From policy to practice: Insights from U.S. Army administrative data into Soldier performance

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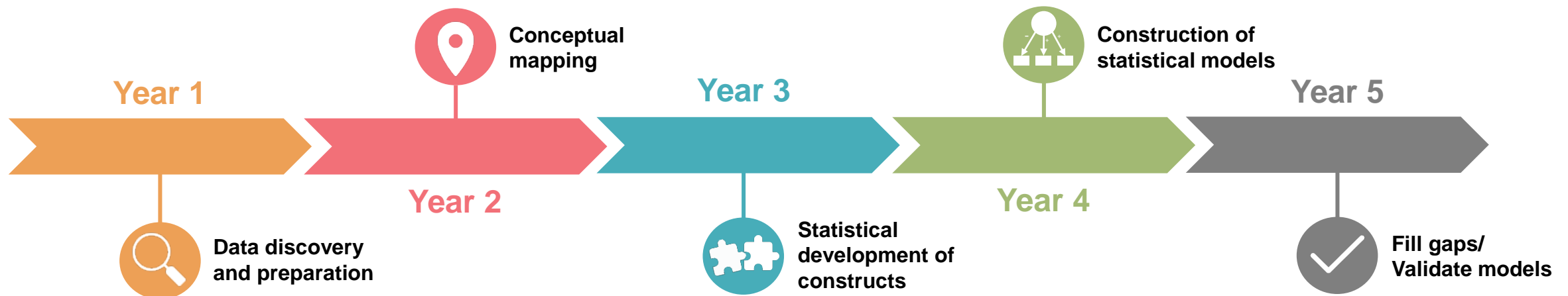Army Research Institute for the Behavioral and Social Sciences (ARI)

UNIVERSITY *of* VIRGINIA

BIOCOMPLEXITY INSTITUTE

Leveraging Archival Data to Predict Performance

Project: Use modern data science techniques to develop models that integrate existing DOD data to make predictions about Soldier behavior and performance.

Payoff: Knowledge about how best to utilize data from disparate sources to form a holistic picture of Soldier and unit performance that can be used to:

- Improve training
- Identify informative performance metrics
- Optimize talent management decisions across Soldier lifecycle

Year 1 — Data discovery and preparation

Year 2 — Conceptual mapping

Year 3 — Statistical development of constructs

Year 4 — Construction of statistical models

Year 5 — Fill gaps/ Validate models

What is Performance?

Start with the literature

- 1980 congressional mandate led to seminal research performance (e.g., Project A)
- Widely adopted by those outside military (e.g., academia, business)
- Researchers developed frameworks

