When statistics met formal linguistics
Variation in Dutch verb clusters

Jeroen van Craenenbroeck
KU Leuven

GLOW 38
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Outline

1 One-slide summary

2 The data: dialect Dutch verb clusters

3 Theoretical background: dialectometry

4 Methodology: reverse dialectometry

5 Results

6 Main conclusion
One-slide summary

Main goal
Explore the interaction between formal-theoretical and quantitative-statistical approaches to linguistics.

Central data
Word order variation in two- and three-verb clusters in 267 Dutch dialects.

Main result
Roughly 80% of the attested variation can be reduced to three grammatical microparameters: (i) whether or nor a dialect uses movement in deriving its verb clusters, (ii) whether or not there is an economy condition on movement, and (iii) a head parameter regulating the order of participles and infinitives vis-à-vis their selecting verbs.
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2. The data: dialect Dutch verb clusters

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4. Methodology: reverse dialectometry

5. Results

6. Main conclusion
The data: dialect Dutch verb clusters

- in Dutch (like in many Germanic languages) verbs cluster together at the right edge of the (embedded) clause:

(1) dat hij gisteren tijdens de les _gelachen_ heeft.
that he yesterday during the class laughed has
‘that he laughed yesterday during class.’
The data: dialect Dutch verb clusters

- in Dutch (like in many Germanic languages) verbs cluster together at the right edge of the (embedded) clause:

(1) dat hij gisteren tijdens de les gelachen heeft.
that he yesterday during the class laughed has
‘that he laughed yesterday during class.’

- moreover, such verbal clusters typically show a certain degree of freedom in their word order:

(2) dat hij gisteren tijdens de les heeft gelachen.
that he yesterday during the class had laughed
‘that he laughed yesterday during class.’
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that he yesterday during the class had laughed
‘that he laughed yesterday during class.’
this word order freedom is typically a source of interdialectal variation:
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(3) **Ferwerd Dutch**

a. dasto it ook net zien meist.
   that.you it also not see may
   ‘that you’re also not allowed to see it.’

b. *dasto it ook net meist zien.
   that.you it also not may see
   ‘that you’re also not allowed to see it.’
this word order freedom is typically a source of interdialectal variation:

(4) Gendringen Dutch

a. dat ee et ook nie zien mag.
   that you it also not see may
   ‘that you’re also not allowed to see it.’ (√21)

b. dat ee et ook nie mag zien.
   that you it also not may see
   ‘that you’re also not allowed to see it.’ (√12)
this word order freedom is typically a source of interdialectal variation:

(5) **Poelkapelle Dutch**

a. *dajtgie ook nie zien meug.  
   that.it.you also not see may  
   ‘that you’re also not allowed to see it.’  
   

b. dajtgie ook nie meug zien.  
   that.it.you also not may see  
   ‘that you’re also not allowed to see it.’  

\( \ast 21 \)  
\( \Box 12 \)
and the more complex the verbal cluster, the more variation there is: in verbal clusters consisting of two modal auxiliaries and one main verb, out of the six orders that are theoretically possible, four are attested in Dutch dialects:
and the more complex the verbal cluster, the more variation there is: in verbal clusters consisting of two modal auxiliaries and one main verb, out of the six orders that are theoretically possible, four are attested in Dutch dialects:

(6) Ik vind dat iedereen moet_1 kunnen_2 zwemmen_3.
I find that everyone must can swim
‘I think everyone should be able to swim.’ 

(✓123)
and the more complex the verbal cluster, the more variation there is: in verbal clusters consisting of two modal auxiliaries and one main verb, out of the six orders that are theoretically possible, four are attested in Dutch dialects:

(6)  Ik vind dat iedereen moet\textsubscript{1} kunnen\textsubscript{2} zwemmen\textsubscript{3}.
    I find that everyone must can swim
    ‘I think everyone should be able to swim.’  \(\checkmark\) 123

