Using Linguistic Analysis to Identify High Performing Teams

Mary T. Dzindolet & Linda G. Pierce
Cameron University & Army Research Laboratory
Demands on Military Teams

• Perform a wide variety of tasks
  – Peace-keeping
  – War
• Ever-changing
  – Team members
  – Situation
  – Leadership
• High threat
Purpose

This presentation will explore the usefulness of one technological tool, the Linguistic Inquiry Word Count (LIWC), in identifying high-performing teams.
**LIWC Variables**

LIWC analyzes text word-by-word and categorizes the text into 74 different linguistic dimensions.

<table>
<thead>
<tr>
<th>Category</th>
<th>(Examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pronouns</td>
<td>(I, me, we, you)</td>
</tr>
<tr>
<td>positive emotions</td>
<td>(happy, pride, good)</td>
</tr>
<tr>
<td>negative emotions</td>
<td>(hate, afraid, sad)</td>
</tr>
<tr>
<td>insight</td>
<td>(think, know, consider)</td>
</tr>
<tr>
<td>time</td>
<td>(past, present, future)</td>
</tr>
<tr>
<td>communication</td>
<td>(talk, share, converse)</td>
</tr>
<tr>
<td>anxiety words</td>
<td>(nervous, afraid, tense)</td>
</tr>
</tbody>
</table>
Prior Research

- Pennebaker, Mehl, and Niederhoffer (2003) used the LIWC in dyadic social interactions to understand relationships.
- We have extended this work to explore the usefulness of the LIWC in identifying high-performing teams.
Predicting Group Performance

- Groups may differ in many important ways
  - Size (number of members)
  - Degree to which members are stratified (hierarchical)
  - Degree to which members exercise control over the behavior of other members
  - Degree of participation expected, permitted, or demanded of members
  - Ease of access to membership in the group and ease with which member can leave or be expelled from the group
Predicting Group Performance

• Groups may differ in many important ways
  – Degree of stability of the group over time and the continuity of its members over time
  – Degree to which group members relate to one another intimately vs formally
  – Degree to which the group is subdivided into smaller groups or cliques, and the extent to which such cliques are in conflict with one another
  – Degree of homogeneity among group members
  – Type of Task
McGrath’s Circumplex of Group Tasks

- Type 1: planning tasks
- Type 2: creativity tasks
- Type 3: intellective tasks
- Type 4: decision-making tasks
- Type 5: cognitive conflicts tasks
- Type 6: mixed-motive tasks
- Type 7: contests/battles/competitive tasks
- Type 8: performance/psycho-motor tasks

Cooperation vs. Conflict

Choose vs. Negotiate

Conceptual vs. Behavioral
McGrath’s Circumplex of Group Tasks

Type 2: creativity tasks
Type 3: intellective tasks
Type 4: decision-making tasks
Type 5: cognitive conflicts tasks
Type 6: mixed-motive tasks
Type 7: contests/battles/competitive tasks
Type 8: performance/psycho-motor tasks

Generating ideas
Generating plans
Resolving conflicts
Resolving conflicts
Resolving conflicts
Resolving conflicts
Resolving conflicts
Resolving conflicts

Cooperation
Conflict

Generating
EXECUTE
EXECUTE
EXECUTE
EXECUTE
EXECUTE
EXECUTE
EXECUTE
EXECUTE

Choose

Conceptual
Behavioral

Negotiate

Choose

Conceptual
Behavioral

Negotiate
Predicting Group Performance
Task Type 2: Generating Ideas
Brainstorming Tasks

• Can linguistic analysis predict performance on a brainstorming task?
• We examined correlations between number of ideas generated and LIWC variables for ten studies performed either at Cameron University or the University of Texas at Arlington
Study Differences