Frameworks: Campbell et al., 1993 & 2015 and Koopmans et al., 2011

- Performance is **multidimensional, abstract, latent** construct
- Manifests as **behavior** → something people do and can be observed
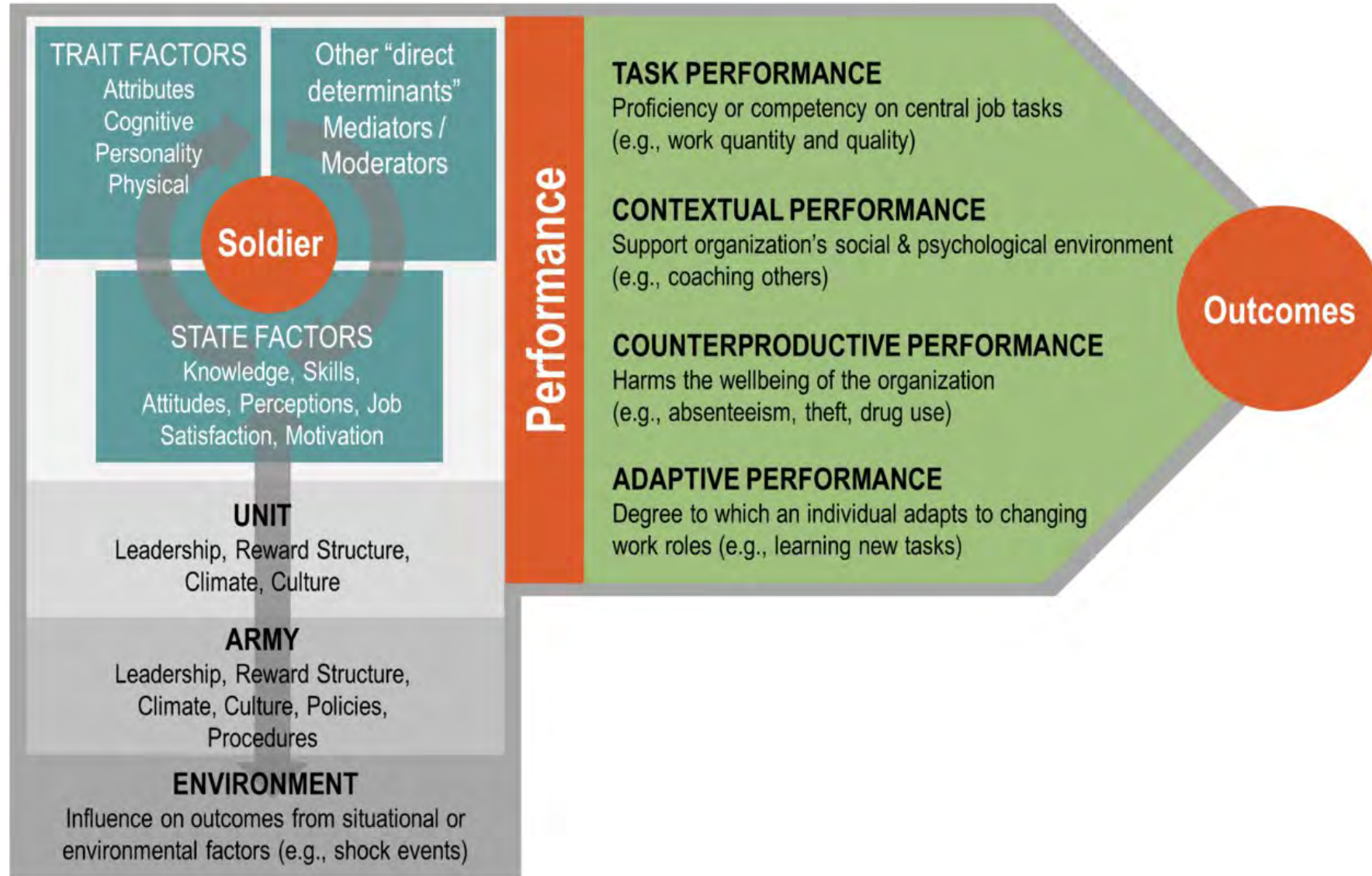- Behaviors relevant to **organizational goals**

