A MULTIPLE DISCRIMINATE ANALYSIS OF ELIZABETHAN KEYBOARD VARIATIONS

by

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B. A., University of Oregon, 1975

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF MUSIC

Department of Music

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1984

Approved by:

Major Professor

ACKNOWLEDGMENTS

From inspiration to completion, several contributors to this thesis deserve my grateful acknowledgment. Dr. George Milliken's assistance with statistical interpretation and Dr. Mary Ellen Sutton's scrutiny of the musical variables provided necessary checks along the way. Dr. Chappell White's patience, William Schenck-Hamlin's persistence, and Nikki Carpenter's perfectionism helped bring this project to fruition.

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CHAPTER I: INTRODUCTION

Editors of Elizabethan keyboard literature often face authorship questions just as problematical as the transcription of the music itself. Classifying compositions from 1558 to 1603 among contemporary composers is complicated by unauthorized manuscripts, multiple copies, conflicting attributions by copyists, and use of common themes by composers of variations. Variations on song or dance tunes were the predominant genre of secular keyboard music at that time, and their surviving quantity represents a remarkable collection of popular music as well as a baffling array of unsolved authorship problems. The following paper will examine keyboard variations with regard to the problem of authorship verification. The challenge presented in their duplication of techniques as well as themes especially lends itself to a study of stylistic classification.

Literature about Elizabethan composers has only begun the task of identifying "giants" of the period by stylistic features. Less than six books have been written about the works of William Byrd. Orlando Gibbons and John Bull, co-contributors with Byrd to the famous Parthenia together, have been the subject of three, and a number of other composers represented in such collections as the Fitzwilliam Virginal Book remain barely known in terms of their stylistic individuality. Though keyboard music makes up a varying portion of their total works, such composers as Thomas Morley, Peter Philips and Giles Farnaby may show noteworthy differences when compared on the basis of their variation pieces. By examining the above group of six composers the author intends to discover something of the stylistic identity of each.

A method for selecting and evaluating stylistic variables for the purposes of identifying anonymous pieces is the major concern of the thesis. Since the problem is one that requires detailed quantification of notational observations, the author has followed a statistical procedure used widely in scientific research. Discriminant analysis provides a technique for analyzing quantified measurements taken from several groups. Stylistic features that can be counted from the musical score can be statistically evaluated using this model for their probability of successful classification. In employing discriminant analysis to study stylistic variables, a systematic, reproduceable procedure for composer classification will be provided that, to the author's knowledge, has never been used in musical research.

Characteristically, modern editions of Elizabethan keyboard music mention little procedure, other than general advice such as the following, in Margaret Glyn's edition of Orlando Gibbons' keyboard pieces:

> . . . mature experience only can decide which compositions Gibbons is likely to have written. I have revised many of my earlier readings as my ear of the details of the style has developed, and what is left to stand here is the result of much study.

Margaret Glyn's competence to distinguish the music of Orlando Gibbons from others' rests on her years of scholarship and editions of many works from this period.[1] Still, the stated attribution of her final choices to "mature experience only" and a trained ear leaves many questions unanswered for followers in the field. Her preface might be aided by additional clarification: specifically, by a systematically explained technique for decision-making regarding authorship problems.

A glance through the manuscript sources of Gibbons' music listed in Musica Britannica[2] demonstrates some of the problems that Glyn and other

editors have faced. Of the forty-one sources, only Parthenia[3] was printed. The remaining manuscripts represent the work of a wide range of copyists, from amateurs to professionals. Editors must question their accuracy by considering copyists' identity, sources, proximity to the original composer, and their purposes in making copies. William Ellis, identified by editor Gerald Hendrie as copyist for Music MSS 1113, Christ Church might be an example of a reliable source. He was organist at St. John's College, Oxford (where Gibbons received his Doctor of Music degree in 1622) from 1639 to 1646.[4] Yet editor Hendrie claims that three pieces ascribed to Gibbons in Ellis' hand are unauthentic.

Verifying a piece copied anonymously--or pieces unidentified by known copyists--involves a variety of bibliographic and style-analysis techniques. Many editors find it unnecessary to detail their investigations of handwriting, paper analysis, etc. in prefaces or appendices. However, some feel free to claim vague "stylistic" reasons without explanation for verifying or omitting a given version. In Alan Brown's textual commentary to the collected keyboard works of William Byrd[5] several references to "style" refer to some criteria for decision-making. "Echo Pavan," whose source is anonymous, "seems probable on grounds of style (to be) comparatively early."[6] "Pavan #102" in the same collection is read from two sources, one attributed to Byrd and the other to Thomas Morley. Brown describes the attribution to Morley as "certainly incorrect" without giving his reason. "Pavan 101" Brown verifies as Byrd's, though qualifying that it is "diffuse in style, lacks a sense of logical harmonic progression, and . . . much of the figuration is untypical."[7] "Pavan #99B" has only one source, and that an anonymous ascription. Brown includes it as Byrd's without any explanation.

A lack of convincing evidence or reasoning in such cases weakens the authority of any definitive collection. Musicians using the edition may question whether the editor had proof of authorship of certain pieces. There may be speculation that an editor is biased against inclusion of weaker pieces by a favored composer. Perhaps their stylistic criteria for authenticity is based on mature works, overlooking artistic development during a composer's career.

Unverified or ambiguous ascriptions of pieces to composers leave at least two problems for musicians and musicologists. The identity and stature of individual composers remains hazy or perhaps distorted. And the style of an entire period may be confused with the style of a few individual composers, where too many pieces remain unidentified. As research on Elizabethan composers produces more editions, a more adequate explanation of procedure would answer some of these needs. Students of a single composer's music would be aided in understanding specifics of that composer's style. When conflicts between editions did occur, an editor's criteria could be self-explanatory.

When an authorship question rests solely on stylistic rather than bibliographic elements, analysts are required to take a dual approach: the close study of one composer's output and the broader examination of contemporaneous or traditional music for comparison. Jan LaRue's preface to Guidelines for Style Analysis gives a careful definition of the term "style" in both contexts:

> . . . the style of a piece consists of the predominant choices of elements and procedures a composer makes in developing movement and shape. . . . By extension, we can perceive a distinguishing style in a group of pieces from the recurrent use of similar choices; and a composer's style as a whole can be described in terms of consistent and changing preferences in his use of musical elements and procedures. Even more broadly, common characteristics may individualize a whole school or chronological period. As these shared choices become increasingly general, of course, their application to any particular composer decreases.[8]

Measurements of style according to LaRue's Guidelines are derived from the musical elements he classifies as "SHMRG": Sound, Harmony, Melody, Rhythm, and Growth.[9] The procedure outlined in the excerpt above shows a decidedly quantitative approach to the analysis of those elements. The terms "predominant," "recurrent," "consistent" and "changing" all describe statistical measures of central tendency and distribution (i.e., "mean" and "standard deviation"). The last sentence quoted embodies the statistical determination of stylistic identity. "As these shared choices become increasingly general" describes a region of measurement that can most effectively be pinpointed by a statistical procedure known as discriminant analysis.

Discriminant analysis provides a model for separating the individual tendency from the general, once variables based upon LaRue's five musical elements have been put into quantitative form and counted from pieces by several composers. Not only can it indicate from a total group's data what variables distinguish individual members, but it can classify "unknown" examples as being most or least similar to individuals in the group.

Though no current literature describes the use of discriminant analysis in musicology,[10] there are examples of research in literary style employing it successfully. The most famous case is the disputed authorship of twelve of the eighty-five "Federalist Papers" written variously by John Jay, James Madison, and Alexander Hamilton.[11] The papers represent newspaper articles written from 1787-88 in very similar rhetorical style urging New York residents to ratify the U.S. Constitution. With inadequate historical evidence to answer the question, Frederick Mosteller and David Wallace used analysis of frequencies of certain words to distinguish the sets of known papers by Madison and Hamilton, the two most probable authors.

Those word-rates that showed the greatest discrepancy between them were used to build profiles against which identical word counts from the questionable papers were tested.

In choosing the words to count in the essays, Mosteller and Wallace first tried stylistic "markers": words which an author used so consistently that their appearance might give a strong indication of authorship. They were advised by historian Douglass Adair that Madison used "whilst" in place of Hamilton's fairly consistent "while."[12] Basing discrimination on the occurrence of such words was inadequate. Discovering a longer list of such words takes a great deal of time, and this pair of markers did not occur with enough frequency throughout each essay to be reliable.

Even more effective than the counts on "while" and "whilst" were the combined rates of nine common "filler" words--also, an, by, of, on, there, this, to, and upon--per 1,000 words in each essay. It may be wondered why such words and not more meaningful contextual ones should produce significant discriminations. It was apparent that contextual nouns and verbs were less a part of the author's stylistic choices than part of the subject choice. Given the set of 18 essays, there would be no way of guaranteeing a consistent profile of counts based on words that may or may not be appropriate to the topic of each. The commonly used prepositions and articles did discriminate effectively enough to show a decided stylistic slant toward Madison in the disputed papers. Such results indicate that the authors' style was expressed more in the way they connected their "contextual" vocabulary than in the choice of that vocabulary itself.

The appropriateness of Mosteller and Wallace's procedure to musical analysis can be asserted without undue reliance on linguistic/musical analogies. LaRue's previously cited definition of musical style as a

composer's "predominant choices of elements and procedures" aptly describes the statistical profile sought in the Federalist Papers. The elements quantified in that case were seemingly insignificant filler words. In this study measures of notational values will be used. According to LaRue, quantifying the observable changes in a score is an essential analytical procedure. Important as a well-trained ear is, the memory of the music analyst is better served by separating out individual elements one usually hears simultaneously, then counting their occurrences.

A count of this sort lacks evaluative bias. In disregarding contextual words for analysis, Mosteller and Wallace may have overlooked aspects of political rhetoric that a Madison or Hamilton scholar considers significant. Similarly, a chord or figuration that one composer is known to have used characteristically may not discriminate his or her works from another's. This study leaves the task of examining style from an aesthetic or historical standpoint to others. In the process of scrutinizing note values for their cumulative discriminating power, it is assumed that the quality of the works will not bias the results.

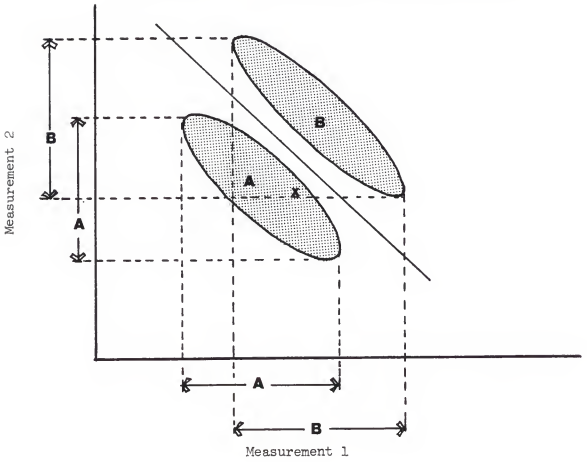
It should be evident that a statistical approach to quantifying musical data is permissible. The use of a multivariate model to analyze that data can now be shown to be appropriate when studying a group of composers. Multivariate analyses provide "assessments of patterns within, among and between clusters of variables."[13] The variables in this study fall into three types: 1) six individual composers 2) fifty-six keyboard pieces, and 3) fourteen quantified stylistic variables expected to distinguish, or discriminate between the works. If one had no statistical model with which to compare these groups, it would be difficult to assess all of the interrelationships among composers, pieces, and style variables. Using a multivariate model, one could evaluate the significance of a given style choice to

a particular piece and composer. Distinctions among pieces by one composer as well as among several composers' pieces can be estimated at the same time. Statistical analyses allow one to assess the extent to which certain variables contribute to an explanation of some phenomenon. Discriminate multivariate analysis will indicate the relative importance of the stylistic variables as discriminators.

