Exploring a Dynamic Model of Trust Management
Presentation

Dr. Charlene Schwartz / Dr. Joseph Lyons / Dr. Kevin Eschleman
Air Force Research Laboratory
711 Human Performance Wing
Wright-Patterson AFB OH 45433

Dr. Mei Hua Lin
Sunway Univ., Malaysia

Dr. Fang Chen
NICTA, Australia

Dr. Asif Khawaja
NICTA, Australia

Dr. Natalie Ruiz
Formerly NICTA, Austria

Ms. Johanna Culbertson
SRA

Ms. Corinne Wright
Formerly AFRL

Dr. Patrick Clark
Formerly AFRL

AUGUST 2013
Interim Report for July 2011 – July 2013

DISTRIBUTION A. Approved for public release; distribution unlimited.
NOTICE AND SIGNATURE PAGE

Using Government drawings, specifications, or other data included in this document for any purpose other than Government procurement does not in any way obligate the U.S. Government. The fact that the Government formulated or supplied the drawings, specifications, or other data does not license the holder or any other person or corporation; or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.

Qualified requestors may obtain copies of this report from the Defense Technical Information Center (DTIC) (http://www.dtic.mil).

AFRL-RH-WP-TR-2014-0013 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

//signature//

Charlene Schwartz, Ph.D.
Work Unit Manager
Human Trust and Interaction Branch

//signature//

Louise Carter, Ph.D.
Chief, Human-Centered ISR Division
Human Effectiveness Directorate
711th Human Performance Wing
Air Force Research Laboratory

This report is published in the interest of scientific and technical information exchange, and its publication does not constitute the Government’s approval or disapproval of its ideas or findings.
Exploring a Dynamic Model of Trust Management Presentation

Dr. Charlene Schwartz/Dr. Joseph Lyons / Dr. Kevin Eschleman
Dr. Mei Hua Lin (Sunway Univ., Malaysia) / Dr. Fang Chen (NICTA, Australia)
Dr. Asif Khawaja (NICTA, Australia) / Dr. Natalie Ruiz (formerly NICTA, Australia)
Ms. Johanna Culbertson (SRA) / Dr. Patrick Clark / Ms. Corinne Wright (formerly AFRL)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)
Air Force Research Laboratory
711 Human Performance Wing
Human Effectiveness Directorate Human-Centered ISR Division
Human Analyst Augmentation Branch
Wright-Patterson AFB OH 45433

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-RH-WP-TP-2014-0013

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A. Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
88ABW-2014-1127; Cleared 20 March 2014

14. ABSTRACT
To critically evaluate, via a series of empirical studies, existing trust paradigms to explore their implications for trust in western and non-western cultures, and reveal situational moderators that influence the relationship between trustworthiness indicators and trust. Deliverables to include, but not limited to, model development, publications, empirical foundation for guidebook development.

15. SUBJECT TERMS
Trust, culture

16. SECURITY CLASSIFICATION OF:

<table>
<thead>
<tr>
<th>a. REPORT</th>
<th>b. ABSTRACT</th>
<th>c. THIS PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>U</td>
<td>U</td>
</tr>
</tbody>
</table>

17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SAR</td>
<td>47</td>
<td>Dr. Charlene Schwartz</td>
</tr>
</tbody>
</table>

19b. TELEPHONE NUMBER (include area code)