Soldiers with Kentucky's CBRN Enhanced Response Force package (CERFP) breech and break team use a hammer drill to extract a victim from a rubble pile during an exercise evaluation at Camp Blanding, Fla., 9 January 2019. U.S. Army National Guard photo by Sgt. Taylor Tribble. https://www.flickr.com/photos/soldiersmediacenter/46128506494/
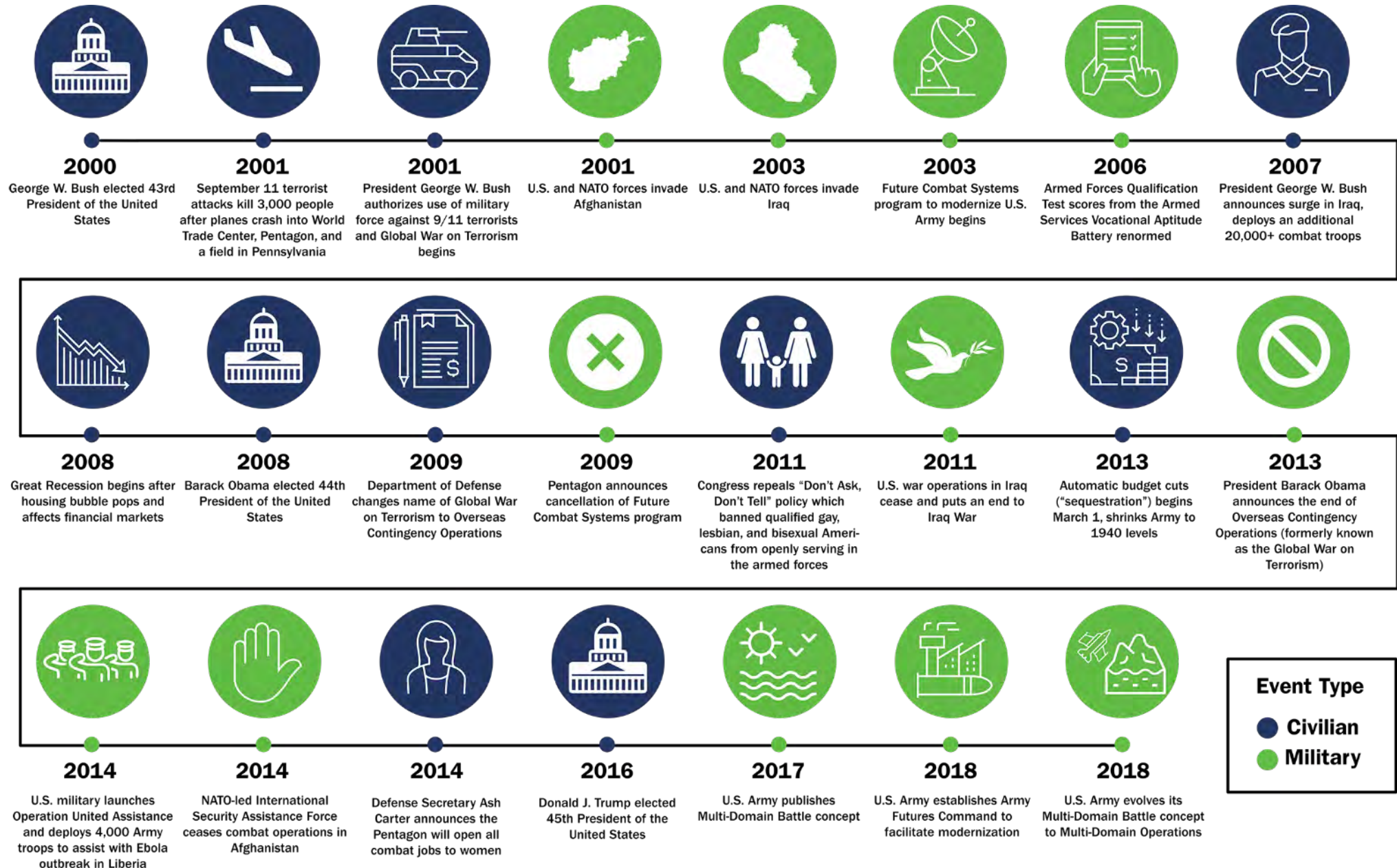

A U.S. Army Soldier provides perimeter security during an Iraqi police dismounted presence patrol in Kirkuk, Iraq, on 24 April 2007. The Soldier is from Charlie Company, 2nd Battalion, 35th Infantry Regiment, 3rd Infantry Brigade, 25th Infantry Division. DoD photo by Tech. Sgt. Maria J. Bare, U.S. Air Force. https://www.flickr.com/photos/soldiersmediacenter/497978091/

Conceptual Performance Framework

TRAIT FACTORS
Attributes
Cognitive
Personality
Physical

Other "direct determinants"
Mediators / Moderators

Soldier

STATE FACTORS
Knowledge, Skills, Attitudes, Perceptions, Job Satisfaction, Motivation

UNIT
Leadership, Reward Structure, Climate, Culture

ARMY
Leadership, Reward Structure, Climate, Culture, Policies, Procedures

ENVIRONMENT
Influence on outcomes from situational or environmental factors (e.g., shock events)

Performance

TASK PERFORMANCE
Proficiency or competency on central job tasks (e.g., work quantity and quality)

CONTEXTUAL PERFORMANCE
Support organization's social & psychological environment (e.g., coaching others)