Discriminate analysis is a multivariate procedure that can answer two related questions: 1) Given a large amount of data in the form of several measures taken of several cases, which measures separate the mass of cases into groups? 2) Given a set of discriminated groups, can a single unknown case be classified as belonging to one of them? Assuming that one had no such technique available, one's procedure in answering the second question would involve taking the averages of each measurement from one group to the next and comparing them to the measurement from the unknown case. The weakness in this procedure becomes apparent when one has to summarize from the entire set of compared means. A useful illustration is offered by Lalitha Sanathanan in her description of discriminant analysis. (see Figure I-A).[14]

The elipses surrounding A and B represent a cluster of observations taken from two measurements, or variables. Groups A and B are seen along the axes for measure 1 to overlap each other. The addition of the vertical axis for measure 2 creates the potential for separation of the clusters. While "x" falls within the overlapping area for measurement 1, it lies just outside the overlap area from measurement 2, within A's elipse. The more measurements one has available for study, the greater the chance that groups can be distinguished without overlapping. Details of the discriminant function which accomplishes this will follow in Chapter Three.

FIGURE I-A: Effectiveness of Two Measurements Taken Simultaneously in Separating Two Groups (A and B).



The choice of variables will determine the effectiveness of a discriminate approach to authorship verification. Because the number of counted observations as well as the number of variables should be high, the items examined need to occur throughout a sample piece. Rather than looking for discrete musical passages or counting the occasional occurrence of certain chord types, this study focuses on each piece's total rhythmic and notational values. The fourteen variables that were tested are drawn from only two of Jan LaRue's five musical elements (See "Discriminating Variables", Chapter 3).

In order to deal with as uniform a musical sample as possible the choice of Elizabethan-period keyboard pieces was limited to keyboard variations based on the Pavan. The style of this dance is strongly controlled by its 8-bar phrasing and stately 4/2 meter, so that the task of tracing one composition's authorship is even more challenging. For each composer, all known pavans were studied from the modern editions listed in Appendix I. A list was made of dubious or disputed pavans noted in editors' prefaces or appendices to those editions. These formed the group of pieces to be classified once the discriminations between composers had been established.

All of the composers chosen were prominant keyboard musicians during the reign of Elizabeth I (1568-1603), though their collected works cover a period of three generations. William Byrd, Giles Farnaby, John Bull, Thomas Morley, Orlando Gibbons, and Peter Philips were selected on the basis of their contemporary reputation, the number of works available for study, and the existence of disputed pieces attributed to them by modern editors.

A more detailed discussion of these composers, of Elizabethan keyboard style in general, and the hypotheses of this study follow in Chapter Two. Succeeding chapters will cover the methodology employed, describe the results of the statistical analysis, and summarize and explore conclusions.

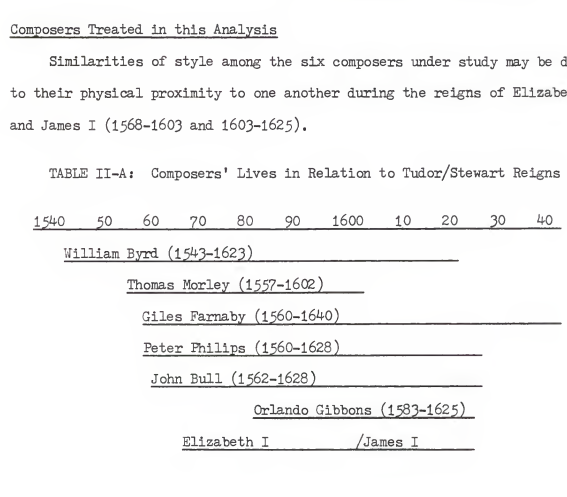
CHAPTER II: HISTORICAL REVIEW

Historical research and style analysis convey the close proximity of these six composers to each other. Their variations, on pavans in particular, collectively illustrate a "school" of composition; it undoubtedly had its leaders and its followers, but many stylistic elements, techniques, and even some thematic material were common to each. This chapter will examine the evidence of a common variation practice that existed during this brief period, and the resulting ambiguity in attributions to its composers.

Composers Treated in this Analysis

Similarities of style among the six composers under study may be due to their physical proximity to one another during the reigns of Elizabeth I and James I (1568-1603 and 1603-1625).

TABLE II-A: Composers' Lives in Relation to Tudor/Stewart Reigns



To examine the probability that they were familiar with each other's music, one must look at three possible points of convergence in their lives: their connections with the musical establishment of the Chapel Royal; their formal educations; and their political/religious affiliations.

The Chapel Royal, or the ecclesiastical establishment of the Queen (or King), provided the most prestigious positions for musicians in English society. Young boys recruited there as singers received a formal training in musicianship (plainsong, fabourdon, discant, counter-tenor, and sometimes keyboard instruction)[15], while they provided the choir for services. When the boys' voices broke, royal support continued with further training, including a university education. A successful scholar might find a career in the church or stay on as singer, keyboardist, copyist or as Master of the Children.

The "Gentlemen" sworn to service in the Chapel Royal were either those who continued in the above-listed functions or persons with exceptional abilities, particularly in composing and performance, who earned an honorary title.[16] The honorary status of Gentleman usually stayed with the musician indefinitely, even if he were employed elsewhere. It is difficult to determine how long and how frequently individuals were active in the Chapel Royal after their recorded swearing-in.

TABLE II-B: Composers as Chapel Royal Children and Gentlemen

1570 - Byrd sworn as Gentleman
1574 - Bull recorded as Child
1583 - Bull recorded as Master of the Children
1586 - Bull sworn as Gentleman
1592 - Morley sworn as Gentleman
1597 - Bull recorded as Organist
1603 - Gibbons recorded as Choirster
1615 - Gibbons recorded as Organist
1619 - Gibbons recorded as Virginalist
1627 - Gibbons sworn as Gentleman

Four of the six composers under study who were part of the Chapel Royal were Byrd, Bull, Morley and Gibbons. From the chronological list of recorded memberships in Table II-B, it can be assumed that at least the first three knew of each others' existences. Morley's relation to Byrd is established by his dedication to Byrd, his "Master", of the Plaine and Easie Introduction to Practical Musicke in 1597.[17] Morley also received the monopoly over music printing in 1598 that William Byrd had shared with Thomas Tallis from 1575 to 1596.[18] It could be inferred that Morley had some familiarity with Bull's works because the date of his swearing-in falls between successive dates of Bull's employment there, but Morley probably knew nothing of the younger Gibbons, who became a singer in the Chapel Royal choir one year after Morley's death in 1602. John Bull, William Byrd, and Orlando Gibbons' birth were about 20 years apart, respectively, and they were collectively represented as the major keyboard composers of England in Parthenia.[19] This first English publication of keyboard music was dedicated to James I's daughter Elizabeth in 1613, the year Bull left England permanently and 10 years before Byrd's death. It is very probable that these three knew of each others' work by this time.

Peter Philips was never a member of Queen Elizabeth's Chapel Royal. He had left Reformation England to receive a Catholic education and employment in 1582, and remained in Europe for the rest of his life.[20] Giles Farnaby is not recorded in connection with the Chapel Royal.

TABLE II-C: Composers Receiving Musical Degrees at Oxford

1586 - Bull, Bachelor of Music
1588 - Morley, Bachelor of Music
1592 - Farnaby, Bachelor of Music
1592 - Bull, Doctor of Music
1622 - Gibbons, Doctor of Music

A Doctor's degree in music could be granted, according to John Stevens, on a musician's proven ability in composing rather than on completion of formal studies at the university. The Bachelor's degree " 'conferred the right of reading and lecturing' on the science of music (i.e. Boethius); no practical ability was required."[21] If the latter degree was earned by Morley and Farnaby as an extension of Chapel Royal sponsorship for choirsters, then perhaps both had been connected with the establishment after all. But if an honorary Doctor's degree were awarded to Bull in 1592 for his musical compositions, it might be insufficient reason to think that he personally knew Farnaby, who received his Bachelor's degree there the same year. Orlando Gibbons earned his Doctor's degree from Oxford so much later than the others that he may have been acquainted with their music without knowing them as individuals there.

The third area of convergence for the group of six composers is religious. Elizabeth Cole established the common Catholic link between the composers and copyist of the Fitzwilliam Virginal Book, copied between 1613 and 1619.[22] This definitive collection includes Peter Philips, but excludes Orlando Gibbons. Francis Tregion ("the Younger") was the compiler of the collection, completed presumably while he was imprisoned in the Fleet for anti-Protestant activities. All composers included and many of the patrons' named in dedications were part of a Catholic minority that maintained close social ties during the Reformation. The many connections Cole brings out between politics and patrons named in the variation titles are intriguing. Thomas Pagget of Peter Philips' "Paget Pavan and Galliarda"[23] was a double agent between the governments of Spain and England. Lord Montegle of Byrd's "Montegle Pavan"[24] was involved in the Essex uprising of 1601. Morley is recorded as having repented of his Protestant associations while serving

Charles Pagget in Antwerp, but apparently he kept up a patriotic, anti-Catholic posture after returning to England.[25] John Bull's departure for the Netherlands in 1613 is politically ambiguous. It was explained as escape from religious persecution in documents from the continent, and described as evasion of punishment for adultery by some in England.[26] His friendship with the Catholic Peter Philips is recorded from a trip to Madrid in 1609/10, and the two probably met again in the Netherlands in 1613.[27]

The existence of the Fitzwilliam Virginal Book provides the strongest support for a common school of composition. That all of the music was written by members of a close political minority argues for some exchange of musical ideas as well.

Development of the Variation Genre

Though Byrd, Bull, Morley, Gibbons, Farnaby and Philips each wrote in several genres for various instruments, the variation seems to have been the predominant form for their keyboard writing, and most of them were acknowledged as keyboard performers. The history of the keyboard variation was still young when they employed it in the late sixteenth century. Early secular forerunners can be seen in the British Library Manuscript Roy.App. 58 (dated c.1530) and in the Spanish lute variations by Louis Milan of 1536.[28] The former contains dances written or transcribed for the virginals. Hugh Aston's "Hornpype" and "My Lady Carey's Dompe" (Anon.) are both grounds in this collection, and represent the earliest models of basso ostinato keyboard variation. Spanish songs are the source material for the sixteenth century lute variations by Milan, Navarro, Mudarra and Valderabanno;[29] but Antonio de Cabezon is credited with the first of such variation sets for keyboard. His possible influence on the English--or

vice versa--has been discussed by Charles Van den Borren in connection with Cabezon's travel to London in 1554. The lack of surviving variation manuscripts between then and his posthumously printed Obras de musica (1578) leaves Cabezon the credit for the first variations written specifically for keyboard. Two years later, Peter Philips' Pavan (FWI, P.343) represents the first dated copy in a long succession of English variations.[30]

Whatever the cross-currents of influence were, it was the English who developed the largest volume of secular keyboard variations between 1588 and 1625. Their music during this time illustrates a high degree of virtuosity among performers and a popular use of familiar dances and songs. Variations were also written as theoretical exercises, such as John Bull's and William Byrd's "Ut, Re, Mi . . ." variation sets. Subjects for variation were sometimes original to the composer, sometimes "borrowed" from another. Instances of one performer challenging another to improvise variations on a given theme is recorded from this period[31], indicating that what has survived represents a small portion of the spontaneous music that Elizabethan musicians played.

Before describing techniques of variation used by Elizabethan composers, it is necessary to define as a self-contained form. In general variations are sets of altered repetitions of a theme that maintain its essential characteristics while highlighting its expressive features. Robert Nelson offers a description specifically of song variations from this period:

> . . . the theme is followed by a moderate number of units, set off by cadences which are arranged more or less progressively according to their rhythmic animation and figural elaboration.[32]

Willi Apel echoes elements of this definition when he distinguishes the two early grounds mentioned above from "genuine" keyboard variations:

> "Hornpype" and "My Lady Carey's Dompe" are each based upon an ostinato of two notes, a formula that is interpreted harmonically to a degree . . . but is too short to be treated structurally in a variation set. On the contrary, the upper parts . . . consciously avoid cadence breaks.[33]

Nelson's definition emphasizes the cadences that preserve an original song's structure. The unity of the whole variation set is established across the repeated cadences by a progressively animated sequence. Apel seems to see a well-defined, cadencing theme as the most legitimate subject for a "true" variation. This dismisses a whole category of Elizabethan variations that were written on terser subjects, and which required different kinds of treatment.