Standard Form 298 (Rev. 8-98) Prescribed by ANSI Std. Z39.18
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title Presentation Sheet</td>
<td>1</td>
</tr>
<tr>
<td>Air Force Relevance</td>
<td>2</td>
</tr>
<tr>
<td>Trust = Influence</td>
<td>3</td>
</tr>
<tr>
<td>The Trust Process</td>
<td>4</td>
</tr>
<tr>
<td>Trustworthiness: Ability, Benevolence, Integrity (ABI)</td>
<td>5</td>
</tr>
<tr>
<td>Cultural Norms</td>
<td>6</td>
</tr>
<tr>
<td>Individualism-Collectivism</td>
<td>7</td>
</tr>
<tr>
<td>Cognitive Load</td>
<td>8</td>
</tr>
<tr>
<td>Personal Relevance</td>
<td>10</td>
</tr>
<tr>
<td>Method</td>
<td>12</td>
</tr>
<tr>
<td>Task 1 – Trust Rating</td>
<td>14</td>
</tr>
<tr>
<td>Task 2 - Job Selection</td>
<td>15</td>
</tr>
<tr>
<td>Task 3 - Ranking</td>
<td>16</td>
</tr>
<tr>
<td>High Cognitive Load</td>
<td>17</td>
</tr>
<tr>
<td>Preliminary Results Job Selection</td>
<td>18</td>
</tr>
<tr>
<td>Preliminary Results Trust Ratings</td>
<td>19</td>
</tr>
<tr>
<td>Preliminary Interpretation</td>
<td>20</td>
</tr>
<tr>
<td>Dynamic Model of Trust</td>
<td>22</td>
</tr>
<tr>
<td>Dynamic Trust Model Project – Overall Objectives</td>
<td>23</td>
</tr>
<tr>
<td>Conceptual Model of Trust</td>
<td>24</td>
</tr>
<tr>
<td>Trust and Cognitive Load</td>
<td>25</td>
</tr>
<tr>
<td>Hypotheses and Expected Outcomes</td>
<td>26</td>
</tr>
<tr>
<td>User Study Design and Testing Tool</td>
<td>27</td>
</tr>
<tr>
<td>User Study Design and Data</td>
<td>28</td>
</tr>
<tr>
<td>Project Progress Overview</td>
<td>30</td>
</tr>
<tr>
<td>Data Collection and Analysis Summary</td>
<td>31</td>
</tr>
<tr>
<td>Analysis Summary</td>
<td>33</td>
</tr>
<tr>
<td>Next Tasks</td>
<td>40</td>
</tr>
</tbody>
</table>
Exploring a Dynamic Model of Trust Management

Principal Investigator (PI): Dr. Charlene Stokes (Air Force Research Laboratory (AFRL))

Co-PI: Dr. Joseph Lyons (AFRL)

Senior Personnel:
Dr. Mei Hua Lin (Sunway Univ., Malaysia – Asian Office of Aerospace Research and Development (AOARD) PI)
Dr. Fang Chen (National Information and Communications Technology Australia (NICTA, Australia – AOARD PI)
Dr. Asif Khawaja (NICTA, Australia)
Dr. Natalie Ruiz (formerly NICTA, Australia)
Dr. Kevin Eschleman (formerly AFRL / San Francisco State Univ.)
Ms. Johanna Culbertson (SRA International Inc.)
Dr. Patrick Clark (formerly AFRL)
Ms. Corinne Wright (formerly AFRL)

AFOSR Program Review – Socio-Cultural Modeling/Collective Behavior
(14-17 January 2013, Dayton, OH)

Distribution A. Approved for public release; distribution unlimited.
88ABW-2014-1127, cleared 20 March 2014
Air Force Relevance

• Current influence domain (e.g., Influence Operations, Joint Targeting Cycle, Military Deception, Psychological Operations) must adapt to meet the demands of irregular warfare
  
  – “A one-size-fits-all deterrence strategy will not suffice in the future joint operating environment. Such an approach assumes that we fully understand the thought processes, strategic culture, and value hierarchy and can precisely ascertain ‘red lines’ of the enemy” (Joint Operating Environment, 2010; p. 64).

• The necessary *Precision Influence* can be realized through basic and applied research in the social sciences

  **Precision Influence represents a theoretically-driven model for behavioral influence**
Trust = Influence

• Developing and applying theoretical-driven and empirically supported models of trust is a key leverage point
• Trust is a critical factor driving human decision making and behavior
  – Key determinant of influence (Sweeney et al., 2009)
  – …of automated tools use (Lee & See, 2004)
  – …of performance & positive work attitudes (Dirks & Ferrin, 2002)
  – …of ability to adapt (Stokes, Lyons, & Schneider, 2011)

Trust: Willingness of an individual to accept vulnerabilities from others based on positive expectations (Mayer et al., 1995)
The Trust Process

Beliefs & Perceptions  Attitudes  Intention  Behavior

Trust Propensity

Cognitive Calculation

Trustworthiness

Trust

Intention

Behavior/Decision-making

Trustor Attributes
- Cultural norms
- Personal relevance

Trustee Attributes
- Ability
- Benevolence
- Integrity

Intentions translate to behavior depending on environmental and cognitive constraints e.g., Cognitive load, situation awareness, social networks

Modified model based on Lee & See (2004), Mayer et al. (1995), and Colquitt et al. (2007).
Trustworthiness: Ability, Benevolence, Integrity (ABI)

• Parsimonious foundation of trustworthiness indicators (Mayer et al., 1995)
  – Ability: that group of skills, competencies, and characteristics that enable a party to have influence within some specific domain.
  – Benevolence: extent to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive.
  – Integrity: perception that the trustee adheres to a set of principles that the trustor finds acceptable.