COUNTERPRODUCTIVE PERFORMANCE
Harms the wellbeing of the organization (e.g., absenteeism, theft, drug use)

ADAPTIVE PERFORMANCE
Degree to which an individual adapts to changing work roles (e.g., learning new tasks)

Outcomes

Timeline of Major Events Relevant to the U.S. Army from 2000-2019

2000 — George W. Bush elected 43rd President of the United States

2001 — September 11 terrorist attacks kill 3,000 people after planes crash into World Trade Center, Pentagon, and a field in Pennsylvania

2001 — President George W. Bush authorizes use of military force against 9/11 terrorists and Global War on Terrorism begins

2001 — U.S. and NATO forces invade Afghanistan

2003 — U.S. and NATO forces invade Iraq

2003 — Future Combat Systems program to modernize U.S. Army begins

2006 — Armed Forces Qualification Test scores from the Armed Services Vocational Aptitude Battery renormed

2007 — President George W. Bush announces surge in Iraq, deploys an additional 20,000+ combat troops

2008 — Great Recession begins after housing bubble pops and affects financial markets

2008 — Barack Obama elected 44th President of the United States

2009 — Department of Defense changes name of Global War on Terrorism to Overseas Contingency Operations

2009 — Pentagon announces cancellation of Future Combat Systems program

2011 — Congress repeals "Don't Ask, Don't Tell" policy which banned qualified gay, lesbian, and bisexual Americans from openly serving in the armed forces

2011 — U.S. war operations in Iraq cease and puts an end to Iraq War

2013 — Automatic budget cuts ("sequestration") begins March 1, shrinks Army to 1940 levels

2013 — President Barack Obama announces the end of Overseas Contingency Operations (formerly known as the Global War on Terrorism)

2014 — U.S. military launches Operation United Assistance and deploys 4,000 Army troops to assist with Ebola outbreak in Liberia

2014 — NATO-led International Security Assistance Force ceases combat operations in Afghanistan

2014 — Defense Secretary Ash Carter announces the Pentagon will open all combat jobs to women

2016 — Donald J. Trump elected 45th President of the United States

2017 — U.S. Army publishes Multi-Domain Battle concept

2018 — U.S. Army establishes Army Futures Command to facilitate modernization

2018 — U.S. Army evolves its Multi-Domain Battle concept to Multi-Domain Operations

Event Type
- Civilian
- Military

Research Question

How does U.S. Army policy & doctrine impact or contextualize the description of behaviors related to individual and team performance?

Analyses:

- Extract performance themes from Army policy and team science literature

- Examine changes in the conceptualization of performance in Army policy over time

- Analyze Army policy for mentions of performance behaviors

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Performance Themes: Corpus

Army administrative documents

- Officer Professional Development and Career Management (PAM 600-3)
- Army Leadership and the Profession (ADP 6-22)
- Evaluation Reporting System (PAM 623-3)
- Performance Evaluation Guide - Leadership Requirements Model and Example Behavioral Indicators (AR-623-23)
- Building Cohesive Teams Handbook
- Leader Development (FM 6-22)
- Leaders Guide to Team Building Handbooks
- Soldier's Guide (TC 7-21.13)

Team science literature

- Svyantek, D. J., Goodman, S. A., Benz, L. L., & Gard, J. A. (1999). The relationship between organizational characteristics and team building success. Journal of Business and Psychology, 14(2), 265-283.
- Cohen, S. G., & Bailey, D. E. (1997). What makes teams work: Group effectiveness research from the shop floor to the executive suite. Journal of management, 23(3), 239-290.

