33	Mac
Antony and Cleopatra	1606	34	Ant
Coriolanus	1608	37	Cor
The Winter's Tale	1609	38	WT
Cymbeline	1610	39	Cym
The Tempest	1611	40	Tem
Henry VIII or All is True	1613	42	H8
Middleton Texts			
The Phoenix	1603-04	28	Phn
A Mad World, My Masters	1605-06	32	Mad
A Trick to Catch the Old One	1606	35	Trk
The Puritan or The Widow of Watling Street	1606	36	Pur
No Wit/Help Like a Woman's or The Almanac	1611	41	Wit
A Chaste Maid in Cheapside	1613	43	CMC
More Dissemblers Besides Women	1615	44	Dis
The Nice Valour or The Passionate Madman	1615-16	45	Val
Women Beware Women	1622	46	WBW

Appendix Two

	Code	Phm 28	Mad 32	Trk 35	Pur 36	Wit 41	CMC 43	Dis 44	Val 45	WBW 46
TGV	1	0.362	0.375	0.371	0.372	0.367	0.382	0.346	0.367	0.354
Shr	2	0.359	0.377	0.352	0.356	0.358	0.371	0.359	0.373	0.343
2H6	3	0.399	0.429	0.426	0.413	0.416	0.431	0.400	0.434	0.434
3H6	4	0.425	0.457	0.442	0.423	0.429	0.450	0.419	0.442	0.450
1H6	5	0.419	0.445	0.434	0.423	0.427	0.445	0.408	0.435	0.431
Tit	6	0.418	0.442	0.433	0.425	0.423	0.439	0.403	0.437	0.429
R3	7	0.372	0.412	0.387	0.379	0.393	0.415	0.370	0.392	0.399
Err	8	0.371	0.383	0.359	0.365	0.361	0.378	0.375	0.380	0.372
LLL	9	0.379	0.400	0.389	0.387	0.386	0.397	0.367	0.383	0.385
MND	10	0.406	0.411	0.404	0.402	0.393	0.402	0.379	0.400	0.381
Rom	11	0.378	0.389	0.383	0.375	0.372	0.381	0.363	0.390	0.371
R2	12	0.410	0.449	0.439	0.425	0.430	0.450	0.400	0.438	0.431
Jn	13	0.411	0.444	0.426	0.414	0.423	0.438	0.400	0.343	0.423
MV	14	0.357	0.390	0.359	0.354	0.369	0.386	0.365	0.370	0.366
1H4	15	0.387	0.402	0.395	0.372	0.397	0.398	0.390	0.402	0.402
Wiv	16	0.373	0.376	0.353	0.365	0.379	0.376	0.393	0.391	0.395
2H4	17	0.354	0.375	0.368	0.351	0.364	0.381	0.366	0.381	0.387
Ado	18	0.354	0.376	0.359	0.349	0.370	0.379	0.352	0.363	0.342
H5p	19	0.382	0.476	0.395	0.374	0.404	0.418	0.388	0.397	0.403
H5v	20	0.452	0.493	0.476	0.463	0.461	0.478	0.442	0.472	0.403
JC	21	0.385	0.412	0.395	0.379	0.406	0.416	0.385	0.391	0.394
AYL	22	0.354	0.383	0.357	0.348	0.364	0.373	0.353	0.358	0.355
Ham	23	0.377	0.409	0.395	0.391	0.388	0.419	0.374	0.393	0.388
TN	24	0.341	0.354	0.338	0.348	0.350	0.357	0.330	0.350	0.341
Tro	25	0.403	0.427	0.415	0.404	0.415	0.431	0.391	0.405	0.405
MM	26	0.350	0.382	0.365	0.366	0.365	0.382	0.346	0.361	0.355
Oth	27	0.360	0.386	0.372	0.368	0.374	0.388	0.347	0.376	0.360
AWW	29	0.328	0.357	0.342	0.351	0.351	0.368	0.328	0.353	0.338
Tim	30	0.332	0.355	0.351	0.352	0.362	0.379	0.345	0.360	0.359
KL	31	0.355	0.377	0.367	0.375	0.362	0.386	0.361	0.370	0.370
Mac	33	0.400	0.420	0.417	0.411	0.407	0.421	0.394	0.410	0.411
Ant	34	0.370	0.399	0.382	0.375	0.379	0.385	0.364	0.374	0.370
Cor	37	0.378	0.414	0.395	0.385	0.395	0.409	0.391	0.395	0.388
WT	38	0.346	0.369	0.377	0.394	0.363	0.381	0.344	0.363	0.355
Cym	39	0.348	0.370	0.370	0.366	0.360	0.374	0.338	0.351	0.345
Tem	40	0.369	0.389	0.384	0.372	0.375	0.386	0.375	0.374	0.388
H8	42	0.345	0.384	0.380	0.367	0.370	0.395	0.349	0.364	0.368
Phr	28		0.312	0.301	0.315	0.335	0.343	0.319	0.330	0.322
Mad	32	0.312		0.314	0.344	0.319	0.328	0.326	0.339	0.325
Trk	35	0.301	0.314		0.310	0.314	0.326	0.335	0.338	0.330
Pur	36	0.315	0.344	0.310		0.338	0.340	0.337	0.346	0.338
Wit	41	0.335	0.319	0.314	0.338		0.314	0.313	0.333	0.344
CMC	43	0.343	0.328	0.326	0.340	0.314		0.339	0.349	0.311
Dis	44	0.319	0.326	0.335	0.337	0.313	0.339		0.318	0.284
Val	45	0.330	0.339	0.338	0.346	0.333	0.349	0.318		0.320
WBW	46	0.322	0.325	0.330	0.338	0.344	0.311	0.284	0.320	

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NOTES

1. Cf. Labbé, Cyril and Dominique Labbé (2001).

2.. The absence of lemmatization does not entail the same drawbacks that it does in French, because of the fewer number of flexible endings and different words with the same spelling in English.