• To date, there have been no such studies that have empirically tested this model in different cultures.
Cultural Norms

• Foundational psychological processes are dependent, in part, on the surrounding culture within which individuals live (Fiske, Kitayama, Markus, & Nisbett, 1998)

• Culture has been defined according to several dimensions which are believed to influence the mechanisms through which people evaluate self and others, situations, and relationships (Fiske et al., 1998; Hofstede, 1980; Huff & Kelley, 2003)
  – Individualism-Collectivism
  – Power Distance
  – Masculinity-Femininity
  – Uncertainty Avoidance
Individualism-Collectivism

- Individualism: Characterized by strive for independent success, formulate and evaluate self based on personal goals, make independent choices, and base decisions on utility
  - Greater value for utility and personal empowerment (Fiske et al., 1998)
  - U.S. managers use more task-related appeals as influence tactic (Fu & Yukl, 2000)

H1: Participants from an individualistic culture will rate trust higher when trustee ability is high
Individualism-Collectivism Continued….

• Collectivism: characterized by value of the group above self, emphasize relationships and group goals, motivated to maintain harmony, and evaluate life based on collective needs

  – Greater value for relationships and social harmony (Fiske et al., 1998)
  – Asian managers use more relationship-oriented appeals as influence tactic (Fu & Yukl, 2000)

H1: Participants from an collectivistic culture will rate trust higher when trustee benevolence is high
Cognitive Load (CL)

- CL represents the load that performing a particular task imposes on the cognitive system and is a key component of human information processing (Paas et al., 1994; Parasuraman et al., 2000).
- Increased CL leads to entrenchment of established behaviors in relation to user interfaces (Oviatt et al., 2004).
- The Affect Infusion Model (Forgas, 1995) suggests that during faster processing, individuals use their affective states as a short-cut to infer their evaluative reactions to a target.
  - Similar process may occur with reliance on cultural norms as a heuristic during high CL.

H3: CL will interact with culture such that culture effects will be strongest under high CL.
Personal Relevance

Relative impact of ABI indicators may vary according to the type of activity to be performed

- **Action-oriented (direct involvement)**
  - Ability strongest trust predictor for situations where teams worked on a joint project (Serva et al., 2005)

  **H4: Participants will select applicants with higher ability in direct involvement situations (e.g., direct supervisor)**

- **Judgment-oriented**
  - Integrity strongest trust predictor in politically sensitive situations, e.g., performance appraisal system (Mayer & Davis, 1999; Mayer et al., 1995)

  **H5: Participants will select applicants with higher integrity in judgment-oriented situations (e.g., non-profit org)**
Personal Relevance Continued....

- **Relationship-oriented** (limited empirical evidence)

  H6: Participants will select applicants with higher benevolence in relationship-oriented situations (e.g., co-worker)
Method

- **Design:** 3 (culture) x 2 (cog. load) x 3 (ABI), mixed
- **Target N = 120 per country (U.S., Malaysia, Australia)**
  - U.S. sample classified as individualistic, Malaysian as collectivistic, consistent with previous taxonomies (Fiske et al., 1998)
  - Australian sample will serve as a comparison group for the more traditional individualistic and collectivistic nations
  - Participants recruited from local universities

- **Measures**
  - Audio recording
  - Trust Propensity (8-item; Mayer & Davis, 1999)
    - “One should be very cautious with strangers.”
Method Continued....

- Trust (10-item; Mayer & Davis, 1999)
  - “If I had my way, I wouldn't let this person have any influence over issues that are important to me.”*

- CL (manipulation check)
  - “Please rate your mental effort in the task you just performed.”
Task 1 – Trust Rating

---

**Applicant 59-Q**

**Project Manager/Consultant at Bing and Jakobson, Inc.**

**Education**

Earlham University, 1996
Bachelor of Arts: Business Finance

"Is kind and caring toward others. Goes well above and beyond the call of duty to look out for other students’ best interests." - Professor of Business Finance

**Volunteer Experience and Personal Interests**

Community Dancing Club, 1996 - Present
Member

- Assisted in the organization and planning of dancing lessons and events.