Performance Themes: Methods

- Manual Qualitative Coding
  - Initial coding by a team of 4 (inter-rater reliability tested with a group of 5)
  - Performed in Dedoose
- Topic Modeling
  - Latent Dirichlet Allocation (LDA)
  - Bayesian (probabilistic), unsupervised
  - Assumes topics consist of underlying sets of words
  - Performed using the topicmodels package

Qualitative Analysis Yields Performance Themes

- Identified 320 excerpts
- Tagged with 506 applications of 18 codes

Initial codes: (A-priori)

- Qualities of an Individual:
  - Responsibility
  - Intellectual efficiency
  - Adaptability
  - Team orientation
  - Commitment to serve
  - Communication
- Qualities of a Team:
  - Organizational Trust
  - Definition of Team Success
  - Team building
- Qualities of a Leader:
  - Leader development

Document coding and group discussion

Final codes

- Qualities of an Individual:
  - Responsibility
  - Intellectual efficiency
  - Adaptability
  - Team orientation
  - Commitment to serve
  - Communication
  - **Influence**
  - **Integrity**
  - **Cooperation**
  - **Negation of Positive Quality**

- Qualities of a Team:
  - Organizational Trust
  - Definition of Team Success
  - Team building
  - **Shared Vision**
  - **Diversity in Teams**
  - **Negative qualities**

- Qualities of a Leader:
  - Leader development

Topic Modeling Triangulates on Performance Themes

Manual Codes

- **Qualities of a Leader**
- **Leader Development**
- Organizational Trust
- Diversity in Team
- **Negative Qualities**
- **Team Success**
- **Shared Vision**
- **Team Building**
- **Responsibility**
- Cooperation
- **Influence**
- **Intellectual Efficiency**
- Negation of Positive Qualities
- **Adaptability**
- **Team Orientation**
- **Commitment to Serve**
- **Communication**
- **Integrity**

Bolded codes also appeared in automated analysis

Results of the 18 Term Topic Model

- Many manual codes appeared in topic models
  - Adaptability
  - Commitment to serve
  - Leader development
- Some manual codes did not appear in topic model
  - Negation of Positive Qualities
- One topic did not appear in manual codes
  - Family support

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Performance Concept Over Time: Corpus

- 45 Army Administrative documents from 1946-2021, including

    - **ADP 6-22: Army Leadership and the Profession**
    - Establishes the Army's concepts of leadership and leader performance (~130 pages)

- Items from the **Global Assessment Tool (GAT)** assessing social characteristics of Soldiers, e.g.

    - Spiritual fitness – "It is very much like me that my life has lasting meaning."
    - Friendship – "I do have someone to talk to when I feel down."

- Bonus: Center for Army Profession and Leadership (CAPL) document on the thematic changes in most of our corpus

ADP 6-22
ARMY LEADERSHIP
AND THE PROFESSION

JULY 2019
DISTRIBUTION RESTRICTION:
Approved for public release; distribution is unlimited.
This publication supersedes ADP 6-22 and ADRP 6-22, dated
1 August 2012 and ADRP 1, dated 14 June 2015.
HEADQUARTERS, DEPARTMENT OF THE ARMY
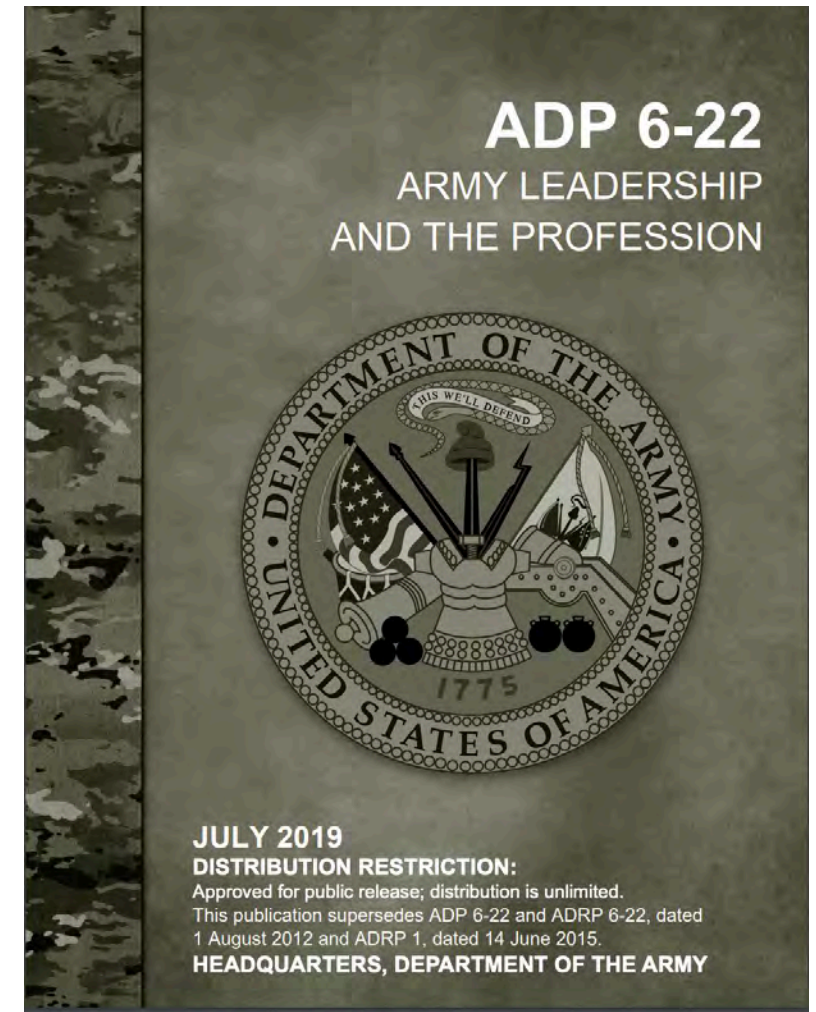
Performance Concept Over Time: Methods