(7)  a.  \ldots dat iedereen moet\textsubscript{1} zwemmen\textsubscript{3} kunnen\textsubscript{2}.
    \(\checkmark\) 132
    b.  \ldots dat iedereen zwemmen\textsubscript{3} moet\textsubscript{1} kunnen\textsubscript{2}.
    \(\checkmark\) 312
    c.  \ldots dat iedereen zwemmen\textsubscript{3} kunnen\textsubscript{2} moet\textsubscript{1}.
    \(\checkmark\) 321
    d.  *[\ldots dat iedereen kunnen\textsubscript{2} zwemmen\textsubscript{3} moet\textsubscript{1}.]
    \(*\) 231
    e.  *[\ldots dat iedereen kunnen\textsubscript{2} moet\textsubscript{1} zwemmen\textsubscript{3}.
    \(*\) 213
but once again, it is not the case that each of the four allowed orders is attested in all dialects:
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(8) \textit{Midsland Dutch}

   that everyone must can swim
   ‘that everyone should be able to swim.’ (*123)

b. dat elkeen mot zwemme kanne. (✓ 132)

c. *dat elkeen zwemme mot kanne. (*312)

d. dat elkeen zwemme kanne mot. (✓ 321)

e. *dat elkeen kanne zwemme mot. (*231)

f. *dat elkeen kanne mot zwemme. (*213)
but once again, it is not the case that each of the four allowed orders is attested in all dialects:

(9) *Langelo Dutch*

a. dat iedereen mot kunnen zwemmen.  
   that everyone must can swim  
   ‘that everyone should be able to swim.’  
   (√123)

b. *dat iedereen mot zwemmen kunnen.  
   (*132)

c. dat iedereen zwemmen mot kunnen.  
   (√312)

d. *dat iedereen zwemmen kunnen mot.  
   (*321)

e. *dat iedereen kunnen zwemmen mot.  
   (*231)

f. *dat iedereen kunnen mot zwemmen.  
   (*213)
more generally, the four possible cluster orders yield a total of 16 possible combinations, of which 12 are attested in Dutch dialects:

<table>
<thead>
<tr>
<th>Sample Dialect</th>
<th>123</th>
<th>132</th>
<th>321</th>
<th>312</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beetgum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hippolytushoef</td>
<td></td>
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<tr>
<td>Warum</td>
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<tr>
<td>Oosterend</td>
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<tr>
<td>Schermerhorn</td>
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<tr>
<td>Visvliet</td>
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<td>Kollum</td>
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<tr>
<td>Langelo</td>
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<td>Midsland</td>
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<tr>
<td>Lies</td>
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<tr>
<td>Bakkeveen</td>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Beetgum</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Hippolytushoef</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
</tr>
<tr>
<td>Warffum</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
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<td>*</td>
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<tr>
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</tr>
<tr>
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- dialect interviews in 267 dialect locations in Belgium, France, and the Netherlands
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  ▶ dialect interviews in 267 dialect locations in Belgium, France, and the Netherlands
• the SAND-questionnaire contained eight questions on word order in verb clusters for a total of 31 cluster orders
• if we map, for each of the 267 SAND-dialects, which dialect has which combination of cluster orders, we find 137 different combinations of verb cluster orders
• in other words, there are 137 different types of dialects when it comes to word order in verbal clusters
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one possible position: Barbiers (2005): the grammar rules out 231 and 213 in MOD-MOD-V-cluster, but all other orders are freely available to all speakers; the choice between them is determined by sociolinguistic factors (geographical and social norms, register, context, ...)

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in this talk I use quantitative-statistical methods to identify three grammatical (micro)parameters that together are responsible for the bulk of the variation
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Theoretical background: dialectometry