"Bends over backwards to help you out whenever possible. Has always been particularly good to me." - Co-Club Member

**Experience**

Bing and Jakobson, Inc., 2003 - Present
Project Manager / Consultant

- Responsibilities: Developed formal presentations for potential customers, the delivery of a final product to customers under strict deadlines, and development of team building exercises.

- "Puts forth an extra effort to support others. Takes good care of the employees." - Executive Supervisor

Creations 4 Us, 1995 - 2003
Human Services Manager

- Responsibilities: Organization and development of training programs for customer care relations

**ABI Manipulations (benevolence)**
Task 2 – Job Selection

- **Benevolence**
  - Applicant 59-Q
  - "Is kind and caring toward others. Goes well above and beyond the call of duty to look out for other students' best interests.", Professor of Business Finance
  - "Puts forth an extra effort to support others. Takes good care of the employees.", Executive Supervisor
  - "Bends over backwards to help you out whenever possible. Has always been particularly good to me.", Co-Club Member

- **Ability**
  - Applicant 47-S
  - "Consistently demonstrated strong skills on class projects and understanding of course material.", Professor of Management
  - "A good employee who's technical know-how is widely regarded as state-of-the-art.", Executive Supervisor
  - "Proficient and competent while completing work. Performs quality work. Always gets things done well.", Co-Club Member

- **Integrity**
  - Applicant 69-K
  - "Acts on the up and up from what I've seen and heard. Always fair and honest.", Professor of Business Finance
  - "Has a strong moral foundation. Always does the right thing even in morally difficult situations.", Executive Supervisor
  - "Is honest, just, and impartial without fail.", Co-Club Member

- **Neutral**
  - Applicant 24-V
  - "Judgment is not always ethically sound.", Professor of Business
  - "Does not have a strong set of principles. Lacks a moral center.", Executive Supervisor
  - "We have known each other for about two years.", Co-Club Member

Drag and Drop the applicant to a position.
Please select the level of confidence you have in your decision.

Your Supervisor:
- Drop Applicant Here
- Unselected

Co-Worker:
- Drop Applicant Here
- Unselected

Other's Supervisor:
- Drop Applicant Here
- Unselected

Continue
Task 3 – Ranking

<table>
<thead>
<tr>
<th>Rank</th>
<th>Applicant</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Applicant 59-Q</td>
<td>Is kind and caring toward others. Goes well above and beyond the call of duty to look out for other students' best interests., Professor of Business Finance</td>
</tr>
<tr>
<td>2</td>
<td>Applicant 47-S</td>
<td>Consistently demonstrated strong skills on class projects and understanding of course material., Professor of Management</td>
</tr>
<tr>
<td>3</td>
<td>Applicant 68-K</td>
<td>Acts on the up and up from what I've seen and heard. Always fair and honest., Professor of Business Finance</td>
</tr>
<tr>
<td>4</td>
<td>Applicant 24-V</td>
<td>Judgment is not always ethically sound., Professor of Business</td>
</tr>
</tbody>
</table>

Please rank all applicants from best (1) to worst (4) choice for each position.

Your Supervisor:

(1) Drop Applicant Here
(2) Drop Applicant Here
(3) Drop Applicant Here
(4) Drop Applicant Here
High CL
Preliminary Results
Job Selection

- CL manipulation successful
  - High $M$: 3.625, Low $M$: 3.037; $t(72)=5.201, p<.001

- ABI indicators predicting Position Selection
  - Appears ABI model only predictive under low CL

<table>
<thead>
<tr>
<th>Low CL Condition</th>
<th>% of time selected for position of ..</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant</td>
<td>Supervisor</td>
</tr>
<tr>
<td>HiAbility</td>
<td>0.250</td>
</tr>
<tr>
<td>HiBenev</td>
<td>0.513</td>
</tr>
<tr>
<td>HiIntegrity</td>
<td>0.238</td>
</tr>
<tr>
<td>Neutral</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>1.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High CL Condition</th>
<th>% of time selected for position of ..</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant</td>
<td>Supervisor</td>
</tr>
<tr>
<td>HiAbility</td>
<td>0.250</td>
</tr>
<tr>
<td>HiBenev</td>
<td>0.350</td>
</tr>
<tr>
<td>HiIntegrity</td>
<td>0.400</td>
</tr>
<tr>
<td>Neutral</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Preliminary Results
Trust Ratings

