Towards Saving Lives with Natural Language Processing

H. Andrew Schwartz

Stony Brook University
Human Language Analysis Beings
Towards Saving Lives with Natural Language Processing

Part I.
Background and Current Work: Human Language Analysis

Part II.
Discussion: Technical Barriers to Lives Saved
Language Says A Lot About People

Computational Linguistics

Psychology + Health
Language Says A Lot About People

Does language use reflect who we are?
Does language use reflect who we are?


19M Facebook posts
75,000 personality surveys

Language Says A Lot About People
Language Says A Lot About People

Words and Phrases

extraversion -- sociable, assertive, active, energetic, talkative, outgoing

19M Facebook posts

75,000 personality surveys


Does language use reflect who we are?
relax, finals, excited, blessings, great_day, ready_for, to_work, weekend, wonderful, long_day, relaxing,ablo, prayers, much_fun, classes, fam, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, vacation, thankful, 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Language Says A Lot About People

Words and Phrases

19M Facebook posts

extraversion -- sociable, assertive, active, energetic, talkative, outgoing

insights

75,000 personality surveys
Language Says A Lot About People

Words and Phrases
19M Facebook posts

Predict?

extraversion -- sociable, assertive, active, energetic, talkative, outgoing

“Language-based Assessments”

75,000 personality surveys
I am **blessed** to spend so much **time** with my **family**.

Need **some help**!

...
Language use patterns

I am **blessed** to spend so much **time** with my **family**.

Need **some help**!

Human Language Encoding

| .37 | .12 | .45 | .31 | .25 | ... |

Words: very, beautiful, amazing, most, thankful, blessed, time, family, spending, great, somebody, need, please, help, save, bring, somewhere, anybody, needs.
Language use patterns

I am **blessed** to spend so much **time** with my **family**.

Need **some help**!

Human Language Encoding

| .37 | .12 | .45 | .31 | .25 | ... |

Language-based Assessments

- regression
- classification
- deep learning
Language use patterns

I am **blessed** to spend so much **time** with my **family**.

Need **some help**!

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Research Participants

States and Traits

- affective valence
- depression
- anxiety
- personality
- mood

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Human Language Encoding

| .37 | .12 | .45 | .31 | .25 | ...

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Language-based Assessments

- regression
- classification
- deep learning
Language-Based Assessment Evaluation

Predictive Accuracy

- Openness: Language (.46)
- Conscientiousness: Language (.34)
- Extraversion: Language (.43)
- Agreeableness: Language (.38)
- Neuroticism: Language (.35)

Correlation with questionnaire
Language-Based Assessment Evaluation

Disattenuated for measurement error and shared method variance:

$r = \text{.49 to .66}$
Language-Based Assessment Evaluation

Predictive Accuracy

- Openness
  - Language: .46
  - Friend: .25

- Conscientiousness
  - Language: .34
  - Friend: .30

- Extraversion
  - Language: .43
  - Friend: .39

- Agreeableness
  - Language: .38
  - Friend: .30

- Neuroticism
  - Language: .35
  - Friend: .34

Disattenuated for measurement error and shared method variance:

\[ r = .49 \text{ to } .66 \]
Is it reliable and stable over time?

Online 6-month test-retest of 20-item questionnaire:

$r = .71$
Does it generalize to other outcomes?

Example: extraversion

<table>
<thead>
<tr>
<th>Satisfaction with life</th>
<th>questionnaire extraversion</th>
<th>.24</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>language extraversion</td>
<td>.13</td>
</tr>
<tr>
<td>Number of Facebook friends</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>correlation between outcome and extraversion</td>
<td></td>
</tr>
</tbody>
</table>
Does it generalize to other outcomes?

**Example: extraversion**

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<th>Satisfaction with life</th>
<th>Number of Facebook friends</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>questionnaire extraversion</strong></td>
<td>0.24</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>language extraversion</strong></td>
<td>0.13</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*correlation between outcome and extraversion*
Other Outcomes?

Personality
(Schwartz et al., 2013;
Park et al., 2015)
Other Outcomes?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Personality
(Schwartz et al., 2013;
Park et al., 2015)
Other Outcomes?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Personality
(Schwartz et al., 2013; Park et al., 2015)

Emotion / Affect
(Preotiuc-Pietro et al., 2016)
Other Outcomes?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Mental Health
(Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

Personality
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Emotion / Affect
(Preotiuc-Pietro et al., 2016)

Characterizing Gratitude
(Carpenter et al., 2016)
Other Outcomes?