- Time to Brainstorm
  - 5, 10, 20, or 45 minutes
- Group Cohesiveness
- Research Location
  - Cameron University, University of Texas at Arlington, Walmart, or City National Bank
- Group Size
  - dyad, triad, or quad
- Communication Medium
  - face-to-face, distributed, or groupshareware
- Brainstorming Problem
Brainstorming Rules

• Criticism is ruled out. Adverse judgement of ideas must be withheld.
• Freewheeling is welcome, the wilder the idea, the better.
• Quantity is wanted. Come up with as many as you can.
• Combination and improvement are sought. Do not be afraid to combine and improve on ideas.
Pronoun Use
Total Pronouns
I, our, they, you, we

* p<.05
First Person Singular Pronouns

$I$, $me$, $my$

Study correlation with performance

* $p<.05$
First Person Plural Pronouns

we, our, us

Study

* p<.05
Second Person Pronouns
you, your, y’all

Study
-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 123456789
* p<.05

* correlation with performance

Study
Third Person Pronouns
he, she, they

* p<.05
Why Is Use of First Person Pronouns Related to Poor Performance?

- Self-focus rather than other-focus
References to Other People
them, you, anyone, everybody, someone

Study -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 1 0

* p<.05
Why Is Use of First Person Pronouns Related to Poor Performance?

- Self-focus rather than other-focus
- Subordinate status of some group members
Tentative Words
maybe, perhaps, depending

* p<.05

correlation with performance

Study
Certainty Words

clearly, always, confidently

Study

-0.8
-0.6
-0.4
-0.2
0
0.2
0.4

correlation with performance

1 2 3 4 5 6 7 8 9 10

* p<.05
Why Is Use of First Person Pronouns Related to Poor Performance?

• Self-focus rather than other-focus
• Subordinate status of some group members
• Defending own views; lack of supportive group environment
Negate

no, never, not

* p<.05
Assent
yes, O.K., alright, agree

* p<.05
Cognitive Complexity
Words with Six or More Letters

* p<.05

Study

* correlation with performance

1 2 3 4 5 6 7 8 9 10

* p<.05
Exclusive Words

but, except, without

Study

-0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0

* p<.05

correlation with performance

Study

1 2 3 4 5 6 7 8 9 10

* * *
Inclusive Words
*together, with, also*

![Graph showing correlation with performance across studies.](image)
Articles

*a, an, the*

* p<.05

The diagram illustrates the correlation with performance across different studies. The studies are numbered from 1 to 10, and the correlation values range from -0.8 to 0.6. The asterisk indicates statistical significance at the p<.05 level.
Prepositions

to, for, at

* p<.05

correlation with performance

Study
Numbers

Study 

Correlation with performance

* p<.05
Emotions
Positive Emotion Words

happy, pretty, good

* p<.05
Words Expressing Positive Feelings

care, encourage, enjoy

* p<.05
Optimistic Words

hope, best, win

* p<.05

Study

correlation with performance

1 2 3 4 5 6 7 8 9 10

*
Negative Emotion Words

hate, worthless, ugly

Study

-0.8 -0.6 -0.4 -0.2 0 0.2 0.4

* p<.05

correlation with performance

Study

*
Anxiety Words

nervous, scared, anxious

* p<.05
Words Expressing Anger

jerk, kill, annoy

* p<.05
**Words Expressing Sadness**

*sad, upset, suffer*

![Bar chart showing correlation with performance over studies.](chart.png)
Cognitive Processes
Cognitive Mechanisms
questioning, acknowledge, inform

Study

* p<.05
**Insight Words**

*think, know, believe*

![Bar chart showing the correlation with performance for different studies.](chart.png)

- The correlation with performance is depicted for studies 1 to 10.
- Significant correlations are marked with asterisks (*).
- A *p* value less than 0.05 indicates statistical significance.