Low CL

Ability

Benevolence

Integrity

High CL

Ability

Benevolence

Integrity

Trust

Propensity

Ability

Benevolence

Integrity

Trust

Propensity

.26*

.27*

.28*

.39

.19

.21

.22

.21

.36

.39*
Preliminary Interpretation

• ABI model did not hold under high CL conditions for personal relevance
  – Trust judgments based more on Trustor attributes and heuristic processing
  – Rational models of cognition and judgment (such as ABI model) fail to capture complex and dynamic nature of human choice and behavior in “the real world” where cognitive demands are high (Kahneman, 2003; Klein, 1993)
  – Kahneman distinguishes b/w:
    • Intuitive reasoning – rapid, automatic, affect-laden (used for High CL)
    • Objective reasoning – slow, effortful, evaluative (used for Low CL)
Preliminary Interpretation Continued…..

• Next Steps w/ remaining data collection:
  – Refine current analyses as needed and conduct primary hypothesis tests
  – Examine state affect and personality effects on trust judgments and position selection
  – Examine if cognitive effects hold in other cultures
  – Compare position selections based on ABI in other cultures
  – Ability approached significance under high CL; will another ABI indicator be significant (or close) in a collectivist culture?
Dynamic Model of Trust

1. **Effects of CL**

Grant AOARD-11-4056

Charlene Stokes, Joseph Lyons, Kevin Eschelman, Johanna Culbertson

US AFRL, Dayton

Mei Hua Lin
Dynamic Trust Model Project – Overall Objectives

• Explore the relative impact of the trustworthiness indicators in the dynamic trust model [Mayer, 1995]

• Three factors in the dynamic trust model:
  – Ability (competence), Benevolence (goodness) and Integrity (reliability/predictability)

• Strength/contribution of each aspect of the trust judgment may vary:
  – By the type of activity being performed e.g. depending on the role the trustee is to take (friend, nanny, or boss)
  – CL in context – how mentally demanding the other tasks are while you are making the judgment
  – By culture e.g. individualistic vs. collectivistic cultural influences – competence vs. benevolence
Conceptual Model of Trust

[Lee & See, 2002; Colquitt et al., 2007; with additions by Stokes, 2010]

**Inputs**
- Personality Cultural Factors
- Sensor Attributes
  - Purpose, process and performance dimensions that describe the goal-oriented characteristics of the agent

**Beliefs & Perceptions**
- Trust Propensity
  - Cognitive calculation
- Trustworthiness

**Attitudes**
- TRUST
  - Defined as an attitude: affective evaluation of beliefs (self-report measure)

**Intention**
- Intention

**Behavior**
- BEHAVIOR
  - Automation use (route choice-RHXS)
  - Depth of sensor meta-info reviewed

**Error Feedback**

Intentions translate to behavior depending on environmental & cognitive constraints
- Workload, situation awareness, and self-confidence of the operator
Trust and CL

- Trust is “willingness of an individual to accept vulnerabilities from others” [Mayer95]
- CL is “a multidimensional construct that represents the load that performing a particular task imposes on the cognitive system” [Paas94].
- Central to the importance of CL is the working memory.
- Working memory is defined as a “limited capacity system, which temporarily stores information, and supports human thought processes by providing an interface between perception, long-term memory and action” [Baddelley2003].
- Increased CL leads to overload of the working memory resources [Baddelley2001] and change in the established cognitive behaviour [Oviatt2004]
Hypotheses and Expected Outcomes

- Cognitive processes are involved in cognitive trust and affective trust
- CL manipulations are likely to affect the thought process
- CL manipulations are more likely to affect/disrupt cognitive trust
  - e.g. gauging the suitability of a job candidate for the manager role or as a colleague
- Load manipulations are less likely to affect judgement whether a person is trustworthy enough to be a friend
- Expect to find greatest difference in experienced CL in decisions involving manager/colleague than friend *
- Cultural factors can affect the interdependence of CL and trust, such that cultural biases in trust will be exacerbated under high CL.
User Study Design and Testing Tool

• HR Applicant Screening Tool
  – Developed in-house, cross-platform custom application that incorporates all data collection, Dual versions (high CL and low CL)
  – Several design, story boarding, wireframe iterations
User Study Design and Data