- **Life Satisfaction**
  (Schwartz et al., 2013; 2016)
- **Mental Health**
  (Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)
- **Emotion / Affect**
  (Preotiuc-Pietro et al., 2016)
- **Personality**
  (Schwartz et al., 2013; Park et al., 2015)
- **Characterizing Gratitude**
  (Carpenter et al., 2016)
- **Demographics**
  (Sap et al., 2014)
Other Outcomes?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Mental Health
(Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

Emotion / Affect
(Preotiuc-Pietro et al., 2016)

Dark Triad
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Personality
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Dark Triad
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Spiritual/Religious Outcomes
(Yaden et al., 2016, 2017)

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Causal Explanations
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Characterizing Gratitude
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Demographics
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Other Outcomes?

Life Satisfaction
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Emotion / Affect
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Temporal Orientation
(Schwartz et al., 2015)

Causal Explanations
(Son et al., 2018)
Other Outcomes?

Life Satisfaction
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Mental Health
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Spiritual/Religious Outcomes
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Dark Triad
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Meaning in Life
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Characterizing Gratitude
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Demographics
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Temporal Orientation
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Other Outcomes?

Life Satisfaction (Schwartz et al., 2013; 2016)

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Emotion / Affect (Preotiuc-Pietro et al., 2016)

Meaning in Life (Schwartz et al., 2016)

Personality (Schwartz et al., 2013; Park et al., 2015)

Spiritual/Religious Outcomes (Yaden et al., 2016, 2017)

Dark Triad (Preotiuc-Pietro et al., 2016)

Causal Explanations (Son et al., 2018)

Characterizing Gratitude (Carpenter et al., 2016)

Demographics (Sap et al., 2014)

Temporal Orientation (Schwartz et al., 2015)

Meaning in Life (Schwartz et al., 2016)

Trustfulnessness (Buffone et al., 2018)
Other Outcomes?

Life Satisfaction (Schwartz et al., 2013; 2016)

Meaning in Life (Schwartz et al., 2016)

Emotion / Affect (Preotiuc-Pietro et al., 2016)

Personality (Schwartz et al., 2013; Park et al., 2015)

Dark Triad (Preotiuc-Pietro et al., 2016)

Causal Explanations (Son et al., 2018)

Mental Health (Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

Spiritual/Religious Outcomes (Yaden et al., 2016, 2017)

Coping (Preotiuc-Pietro et al., 2016)

Characterizing Gratitude (Carpenter et al., 2016)

Demographics (Sap et al., 2014)

Temporal Orientation (Schwartz et al., 2015)

Meaning in Life (Schwartz et al., 2016)

Control (Rouhizadeh et al., 2018)

Trustfulness (Buffone et al., 2018)
Characterizing Gratitude (Carpenter et al., 2016)

Other Outcomes?

Life Satisfaction (Schwartz et al., 2013; 2016)

Mental Health (Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

Emotion / Affect (Preotiuc-Pietro et al., 2016)

Dark Triad (Preotiuc-Pietro et al., 2016)

Spiritual/Religious Outcomes (Yaden et al., 2016, 2017)

Causal Explanations (Son et al., 2018)

Personality (Schwartz et al., 2013; Park et al., 2015)

Meaning in Life (Schwartz et al., 2016)

Demographics (Sap et al., 2014)

Temporal Orientation (Schwartz et al., 2015)

Control (Rouhizadeh et al., 2018)

Trustfulness (Buffone et al., 2018)

Other Outcomes

**Life Satisfaction**
(Schwartz et al., 2013; 2016)

**Mental Health**
(Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

**Spiritual/Religious Outcomes**
(Yaden et al., 2016, 2017)

**Causal Explanations**
(Son et al., 2018)

Eichstaedt, …, & Schwartz
*PNAS, October, 2018.*
Other Outcomes?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Meaning in Life
(Schwartz et al., 2016)

Emotion / Affect
(Preotiuc-Pietro et al., 2016)

Mental Health
(Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

Personality
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Dark Triad
(Preotiuc-Pietro et al., 2016)

Temporal Orientation
(Schwartz et al., 2015)

Spiritual/Religious Outcomes
(Yaden et al., 2016, 2017)

Control
(Rouhizadeh et al., 2018)

Demographics
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Causal Explanations
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Life Satisfaction
(Schwartz et al., 2013; 2016)

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Spiritual/Religious Outcomes
(Yaden et al., 2016, 2017)

Temporal Orientation
(Schwartz et al., 2015)

Demographics
(Sap et al., 2014)

Topics that predict depression

Crying
cry
cold
closed
sick
sore
fever
flu
feeling

Control
(Rouhizadeh et al., 2018)

Trustfulness
(Buffone et al., 2018)

Eichstaedt, …, & Schwartz
PNAS, October, 2018.
Depth?