The variety of themes Elizabethans used governed the variety of techniques they employed. One of the reasons that one composer's style is difficult to isolate is that his way of treating one theme did not necessarily translate to another variation set with a different theme. To have done so would have exposed his inadequacy at improvising fresh variations. Nevertheless, it is useful to recognize a few patterns in variation technique that do recur in the literature. These four categories are derived, using various labels, by Apel, Nelson and Van den Borren from 1) the subject's location in the musical text and 2) its embellishment in any of the horizontal lines, or voices.[34]

"Cantus Firmus" (Nelson) - "Polyphonic" (Van den Borren). These labels describe a subject remaining unembellished in the particular voice that presents it, but which can move from voice to voice during the set. Embellishment is carried out by the remaining voices in chords or melodic figuration.

"Harmonic" (Nelson) - "Harmonic" (Van den Borren) - "Melody of the theme in a lower part of the variation" (Apel). The subject begins and

remains a bass-voice theme. Typical of basso ostinato form, or any dance using a standard harmonic sequence, the upper voices provide the embellishment.

"Melodic" (Van den Borren) - "Ornamented melody of the theme in the top part of the variation" (Apel). The theme is consistently an upper-voice melody--sometimes embellished itself, sometimes straightforward--but lower voices provide much of the alternate material.

"Melodico/Harmonic" (Nelson) - "Mixed" (Van den Borren). Where both the soprano melody and its bass harmonic underpinning form the subject, and where each of the voices are embellished at different stages, the broadest category is used. This covers the greatest number of Elizabethan song and dance variations.

Since these categories are derived from variations that do not fit very neatly into any one of them, they cannot be helpful in identifying one composer's stylistic profile either. Returning to the problem of style in variations, a comparison of narrower musical categories across variations is likely to be the next step in identifying stylistic elements.

Comparison of Variations

Examining three variations by Byrd, Farnaby, and Morley on John Dowland's Lachrymae Pavan can test the adequacy of that approach.[35] This is only one example of several variations composed on the same theme by Elizabethan keyboardists. One would suppose that each composer, whether he knew of the others' versions or not, would write in a style that exhibited his special talents.

Apart from their common theme, the similarities between these three "Lachrymae's" begin with their length; six variations make up each set, each variation being eight (plus 1 or 2) bars of $\frac{4}{2}$ length. The last two

variations in the sets are usually expanded by all three composers to 9 or 10 bars, and all end on a 6- or 7-breve chord.

In the first variation the falling-note motif of Dowland's melody is treated by all three with some imitation among voices, and its harmonic outline can be seen in whole-note values. Byrd's first variation utilizes extensive sixteenth- and thirty-second-note figuration, which occurs more in later variations by the other two composers, and he uses the key of d-minor instead of their a-minor. The way that all three composers treat the melody at its half-way point through the first variation is another point of comparison. Morley highlights by three repeated whole notes on E in the upper voice and C in the lower, the tension between a-minor and c-major sonorities. From that climax the melody descends to its completion. At the same measure Farnaby substitutes c# as an ornamental passing tone on a weak beat. Byrd's progress to the second half of the melody is smoother than Farnaby's and less climactic than Morley's.

One could proceed with categorical comparisons of the three composers' variations without coming to any convincing conclusion on each one's style. The composers' choices that were just contrasted represent melodic expansions on the given tune. Such choices won't necessarily repeat themselves in another tune. To avoid such problematic melodic variables, it would be preferable to examine what characterizes the rhythmic variation a melody undergoes with each piece. Five related variables can build a quantifiable profile of each composer's rhythm and texture: 1) durational note values most-to-least used within the variations; 2) changes in (1) over the entire variation set; 3) degree of chordal (vs. monophonic) texture within the variations; 4) changes in (3) over the entire variation set; 5) average size of chords within variations. The first variable, a count of durational

note values, is the crudest, since it does not consider the notes' vertical alignment. Table II-D shows results of durational note counts for the three pieces examined.

TABLE II-D: Rhythmic Note Values Ranked by Quantity for Lachrymae Pavan Variations of Farnaby, Morley and Byrd. (Left to Right = Greatest to Smallest Quantity)

	FARNABY	MORLEY	BYRD
Variation			
1	E H Q = S W	E H W Q S	S H T E Q W
2	S E H Q W	H T W S Q = E	S E Q H W
3	E S H Q W	Q W = H E S T	E H Q S W
4	S E H Q	E S Q W H T	S H E Q T W
5	E S Q H W	Q E H W S T	E S Q H T W
6	S E Q H W	T E Q S H W	S E H = Q W

W = whole notes Q = quarter notes S = sixteenth notes

H = half notes E = eighth notes T = thirty-second notes

Notes with identical quantities are paired with an equal sign (=).

Whole notes in Farnaby and Byrd are consistently the least frequently used, and their most frequently-used note durations are either eighth- or sixteenth-note values. Morley's whole notes, on the other hand, are dispersed unevenly throughout the variations. His most-used durations range from thirty-second to half-notes. Examining downward the progression of most- and least-used durations reveals the amount of change occurring in this element over the entire set. Judging from the above table, it might appear that Farnaby's and Byrd's pieces don't alter their rhythm as radically as Morley's from variation to variation. The next variables measured should reinforce or qualify that observation.

The degree of chordal (vs. homophonic) texture can be measured by taking the ratio of simultaneously struck notes (tied notes being counted as one) over total notes per measure. Table II-E shows the average ratios for each variation in the set. It would also have been possible to make percentages of the remaining "solo" notes and label them a measure of homophonic texture, or texture with melody prevailing over accompaniment.

TABLE II-E: Average Degree of Chordal Texture by Variation

Composer	Variations						Total Average
	1	2	3	4	5	6	
Byrd	48.1	48.9	43.9	74.6	51.1	52.4	53.2
Farnaby	68.3	67.6	62.5	68.7	61.6	56.9	64.3
Morley	74.2	47.9	70.6	55.1	74.7	63.2	64.3

The resulting grand means for Farnaby and Morley are identical, providing further testimony to editors' authorship dilemmas. All three composers' textures are slightly more chordal than homophonic. A plot of the above means illustrates the direction of change in texture over time. (See Figure II-A on following page.)

Morley makes radical changes of texture with every new variation, alternating primarily chordal with more figural movement in a methodical fashion. Farnaby's movement is more gradual, and excepting the change of direction between variations #3 and #4, goes from a more chordal to a less chordal texture. Byrd's fourth variation is outstanding in its contrast to the other, less chordal ones. Without that particular variation, his set would exhibit the narrowest range of textural changes.

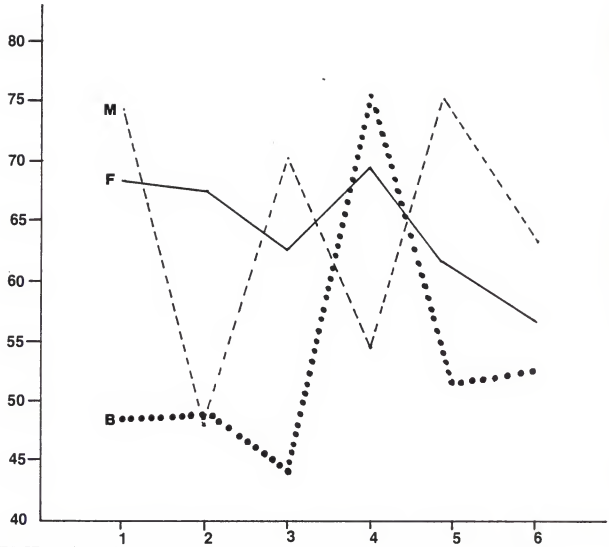


FIGURE II-A: Plot of Average Degrees of Chordal Texture, by Variation.

Lachrymae Pavans, by Byrd, Morley, and Farnaby.

M – – – – – –

F ————————

B ••••••••••••

The variety of textures within each variation is illustrated better by standard deviation than by means. The standard deviations, averaged over each movement in Table II-F show a composer's tendency toward consistency or changeability within one variation. They are plotted in Figure II-B on the following page.

TABLE II-F: Standard Deviation in Chordal Texture, by Variation

Composer	Variations						Total Average
	1	2	3	4	5	6	
Byrd	15.9	8.6	9.7	15.4	12.4	18.4	13.4
Farnaby	12.7	18.4	16.7	10.5	20.1	21.3	16.6
Morley	10.9	19.3	14.7	18.5	15.8	17.5	16.1

Again, Farnaby's and Morley's grand means are slightly more comparable, each showing a more changeable character within variations than Byrd, whose style is more consistent. The three plotted averages all move from a lower degree of deviation to a higher point, substantiating what has been noted earlier about an accelerated or intensified movement toward the end of most variation sets. The similar ranges of their standard deviations (Byrd 8.6-18.4; Farnaby 10.5-21.3; Morley 10.9-19.3) are another indication of similarity in choices. Their starting and ending deviations are within 5.00 and 2.93 points of each other respectively, another highlight of close stylistic proximity.

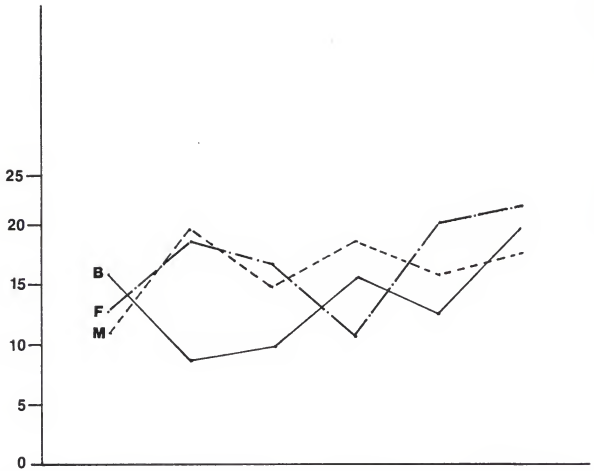


FIGURE II-B: Plot of Within-Variation Deviation From Average Chordal Texture. Lachrymae Pavans, by Byrd, Morley and Gibbons.

B ——————————

F ——·——·——·——

M - - - - - - - - - - -

A final variable related to texture is a measure of chord voices. The results of averages by variation of total chords reveals some significant difference among the three composers.

TABLE II-G: Average Chord Size (Number of Voices) Per Variation

Composer	Variations						Total Average
	1	2	3	4	5	6	
Byrd	3.1	2.7	2.7	2.9	2.8	3.4	2.9
Farnaby	2.4	2.3	2.3	2.4	2.4	3.0	2.5
Morley	3.7	4.1	3.0	2.8	3.4	3.7	3.4

Although these averages represent a considerable variety of textures from contrapuntal to homophonic the ranges illustrate tendencies either toward an idiomatic keyboard style or a more choral writing style. Morley's numerous compositions for voices may have influenced his higher score on chord size. Byrd's chords come near to a three-voiced mean. And Farnaby, who wrote primarily for keyboard, has the smallest chord size. It should be noted that the values for the last variation are highest because the final breve chord is counted as a full measure.

Summarizing the above measures, one gets a complicated and inconsistent comparison of three pieces. While Morley's stands out in the first variable, Byrd's is distinctive in the second and fourth, and all three composers are distinctive in the fifth. The weighting of these chosen variables for importance is a technique that musicology provides no standard procedure for at this time. Some special combination of these and additional variables comprises the composers' unique stylistic profiles.

Even given that the optimum number and combination of variables had been measured for these pieces, there is no basis for a generalization from three individual cases to the complete works of each. The means and standard deviations of "Pavan Lachrymae" might be entirely different from another Pavan. What is needed is an approach to highly similar works such as these that will provide the necessary weightings for variables, and also be usable in a comparison of a broad array of pieces. In the next chapter the statistical procedure known as discriminant analysis will be described in application to these problems.