• Study Design
  – **Tasks**: Rating, Positioning, and Ranking job applicants
  – **CL** (High vs Low): dual task (queuing job applicants)
  – Manipulation of **trustee**: my manager, my colleague, others’ manager
  – Manipulation of **trust** factors: ability, benevolence, integrity
  – Cultural: Malaysian, Australian, American (collectivistic, individualistic)

• Behavioural Measures
  – Speech: think-aloud protocol was used for CLM
  – Interactive Behaviour:
    • mouse trajectories, selection, typing, browsing activity (attentional focus)
User Study Design and Data Continued…

- **Performance Measures**
  - Time-to-completion; time to response; amount of speech
  - Performance on secondary task (queuing incoming applicants)
  - Trust ratings for different positions/roles
  - Rank ordering of the applicants into three categories/roles

- **Self Report Measures**
  - Subjective ratings of mental effort (Lickert scales)
  - Trust propensity
Project Progress Overview

• Internal Review Board (IRB) Approvals
  – All sites were approved.

• Pilots
  – Pre-pilot material and experiment tool design completed
  – Pilot experiments were conducted in mid-2011
  – Content/manipulations were tested for bias using Survey Monkey.
  – A student group from University of New South Wales (Australia) (UNSW) (30) participated

• Wright-Patterson team visited Sydney late August 2011
  – Trial runs, pilots and think-aloud tests, final interface designs
  – Planning for data collection, analyses and next stage proposal.

• Study/Participants
  – Australian group: 90 students from the University of Sydney participated in the user study in November 2011
  – Malaysian group: 130 students from Sunway University participated in the user study in July 2012
  – US group: data collection in progress
Data Collection and Analysis Summary

- **Australian data collection brief stats:**
  - 90 subjects completed both conditions (high and low CL)
  - 239 survey/response data points per subject
  - Speech data: 6.5Gb = 58 hours of speech
  - Interactive Behaviour: ~96 million data points
    - including mouse trajectories, selection, typing, browsing activity (attentional focus)
  - Speech transcriptions: ~80,000 words from effective speech
Data Collection and Analysis
Summary Continued….

- **Analysis of Data from Australian site:**
  - Subjective Analysis of CL
  - Performance Analysis
    - Completion times
    - Response times
    - Amount of speech (proportional speech, word count, words per sentence)
    - Dual-task performance
  - Behavioural Analysis
    - Linguistic data
    - Speech data
    - Mouse and interaction behaviour
Analysis Summary

• Analysis of Data from Australian site:
  – **Subjective Analysis** of CL (to validate the experiment design)
  – Collected at the end of both the high load and low load task sessions
  – Based on a 7-point Likert scale (1=“Extremely easy” and 7=“Extremely difficult”).
  – Mean ratings:
    - Low load: 3.037
    - High load: 3.625
    - \( t(72)=5.201, p<0.001 \)
Analysis Summary
Continued.....

- Analysis of Data from Australian site:
  - Performance Analysis
    - Completion times and Response times
    - On average, participants spent more time on high CL task than low CL task
    - On average, their response latency was higher under high CL task
    - Effective speech amount
      - Proportional speech – no difference under low and high CL (p=0.2)
      - Average word count – no difference (p=0.1) (confirming above)
      - Average # words per sentence – longer sentences under high CL task

![Graphs showing task completion time, response time, and words per sentence]
Analysis Summary Continued.....

• Analysis of Data from Australian site:
  – Behavioural Analysis
    – Linguistic Analysis of Speech Data
  • Over 70 participants’ speech being transcribed and annotated
  • Preliminary analysis results based on 55 subjects
  – Pause Analysis
  – Linguistic Category Analysis
Analysis Summary Continued.....

- Analysis of Data from Australian site:
  - Behavioural Analysis
    - Pause Analysis
      - On average, participants paused more under high CL task
      - On average, they also paused longer under high CL task than low CL task

![Graphs showing analysis results]
Analysis Summary
Continued.....