Life Satisfaction
(Schwartz et al., 2013; 2016)

Meaning in Life
(Schwartz et al., 2016)

Emotion / Affect
(Preotiuc-Pietro et al., 2016)

Personality
(Schwartz et al., 2013; Park et al., 2015)

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Spiritual/Religious Outcomes
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Demographics

Trustfulness
(Buffone et al., 2018)

Interpersonal Circumplex

Established Gender Difference:
Women are warmer and less assertive.

(e.g. Baker 1966; Wiggins, 1991)

(Park et al., 2017)
Life Satisfaction
(Schwartz et al., 2013; 2016)
Meaning in Life
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Trustfulness
(Buffone et al., 2018)

Depth?

Warm-Agreeable
(Park et al., 2017)
Life Satisfaction
(Schwartz et al., 2013; 2016)
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(Rouhizadeh et al., 2018)

Demographics
(Park et al., 2017)

Gender difference effect size ($d$) -0.5

Depth?
Life Satisfaction
(Schwartz et al., 2013; 2016)

Meaning in Life
(Schwartz et al., 2016)

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(Rouhizadeh et al., 2018)

Demographics

Depth?

(Park et al., 2017)
Gender Differences: Women are warmer but less assertive.

(e.g. Baker 1966; Wiggins, 1991)

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(Schwartz et al., 2015)

Meaning in Life
(Schwartz et al., 2016)

Control
(Rouhizadeh et al., 2018)

Trustfulness
(Buffone et al., 2018)
**Depth?**

**Life Satisfaction**
(Schwartz et al., 2013; 2016)

**Mental Health**
(Schwartz et al., 2013; Coppersmith et al., 2014; Eichstaedt et al., 2018)

**Spiritual/Religious Outcomes**
(Yaden et al., 2016, 2017)

**Causal Explanations**
(Son et al., 2018)

**Characterizing Gratitude**
(Carpenter et al., 2016)

**Emotion / Affect**
(Preotiuc-Pietro et al., 2016)

**Dark Triad**
(Preotiuc-Pietro et al., 2016)

**Meaning in Life**
(Schwartz et al., 2016)

**Personality**
(Park et al., 2015)

**Demographics**
(Sap et al., 2014)

**Temporal Orientation**
(Schwartz et al., 2015)

**Spiritual/Religious Outcomes**
(Yaden et al., 2016, 2017)

**Meaning in Life**
(Schwartz et al., 2016)

**Trustfulness**
(Buffone et al., 2018)

**Control**
(Rouhizadeh et al., 2018)
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**Age-gender adjusted beta**

Trustfulness

(Buffone, Zamani et al., 2018)
## Depth?

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*Age-gender adjusted beta* (Buffone, Zamani et al., 2018)
## Depth?

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*Age-gender adjusted beta*  

**Trustfulness**  

(Buffone, Zamani et al., 2018)
Also Applicable to Community Assessment
Language-based Assessment

- inexpensive, behavior-based (different biases than questionnaires)
- reliable: test-rest; external validity
- signals many different conditions / behaviors / psychological traits and states
- captures nuance -- nearly infinite conceptual resolution
Toward Forecasting in Mental Health

diagnose

mental health

detect & prevent

monitor

treat
Current Work: Forecasting relapse during addiction treatment
With:
Parth Limbachiya (SBU),
Brenda Curtis, Salvatore Giorgi, Lyle Ungar - UPenn
Study Design

Pre-treatment Social Media

Entered Treatment

N = 283
Study Design

Pre-treatment Social Media → Entered Treatment

Relapse by week?
- 4 wk
- 8 wk
- 12 wk
Linguistic Features

- Drug Terminology
- LDA Topics (derived from this data)
- Personality: Five Factors / OCEAN (Park et al., 2015)
- Risky Language (Ireland et al., 2016)
- Affect and Intensity (Preotiuc et al., 2016)
Study Design

Pre-treatment Social Media

Entered Treatment

Relapse by week?