CHAPTER III: METHODOLOGY

Variables of Musical Style

In order to limit the array of potential variables for study, two questions have to be addressed: 1) From a methodological standpoint, which forms of measurement--i.e. nominal, ordinal, interval or ratio scales--are meaningful and useful? 2) Which stylistic dimensions of those usually cited in musical analysis--i.e. harmony, melody, rhythm, etc.--seem the preeminent sources of style variation in the given works?

Nominal measurement scales are in use when variable types representing a category are assigned a symbol or number designating their unique identity (i.e., "A = major chord", "B = minor chord"). Ordinal scales assign a sequence of numbers or symbols implying an ordered relation to variables, but without specifying limits or intervals of the order (i.e., "1 = Allegro, 2 = Presto, 3 = Vivace"). Interval- and ratio scales assign numbers to observations based on equally-intervalled scales with arbitrary or absolute zero-points, respectively.[36] For example, naming the tonic note of a scale "1" and numbering the notes occurring above and below it in a piece would regulate an interval scale. Counting notes by their frequencies illustrates the use of a ratio scale with zero vibrations per second constituting the bottom limit.

Arguments against creating categorical variables based upon nominal and ordinal scales have been presented by two analysts from the social sciences. Hubert Blalock stresses that such measures prove to be multidimensional on closer inspection, and are therefore too broad to be relied

upon for comparisons between samples.[37] One may cite musical examples from the Elizabethan period in which "major" and "minor" are categories too broad to measure the varieties of mode occurring in the piece. Jerald Hage criticizes categorical variables for being bound to current, transient modes of interpretation.[38] Again, music history reveals an evolution in analytical vocabulary when it no longer describes the categories of musical style under study in some music. Hage prefers interval- or ratio-scaled variables for their generalizability to different periods or groups.

When the selected Elizabethan variations were initially studied for a choice of variables, it was found that musical dimensions lending themselves most to ratio- and interval-scaling were rhythmic and textural. Harmony and melody were obviously categorical variables, there being no continuous range of "majorness" or "minorness". Further, given that the theme for variation is based on a melodic and/or harmonic progression, it is unlikely that they contribute greatly to style change from one variation to the next. Their very redundancy is the unifying element of the work. Timbre, in reference to the choice of instrumentation, is also an unuseable variable for discrimination in these cases since all pieces are for harpsichord. The two other major musical elements, rhythm and texture, not only are suitable for interval- and ratio-scaling, but are primarily responsible for the stylistic development within Elizabethan variation.

Rhythm lends itself to at least interval scaling because it is itself scaled. In music of the Elizabethan period, all divisions of the beat were multiples of one another within the framework established by the piece's meter. That meter being kept constant, the variation occurred with the composers' choices of rhythmic subsets of the beat. Whether groupings are based on duple or triple division, the range of rhythmic values from breve

to thirty-second note could be selected by composers of variations. The extent to which they did utilize all possible values, or concentrate on certain ones can be expected to have a strong effect on the resulting style of the piece.

The first step toward creating interval-scaled variables of composers' rhythm was to catalog the array of rhythmic values in the pieces. The first six variables named for the study were the occurrences of whole-, half-, quarter-, eighth-, sixteenth-, and thirty-second notes. Since the breve rarely occurred except at the final chord of the pieces, it was counted as two whole notes. Dotted values were rounded upward and counted as the larger note values. Because every group represented one composer's set of Pavan variations, the total counts were averaged per group and a mean determined that represented the entire set. A variable was also desired that would express the proportion of each rhythmic value to the total values employed by the composer. The first six measures were therefore re-computed as ratios and six new variables were added in decimal form. All twelve rhythmic variables names and their definitions are listed below.

MR1 = Mean number of whole notes per measure
MR2 = " " " half " " "
MR3 = Mean number of quarter notes per measure
MR4 = " " " eighth " " "
MR5 = Mean number of sixteenth notes per measure
MR6 = Mean number of thirty-second notes per measure

MP1 = Mean proportion of whole notes to total notes per measure
MP2 = " " " half " " " " " " "
MP3 = Mean proportion of quarter notes to total notes per measure
MP4 = " " " eighth " " " " " "
MP5 = Mean proportion of sixteenth notes to total notes per measure
MP6 = Mean proportion of thirty-second notes to total notes per measure

Texture in the context of this study is defined as the number of "voices" (linear musical lines) and patterns of their combination throughout the piece. Whether arranged vertically in chordal fashion, horizontally as

independent melodies, or in homophonic combination, the "voices" of vocal or instrumental music are easily quantified from a score into ratio-scaled data. Textural changes can be observed in the variations that pass a given melody from one voice to another or alter it in figuration and chordal embellishment. Initial readings of the variations showed a general tendency toward uniformity of texture within a single variation, but diversity between variations of a set. This is accepted as evidence that composers chose specifically textural elements as style variants, but how each composer did so needs examination.

A count was taken first of the number of voices sounding simultaneously at every strong beat of the composition. Since all of the pieces chosen had identical meters, there could be no distortion from fewer or greater count locations. The count was averaged across all pieces per composer, then a standard deviation derived from the mean. The resulting two variables are defined below.

MMS = The mean number of voices sounding simultaneously per measure.
MSTD = The standard deviation in number of voices sounding simultaneously per measure.

Two questions underlay the choice of these related variables. First, did composers of variations differ with respect to a polyphonic vs. a homophonic approach? In other words, would some variations illustrate a more consistently 4-voiced texture suggestive of choral writing, while others divided the texture into melodic and harmonic functions typical of the later thoroughbass style? It was expected that low scores on the MMS variable would illustrate the latter tendency, since inner voices are dropped or added according to the need for harmonic or rhythmic emphasis.

The measure based upon standard deviation from the mean illustrates the amount of variability within variations. Does a composer adopt one

texture and keep it constant until the next variation, or does he have a more diverse, volatile texture within each section? A cursory examination of variations by William Byrd and Orlando Gibbons indicated that Byrd would have a higher standard deviation (illustrating greater textural changeability) and Gibbons a lower (more constancy).

Fourteen variables only begin to build a framework for analyzing rhythm and texture using interval- or ratio-scaled measures, but for the purposes of this project no attempts were made to derive more complicated variables. It has been noted how controlled the choice of variables is by the variation genre. Any attempts to compare total works (vocal and instrumental genres) by several composers would complicate the creation of interval- or ratio-scaled measures. Conventions governing the coordinated changes in harmony, melody, rhythm, etc. could require complex measurements that suit some genres, but are inappropriate for others. By limiting the choice of samples for classification to a relatively simple genre, one can focus on a narrower range of stylistic elements and procedures within which composers displayed their individuality.

Discriminate Analysis

Discriminate analysis tests the ability of selected variables (i.e. "number of whole notes per measure") to distinguish groups (i.e. "known Pavans by William Byrd") from each other. For each group a discriminate function is derived. The probability of identity for a sample piece is derived from a comparison of that piece's discriminate score with the group's discriminate function. This half of the analysis not only indicates individual identity between groups, but shows the strength of each variable in contributing to that identity.

Once variables have been verified as strong discriminators, the analysis can attempt on the basis of the generated discriminate scores to classify unknown or questionable samples. Scores derived for the "unknowns" are compared with each group's average score and matched to the closest one.

Probability is a fundamental concept in all statistical analyses. In each half of the discriminate analysis, one is testing the probability of group membership given a certain allowance for error. This is specified at the outset as the "probability level." In this study, .01 is stipulated as the probability level, meaning acceptance of the probability for error in the scores of one out of every hundred posited cases.

Another stipulation of probability is in the classification itself. A simple 2-groups case of classification described by Tatsuoka[39] illustrates "probability densities" within which classification regions are located.

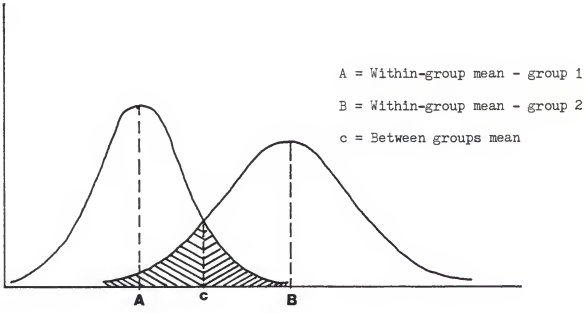


FIGURE III-A: Classification Regions for Two Populations

Given two groups, the diagram exhibits areas of overlapping characteristics based on one measurement only. The two curves represent probability density, or the likelihood that a single observation belongs to a group when located inclusively along the X axis below it. "C" is the mid-point of overlap, at which an observation might be classified into either Group 1 or Group 2. Given an observation "x", and two hypotheses (H_1, H_2) that x could have been randomly selected from Group 1 or 2 respectively, the likelihood region for classification is described by Tatsuoka as follows:[40]

$$L\ (x/H_1) > L\ (x/H_2) \text{ when } x < c$$
$$L\ (x/H_2) > L\ (x/H_1) \text{ when } x < c$$

This states that the likelihood that x was randomly selected from Group 1 is greater than the likelihood that x was randomly selected from Group 2 when the value of x is less than the value of c (and vice versa). It is important to clarify the phrases "less than" and "greater than". Group 1 may have higher numerical values than Group 2 or vice versa, so it is not a matter of which is greater than c (the between-groups, or "grand" mean). Instead it is the opposing distance in either direction from c that will distinguish groups from each other.

An indirect way to approach classification is by testing the hypothesis that groups are identical, or that their within-group means are identical. Multivariate analysis of variance (MANOVA) provides a partition theorem that describes the within-group means' comparative relation to the between-groups mean, as well as a test for rejection of the hypothesis of equal within-group means.

In the following formula X_{ki} represents the variable score for the i^{th} sample (i.e. variation) in the j^{th} group (i.e. pieces by Farnaby). K

defines the groups under study, m is the overall mean, and m_k is the group mean for group k.[41]

$$X_{ki} = m + (m_k - m) + (X_{ki} - m_k)$$

When the theorem is summarized for all groups under study and each element squared, the resulting equation is symbolized by the relation T = B + W. T is the matrix of sums of squares and cross products of deviations of all group samples from the overall mean (or "Total"). B is the matrix of weighted squares and cross-products of deviations of group means from the overall mean (or "Between"). W is the matrix of squares and cross-products of deviations of group samples from their within-group means pooled over all groups (or "Total").

A test of the ratio of |T| to |W| called "Wilkes' Lambda" will determine the degree of significant dissimilarity between groups.[42]

$$\lambda = \frac{|W|}{|T|}$$

An increase in the value of |T| relative to |W| increases the likelihood of rejecting the hypothesis of no difference between groups.

Where MANOVA tests the hypothesis of group differences, discriminate analysis weights the equation in favor of between-groups means:[43]

$$\lambda = \frac{B}{W} \text{ maximum}$$

The value of lambda resulting will contribute to weights on the discriminate score for each group. The discriminate score, or function is formulated as follows:[44]

$$D_i = d_{i1}Z_1 + d_{i2}Z_2 + \ldots d_{ip}Z_p$$

D_i is the score on discriminate function i, weighting values are represented as d, Z's are standard values of the variables 1 through p, and p is the maximum number of variables. There can be a maximum number of discriminate functions of one less than the total number of groups. The discriminate scores produced for each group provide a reference for comparison against the score from an unknown sample.

To test variables in the analysis and discard insignificant discriminate functions, a procedure known as step-wise discriminate analysis is used. The first discriminate function is based upon the scores on a single variable that most effectively answer the equation for lambda above, maximizing between-group differences. The second discriminate function uses the first score as a referent and determines which second variable in comparison produces the most divergent, or orthagonal score in relation to the previously pooled scores. This procedure taken through several steps guards against a final discriminate analysis in which weakly contributing variables are unidentified.

The procedure taken in this research began with a pretest of the data using analysis of variance to determine the amount of variable overlap occurring between groups. Stepwise discriminate analysis was run to derive the most effective discriminate scores. The discriminate analysis proper was run twice, once using all variables and again using only those variables recommended by the step-wise procedure. To verify the validity of the results, another separate discriminate analysis was run comparing known pieces by two composers to other known pieces from the same sample groups. The results of each test are described in the following chapter.