- **dialectometry** is a subdiscipline of linguistics that uses computational and quantitative techniques in dialectology (Nerbonne and Kretzschmar Jr., 2013)
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  - 3 about particle placement inside the cluster
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  - 3 about particle placement inside the cluster
  - 2 about morphology of the past participle
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  - 4 about three-verb clusters (**modal-modal-infinitive**, **modal-auxiliary-participle**, **auxiliary-auxiliary-infinitive**, **auxiliary-modal-infinitive**)
  - 3 about particle placement inside the cluster
  - 2 about morphology of the past participle
- for a total of 67 linguistic variables in 267 locations
this yields a $267 \times 67$ matrix with one row per location and one column per linguistic variable, i.e. locations = individuals and linguistic phenomena = variables
<table>
<thead>
<tr>
<th></th>
<th>AUX1(be.sg)-PART2</th>
<th>PART2-AUX1(be.sg)</th>
<th>AUX1(have.sg)-PART2</th>
<th>PART2-AUX1(have.sg)</th>
<th>AUX1(have)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midsland / Midslân</td>
<td>no</td>
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<td>no</td>
<td>yes</td>
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</tr>
<tr>
<td>Lies</td>
<td>no</td>
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<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>West-Terschelling</td>
<td>no</td>
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<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Oosterend</td>
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<tr>
<td>Langelo</td>
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<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
this yields a $267 \times 67$ matrix with one row per location and one column per linguistic variable, i.e. locations = individuals and linguistic phenomena = variables

step 1: convert the table into a $267 \times 267$ (symmetric) distance matrix, whereby for each pair of locations a distance between them is calculated based on the linguistic features they share
<table>
<thead>
<tr>
<th></th>
<th>Midsland</th>
<th>Lies</th>
<th>West-Terschelling</th>
<th>Oosterend</th>
<th>Hollum</th>
<th>Schiermonniken</th>
<th>Ferwerd</th>
<th>Anjum</th>
<th>Kollum</th>
<th>Visvliet</th>
<th>Oosterbierum</th>
<th>Beet</th>
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<td>0,500</td>
<td>0,333</td>
<td>0,706</td>
<td>0,250</td>
<td>0,647</td>
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<td>0,611</td>
<td>0,650</td>
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<td>0,000</td>
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<td>0,000</td>
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<td>0,667</td>
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<td>0,706</td>
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<td>0,567</td>
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<td>0,625</td>
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<td>0,000</td>
<td>0,667</td>
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<td>0,000</td>
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<td>0,563</td>
<td>0,625</td>
<td>0,400</td>
<td>0,588</td>
<td>0,571</td>
<td>0,000</td>
<td>0,353</td>
<td>0,625</td>
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<td>Visvliet</td>
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<td>0,714</td>
<td>0,556</td>
<td>0,682</td>
<td>0,625</td>
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<td>0,588</td>
<td>0</td>
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<td>0,632</td>
<td>0,500</td>
<td>0,600</td>
<td>0,462</td>
<td>0,706</td>
<td>0,308</td>
<td>0,417</td>
<td>0,625</td>
<td>0,588</td>
<td>0,000</td>
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</tr>
<tr>
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<td>0,714</td>
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<td>0,750</td>
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<td>0,813</td>
<td>0,500</td>
<td>0,571</td>
<td>0,333</td>
<td>0,500</td>
<td>0,429</td>
<td>0,667</td>
<td>0,571</td>
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<tr>
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<td>0,545</td>
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<td>0,385</td>
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<td>0,438</td>
<td>0,579</td>
<td>0,533</td>
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</tr>
<tr>
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<td>0,500</td>
<td>0,588</td>
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<td>0,652</td>
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<td>0,611</td>
<td>0,810</td>
<td>0,563</td>
<td>0,357</td>
<td>0,529</td>
<td>0,600</td>
<td>0,333</td>
<td>0,636</td>
<td>0,706</td>
<td>0</td>
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<tr>
<td>Warffum</td>
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<td>0,438</td>
<td>0,667</td>
<td>0,737</td>
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<td>0,588</td>
<td>0,643</td>
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<td>0,600</td>
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<tr>
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<td>0,739</td>
<td>0,550</td>
<td>0,773</td>
<td>0,650</td>
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<td>0,722</td>
<td>0,389</td>
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<tr>
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<td>0,682</td>
<td>0,714</td>
<td>0,636</td>
<td>0,783</td>
<td>0,762</td>
<td>0,800</td>
<td>0,778</td>
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<tr>
<td>Nieuw-Scheem</td>
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<td>0,682</td>
<td>0,650</td>
<td>0,652</td>
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<td>0,739</td>
<td>0,722</td>
<td>0,556</td>
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<td>Langelo</td>
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<td>0,739</td>
<td>0,652</td>
<td>0,792</td>
<td>0,650</td>
<td>0,760</td>
<td>0,647</td>
<td>0,550</td>
<td>0,500</td>
<td>0,700</td>
<td>0</td>
</tr>
</tbody>
</table>
• this yields a $267 \times 67$ matrix with one row per location and one column per linguistic variable, i.e. locations = individuals and linguistic phenomena = variables