3.. The algorithm used for reduction of the larger of the two texts in French is being adapted for use in English in the future.

4.. See Park Honan, *Shakespeare: a Life* (Oxford : Oxford University Press, 1998), 347. D. M. Farr, *Thomas Middleton and the Drama of Realism* (New York : Harper Row, 1973).

5.. Labbé and Labbé, 2001 : 219.

6.. The eight texts are *2H6, 3H6, 1H6, Tit, R3, R2, Jn* and *H5*v.

7.. The dates of the eight texts, *2H6, 3H6, 1H6, Tit, R3, R2, Jn* and *H5*v, are earlier than any of the Middleton plays. See Appendix I. However, according to the Oxford dating, *TGV* and *Shr* are the earliest Shakespeare plays, and they are closer in time to the Middleton plays than the eight texts.

8.. For a detailed explanation of the technique, see Joseph B. Kruskal and Myron Wish, *Multidimensional Scaling* (Beverley Hills and London, Sage, 1978). Also Brian F.J. Manly, *Multivariate Statistical Methods: A Primer* (London, Chapman and Hall, 1986), 126-41.

9.. Brian Vickers, *Shakespeare Co-Author: A Historical Study of Five Collaborative Plays* (Oxford, Oxford University Press, 2002), 244-290; 333-402. See also Gary Taylor, 'The Canon and Chronology of Shakespeare's Plays' in *William Shakespeare: a Textual Companion*, ed. Stanley Wells and Gary Taylor with John Jowett and William Montgomery (Oxford, Clarendon Press, 1987, 127-28, 133-34; *Henry VIII or All is True*, ed. Jay. L. Halio (Oxford, Oxford University Press, 1999), 16-24. Also M.P. Jackson, *Studies in Attribution: Middleton and Shakespeare* (Salzburg: Salzburg University Press, 1979.) For the opposite point of view on *Henry VIII*, see *King Henry VIII*, ed. R.A. Foakes (London, Methuen, 1964), xv-xxviii. Jackson

views on the authorship of *Timon* have not, to my knowledge, been disputed in resent years.

10.. W. Elliott and Valenza, R., 'And Then There Were None', *Computers and the Humanities*, 30 (1996), 191-210. Taylor, 111-115. See also Vickers, 148-243. For the opposite view, see *Titus Andronicus*, ed. Jonathan Bate (London and New York, Arden, 1995), 79-83.

11.. See Appendix II for a table of distances between the Middleton plays and the non-Middleton and Middleton plays.

12.. Taylor, 128.

13.. In addition to the works cited above in notes 6 and 7, see the most recent edition of the play, *King Henry VIII*, ed. Gordon McMullan (London and New York, Arden, 2000), which carries on the title page 'William Shakespeare and John Fletcher'.

14.. Thomas Merriam, 'Tamburlaine Stalks in *Henry VI*', *Computers and the Humanities*, 30 (1996), 267-80. Thomas Merriam, 'Heterogeneous Authorship in Early Shakespeare and the Problem of *Henry V*', *Literary and Linguistic Computing*, 13 (1998), 15-28.

RÉSUMÉS

Une application d'attribution d'auteur au moyen de la distance intertextuelle en anglais
Le calcul de distance intertextuelle que C. et D. Labbé appliquent aux textes français peut être utilisé pour différencier les œuvres d'au moins deux auteurs dramatiques contemporains de l'époque élisabéthaine, William Shakespeare et Thomas Middleton. Bien que les 46 textes sous étude, transcrits avec une orthographe moderne, ne soient pas lemmatisés et que seuls des échantillons de textes de même longueur aient été utilisés, les indices de distance intertextuelle qu'on a pu ainsi établir empiriquement sont du même ordre de grandeur que ceux qu'ont établis C. et D. Labbé pour le français. *Timon of Athens* considéré comme étant pour deux-tiers de Shakespeare et pour un tiers de Middleton se place entre le groupe des œuvres de Shakespeare et celui des œuvres de Middleton dans une analyse multidimensionnelle de 1035 distances intertextuelles.

The method of Intertextual Distances, which C. and D. Labbé applied in French, can be used to differentiate by author at least two contemporary Elizabethan/Jacobean playwrights, William Shakespeare and Thomas Middleton. Although the 46 modern-spelling texts in question were not lemmatized, and only truncated text samples of the same length were used, the resulting empirical indices of intertextual distance in English were of the same order of magnitude as those established by the Labbés in French. *Timon of Athens*, considered to be two-thirds by Shakespeare and one third by Middleton, is placed between the Shakespeare cluster and the Middleton cluster in a multidimensional scaling of the 1035 intertextual distances.

INDEX

Mots-clés : indice de distance, théâtre anglais, attribution d'auteur

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