CHAPTER IV: RESULTS

In order to use the collected data to distinguish between composers, discriminate analysis was carried out in several steps. Before discriminate analysis could be effectively computed, the variables needed to be examined for their appropriateness as possible discriminators.

Preliminary Analysis of the Known Pieces

An analysis of variance and a discriminate analysis were used to determine which of the fourteen variables (see pp.30-31, Chapter III) were possible candidates for discrimination between composers. The ANOVA for a given variable provides a test of where composers' means are different. The significance level of the corresponding F statistic indicates whether the variable merits further study. If the significance level of the F statistic is .05 or smaller, there is evidence that the composer means are different for that variable, and it is a candidate for further study in the discriminate analysis. Table IV-A summarizes the ANOVA results from all 56 pavans by the six composers.

TABLE IV-A: Analysis of Variance Results on the Fourteen Variables

Variable	F-Value	Significance Level	Variable	F-Value	Significance Level
MMS	5.78	0.0003	MP1	4.11	0.0034
MSTD	2.60	0.0363	MP2	3.82	0.0053
MR1	4.01	0.0040	MP3	3.82	0.0053
MR2	10.98	0.0001	MP4	8.82	0.0001
MR3	3.69	0.0065	MP5	3.42	0.0100
MR4	7.14	0.0001	MP6	8.99	0.0001
MR5	3.82	0.0053			
MR6	3.35	0.0110			

Variable Definitions

MMS = mean voices/measure
MSTD = standard deviation voices/measure
MR1 = mean whole-notes/measure
MR2 = mean half-notes/measure
MR3 = mean quarter-notes/measure
MR4 = mean eighth-notes/measure
MR5 = mean sixteenth-notes/measure
MR6 = mean thirty-second-notes/measure

MP1 = mean whole-notes/total notes
MP2 = mean half-notes/total notes
MP3 = mean quarter-notes/total notes
MP4 = mean eighth-notes/total notes
MP5 = mean sixteenth-notes/total notes
MP6 = mean thirty-second-notes/total notes

All F statistics showed a significance difference between composers (i.e., the significance levels are all less than .05) where the variables MR2, MR4, and MP6 show the greatest variance between composer means.

The Statistical Analysis System (SAS) program which runs ANOVA also provides a Duncan's multiple range test to compare the composer means for each variable. The results, in Appendix 2, verified the statistical dissimilarity between composers on all variables.

To test the accuracy of discriminate analysis in classification of composers' pieces, DISCRIM (SAS name for the discriminate analysis program) was run using all of Byrd's and Bull's "known" pavans. Each composer's data was randomly divided in half where the first half of each composers' data was used in the discriminate analysis and the second half was used as "unknown" test cases to check on the accuracy of the classification. The first half of the data is subjected to the discriminate analysis and is used to test against itself for accuracy of classification. The results of the first stage of DISCRIM on the first half of Byrd's and Bull's known pavans are given in Table IV-B.

TABLE IV-B: DISCRIM Results Using "Known" Pieces by Byrd and Bull

Data to be Classified from: ("known")	# Observations and Percents* Classified into: ("known")	
	Byrd	Bull
Byrd	64 (94.12)	4 (5.88)
Bull	10 (25.64)	29 (74.36)
Total	74 (69.16)	33 (30.84)

*Percents presented within parentheses.

The first half of Byrd's known pavans could be mis-classified as Bull's 5.88% of the time. The variables used in this study correctly classified Byrd's pavans in 94.12 out of 100 cases. Bull's known pieces could not be so easily identified as his own, given these pavans and these variables, but 74.36% is quite an acceptable level of success.

The next step was to use the second half of each composer's grouped pavans as "unknown" cases and use the model from the first half to classify the "unknown" cases. This provides a check as to how well the discriminate procedure will work when classifying known pavans.

TABLE IV-C: DISCRIM Results Using "Unknown" Pieces by Byrd and Bull

Data to be Classified from: ("unknown")	# Observations and Percents Classified into: ("known")	
	Byrd	Bull
Byrd	62 (86.11)	10 (13.89)
Bull	25 (65.79)	13 (34.21)
Total	87 (79.09)	23 (20.91)

The classification based on the first half of the data correctly classified 86.11% of Byrd's and 34.21% of Bull's second-half data. 86.11% verification is still a good indicator of group membership for Byrd's pavans, while Bull's 34.21% shows just the opposite tendency. It would appear that the second half of Bull's total pavans are less similar to his first than they are to Byrd's pavans. (For a list of which pavans by both composers make up the first and second stages of this discriminate analysis, see Appendix 1.)

The surprising results from Bull's second pavan group might be attributable to at least three causes. The pavans themselves were arbitrarily chosen from the second half of a list derived from the editions listed in Appendix 2. Had they been randomized further, perhaps some difference would show in scores between the two stages of analysis. The variables themselves may lack discriminatory power given a wider variety of pieces, as evidenced by the second set of Bull's pavans. Discriminate analysis is not a perfect test, and may not provide an adequate method to classify pavans as to group membership in this case.

However, the two tests taken together show the analysis verifying two composers' pavans in three out of four cases. It was determined that the variables looked positive enough from this and the ANOVA results to merit continuing with a discriminate analysis on all of the composers under study.

Discriminate Analysis on all 6 Composers

The second part of the research was to conduct a discriminate analysis based on the 14 variables using all six composers' known pavans and five disputed pavans. A list of sources for all of the pieces is given in Appendix 1. The number of pavans making up the sample for Farnaby, Gibbons, Byrd, Bull, Morley and Philips were, respectively, 6, 3, 25, 13, 4, and 4.

Resulting observations and percents of classification are as follows:

TABLE IV-D: DISCRIM Results Using All Sample Pieces by the Six Composers

Data to be Classified from:	# Observations and Percents Classified into:					
	Farnaby	Gibbons	Byrd	Bull	Morley	Philips
Farnaby	25 (75.76)	0 (0.00)	2 (6.06)	1 (3.03)	2 (6.06)	3 (9.09)
Gibbons	0 (0.00)	15 (100%)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Byrd	5 (3.57)	2 (1.43)	108 (77.14)	6 (4.29)	11 (7.86)	8 (5.71)
Bull	6 (7.79)	2 (2.60)	16 (20.78)	35 (45.45)	4 (5.19)	14 (18.18)
Morley	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	22 (100%)	0 (0.00)
Philips	1 (3.70)	1 (3.70)	5 (18.52)	0 (0.00)	3 (11.11)	17 (62.96)
Total	37 (11.78)	20 (6.37)	131 (41.72)	42 (13.38)	42 (13.38)	42 (13.38)

Table IV-D shows that in the first half of DISCRIM, each composer's pavans were correctly classified in a majority of cases, with the exception of Bull's. His misclassified pieces most often resembled Byrd's or Philips', with far fewer classified as Farnaby's, Morley's, or Gibbons'. Such a spread of his misclassifications across several composers reinforces the earlier assumption that Bull's individuality may have little to do with the measures in this study. Gibbons and Morley on the other hand stand out as the most "distinctive" composers, with no misclassifications of their pieces to any others. Farnaby is never classified as Gibbons, but his remaining misclassifications are spread across the other composer groups, as are Byrd's and Philips'. Misclassifications between two composers are not mutually proportional. That is, Philips' pieces are never classified as Bull's,

even though Bull's pieces are attributed to him in 18.18% of the cases. This is because the discriminate scores reflect compound results of all 14 variables, any of which might weight the final score differently from one composer to the other.

Variables 1 - 14 appear from Table IV-D to be very effective discriminators for this group of composers. The next stage of DISCRIM was to use the results of known pavan's discriminate analysis to classify the five disputed pieces into the six composer groups. Sources of the five pieces and editorial comments are given in Appendix 1. The labels in Table IV-E assigned to each disputed piece were taken from those editorial judgments.

TABLE IV-E: DISCRIM Results from 14 Variables; "Unknown or Disputed Pieces" Classified into "Known Groups"

Data to be Classified:	# Observations and Percents Classified into:					
	Farnaby	Gibbons	Byrd	Bull	Morley	Philips
Anon/Bull 1	0 (0.00)	0 (0.00)	3 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)
Anon/Bull 2	0 (0.00)	0 (0.00)	4 (66.67)	1 (16.67)	0 (0.00)	1 (16.67)
Byrd/Anon 1	2 (66.67)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)
Byrd/Anon 2	0 (0.00)	0 (0.00)	2 (40.00)	3 (60.00)	0 (0.00)	0 (0.00)
Morley/Byrd	2 (9.09)	0 (0.00)	14 (63.64)	4 (18.18)	0 (0.00)	2 (9.09)

In only two of the five pieces do the discriminate scores reinforce editorial judgments about these cases. Byrd/Anon 2 was thought by editor Hendrie to be unauthentic and DISCRIM does show a close correspondence to Bull in this case. Both Anon/Bull 1 and Anon/Bull 2 indicate Byrd where the editor assumed Bull was composer. A tendency to confuse Byrd and Bull is

indicated by these three cases, and recalls their mixed scores in the initial DISCRIM run. Morley/Byrd is verified as Byrd's, with zero classification as Morley's, upholding the editor's decision. In this case, as in all four others, Gibbons and Morley never figure as likely composers. They were also the two composers with 100% correct classification in the first stage of DISCRIM. For these two composers, the variables provide an excellent means of identification as well as classification. Farnaby is the most likely composer of Byrd/Anon 1 according to this analysis, though Byrd receives 33.33% of the classification. The verification of Farnaby's pieces in the first part of DISCRIM was high at 72.73%, but coincidentally his pieces were incorrectly attributed to Morley's and Byrd's in an equal number of cases.

The result of DISCRIM is a profile of classification that rarely matches the cited editorial opinions. Because editors never described specific measurements on which their selections were made, this test could not check the accuracy of their models. Having created a model based on 14 rhythmic and textural variables, this study could only highlight the discrepancy between the findings and further examine its own model. A procedure for selecting only the best discriminators out of the fourteen variables was then used.

Stepwise Discriminate Analysis

The program STEPDISC in SAS provides forward selection and backward elimination procedures that test each variable before adding it to or deleting it from the set for discriminate analysis. The forward selection procedure uses two tests--Wilkes' Lambda and Pillais' Trace--to select successive variables from the group that best discriminates between the six composers. After a variable is selected, new F values are computed for the

remaining variables in the set, and the variable with the highest F value is selected next. Forward selection continues until the next variable to be included is not significant. Backward elimination eliminates that variable with the smallest F value and continues until all remaining variables are significant.

Forward selection resulted in the following sequence of variables: MR2, MR1, MP2, MP5, MR6, MMS. (Refer to Chapter III, pp. 30 - 31 for variable names.) Backward elimination discarded six variables as ineffective discriminators and returned the variables MMS, MR2, MR4, MR5, MR6, MP2, MP5, and MP6. Variable MR1 was the last item to be eliminated, yet it was the second selected variable for inclusion in the forward procedure. For this reason, it was retained in the variables for the second DISCRIM procedure.