• step 1: convert the table into a $267 \times 267$ (symmetric) distance matrix, whereby for each pair of locations a distance between them is calculated based on the linguistic features they share

• step 2: apply multidimensional scaling (MDS) to the distance matrix
this yields a $267 \times 67$ matrix with one row per location and one column per linguistic variable, i.e. locations $=$ individuals and linguistic phenomena $=$ variables

step 1: convert the table into a $267 \times 267$ (symmetric) distance matrix, whereby for each pair of locations a distance between them is calculated based on the linguistic features they share

step 2: apply multidimensional scaling (MDS) to the distance matrix

MDS is a mathematical technique for reducing a multidimensional distance matrix to a low dimensional space in which each point represents an object from the distance matrix, and distances between points represents, as well as possible, dissimilarities between objects (Borg and Groenen, 2005)
2-dimensional MDS-representation 67 verb cluster phenomena
this yields a $267 \times 67$ matrix with one row per location and one column per linguistic variable, i.e. locations = individuals and linguistic phenomena = variables

- step 1: convert the table into a $267 \times 267$ (symmetric) distance matrix, whereby for each pair of locations a distance between them is calculated based on the linguistic features they share
- step 2: apply multidimensional scaling (MDS) to the distance matrix
- step 3: project the data back onto a geographical map
**Note:** The linguistic variables (i.e., cluster orders) are used to determine the degree of similarity/difference between dialect locations.
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- these similarities and differences are then projected back onto a geographical map, which makes it possible to discern dialect regions based on what verb cluster phenomena they possess.
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• shortcomings of this approach for our current purposes:
• **note:** the linguistic variables (i.e. cluster orders) are used to determine the degree of similarity/difference between dialect locations.
• these similarities and differences are then projected back onto a geographical map, which makes it possible to discern dialect regions based on what verb cluster phenomena they possess.
• shortcomings of this approach for our current purposes:
  1. the linguistic constructions themselves play only an indirect role in the outcome of the analysis: we can see when two dialects differ, but we don’t see which cluster orders are responsible for this difference and to what extent.
note: the linguistic variables (i.e. cluster orders) are used to determine the degree of similarity/difference between dialect locations

these similarities and differences are then projected back onto a geographical map, which makes it possible to discern dialect regions based on what verb cluster phenomena they possess

shortcomings of this approach for our current purposes:

1. the linguistic constructions themselves play only an indirect role in the outcome of the analysis: we can see when two dialects differ, but we don’t see which cluster orders are responsible for this difference and to what extent

2. there is no link between the data that feed into the quantitative analysis and the formal theoretical literature on verb clusters
Outline

1 One-slide summary

2 The data: dialect Dutch verb clusters

3 Theoretical background: dialectometry

4 Methodology: reverse dialectometry

5 Results

6 Main conclusion
Methodology: reverse dialectometry

- proposal: two changes to the classical dialectometric setup:
Methodology: reverse dialectometry

- **proposal:** two changes to the classical dialectometric setup:
  1. cluster orders are *individuals* rather than variables, i.e. instead of calculating differences between dialect locations, we measure differences between linguistic constructions
Methodology: reverse dialectometry