- Large Language Models (LLMs)
  - Use deep learning to analyze vast amounts of text
  - Can be trained to perform general or specific tasks
- Bidirectional Encoding using Transformers (BERT)
  - Captures the **contextual relationships** between words in a sentence and across documents
  - Output is a numerical representation of documents (vectors)
  - Performed using bert-based-uncased
    - Pretrained model on English language
    - Also performed using GPT-2
- We compared documents by a distance measure (cosine similarity)
  - Also compared by clustering (using K-nearest neighbors)

The Concept of Performance Stays Relatively Similar Over Time

- Only three performance documents have a mean cosine similarity less than 0.6
  - Functional Manuals from 1957, 2002, and 2010
- There is slightly more cohesion in performance concepts since 2012
- Example of conceptual dissimilarity of the ADP 6-22: Army Leadership and the Profession (2017) and the AR 600-3: The Army Personnel Development System (1993)
  - Cosine similarity of 0.6

ADP 6-22 (2017)

Leadership is the activity of influencing people by providing purpose, direction, and motivation to accomplish the mission and improve the organization

AR 600-3 (1993)

Leadership is the process of influencing others to accomplish the mission by providing purpose, direction, and motivation

CAPL Definitions of Leadership

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ADP 6-22 (2017)

Leadership is the **activity** of influencing **people** by providing purpose, direction, and motivation to accomplish the mission and **improve the organization**

AR 600-3 (1993)

Leadership is the **process** of influencing **others** to accomplish the mission by providing purpose, direction, and motivation

- Leadership as an activity (versus process)
- Influencing people (versus others)
- Addition of improving the organization

CAPL Definitions of Leadership

Cosine Similarity between the Positive and Counterproductive Characteristic for Each Measure of the GAT

GAT Item	Cosine Similarity
adaptability	1
bad coping	1
catastrophizing	0.94
character	0.94
depression	0.99
family closeness	0.92
family satisfaction	0.92
family support	0.88
friendship	0.91
good coping	0.91
life meaning	0.92
loneliness	0.9
negative affect	0.92
non-work interests	0.89
optimism	0.89
organizational trust	0.84
positive affect	0.97
work engagement	1

BERT Does Not Discern between Positive and Counterproductive Performance Measures

"I am extremely satisfied with my marriage" ⟷ "I am not at all satisfied with my marriage"

- Overall the item text of positive and counterproductive psychosocial characteristics are highly similar
- Potential issues
  - Model specification
  - Translation of item text