* * *
Discrepancy Words
should, ought, could

* p<.05

correlation with performance

Study

1 2 3 4 5 6 7 8 9 10
Social Processes
Social Mechanisms
friend, phone, gossip, group

* p<.05

correlation with performance

Study
Communication Words

talk, ask, chat, counsel

correlation with performance

* p<.05
Time
Past Tense

Study

Correlation with performance

* p<.05
Present Tense

The graph shows the correlation with performance across different studies. Each bar represents a study, and the correlation coefficient is indicated on the y-axis. Asterisks (*) denote significance levels: * p<.05.
Future Tense

* p<.05
Conclusion

Idea Generation Tasks

- High-performing groups tend to
  - Avoid first person pronouns possibly due to group support (few negations)
  - Use more cognitively complex language (avoid exclusive and inclusive words and use words with six or more letters)
  - Avoid communication words
  - Avoid words indicating cognitive processes including causal words
  - Avoid negative emotion words
  - Avoid the present tense

- This pattern existed across many studies of groups that differed in size, communication medium, problem, location, and prior knowledge of one another
Predicting Group Performance

Task Type 3: Solving Problems with Correct Answers

Desert Survival Problem

Rank order 15 items in terms of utility for desert survival

Responses are compared with that of an expert
Survival Problem
Survival Problem

- flashlight (4-battery size)
- jackknife
- sectional air map of the area
- plastic raincoat (large size)
- magnetic compass
- compress kit with gauze
- .45 caliber pistol (loaded)
- parachute (red and white)
- bottle of salt tablets (1000 tablets)
- 1 quart of water per person
- book entitled, *Edible Animals of the Desert*
- 1 top coat per person
- pair of sunglasses per person
- cosmetic mirror
- 2 quarts (2 liters) of 180 proof Vodka
Pronoun Use

* p<.05 correlation with performance
Cognitive Complexity

* p<.05
Cognitive Complexity
Concrete Words

Correlation with performance

Articles  Prepositions  Numbers

Dyad  Triad

* p<.05
Words Expressing Emotion

**correlation with performance**

- Affect
- Pos Emot
- Pos Feel
- Neg Emot
- Anger
- Sad

* p<.05 correlation with performance

**Dyad** vs. **Triad**
Cognitive & Social Processes

The graph shows the correlation with performance for different processes:
- Cog Mech
- Insight
- Discrep
- Social
- Comm

Dyad and Triad are compared with different colors:
- Dyad: Red
- Triad: Blue

* p<.05
Tense

* * p<.05 correlation with performance
Conclusion
Desert Survival Task

High performing dyads
• Avoid prepositions and use numbers (both indicators of concrete rather than abstract thought)
• Though not statistically significant, tend to
  – Avoid pronouns
  – Avoid negations
  – Use exclusive words
  – Use words with six or more letters
  – Avoid discrepancy words
  – Avoid communication words
  – Avoid words expressing emotion
  – Avoid present tense
  – Use the past tense

High performing groups of three
• Avoid prepositions
• Though not statistically significant, tend to
  – Use third person pronouns
  – Express emotions
  – Use the past tense
Predicting Group Performance

Task Type 3: Solving Problems with Correct Answers

Student Government Task

Choose the best student government candidate using the characteristics of each candidates (Candidate A, B, and C)

Some information given to each group member is unique; other pieces of information are given to all group members
Correlation with Time Spent on Shared Info

**Pronoun Use**

- Total
- First Singular
- First Plural
- Second
- Third

* p<.05

* Dyad  ▬  Group
Pronoun Use

Correlation with Time Spent on Unique Info

* p<.05
Cognitive Complexity

Correlation with Time Spent on Shared Info

- 6+
- Causal
- Negate
- Excl
- Incl

Dyad
Group

* p<.05
Cognitive Complexity

Correlation with Time Spent on Unique Info

* p<.05
Cognitive Complexity

Concrete Words

Correlation with Time spent on Shared Info

* p<.05
Cognitive Complexity

Concrete Words

Correlation with Time Spent on Unique Info

- Articles
- Prepositions
- Numbers

Dyad  Group

* p<.05
Correlation with Time Spent on Shared Info

Words Expressing Emotion

* p<.05
Words Expressing Emotion

* p<.05

Correlation with Time Spent on Unique Info

Dyad  Group

Affect  Pos  Pos  Neg  Anger  Sad
Emot  Feel  Emot
**Cognitive & Social Processes**