**proposal:** two changes to the classical dialectometric setup:

1. cluster orders are *individuals* rather than variables, i.e. instead of calculating differences between dialect locations, we measure differences between linguistic constructions
2. theoretical analyses of verb cluster orders are decomposed in their constitutive parts, which makes it possible to include them as supplementary variables in the analysis
starting point: a $31 \times 267$ data table whereby each cluster order represents a row and each dialect location a column
<table>
<thead>
<tr>
<th>AUX1(be.sg)-PART2</th>
<th>Midland</th>
<th>Lies</th>
<th>West.Tersch</th>
<th>Oosterend</th>
<th>Hollum</th>
<th>Schiermonnl</th>
<th>Ferwerd</th>
<th>Anjum</th>
<th>Koilm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PART2-AUX1(be.sg)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>NA</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>AUX1(have.sg)-PART2</td>
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<td>no</td>
<td>no</td>
<td>NA</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>PART2-AUX1(have.sg)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>NA</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>AUX1(have.pl)-PART2</td>
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<td>no</td>
<td>no</td>
<td>no</td>
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<td>no</td>
<td>no</td>
</tr>
<tr>
<td>PART2-AUX1(have.pl)</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>MOD1(sg)-INF2</td>
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<td>no</td>
<td>yes</td>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>MOD2-INF3-MOD1(sg)</td>
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<tr>
<td>MOD1(sg)-MOD2-INF3</td>
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<tr>
<td>PART3-MOD1(sg)-AUX2(have)</td>
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<td>no</td>
<td>yes</td>
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<td>no</td>
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<td>no</td>
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<td>NA</td>
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</tr>
<tr>
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<td>no</td>
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<td>no</td>
<td>no</td>
<td>no</td>
<td>NA</td>
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<tr>
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<td>no</td>
<td>no</td>
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<td>AUX2(go)-AUX1(be.sg)-INF3</td>
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<tr>
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<td>INF3-AUX1(have.sg)-MOD2(inf)</td>
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<tr>
<td>INF3-AUX1(have.sg)-MOD2(part)</td>
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<tr>
<td>INF3-MOD2(part)-AUX1(have.sg)</td>
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<tr>
<td>INF3-MOD2(inf)-AUX1(have.sg)</td>
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<td>no</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>
• starting point: a $31 \times 267$ data table whereby each cluster order represents a row and each dialect location a column

• the dialect locations are now used to determine the degree of difference/similarity between the various cluster orders $\rightarrow$ each of the 31 cluster orders is compared to each other cluster order on 267 variables (i.e. as many as there are dialect locations)
starting point: a $31 \times 267$ data table whereby each cluster order represents a row and each dialect location a column

the dialect locations are now used to determine the degree of difference/similarity between the various cluster orders → each of the 31 cluster orders is compared to each other cluster order on 267 variables (i.e. as many as there are dialect locations)

when we reduce the 31-dimensional distance matrix to a two-dimensional space, we can plot the differences and similarities between the cluster orders from the SAND-project
● **note:** each point now represents a particular cluster order and closeness of points indicates how alike two verb cluster orders are based on their geographical spread
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if this likeness is the result of grammar, i.e. grammatical microparameters, then verb cluster orders that are near one another should be the result of the same parameter setting, i.e. parameters create ‘natural classes’ of verb cluster orders
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• in order to find those parameters, we can also encode the cluster orders in terms of their theoretical linguistic analyses
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- In order to find those parameters, we can also encode the cluster orders in terms of their theoretical linguistic analyses.

- Example: Barbiers (2005)
Barbiers (2005) derives verb cluster orders as follows:
Barbiers (2005) derives verb cluster orders as follows:

- base order is uniformly head-initial → derives 12 and 123
Barbiers (2005) derives verb cluster orders as follows:
- base order is uniformly head-initial → derives 12 and 123

(10) \[ \text{VP}_1 \quad \text{VP}_2 \]
\[ \text{V}_1 \quad \text{V}_2 \]

(11) \[ \text{VP}_1 \]
\[ \text{VP}_2 \quad \text{VP}_3 \]
\[ \text{V}_1 \quad \text{V}_2 \quad \text{V}_3 \]
Barbiers (2005) derives verb cluster orders as follows:

- movement is VP-intraposition $\rightarrow$ derives 21 and 231, 312 and 132, and fails to derive 213
Barbiers (2005) derives verb cluster orders as follows:

- movement is VP-intraposition → derives 21 and 231, 312 and 132, and fails to derive 213

(12)

```
VP₁
  /\  
VP₂ V₁'
  |  
V₂ V₁ t_{VP₂}
```
Barbiers (2005) derives verb cluster orders as follows:

- movement is VP-intraposition $\rightarrow$ derives 21 and 231, 312 and 132, and fails to derive 213

(12)

$$
\begin{array}{c}
\text{VP}_1 \\
\text{VP}_2 \leftarrow \text{V}_2 \text{ V}_1 \text{ V}'_1 \text{ t}_{\text{VP}_2} \\
\end{array}
$$

(13)

$$
\begin{array}{c}
\text{VP}_1 \\
\text{VP}_2 \leftarrow \text{V}_2 \text{ V}_1 \text{ V}'_1 \text{ t}_{\text{VP}_2} \\
\text{VP}_3 \leftarrow \text{V}_3 \\
\end{array}
$$
Barbiers (2005) derives verb cluster orders as follows:
- movement is VP-intraposition $\rightarrow$ derives 21 and 231, 312 and 132, and fails to derive 213

(14)
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(14) \[
\begin{array}{c}
\text{VP}_1 \\
\text{VP}_3 & \text{V'}_1 \\
\text{V}_3 & \text{V}_1 & \text{VP}_2 \\
& \text{t}_{\text{VP}_3} & \text{V'}_2 \\
& & \text{V}_2 & \text{t}_{\text{VP}_3}
\end{array}
\]

(15) \[
\begin{array}{c}
\text{VP}_1 \\
\text{V}_1 & \text{VP}_2 \\
\text{VP}_3 & \text{V'}_2 \\
\text{V}_3 & \text{V}_2 & \text{t}_{\text{VP}_3}
\end{array}
\]
Barbiers (2005) derives verb cluster orders as follows:

- VP-intraposition can pied-pipe other material → derives 321 (movement of VP3 to specVP1 via specVP2 and with pied-piping of VP2)
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(16)
Barbiers (2005) derives verb cluster orders as follows:

- VP intraposition is triggered by feature checking: modal and aspectual auxiliaries enter into a(n eventive) feature checking relation with the main verb, while perfective auxiliaries enter into a perfective checking relationship with their immediately selected verb → rules out 231 in the case of MOD-MOD/AUX-V-clusters and 312 in the case of AUX-AUX/MOD-V-clusters.
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(17) \[
[ VP_1 \text{mod}_{uEvent} [ VP_2 \text{mod}_{uEvent} [ VP_3 \text{inf}_{iEvent} ] ] ]
\]
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(17) \[ [\text{VP}_1 \text{mod}_{[u\text{Event}]}] [\text{VP}_2 \text{mod}_{[u\text{Event}]}] [\text{VP}_3 \text{inf}_{[i\text{Event}]}] ] \]

(18) \[ [\text{VP}_1 \text{aux}_{[u\text{Perf}]}] [\text{VP}_2 \text{mod}_{[i\text{Perf},u\text{Event}]}] [\text{VP}_3 \text{inf}_{[i\text{Event}]}] ] \]
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- [±feature-checking violation]: does the order involve a feature checking violation?

and the 31 SAND cluster orders can be encoded in terms of these micro-parameters
<table>
<thead>
<tr>
<th>AUX1 (be.sg)-PART2</th>
<th>Barbiers-base generation</th>
<th>Barbiers-movement</th>
<th>Barbiers-spec-pied-piping</th>
<th>Barbiers-feature checking-failure</th>
</tr>
</thead>
<tbody>
<tr>
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<td>noMvt</td>
<td>noPiedP</td>
<td>noFeatCheckFail</td>
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**In total:** 70 additional variables distilled from the theoretical literature on verb clusters:

- a head-initial head movement analysis, a head-final head movement analysis, a head-initial XP-movement analysis, a head-final XP-movement analysis (all based on Wurmbrand (2005))
- 17 additional variables based on the theoretical literature, but not linked to a specific analysis
there are various ways of testing how well a linguistic variable lines up with the output of the geographical analysis, e.g.:
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1. visual inspection of a color-coded plot
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<table>
<thead>
<tr>
<th>dimension 1</th>
<th>dimension 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HypotheticalVariable</td>
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</tr>
</tbody>
</table>

*word of caution:* $\eta^2$ also goes up if the number of possible values of the linguistic variable goes up (Richardson (2011)).
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<tr>
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<td>0.043</td>
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</table>

★ word of caution: $\eta^2$ also goes up if the number of possible values of the linguistic variable goes up (Richardson (2011)) → safest option is to look for variables with a high $\eta^2$ and only two or three possible values
Outline

1 One-slide summary

2 The data: dialect Dutch verb clusters

3 Theoretical background: dialectometry

4 Methodology: reverse dialectometry

5 Results

6 Main conclusion
Results

- **recall:** we are trying to determine if the variation in word order in verbal clusters is determined by grammatical parameters, and if so to what extent.
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- **how many:** the number of parameters responsible for the verb cluster variation = the number of dimensions we reduce our data set to
- **what they are:** the identity of those parameters = the interpretation of the dimensions
Results: The number of relevant dimensions
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- recall: the analysis reduces a multi-dimensional distance matrix into a low-dimensional space, *while retaining as much as possible of the information present in the original object*
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- we can plot the percentage of variance explained per dimension (= scree plot)
• **note:** there seems to be a clear cut-off point after the third dimension
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• together, the first three dimensions account for 78.46% of the variation in the SAND verb cluster data
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- together, the first three dimensions account for 78.46% of the variation in the SAND verb cluster data
- this means that roughly 80% of the variation in verb cluster ordering in SAND can be reduced to three parameters
- in order to know what those parameters are, we need to interpret the first three dimensions
Results: Dimension 1
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- highest $\eta^2$-values:
  - Barbiers and Bennis (2010): the infinitival main verb is nominalized
  - Bader (2012): the complement of a modal verb precedes the modal
Results: Dimension 1

- highest $\eta^2$-values:

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<tr>
<td>BarBen.NomInf</td>
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<tr>
<td>Bader.VMod</td>
<td>0.398</td>
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</tbody>
</table>

- BarBen.NomInf: Barbiers and Bennis (2010): the infinitival main verb is nominalized
- Bader.VMod: Bader (2012): the complement of a modal verb precedes the modal
note: while both variables propose a general split that seems well represented on dimension 1, there are a number of verb clusters orders for which they are irrelevant (because the cluster doesn’t contain the relevant configuration)
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- new variable: `InfMod.AuxPart`:
  - set to ‘no’ when the modal precedes the infinitive (when present) and the participle precedes the auxiliary (when present)
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new variable: InfMod.AuxPart:

- set to ‘no’ when the modal precedes the infinitive (when present) and the participle precedes the auxiliary (when present)
- set to ‘yes’ when at least one of these conditions is not met
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• $\eta^2$ of InfMod.AuxPart: 0.6142
**note:** this new variable aligns very nicely with the first dimension
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- **this means** that the first (and most important) source of variation in Dutch verb clusters—i.e. the first microparameter—concerns the placement of modals and auxiliaries vs. the verbs they select
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this means that the first (and most important) source of variation in
Dutch verb clusters—i.e. the first microparameter—concerns the
placement of modals and auxiliaries vs. the verbs they select

it sets apart dialects that consistently place infinitives to the right and
participles to the left from those that don’t
Results: Dimension 2

<table>
<thead>
<tr>
<th>Dimension 2-values:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SchmiVo.MAPhc 0.379</td>
</tr>
<tr>
<td>Barbiers.base.generation 0.309</td>
</tr>
</tbody>
</table>

SchmiVo.MAPhc: Schmid and Vogel (2004): "If A and B are sister nodes at LF, and A is a head and B is a complement, then the correspondent of A precedes the one of B at PF."