TABLE IV-F: STEPDISC, Forward Selection

Summary

Step	Variable	Partial R**2	F Statistic	Prob F	Wilks' Lambda	Prob Lambda	Average Squared Canonical Correlation	Prob ASCC
1	MR2	0.2639	22.079	0.0001	0.73614932	0.0001	0.05277014	0.0001
2	MR1	0.1231	8.620	0.0001	0.64552207	0.0001	0.07503860	0.0001
3	MP2	0.0873	5.854	0.0001	0.58917040	0.0001	0.09219415	0.0001
4	MP5	0.0821	5.455	0.0001	0.54080566	0.0001	0.10799159	0.0001
5	MR6	0.0777	5.119	0.0002	0.49880564	0.0001	0.12172853	0.0001
6	MMS	0.0498	3.177	0.0084	0.47395721	0.0001	0.13113715	0.0001

TABLE IV-G: STEPDISC, Backward Elimination

Summary

Step	Variable	Partial R**2	F Statistic	Prob F	Wilks' Lambda	Prob Lambda	Average Squared Canonical Correlation	Prob ASCC
0		-1.3E+20	252413408	-78E39	0.38167857	0.0001	0.16780650	0.0001
1	MSTD	0.0100	0.595	0.7601	0.38551679	0.0001	0.16616542	0.0001
2	MR3	0.0162	0.978	0.4320	0.39186568	0.0001	0.16357522	0.0001
3	MP4	0.0261	1.597	0.1595	0.40236694	0.0001	0.15919877	0.0001
4	MP3	0.0356	2.210	0.0528	0.41723795	0.0001	0.15338430	0.0001
5	MP1	0.0383	2.393	0.0375	0.43387626	0.0001	0.14707490	0.0001
6	MR1	0.0354	2.207	0.0530	0.44978368	0.0001	0.14060408	0.0001

The variable with the greatest F value is MR2 (the number of half-notes per measure). Its counterpart, MP2 (the proportion of half-notes to total notes), was also included in the forward selection. The use of quarter- and eighth-note values is too similar among these composers to distinguish among them. MMS (mean number of voices sounding simultaneously) is a static measurement and it also discriminates among composers. Its more active counterpart, MSTD, measures the extent to which a composer deviates from MMS during the piece. This latter measure did not successfully discriminate among composers as the author had expected. It would require further study of more such "dynamic" measures to determine whether composers were following similar procedures or progressions in their compositions.

Discriminate Analysis Run with Nine Selected Variables

The five variables discarded in backward elimination of STEPDISC were not included in the second run of DISCRIM. All other variables were

retained. Table IV-H shows the classification results based on the nine variables of the six "known" pavan groups.

TABLE IV-H: DISCRIM Results from 9 Variables Derived After STEPDISC; "Known Groups" Classified into "Known Groups".

Data to be Classified:	# Observations and Percents of Classification into:					
	Farnaby	Gibbons	Byrd	Bull	Morley	Philips
Farnaby	24 (72.73)	0 (0.00)	3 (9.09)	1 (3.03)	3 (9.09)	2 (6.06)
Gibbons	0 (0.00)	13 (86.67)	2 (13.33)	0 (0.00)	0 (0.00)	0 (0.00)
Byrd	5 (3.57)	2 (1.43)	102 (72.86)	6 (4.29)	15 (10.71)	10 (7.14)
Bull	8 (10.39)	4 (5.19)	14 (18.18)	26 (33.77)	6 (7.79)	19 (24.68)
Morley	2 (9.09)	0 (0.00)	1 (4.55)	0 (0.00)	18 (81.82)	1 (4.55)
Philips	2 (7.41)	1 (3.70)	6 (22.22)	2 (7.41)	4 (14.81)	12 (44.44)
Total	41 (13.06)	20 (6.37)	128 (40.76)	35 (11.15)	46 (14.65)	44 (14.01)

In comparison with Table IV-D, the new percentages have declined for all composers. Gibbons and Morley no longer are verified 100%, but have dropped to 86.67% and 81.82%, respectively. Bull's pieces are even less frequently attributed to him, and a shift from similarity to Byrd to similarity to Philips has taken place with the new selection of variables. Byrd's misclassifications to Farnaby, Gibbons and Bull remain the same, but the likelihood that he could be confused with Morley or Philips has increased. Philips now has a minority of his pieces classified as his own, and while he was never attributed to Bull before, he is in this case at 7.41%.

These declines in individual verifications are not disappointing results, because 1) they suggest that the previous DISCRIM contained distortions in weightings of less significant variables, producing such high percent verifications as 100%; and 2) the total verification picture still shows the variables as effective discriminators in a majority of the cases.

TABLE IV-I: DISCRIM Results from 9 Variables Derived After STEPDISC; "Unknown or Disputed Pieces" Classified into "Known Groups".

Data to be Classified:	# Observations and Percents of Classification into:					
	Farnaby	Gibbons	Byrd	Bull	Morley	Philips
Anon/Bull 1	0 (0.00)	0 (0.00)	2 (66.67)	0 (0.00)	0 (0.00)	1 (33.33)
Anon/Bull 2	0 (0.00)	0 (0.00)	3 (50.00)	1 (16.67)	1 (16.67)	1 (16.67)
Byrd/Anon 1	2 (66.67)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)
Byrd/Anon 2	0 (0.00)	0 (0.00)	2 (40.00)	2 (40.00)	1 (20.00)	0 (0.00)
Morley/Byrd	0 (0.00)	0 (0.00)	3 (60.00)	0 (0.00)	1 (20.00)	1 (20.00)
Total	2 (9.09)	0 (0.00)	11 (50.00)	3 (13.64)	3 (13.64)	3 (13.64)

When the five unknown pieces were classified using the nine variables, only one case completely verified the classification of a disputed piece as it did with the 14-variable set. "Byrd/Anon 1" still resembles Farnaby more than it does Byrd. While "Anon/Bull 1" is no longer 100% Byrd, it is still classified as his in a 66.67% majority of cases. The single other classification of this piece is to Philips, to whom slightly more of Byrd's own pieces were also attributed in the new DISCRIM analysis. Byrd is still the most likely candidate for "Anon/Bull 2" but Morley is just as likely a

candidate for the remaining attributions of it as Bull and Philips. Morley also takes a larger share of attributions of B/A 2 from Bull, who originally figures as the strongest candidate. In the last disputed piece, Morley also becomes a likely target for classification, though Byrd still has the majority of attributions. Since the change of variables, Morley has stood out less from the group and becomes as likely a candidate for misclassification as Philips and Bull. These changes suggest that multiple runs of DISCRIM are essential to establish a trend of consistent attribution. The total variables still look effective for classifying pieces Anon/Bull 1, Byrd/Anon 1, and Morley/Byrd, where the majorities are retained in the same composer group. But the shifts of attribution in Anon/Bull 2 and Byrd/Anon 2 suggest that new variables should be initiated before a satisfactory classification can be substantiated.

CHAPTER V: CONCLUSIONS

Evaluating the effectiveness of discriminate analysis to this music requires answers to three questions: 1) How effective were the fourteen formulated variables? 2) Did the composers' individual stylistic profiles begin to emerge as a result? 3) What has been learned about discriminate analysis, and what musicological research can be done because of these results?

Variables

It was shown in Chapter IV and Appendix 2 that analysis of variance by itself indicated significant differences in the data for all fourteen variables. Without these results, they would not have merited further study, but their value as effective discriminators between the given composers can only be estimated by the discriminate analysis of Byrd's and Bull's known works, and by the stepwise discriminate analysis.

The use of discriminate analysis only on the known pavans of Byrd and Bull tested the variables' strength at distinguishing a particular composer's style. When their known works were divided into two groups, the latter becoming "unknown" test cases for classification into the former, the analysis provided two tests of group consistency. Because discriminate analysis requires at least two groups for comparison, composers must be paired. However, any misclassifications into the alternate composer (group) should receive less attention at this stage than the misclassifications into all other groups in the larger discriminate analysis.

High percentages of correct classification, as with Byrd (94.12%, first pavan set; 86.11%, second set classified into the first) verified the variables' appropriateness. Bull's mixed results (74.36%; 34.21%) showed some weakness within the variables in classifying his pavans as his own. Though this had to be considered throughout the other analyses when viewing Bull's scores, it did not invalidate the variables' use for the remaining composers. Ideally, their pavans would also have been listed in pairs before discriminate analysis was run on the entire group. Sample sizes for the other four composers were so small, however, that they would not have been adequate for testing overall variable effectiveness. For groups of composers it would be expected that some stylistic variables are more pertinent to one composer's style than to another's. Rather than discarding variables that are weak for one, the addition of related variables would substantiate the discriminate analysis for the entire group.

Stepwise discriminate analysis provided another test of variables as discriminators, and conversely indicated composer similarities. Backward elimination indicated that the following sequence of variables were not sufficiently effective: MSTD, MR3, MP4, MP3, MP1, and MR1.

MSTD was a dynamic variable expressing deviations within variations from the mean number of simultaneous voices. In deriving the standard deviation, the author anticipated that composer differences might be in their degree of texture changes during variation sets. Earlier examination of Byrd's pavans compared to Gibbon's and Bull's seemed to indicate a significantly more varied texture in Byrd's pieces. In fact, mean scores on MSTD for Byrd, Gibbons and Bull were .67, .65, and .60 respectively, but stepwise discriminate analysis rejected the variable as a significant discriminator. The initial assumption may still be valid, but the rejection

indicates that other variables might illustrate changeable texture more accurately. For example, sizes of intervals between simultaneous voices may have been changing, along with the type of rhythmic values making up each successive chord. Any future study of this variable should produce additional sets of such related variables.

The rejected variables MR3 and MP3 show that all six composers used quarter notes to a similar extent and in similar proportions to the rest of their rhythmic values. Quarter notes were the only rhythmic values to be discarded as discriminators in both their sum (R) and proportional (P) forms. The other two proportional variables rejected were MP1 and MP4, indicating that all composers used whole and eighth-notes in similar proportion to their total notes.

The final variable (MR1) which was discarded in backward elimination is problematical, because forward selection procedure actually included it as a positive discriminator. MR1's position at the end of backward elimination indicates that it is not as poor a discriminator as MSTD, but does not explain its advanced position (second choice) in the forward selection results. The sequence of variables selected was: MR2, MR1, MP2, MP5, MR6, and MMS. Table V-A summarizes the forward and backward results of stepwise discriminate analysis, including those variables that were neither accepted nor rejected by the procedure.

TABLE V-A: Variables Rank-ordered According to Stepwise Discriminate Analysis Results (Left to Right indicates Most-to-Least Effective, While Central Variables can only be Considered to be Equally Effective.)

MR2	MR1	MP2	MP5	MR6	MMS	MR4	MR5	MP6	MR1	MP1	MP3	MP4	MR3	MSTD

It is apparent from the rank-ordering that developing the set of six proportional rhythmic variables was legitimate. Had there been no essential difference between most individual rhythmic values and their ratios, then the stepwise procedure would have been systematically eliminating one set or the other. Instead, P- and R-values are fairly evenly interspersed on both sides of the range. Half-notes in both their sum (MR2) and proportional counts (MP2) were accepted in forward selection, just as quarter-notes were rejected in both forms. For these two rhythmic variables, differences between the sum and proportional counts as discriminators may have been minimal.

Variables left out of both forward selection and backward elimination were all smaller values (eighth, sixteenth, and thirty-second notes). Though they cannot be ranked with each other, as a group they can be interpreted as neutral-to-positive discriminators, and they were included in the second discriminate analysis as such.

Composers

Despite the variables' relative weakness regarding the pavans of Bull, all other composers were effectively discriminated in the analysis. For those aspects of composer style that were described by the variables, an outline of significant differences was provided. All composers were classified correctly (as themselves) more often than they were misclassified as any one other composer. Of all composers, only Bull was ever correctly classified in less than 50% of the total cases.

TABLE V-B: Composers Ranked According to Averaged Percentages of Correct Classification from the two Discriminate Analyses (see Tables D and H)

1	2	3	4	5	6
Gibbons	Morley	Byrd	Farnaby	Philips	Bull
93.33%	90.91%	75.00%	74.24%	53.70%	39.61%

Perhaps it is surprising that a composer such as Bull would be the least easy to classify, given the larger sample size of available pavans and the extent of his fame among contemporaries. Aside from questioning the fourteen formulated variables, these results prompt one to consider whether the uniqueness of his work is revealed in pieces other than his pavans. It is possible to speculate that in rhythmic or textural dimensions Bull was more of an imitator than an innovator. The quantity of his collected works and the great length of some pieces ("Walsingham" has 30 variations) indicates that his capacity for writing variations was outstanding. This study did not examine melodic variables, but its results suggest that the quality of Bull's need some analysis in order to derive a better profile of his music. Bull's life falls within the central range of dates from Byrd to Gibbons (see Table II-A). His connections with the Chapel Royal, Oxford, and Cambridge, and his frequent travel abroad put him in contact with most of the important musicians of Elizabethan England, including those such as Peter Philips who lived in Europe. Perhaps the wider circle of influences made it possible for Bull to incorporate techniques learned from many sources. Or, to give Bull more credit, it is possible that he never settled into one style long enough to provide consistent data, but was a more experimental composer overall.