Correlation with Time Spent on Shared Info

- **Cog Mech**
- **Insight**
- **Discrep**
- **Social**
- **Comm**

* p<.05
Cognitive & Social Processes

Correlation with Time Spent on Unique Info

- Cog Mech
- Insight
- Discrep
- Social
- Comm

* p<.05
Correlation with Time Spent on Shared Info

Past  Present  Future

Dyad  Group

* p<.05
Tense

Correlation with Time Spent on Unique Info

-0.4
-0.2
0
0.2
0.4

Past
Present
Future

Dyad
Group

* p<.05
Conclusions

Hidden Profile Task

• Dyads using the efficient strategy
  – Use causal words

• Dyads using the inefficient strategy
  – Use causal word
  – Use second person pronouns
  – Use exclusive words
  – Use prepositions
  – Use social words
  – Use present and future tenses

• Groups of four using the efficient strategy
  – Use causal words

• Groups of four using the inefficient strategy
  – Express emotions—especially negative emotions
  – Use the present tense
  – Avoid the past tense
**Predicting Group Performance**

**Task Type 4: Deciding Issues with No Correct Answer**

**Group Polarization Task**

- **Procedure**
  - individual (no time limit)
  - group (30 minutes)
  - individual (no time limit)

- **Indicate the lowest probability of succeeding that was acceptable for 12 different scenarios**

“An electrical engineer may stick with his present job at a modest but adequate salary, or may take a new job offering considerably more money but no long-term security.”

---

**McGrath’s Circumplex of Group Tasks**

- **Type 1:** planning tasks
- **Type 2:** creativity tasks
- **Type 3:** intellective tasks
- **Type 4:** decision-making tasks
- **Type 5:** cognitive conflicts tasks
- **Type 6:** mixed-motive tasks
- **Type 7:** contests/battles/competitive tasks
- **Type 8:** performance/psycho-motor tasks

**Task Types:**

- **Type 1:** planning tasks
- **Type 2:** creativity tasks
- **Type 3:** intellective tasks
- **Type 4:** decision-making tasks
- **Type 5:** cognitive conflicts tasks
- **Type 6:** mixed-motive tasks
- **Type 7:** contests/battles/competitive tasks
- **Type 8:** performance/psycho-motor tasks
Pronoun Use

-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5

Total First Singular First Plural Second Third

FtF Dyad FtF Group Dist Group

* p<.05
Cognitive Complexity

* p<.05
**Cognitive Complexity**

**Concrete Words**

![Bar chart showing correlation with agreement with group for Articles, Prepositions, and Numbers across different settings: Ff Dyad, Ff Group, Dist Group. The chart includes a note that *p* < .05.](image_url)
Words Expressing Positive Emotions

* p<.05
Words Expressing Negative Emotions

![Bar chart showing correlation with agreement with group for different emotions: NegEmot, Anx, Anger, Sad. The chart compares F2F Dyad, F2F Group, and Dist Group. *p<.05](chart.png)
Cognitive & Social Processes

Correlation with agreement with group

-0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4

CogMech  Insight  Discrep  Social  Comm

Face-to-Face Dyad  Face-to-Face 4  Dist-4

* p<.05
Tense

![Graph showing correlation with agreement with group for Past, Present, and Future tenses.](image)

Correlation with agreement with group

- Past: FtF Dyad = -0.2, FtF Group = -0.1, Dist Group = 0.1
- Present: FtF Dyad = -0.3, FtF Group = 0.1, Dist Group = 0.2
- Future: FtF Dyad = 0.7, FtF Group = 0.6, Dist Group = 0.3