4 wk 8 wk 12 wk
Study Design: Survival Analysis Framework

$\Pr(\text{survived until wk}) = \Pr(\text{not relapsed before wk})$

Pre-treatment Social Media

Entered Treatment

4 wk 8 wk 12 wk
Study Design: Survival Analysis Framework

\[ p(\text{survived until wk}) = p(\text{not relapsed before wk}) \]

- Pre-treatment
- Social Media
- Entered Treatment
- 4 wk
- 8 wk
- 12 wk
Study Design: Survival Analysis Framework

Pre-treatment Social Media

Entered Treatment

4 wk  8 wk  12 wk

p(survived until wk) = p(not relapsed before wk)

0.0  0.5  1.0

?
Method: Penalized Cox Proportional Hazards Model

Entered Treatment

Pre-treatment Social Media

Hazard: risk at given discrete point.

Non-parametric, but enforces consistency in shape through all hazards being proportional
Method: Penalized Cox Proportional Hazards Model

Non-parametric, but enforces consistency in shape through all hazards being proportional.

Hazard: risk at given discrete point.

Pre-treatment Social Media

 Entered Treatment

4 wk 8 wk 12 wk
Long-term Health Forecasting

- Early assessment of lifetime risk
- Targeted interventions for prevention and treatment

Joint Work with Veronica Lynn (SBU), Alissa Goodman (University College London), Margaret Kern (Univ. of Melbourne)
National Child Development Study (NCDS)

11                   23                 33               42               50                  60
National Child Development Study (NCDS)

(birth) 11 23 33 42 50 60

BSAG
National Child Development Study (NCDS)

BSAG

psych distress

psych distress

psych distress

psych distress
National Child Development Study (NCDS)

Predict?

BSAG, psych distress, psych distress, psych distress, psych distress, psych distress
CLPsych-2018 Shared Task: Call for Participation Predicting Current and Future Psychological Health from Childhood Essays

We invite participants for the 2018 CLPsych Shared Task.

Motivation and Background

This shared task seeks to encourage new methods not only for analyzing current language use as a signal for mental health, as in previous CL Psych shared tasks, but also for understanding childhood...
National Child Development Study (NCDS)

(Task A) BSAG psych distress 11
(Task B) psych distress 23, 33, 42, 50, 60

Predict?
National Child Development Study (NCDS)

Accuracy:  
- BSAG: 0.56
- TASK A: 0.43
- psych distress: 0.32
- psych distress: 0.21
- psych distress: 0.30*

Predict?
Language, a *human behavior*, often more predictive than traditional assessments alone.

+ study in people’s “own words”.
+ nearly infinite conceptual resolution.
+ longitudinal context.
PART II:
Barriers towards saving lives

Goal
Barriers towards saving lives

One view: not an AI problem

“human issues”
Barriers towards saving lives

Research Agenda

Goal
Barriers towards saving lives

**Care Tasks**
- Prevent
- Detect
- Diagnose
- Treatment
- Monitor

**Goal**

Clinician      Patient

LIFE
Barriers towards saving lives

**Technology**

Predict (cross-sectional)  
*score, classify*

Forecast (future predict)  
*Risk assessment*  
“Data Insights”  
Automated Agent  
Game Theory?  
*Decision Analytics*  
?

**Care Tasks**

Prevent  
Detect  
Diagnose  
Treatment  
Monitor

**Goal**

Clinician  
Patient

LIFE
Barriers towards saving lives

**Technology**

- Predict (cross-sectional)
  - Score, classify
- Forecast (future predict)
  - Risk assessment
  - “Data Insights”
  - Automated Agent
  - Game Theory?
  - Decision Analytics

**BARRIERS**

?  

**Goal**

LIFE
Barriers towards saving lives

**Technology**

Predict (cross-sectional) *score, classify*

Forecast (future predict) *Risk assessment*

“Data Insights”

Automated Agent

Game Theory? *Decision Analytics*


**BARRIERS**

Methods

- Heterogeneous human variables + noisy language
- Multi-level
- Temporal
- Causal Models
- Trust Preservation

**Goal**

Predict (cross-sectional) *score, classify*

Forecast (future predict) *Risk assessment*

“Data Insights”

Automated Agent

Game Theory? *Decision Analytics*
Language, a human behavior, often more predictive than traditional assessments alone.

- study in people’s “own words”.
- nearly infinite conceptual resolution.
- longitudinal context.