- Analysis of Data from Australian site:
  - Behavioural Analysis
    - Linguistic Category Analysis (based on Linguistic Inquiry and Word Count (LIWC) dictionary)

<table>
<thead>
<tr>
<th>Linguistic Categories</th>
<th>Example words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal pronouns</td>
<td>I, they, her, we</td>
</tr>
<tr>
<td>Impersonal pronouns</td>
<td>it, those, it's, that</td>
</tr>
<tr>
<td>Adverbs</td>
<td>very, really, quickly, mostly</td>
</tr>
<tr>
<td>Negations</td>
<td>no, not, never, neither</td>
</tr>
<tr>
<td>Quantifiers</td>
<td>few, many, much, fairly</td>
</tr>
<tr>
<td>Swear words</td>
<td>damn, shit, fuck, piss</td>
</tr>
<tr>
<td>Affective (emotional) processes</td>
<td>happy, cry, glad, afraid</td>
</tr>
<tr>
<td>Positive emotions</td>
<td>nice, sweet, cool</td>
</tr>
<tr>
<td>Negative emotions</td>
<td>ugly, nasty, bad, fail, sorry</td>
</tr>
<tr>
<td>Anxiety</td>
<td>worried, fearful, nervous</td>
</tr>
<tr>
<td>Anger</td>
<td>hate, kill, annoyed</td>
</tr>
<tr>
<td>Sadness</td>
<td>sad, grief, cry</td>
</tr>
<tr>
<td>Cognitive processes</td>
<td>know, cause, opinion</td>
</tr>
<tr>
<td>Insight</td>
<td>think, know, consider</td>
</tr>
<tr>
<td>Causation</td>
<td>hence, effect, because</td>
</tr>
<tr>
<td>Discrepancy</td>
<td>should, would, could</td>
</tr>
<tr>
<td>Tentative</td>
<td>maybe, perhaps, guess</td>
</tr>
<tr>
<td>Certainty</td>
<td>always, never, absolutely</td>
</tr>
<tr>
<td>Achievement</td>
<td>win, hero, ability, perform</td>
</tr>
<tr>
<td>Assent</td>
<td>agree, ok, yes, cool</td>
</tr>
<tr>
<td>Trust</td>
<td>trust, believe, sure</td>
</tr>
<tr>
<td>Distrust</td>
<td>doubt, disbelieve, suspicious</td>
</tr>
</tbody>
</table>
Analysis Summary
Continued.....

- Analysis of Data from Australian site:
  - Behavioural Analysis
    - Linguistic Category Analysis (based on LIWC dictionary)

<table>
<thead>
<tr>
<th>Percentage Category</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Negative Emotion Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Swear Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Anger Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Tentative Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Certainty Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Achievement Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Trust Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>% of Distrust Words</td>
<td>0.0</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Distribution A. Approved for public release; distribution unlimited.
88ABW-2014-1127, cleared 20 March 2014
Analysis Summary
Continued.....

- Analysis of Data from Australian site:
  - Behavioural Analysis
    - **Signal Analysis** of Speech data
      - Data cleaning (e.g. remove cross-talk, segmentation) completed
      - Initial CL Models were built
      - Initial analysis completed
      - Automatic classification of CL levels showed **63% performance**
      - Currently working to improve the results.
    - **Mouse and interaction behaviour analysis**
      - Mouse interaction data cleaning completed
      - Mouse interaction features identified for analysis
      - Currently in the process of developing Machine Learning (ML) method to classify CL
Next Tasks

- Finalize Linguistic analysis
- Speech analysis – refine CL models
- Interaction analysis
  - ML method to be refined to analyse mouse interaction data
  - Selection and Typing data analysis
- Performance analysis
  - Analysis of rating/ranking performance
  - Dual-task performance
- Relationship between CL and individual Trustworthiness (ABI) judgements
- Intercultural analysis
  - Comparison of data collected from all three sites (USA, Malaysia, Australia)
- Consolidating findings from the three sites
- Write-up of findings
- Publication of findings
- Final Year Report
QUESTIONS?

CONTACT: CHARLENE.STOKES@WPAFB.AF.MIL
# LIST OF ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abbreviation/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI</td>
<td>Ability Benevolence, Integrity</td>
</tr>
<tr>
<td>AFRL</td>
<td>Air Force Research Laboratory</td>
</tr>
<tr>
<td>AOARD</td>
<td>Asian Office of Aerospace Research and Development</td>
</tr>
<tr>
<td>CI</td>
<td>Cognitive Load</td>
</tr>
<tr>
<td>IRB</td>
<td>Internal Review Board</td>
</tr>
<tr>
<td>LIWC</td>
<td>Linguistic Inquiry and Word Count</td>
</tr>
<tr>
<td>ML</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>NICTA</td>
<td>National Information and Communications Technology Australia</td>
</tr>
<tr>
<td>PI</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>UNSW</td>
<td>University of New South Wales</td>
</tr>
</tbody>
</table>