* p<.05

Legend:

- FtF Dyad
- FtF Group
- Dist Group
Conclusion

Group Polarization Task

• No linguistic indicators for groups of four
• High performing face-to-face dyads
  – Avoid social words
  – Avoid communication words
  – Use future tense
Conclusion

Choose Tasks

• Very little overlap in linguistic markers across the three Choose Tasks
  – Prepositions indicate poor performance for dyads and groups doing the Desert Survival Task and dyads performing Hidden Profile Task
  – Communication words indicate poor performance for dyads performing the Desert Survival and Group Polarization Tasks
  – Social words indicate poor performance for dyads performing the Hidden Profile and Group Polarization Tasks
  – Use of emotional words indicate poor performance for dyads performing the Desert Survival Task
groups of four performing the Hidden Profile Task
• LIWC-performance relationships may be unique to each task
Predicting Group Performance

Task Type 6: Resolving Conflicts of Interest

Prisoner’s Dilemma

<table>
<thead>
<tr>
<th>Option</th>
<th>Partner 1</th>
<th>Partner 2</th>
<th>Partner 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Decision Blue 4.00</td>
<td>Decision Blue 4.00</td>
<td>Decision Blue 4.00</td>
</tr>
<tr>
<td>2</td>
<td>Decision Green 5.00</td>
<td>Decision Green 5.00</td>
<td>Decision Green 5.00</td>
</tr>
<tr>
<td>3</td>
<td>Decision Green 3.00</td>
<td>Decision Blue 7.00</td>
<td>Decision Green 3.00</td>
</tr>
<tr>
<td>4</td>
<td>Decision Green 1.00</td>
<td>Decision Blue 5.00</td>
<td>Decision Blue 5.00</td>
</tr>
<tr>
<td>5</td>
<td>Decision Blue 7.00</td>
<td>Decision Green 3.00</td>
<td>Decision Green 3.00</td>
</tr>
</tbody>
</table>
**Pronoun Use**

* *p* < .05 correlation with cooperative responses
Cognitive Complexity

Correlation with cooperative responses

* p<.05
Cognitive Complexity
Concrete Words

correlation with cooperative responses

-0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4

Articles Prepositions Numbers

Dist Triad FtF Triad Dist Dyad

* p<.05
Words Expressing Positive Emotions

![Bar chart showing correlation with cooperative responses for different categories of emotions and communication contexts.](image)

- Affect
- PosEmot
- PosFeel
- Optim

- Dist Triad
- FtF Triad
- Dist Dyad

* p<.05 

The chart illustrates the correlation of words expressing positive emotions with cooperative responses across different communication contexts and triad types. Significant correlations are indicated with an asterisk and p-value less than 0.05.
Words Expressing Negative Emotions

![Bar chart showing the correlation with cooperative responses for different emotions and communication modes.]

- **NegEmot**: FtF Triad (0.65), Dist Triad (0.35), Dist Dyad (0.25)
- **Anger**: FtF Triad (0.70), Dist Triad (0.40), Dist Dyad (0.30)
- **Sad**: FtF Triad (0.50), Dist Triad (0.30), Dist Dyad (0.20)

* p<.05

Legend:
- Dist Triad
- FtF Triad
- Dist Dyad
**Cognitive & Social Processes**

The graph shows the correlation with cooperative responses for different social processes and conditions.