Cosine Similarity between Each Measure of the GAT and the ADP 6-22

GAT Item	Cosine Sim.	GAT Item	Cosine Sim.
adaptability	0.99	adaptability	0.99
bad coping	0.91	bad coping	0.92
catastrophizing	0.9	catastrophizing	0.9
character	1	character	0.99
depression	0.9	depression	0.94
family closeness	0.99	family closeness	0.91
family satisfaction	0.91	family satisfaction	0.86
family support	0.89	family support	0.91
friendship	0.91	friendship	1
good coping	0.89	good coping	0.91
life meaning	0.89	life meaning	0.89
loneliness	0.92	loneliness	0.99
negative affect	0.89	negative affect	1
non-work interests	1	non-work interests	0.89
optimism	0.84	optimism	0.99
organizational trust	0.89	organizational trust	0.89
positive affect	0.91	positive affect	0.91
work engagement	1	work engagement	0.91

Performance Measures Align Conceptually with the ADP 6-22: Army Leadership

"I am extremely satisfied with my marriage"
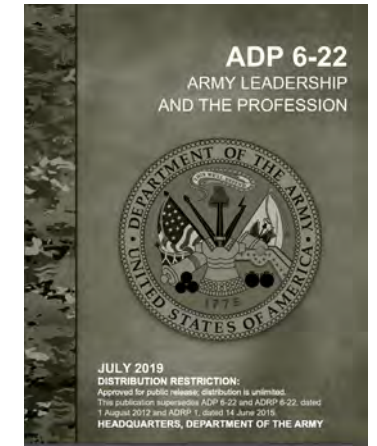
- Overall psychosocial characteristics are highly conceptually similar to the AR-623
  - Minimum cosine similarity of .84
  - Both positive and counterproductive performance

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Performance Behaviors: Corpus

- STP 21-1-SMCT (Soldier's Manual of Common Tasks: Warrior Skills Level 1) from 2021
  - One of several training documents for Soldiers
  - Describes training plans
  - Summarizes Soldier tasks

Performance Behaviors: Methods

- Verb Extraction and Co-occurrence
  - Tagged parts of speech and extracted verbs, extracted co-occurring words in sentences
  - Performed using udpipe
    - Distinguishes part-of-speech in context of a sentence

It is important for a Soldier to **use** good judgement*

A Soldier knows the importance of the **use** of good judgement*

*Example not reflective of text in Soldier's Manual of Common Tasks: Warrior Skills Level 1

Performance Behaviors: Methods

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  - Tagged parts of speech and extracted verbs, extracted co-occurring words in sentences
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    - Distinguishes part-of-speech in context of a sentence

It is important for a Soldier to **use** good judgement*

Use = Verb in context

A Soldier knows the importance of the **use** of good judgement*

Use = Noun in context

*Example not reflective of text in Soldier's Manual of Common Tasks: Warrior Skills Level 1

The Warrior Skills Manual Contains Examples of Performance Behaviors

Counts of the Top 10 Most Frequent Verbs in the Warrior Skills Manual

Lemmatized Verb	Count
use	435
figure	270
go	245
identify	214
do	202
perform	155
have	150
move	129
ensure	126
provide	123

Counts of Each Unique Verb in the Warrior Skills Manual, Ordered by Frequency

- Overall, 13.2% of words in the Warrior Skills Manual are tagged as verb part of speech
- 1,179 unique verbs
- Co-occuring words
  - E.g. "use" cooccurs with
    - People e.g. ("Soldier", "student")
    - Objects e.g. ("map", "compass")
    - Qualifiers e.g. ("without", "must")

Summary

- We find several topics relevant to Soldier performance
  - Helps identify variables for selection in performance models
  - Provides a backdrop for results of performance models
- We find that the way performance has been conceptualized by the Army has shifted over time, but has ultimately remained very similar
  - Backed up by internal Army sources, e.g., CAPL
- We find that psychosocial characteristics and performance behavior are somewhat difficult to measure using large language models
  - Not discerning between positive performance and counterproductive performance
  - Relatively high cohesion overall
    - Could be an issue of item-text writing or the generalized training dataset for models

Recommendations for Future Research

- Inform the development and interpretation of performance models
- Explore other uses of large language models
  - Training models on an Army-specific corpus
  - Models trained to work on short text
- Showcase computational complements to large-scale human-led metadata tracking projects
  - i.e., Tracking of leadership themes by CAPL