Barbiers.base.generation: Barbiers (2005): head-initial base structure
Results: Dimension 2

- highest $\eta^2$-values:

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**note:** just as was the case with dimension 1, the variables culled from the literature leave room for improvement in interpreting dimension 2
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• another variable that does well is slope ($\eta^2 = 0.422$): is the order ascending, descending, first-ascending-then-descending, or first-descending-then-ascending?
**note:** ascDesc and desc pattern towards the positive values of dimension 2, while asc and descAsc tend to yield negative values for this dimension.
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new variable: FinalDescent:
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• new variable: FinalDescent:
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- new variable: FinalDescent:
  - set to ‘yes’ if the cluster ends in a descending order
  - set to ‘no’ if it ends in an ascending order
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**new variable: FinalDescent:**
- set to ‘yes’ if the cluster ends in a descending order
- set to ‘no’ if it ends in an ascending order

<table>
<thead>
<tr>
<th>FinalDescent_yes</th>
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<tbody>
<tr>
<td>21</td>
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<tr>
<td>132</td>
<td>123</td>
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<tr>
<td>321</td>
<td>312</td>
</tr>
<tr>
<td>231</td>
<td>213</td>
</tr>
</tbody>
</table>
• $\eta^2$ of FinalDescent: 0.382
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• possible theoretical interpretation of FinalDescent: it groups together cluster orders which are 0 or 1 movement operations away from a strictly head-final order (i.e. 132, 321, 231), from those that require at least two movement operations (123, 312, 213)
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  - caveat: two-verb clusters $\rightarrow$ there are only two possible orders, so you can always get from one to the other with one movement operation
- **this means** that the second source of variation in Dutch verb clusters—i.e. the second microparameter—concerns the degree to which a cluster order diverges from a strictly head-final order
Results: Dimension 3

最高值：
- SchmiVo.MAPch 0.701
- Bader.base.order 0.686

SchmiVo.MAPch: Schmid and Vogel (2004): “If A and B are sister nodes at LF, and A is a head and B is a complement, then the correspondent of B precedes the one of A at PF.”

Bader.base.order: Bader (2012): a strictly head-final base order
Results: Dimension 3

- highest $\eta^2$-values:
  
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</tbody>
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  - SchmiVo.MAPch: Schmid and Vogel (2004): “If A and B are sister nodes at LF, and A is a head and B is a complement, then the correspondent of B precedes the one of A at PF.”
  - Bader.base.order: Bader (2012): a strictly head-final base order
Dimension 3 vs. Bader's (2012) base-generated order
there is a very strong correlation between a head-final base order and the third dimension in the analysis
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**this means** that the third source of variation in Dutch verb clusters—i.e. the third microparameter—concerns the question of whether a dialect diverges from a strictly head final order or not.
Results: Conclusion

- interpreting the first three dimensions of the quantitative analysis of the verb cluster data in the Syntactic Atlas of Dutch Dialects allows us to construct the following (rough) parametric account of verb cluster ordering:

  1. ah e a d - fin a lb a s eo r d e r
  2. which dialects can diverge from or not: $\pm$ Movement (dimension 3)
  3. those that diverge can diverge strongly or not: Economy of Movement (dimension 2)
  4. above and beyond all this, a headedness parameter regulates the order of infinitives and participles vis-à-vis their selecting verbs: $\pm$ ModInf&PartAux (dimension 1)
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Outline

1. One-slide summary
2. The data: dialect Dutch verb clusters
3. Theoretical background: dialectometry
4. Methodology: reverse dialectometry
5. Results
6. Main conclusion
Main conclusion

- the considerable variation found in Dutch verb cluster orders can be reduced to three grammatical microparameters:
  1. the order of modals and auxiliaries vs. the verbs they select: $\pm \text{ModInf} \& \text{PartAux}$
  2. the degree of divergence from a head-final order: $\text{EconomyOfMovement}$
  3. adherence to a head-final order or not: $\pm \text{Movement}$

more generally, there is room for fruitful collaboration between formal-theoretical and quantitative-statistical linguistics:

- the former can guide the interpretation of results from the latter
- the latter can help evaluate and test hypotheses of the former
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