- **CogMech**
- **Insight**
- **Discrep**
- **Social**
- **Comm**

The conditions are divided into:

- **Dist Triad**
- **FtF Triad**
- **Dist Dyad**

* p<.05
Tense

correlation with cooperative responses

Past  Present  Future

Dist Triad  FtF Triad  Dist Dyad

* p<.05
Conclusions
Prisoner’s Dilemma Task

• Distributed triads that used discrepancy words were more cooperative

• Trends existed:
  – Cooperative distributed triads
    • Avoid second person pronouns
    • Use future tense
    • Use communication words
  – Cooperative face-to-face triads
    • Avoid second person pronouns
    • Use exclusive words
    • Express positive and negative emotions and use anger words
    • Avoid the future tense
  – Cooperative distributed dyads
    • Use positive feeling words
Predicting Group Performance

Task Type 8: Psycho-Motor Tasks

Card Task

Make a house using as many cards as possible from several decks of playing cards
Pronoun Use

correlation with performance

Total  First Singular  First Plural  Second  Third

* p<.05
Cognitive Complexity

* p<.05
Cognitive Complexity
Concrete Words

* p<.05
Words Expressing Emotions

The diagram shows the correlation of various emotions with performance. The emotions are categorized into Affect, PosFeel, and Anger. The correlation values are indicated by the height of the bars. Affect and PosFeel have correlations of 0.2, while Anger has a correlation of 0.4. * p<.05
Cognitive & Social Processes

* p<.05
Tense

* p<.05 correlation with performance
Predicting Group Performance

Task Type 8: Psycho-Motor Tasks

Radio Assembly Task

As a group, we would like you to assemble the AM portion of a radio using a Radio Kit from Radio Shack. To assemble the AM portion of the radio, you will need to insert dozens of components into different places on the circuit board and then connect each component to the others in the proper manner.

fifteen minutes
Pronoun Use

* p<.05
Cognitive Complexity

* p<.05

correlation with time to complete radio

Dyad  Triad

6+  Causal  Negate  Excl  Incl
Cognitive Complexity
Concrete Words

Correlation with time to complete radio

* p<.05
Words Expressing Positive Emotions

-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

Affect PosEmot PosFeel

Dyad Triad

* p<.05
correlation with time to complete radio

* p<.05
Words Expressing Negative Emotions

![Bar graph showing correlation with time to complete radio for different emotions and relationship contexts.]

- **Anger** shows a strong positive correlation with time to complete radio for both Dyad and Triad contexts, indicating a significant increase in expressing negative emotions, especially anger, with increased time.

- **Sad** also shows a positive correlation, but it is less pronounced compared to Anger.

The graph includes annotations indicating significance with a p-value of less than 0.05 (* p<.05). This suggests that the observed correlations are statistically significant.
Cognitive & Social Processes

* p<.05
Tense

correlation with time to complete radio

Past  Present  Future

Dyad  Triad

* p<.05
Conclusion

Radio Assembly Task

- High Performing Dyads
  - Avoid Prepositions
  - Trend to:
    - Use pronouns (esp. first person singular and second person)
    - Use negations
    - Avoid articles
    - Use positive feeling words
    - Avoid anger words
    - Use words expressing cognitive and social processes
    - Use present tense

- High Performing Triads
  - Use words with six or more letters
  - Trend to:
    - Avoid causal words
    - Avoid exclusive words
    - Use prepositions
    - Use numbers
    - Avoid words expressing cognitive mechanisms
    - Avoid discrepancy words
    - Avoid the present and future tenses
General Conclusions

• In several studies across more than one task, the following patterns emerged:
  – The more cognitively complex the language group members use when communicating (specifically, using words with six or more letters and avoiding prepositions), the better they perform.
  – The more groups avoid expressing negative emotions, the better they perform.
  – The more the groups avoid discussing social mechanisms, the better the groups perform.
  – The more groups avoid using the present tense as they talk with one another, the better they perform.
General Conclusions

• LIWC variables have been found to be useful in predicting group performance BUT the linguistic categories that predict performance differ by task, task type, group size, and communication medium
• Cannot imply causation from correlations
• Relationship to group processes have yet to be discovered
Future Research

• Determine the extent to which these findings generalize
• Determine LIWC variables which can indicate group relations (e.g., trust, use of first person singular pronouns to predict status)
• Determine usefulness of LIWC in assessing group readiness
• Examine usefulness of LIWC in determining level of group development