Gibbons and Morley appear from both discriminate analyses to be the easiest composers to correctly classify. Within their pavans there is a consistency unlike Bull's or any of the other composers. It is unusual to find two such cases of 100% verification as in the first analysis of fourteen variables, and their corresponding number of 0.00% misclassifications. Though the second analysis reduced the 0.00% classifications by half, Gibbons and to a lesser extent Morley maintained high profiles as identifiable groups. Their small sample sizes (Gibbons, three pavans; Morley, four pavans) must however be considered before anticipating similar success in a broader study of keyboard works. Before such a study were undertaken, it would be appropriate to run separate discriminate analyses for each composer, using other keyboard genres as the groups into which their pavans are to be classified. If Gibbons' pavan variations, for example, were equally classified into a group of his galliard variations as they were into his fantasias, it would be apparent that the pavan genre did not dictate particular stylistic choices. From this analysis, one can only note the degree of separation that these variables achieved between their pavans and the others', and retain their discriminate scores for future studies using other variables.

Philips' position next to Bull's as one of the least identifiable composers is noteworthy for at least two reasons. As the single composer from the group to have remained outside of England for most of his life, he was likely to have had the least contact with the others, except with Bull (see p.6, Chapter II). Results on these variables indicate little stylistic variance resulting from separation. If contact with Bull in Spain and the Netherlands did make an impact on his style, this study did not show it. In fact, the first discriminate analysis showed 0.00% misclassification into Bull, and the second only 7.41% identical with misclassification into Farnaby. Any previous assumptions that direct contact breeds

homogeneity while geographic isolation encourages individuality is contradicted by these results. It is safer to assume that Philips' use of these rhythmic and textural elements was fairly standard, or that the variables are ineffective discriminators, as they were with Bull.

Discriminate analyses using the fourteen (and nine derived) variables provided credible classification of Byrd's and Farnaby's pavans--perhaps even more credible given their sample size, than Gibbons' and Morley's. Rhythmic and textural elements distinguish the style of each by around 75%, and the remaining misclassification is spread in small values across all other composers (except Gibbons, with whom Farnaby is never misclassified). In the case of Farnaby, the two discriminate analyses exactly reversed the classification scores of 9.09% and 6.06% between Philips and Morley. Misclassification as Morley or Byrd was always identical, but the second analysis gave them the 9.09% previously given to Philips, while he received their previous 6.06%. Without invalidating Farnaby's majority of correct classification, these changes illustrate the fluctuating results to be expected from re-running even subsets of variables, much less introducing new variables. As discriminate analysis becomes more common in musical style analysis, guidelines for evaluating the sequence of results will have to evolve.

Just as the fourteen variables have provided a suggestion of more complex stylistic measures, results of correct pavan classification encourage one to consider a wider sample of variations by these composers. What appeared to be a fairly homogeneous array of rhythmic "choices" across all composers proved to have enough discriminatory power to distinguish most of them. Results were convincing enough to substantiate the classifications of unknown samples in the second half of the discriminate analysis.

TABLE V-C: Disputed Pieces Ranked by Average Percent of Classification into Primary Composer Group

Pavan	Composer	Scores for Primary Composer: 14-Variable Analysis	9-Variable Analysis	Mean
Anon/Bull 1	Byrd	100.00%	66.67%	83.33%
Byrd/Anon 1	Farnaby	66.67	66.67	66.67
Morley/Byrd	Byrd	63.64	60.00	61.82
Anon/Bull 2	Byrd	66.67	50.00	58.33
Byrd/Anon 2	Bull	60.00	40.00	50.00

Classification scores for the five disputed pieces show varying degrees of change between the 14-variable and 9-variable analyses. Narrowing the variable selection had drastic results in classifying Anon/Bull 1 as Byrd's, though the same change caused only a 4.28% difference in Byrd's own scores for the first half of the analysis. Both Anon/Bull pieces are indicated as Byrd's by this analysis, contradicting editor Brown's classification. Bull's scores were only 0.00% and 16.67% for Anon/Bull 1 and Anon/Bull 2 respectively.

The pieces attributed to Byrd that editor Brown assumed were not his are classified as Farnaby's and Bull's according to these variables, though Byrd/Anon 2 showed 40% classification as Byrd's in both analyses. These results should be interpreted cautiously because of the close proximity of Bull to Byrd. Byrd is verified as the composer of Morley/Byrd in the analysis by a sufficiently wide margin in comparison to the classifications into other composers.

In each of these cases, conclusions can only be tentative, pending further discriminate analyses using more variables. Solution of the

authorship dispute for the five pieces cannot depend on discriminate analysis alone, much less a single analysis based on 14 rhythmic variables. A demonstration of the analysis' usefulness in indicating probability has been provided by the five samples, as well as a record for future references. On-going research will be required to establish the reproducibility of these results.

Discriminate Analysis

In the foregoing study, the usefulness of discriminate analysis as a musical research procedure has been demonstrated. Given a well-selected array of quantifiable variables, its simultaneous comparison of groups produces scores of probable membership that can be used in a variety of studies. The groups need not be defined as they were in this study, as genre samples from single composers. The music of one composer could be divided into comparative groups by style period, performance medium, genre, etc. Or several composers' works could be clustered into comparative groups. In either situation one would look for the degrees of difference as well as the variables responsible for differences between groups.

Discriminate analysis' ability to show the internal consistency of a group was demonstrated by Bull's results. His scores' spread over several other composer groups indicated either that his style wasn't consistent with respect to the variables, or that the variables were not choice discriminators. Homogeneity among group scores could be an important finding for research. Studies may have previously posited a difference among several composers that was poorly formulated and proves not to be the key to their respective styles. "Poor" results from a discriminate analysis signal the researcher to refine variables or to adjust preconceptions about group membership.

The process of variable definition is an essential introduction to any style analysis. Quantifying musical variables for discriminate analysis requires that one go beyond the obvious visual impressions of a busy musical score to verify a claim. By defining the rhythmic and textural variables as totals and proportions, this approach also provided a foundation for further modeling of more sophisticated variables.

Researchers trying to establish authorship can use the same analytical technique to verify these conclusions, and can compare results from a growing number of perfected variables before committing themselves to inadequate theories. Discriminate analysis has provided a reproducible procedure that should stimulate more comparative research in authorship questions among musicologists.

The variation literature from Elizabethan England can provide abundant material for discriminate analysis. More authorship questions occur in this music than in most of the keyboard literature, and much remains to be learned of the keyboard style of composers such as William Byrd, Orlando Gibbons, and John Bull.

APENDICES

APPENDIX 1

Source List of Pavan Variations, In Order of Data Entry

Giles Farnaby

1. Walter Erle's Paven. Fitzwilliam Virginal Book, no. 235 (v.2, p.336). = Musica Britannica (v.24, p.57) no. 18.
2. The Flatt Pavan. FW, no. 284 (v.2 p.453). = MB (v.24 p.47) no. 15.
3. Farmer's Paven. FW, no. 287 (v.2 p.465). = MB (v.24 p.61) no. 19.
4. Pavana. FW, no. 285 (v.2 p.456). = MB (v.24 p.53) no. 17.
5. Lachrinae Pavan. FW, no. 290 (v.2 p.472). = MB (v.24 p.49) no. 16.
6. Pavana. FW, no. 39 (v.1 p.141). = MB (v.24 p.44) no. 14.

Orlando Gibbons

1. Pavan in G Minor. Orlando Gibbons; Complete Keyboard works, ed. by M. Glyn, no. 1 (v.3 p.1). = MB (v.20 p.33) no. 16.
2. The Lord of Salisbury His Pavin. Glyn, no. 2 (v.3 p.4). = MB (v.20 p.37) no. 18.
3. Pavan in D Minor. Glyn, no. 4 (v.3 p.8). = MB (v.20 p.29) no. 15.

William Byrd*

1. Passamezzo Pavana. FW, no. 56 (v.1 p.203). = MB (v.27 p.1) no. 2A.
2. Pavan: Sir William Petre. MB (v.27 p.11) no. 3A.
3. Pavana. FW, no. 165 (v.2 p.200). = MB (v.27 p.16) no. 4A.
4. Pavana Delight. FW, no. 277 (v.2 p.436). = MB (v.27 p.19) no. 5A.
5. Pavan. MB (v.27 p.49) no. 14A.
6. Pavana. FW, no. 167 (v.2 p.204). = MB (v.27 p.100) no. 29A.
7. Pavana. FW, no. 254 (v.2 p.389). = MB (v.28 p.14) no. 52A.

8. Pavana Lachrymae . FW no. 121 (v.2 p.42). = MB (v.28 p.21) no. 54.
9. Pavana Bray. FW no. 41 (v.1 p.361). = MB (v.28 p.40) no. 59A.
10. Pavana Ph. Tr. FW no. 43 (v.1 p.367). = MB (v.28 p.46) no. 60A.
11. The Quadran Paven. FW no. 133 (v.2 p.103). = MB (v.28 p.79) no. 70A.
12. Pavana Fantasia. FW no. 257 (v.2 p.398). = MB (v.28 p.91) no. 71A.
13. Pavan: The Earl of Salisbury. MB (v.27 p.57) no. 15A.
14. Pavan. MB (v.27 p.59) no. 16A.
15. Pavan. MB (v.27 p.64) no. 17.
16. Pavan. MB (v.27 p.81) no. 23A.
17. Pavan. MB (v.27 p.105) no. 30A.
18. Pavan. MB (v.27 p.109) no. 31A.
19. Pavan: Kimborough Good. MB (v.27 p.114) no. 32A.
20. Pavan. MB (v.27 p.118) no. 33A.
21. Pavan. MB (v.28 p.95) no. 72A.
22. Pavan. MB (v.28 p.99) no. 73A.
23. Pavan: Canon 2 in 1. MB (v.28 p.102) no. 74.
24. Lady Monteaglis Pavan. MB (v.28 p.105) no. 75.
25. Pavan. MB (v.28 p.107) no. 76.

John Bull**

1. Pavana. FW, no. 13 (v.1 p.62). = MB (v.19 p.177) no. 128A.
2. The Quadran Pavan. FW, no. 31 (v.1 p.99). = MB (v.19 p.153) no. 127A.
3. Variation of the Quadran Pavan. FW, no. 32 (v.1 p.107). = MB (v.19 p.160) no. 127B.
4. Pavana. FW, no. 34 (v.1 p.124). = MB (v.19 p.60) no. 86A.
5. Pavana of My Lord Lumby. FW, no. 41 (v.1 p.149). = MB (v.19 p.181) no. 129A.
6. Pavana. FW, no. 136 (v.2 p.121). = MB (v.19 p.8) no. 66A.

7. The Spanish Paven. FW, no. 139 (v.2 p.131). = MB (v.19 p.31) no. 76.
8. Melancholy Pavan. MB (v.19 p.13) no. 67A.
9. Pavan "Symphony". MB (v.19 p.18) no. 68A.
10. Pavan in the Second Tone. MB (v.19 p.35) no. 77.
11. Chromatic Pavan. MB (v.19 p.66) no. 87A.
12. Pavan. MB (v.19 p.73) no. 88A.
13. Pavan "St. Thomas Wake". MB (v.19 p.146) no. 126A.

Thomas Morley

1. Pavana. FW, no. 153 (v.2 p.173). = Keyboard Works; Thomas Morley, ed. by T. Dart, no. 5 (v.1 p.16).
2. Quadro Pavan. Dart (v.1 p.8) no. 8.
3. Passymeasures Pavan. Dart (v.1 p.14) no. 4.
4. Pavan. Dart (v.2 p.2) no. 8.

Peter Philips

1. Pavana Pagget. FW, no. 74 (v.1 p.291).
2. Passamezzo Pavana. FW, no. 76 (v.1 p.299).
3. Pavana Doloroso, Tregian. FW, no. 80 (v.1 p.321).
4. Pavana. FW, no. 85 (v.1 p.343).

Disputed Pieces: Pieces are named in this thesis by hyphenating the composer's name (if any) in the manuscript to the composer's name (if any) suggested by a modern editor. Editor's comments are quoted from the notes appended to that particular edition.

1. Anon/Bull 1. Pavan. MB (v.19 p.186) no. 130A. "Ascribed to Bull on grounds of style." (T. Dart) p.236.
2. Anon/Bull 2. Pavan. MB (v.19 p.189) no. 131A. No editorial comments explaining inclusion (T. Dart) p.237.

3. Byrd/Anon 1. Pavana. FW, no. 174 (v.2 p.226). = MB (v.28 p.188) no. 99A. No editorial comments (A. Brown) p.202.

4. Byrd/Anon 2. Pavana. FW, no. 256 (v.2 p.394). = MB (v.28 p.188) no. 101. "This Pavan is diffuse in style, lacks a sense of logical harmonic progression, and is clumsily written. Much of the figuration is untypical of Byrd." (A. Brown) p.203.

5. Morley/Byrd. Pavana. FW, no. 169 (v.2 p.209). = MB (v.28 p.188) no. 102. "Followed in Tr. by a Galliard, also attributed to Morley. Dz's ascription is certainly incorrect. . . . There is a further Pavan and Galliard by Morley in Tr., pp.272 and 274. . . This ascription to Byrd can also be rejected." (A. Brown) p.203. The editor is essentially agreeing with the Fitzwilliam attribution to Morley, and pointing out another manuscripts' misattribution to Byrd.

* For the discriminate analysis of William Byrd's and John Bull's known works, pieces 1-12 were used as Byrd's "known", and pieces 13-25 as "unknown" samples.

** For the discriminate analysis of William Byrd's and John Bull's known works, pieces 1-6 were used as Bull's "known", and pieces 7-13 as "unknown" samples.

APPENDIX 2

Analysis of Variance Results for All Composers on All Variables

Duncan's Multiple Range Test for Variables

Variable	Grouping*	Mean	Number of Observations	Composer
MMS	A	3.910635	140	Byrd
	B	3.695991	22	Morley
	C	3.662231	77	Bull
	D	3.522311	27	Philips
	E	3.426094	15	Gibbons
	F	3.334134	33	Farnaby
MSTD	A	0.796443	33	Farnaby
	B	0.734966	22	Morley
	C	0.670796	140	Byrd
	D	0.652509	15	Gibbons
	E	0.642553	27	Philips
	F	0.597629	77	Bull
MR1	A	2.174495	22	Morley
	B	2.103679	140	Byrd
	C	1.904551	27	Philips
	D	1.570424	77	Bull
	E	1.394517	33	Farnaby
	F	0.636582	15	Gibbons
MR2	A	5.930972	140	Byrd
	B	4.588642	77	Bull
	C	4.212246	27	Philips
	D	4.164078	22	Morley
	E	3.628788	15	Gibbons
	F	3.571871	33	Farnaby

APPENDIX 2--Continued

Variable	Grouping*	Mean	Number of Observations	Composer
MR3	A	10.285842	15	Gibbons
	B	7.420339	27	Philips
	C	6.441649	77	Bull
	D	6.357359	140	Byrd
	E	5.977884	33	Farnaby
	F	5.642235	22	Morley
MR4	A	9.582222	15	Gibbons
	B	9.277559	77	Bull
	C	9.275096	33	Farnaby
	D	7.507449	22	Morley
	E	7.102468	27	Philips
	F	5.033633	140	Byrd
MR5	A	15.502294	33	Farnaby
	B	11.324778	77	Bull
	C	7.761852	15	Gibbons
	D	7.755492	22	Morley
	E	7.166463	140	Byrd
	F	7.104102	27	Philips
MR6	A	5.783333	15	Gibbons
	B	2.853788	22	Morley
	C	1.750670	77	Bull
	D	1.171763	33	Farnaby
	E	0.956245	27	Philips
	F	0.457193	140	Byrd

APPENDIX 2--Continued

Variable	Grouping*	Mean	Number of Observations	Composer
MP1	A	0.166063	140	Byrd
	B	0.156486	22	Morley
	C	0.147669	77	Bull
	D	0.147647	27	Philips
	E	0.142159	33	Farnaby
	F	0.125537	15	Gibbons
MP2	A	0.034596	33	Farnaby
	B	0.031247	22	Morley
	C	0.028619	140	Byrd
	D	0.026898	27	Philips
	E	0.024677	15	Gibbons
	F	0.024035	77	Bull
MP3	A	0.092052	22	Morley
	B	0.090103	140	Byrd
	C	0.082094	27	Philips
	D	0.064535	77	Bull
	E	0.060157	33	Farnaby
	F	0.024461	15	Gibbons
MP4	A	0.251922	140	Byrd
	B	0.186215	77	Bull
	C	0.177216	27	Philips
	D	0.176962	22	Morley
	E	0.153387	33	Farnaby
	F	0.136723	15	Gibbons

APPENDIX 2--Continued

Variable	Grouping*	Mean	Number of Observations	Composer
MP5	A	0.369751	15	Gibbons
	B	0.294338	27	Philips
	C	0.263291	140	Byrd
	D	0.245955	77	Bull
	E	0.244582	33	Farnaby
	F	0.231931	22	Morley
MP6	A	0.365119	33	Farnaby
	B	0.331591	77	Bull
	C	0.318850	15	Gibbons
	D	0.311321	22	Morley
	E	0.271806	27	Philips
	F	0.200002	140	Byrd

*Means with the same letter are not significantly different.

FOOTNOTES

1. Margaret Glyn, Orlando Gibbons: Complete Keyboard Works in Five Volumes (London: Stainer and Bell, 1925), Volume I, p. 11.

2. Gerald Hendrie, ed. Orlando Gibbons: Keyboard Music (Volume XX, Musica Brittanica; A National Collection of Music), (London: Stainer and Bell, 1962), pp. 91-94.

3. Parthenia (" . . . or the first musicke that euer was printed for the Virginalls) was first published c. 1611, then underwent several additional editions. The facsimile edition is by O. E. Deutsch, 1943.

4. Gerald Hendrie, op. cit., p. 92.

5. Alan Brown, ed. William Byrd: Keyboard Music I and II (Volumes XXVII, XXVIII, Musica Brittanica; A National Collection of Music), (London: Stainer and Bell, 1969, 1971).

6. Alan Brown, op. cit., Volume XXVIII, p. 205.

7. Ibid., p. 203.

8. Jan LaRue, Guidelines for Style Analysis (New York: W. W. Norton, 1970), p. ix.

9. Ibid., p. 10.

10. T. Cacoullos and George Styan, "A Bibliography of Discriminant Analysis" in Discriminant Analysis and Applications, ed. by T. Cacoullos (New York: Academic Press, 1973), pp. 375-431.

11. Frederick Mosteller and David Wallace, Inference and Disputed Authorship: The Federalist Papers (Reading, Massachusetts: Addison/Wesley Publishing Co., 1964).

12. Ibid., p. 10.

13. Frederick Williams, Reasoning with Statistics (New York: Holt, Rinehart and Winston, 1968), p. 161.

14. Lalitha Sanathanan, "Discriminant Analysis" in Introductory Multivariate Analysis (Berkeley, California; McCutchan, 1975), pp. 236-256.

15. John Stevens, Music and Poetry in the Early Tudor Court (Lincoln: University of Nebraska Press, 1961), p. 304.

16. Stevens, op. cit., p. 305.

17. Thomas Morley, A Plaine and Easie Introduction to Practicall Musicke (1597), ed. by R. Alec Harman (New York: Norton, 1953).

18. Philip Brett, "Thomas Morley," in The New Grove Dictionary of Music and Musicians, ed. by Stanley Sadie (London: MacMillan Publishers, 1980), v. 12, p. 580.

19. Kurt Stone, ed. Parthenia; or the Maydenhead of the First Musicke that Ever was Printed for the Virginalls, composed by William Byrd, John Bull and Orlando Gibbons (New York: Broude, 1951).

20. John Steele, "Peter Philips," in The New Grove Dictionary of Music and Musicians, ed. by Stanley Sadie (London: MacMillan Publishers, 1980), v. 14, p. 654.

21. Stevens, op. cit., p. 310.

22. Elizabeth Cole, "Seven Problems of the Fitzwilliams Virginal Book; An Interim Report", Proceedings of the Royal Music Association, v. ML/28/L8/M8 (1953), p.p. 50-64.

23. Fitzwilliam Virginal Book, ed. from the original MS by J. A. Fuller/Maitland and Barclay Squire (London: Breitkopf & Hartel, 1899), v. 1, p. 291.

24. Fitzwilliam Virginal Book, op. cit., v. 2, p. 483.

25. Brett, op. cit., p. 579.

26. Susi Jeans, "John Bull" in The New Grove Dictionary of Music and Musicians, ed. by Stanley Sadie (London: MacMillan Publishers, 1980), v. 3, p. 441.

27. Steele, op. cit., p. 656.

28. Willi Apel, The History of Keyboard Music to 1700 (Bloomington: Indiana University Press, 1972), Trans. and revised by Hans Tischler, p. 284.

29. Robert Nelson, The Technique of Variation (Berkeley: University of California Press, 1948), p. 29.

30. Charles Van den Borren, The Sources of Keyboard Music in England (London: Oxford University Press, 1948), Trans. by James E. Matthew (London: Novello & Co.), p. 206.

31. Jeans, op. cit., p. 439.

32. Nelson, op. cit., p. 31.

33. Apel, op. cit., p. 284.

34. The terminology are taken from Nelson, op. cit., pp. 10-24; Apel, op. cit., p. 267; and Van den Borren, op. cit., pp. 206-211.

35. William Byrd, "Pavana Lachrymae", Fitzwilliam Virginal Book, v. 2, pp. 42-46 (# CXXI).
Giles Farnaby "Lachrymae Pavan", Fitzwilliam Virginal Book, v. 2, pp. 472-476 (# CCXC)
Thomas Morley, "Pavana", Fitzwilliam Virginal Book, v. 2, pp. 173-176 (CLIII).

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38. Jerald Hage, Techniques and Problems of Theory Construction (New York: John Wiley and Sons, 1972), p. 10.

39. Maurice Tatsuoka, "Classification Procedures" in Introductory Multivariate Analysis (Berkeley, California: McCutchan, 1975), p. 262.

40. Ibid., p. 260.

41. William Cooley and Paul Lohnes, Multivariate Data Analysis (New York: John Wiley and Sons, 1971), p. 224.

42. Ibid., p. 226.

43. Ibid., p. 246.

44. William Klecka, "Discriminant Analysis" in Statistical Package for the Social Sciences, by N. Nie, D. Bent, and C. Hull (New York: McGraw-Hill, 1973), p. 435.

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A MULTIPLE DISCRIMINATE ANALYSIS OF ELIZABETHAN KEYBOARD VARIATIONS

by

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B. A., University of Oregon, 1975

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF MUSIC

Department of Music

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1984

ABSTRACT

Discriminate analysis has not been described as a procedure for musical style analysis, yet has great potential usefulness in authorship verification. Where bibliographic evidence cannot solve an authorship dispute, particularly among groups of pieces as similar as keyboard variations, discriminate analysis can demonstrate their degree of individuality, and can classify sample pieces into groups according to those groups' resulting scores. The analysis was demonstrated using the collected Pavan variations of William Byrd, Giles Farnaby, Orlando Gibbons, Peter Philips, John Bull, and Thomas Morley. With the exception of Bull's, each composer's discriminate scores based on fourteen rhythmic and textural variables showed convincing internal stylistic consistency. Five disputed pieces were classified into the six composer groups using the fourteen variables, and an additional analysis using a subset of nine variables substantiated overall the original results.