Cognitive Performance Indicators

11 indicators for determining how a system supports or hinders
users' sensemaking and decision-making abilities

Recognition-Primed Decisions

Under conditions of time pressure, uncertainty, and change, people use their experience to make rapid and effective decisions without generating and comparing a set of options. Fewer decisions are made using formal analysis processes (i.e., assigning weights to options).

1. Option Workability

Systems should enable users to determine quickly if an option is workable. Systems that require users to generate or compare alternative options hinder users' ability to act in time-pressured and rapidly-changing situations. Experienced users evaluate options individually, focusing on imagining how an option would be carried out to determine if it is workable.

Pattern Matching

People use patterns to size up a situation, judge it as familiar, and recognize a course of action that makes sense. A pattern is a set of cues that usually chunk together so that if you see of few of the cues you can expect to find the others.

2. Cue Prominence

Systems should allow users to rapidly locate key cues from the information presented. Representing all information as equal and presenting as much of it as technologically possible on a display reduces users' ability to recognize patterns. To recognize patterns, users generally make use of only 5-10 key cues. Additional information competes with and reduces the visibility of these cues.

3. Direct Comprehension

Systems should allow users to directly view key cues rather than requiring users to manually calculate information to comprehend these cues. In real-world settings, users' attention and memory are often scarce resources. Systems that only present data in a stove-piped format force users to manually integrate individual pieces of data to comprehend key cues. This hinders users' ability to track and recognize patterns as the demands of their work increase.

4. Fine Distinctions

Systems should allow users to investigate or at least access unfiltered data. Systems that remove variances and "noise" from data representations hinder users' abilities to spot anomalies and detect fine distinctions in a situation. Experienced users pay attention to small changes, differences, or absences to recognize patterns. Users don't need to always see unfiltered data, but they want the opportunity to investigate it.

Mental Simulation

People use mental simulation to make sense of a current situation by imagining how it arose and anticipate how a situation will play out in the future.

5. Transparency

Systems should provide access to the data that it uses and show how it arrives at processed data. Making the workings of systems invisible hinders users' ability to understand how processes work. Users build mental models about how system processes are supposed to perform and what to expect from them in various situations. These mental models permit users to remember how a process was performed in the past or predict how it will perform in the future.

6. Enabling Anticipation

Systems should provide information that allows users to anticipate the future states and functioning of systems. It is not enough for systems to inform a user about what it is doing and why. Users need

to know what the system will do next and when, so they can form expectancies about what will occur in the future. It is only through forming expectancies that users can notice the absence of events that were expected to happen (i.e., expectancy violations). Expectancy violations allow users to detect problems and then use mental simulation to diagnose them.

7. Historic Information
Systems should capture and display historic information so that users can quickly interpret situations, diagnose problems, and project the future. Limiting historic information hinders users' ability to recover from problems and decide on a course of action. When faced with unexpected or unexplained situations, users rely on historic data to build a story about what is currently happening. To build this story, users examine historic information to interpret trends, understand data inter-relationships, compare data, and identify key cues such as shifts and anomalies in data.

Active Engagement

Engagement refers to a user's approach toward carrying out his or her work. Systems can hinder users' ability to actively engage by putting them in monitoring, passive, and/or management roles.

8. Situation Assessment
Systems should help users form their own assessment of a situation rather than provide decisions and recommendations. Systems that provide decisions have been shown to increase decision times and errors. Decision times increase because users do not work independently of system recommendations. Instead, users treat recommendations as additional data points that need to be taken into account before making a decision. Errors increase because users become reliant on systems for what they should do and thus are more likely to follow system decisions that are incorrect or faulty. Users need to form their own assessment of a situation through pattern matching and mental simulation to make rapid and effective decisions.

Adaptability

Complex real-world settings are characterized by ill-defined problems, time pressure, changing conditions, and uncertainty. In these settings people need to be able to adapt and react rapidly to be successful.

9. Directability
Systems should support the directing and redirecting of system priorities and resources so that users can effectively adapt to changing situations. Users want to focus the computational power of systems on particular problems to assist them in their problem solving, especially when users have information that is not available to systems.

10. Adjustable Settings
Systems should allow users to refine and adjust settings as they learn more about a situation. Requiring users to decide on settings in advance and keep them in place makes it difficult to solve ill-defined problems. Ill-defined problems require users to change the way they study data as they learn more about a situation. Consequently, in real-world settings users often have to adjust settings rather than keep them constant.

11. Flexibility in Procedures
Systems should allow users to modify the order of the steps in procedures as doctrine changes or situations call for flexibility. Systems that lock in procedures or exact harsh penalties for not carrying out procedures in the correct order force users to follow inappropriate or out-of-date procedures. In real-world settings, users face non-routine situations where modifications will be necessary. Experienced users know when steps have to be followed and when to make exceptions.

Cognitive Performance Indicators (CPI) Q&A

Q: Why "Cognitive?"

A: We created the CPI to bring together research and experience that was not ready to hand for practitioners and developers. The CPI have a different focus from existing heuristics such as Nielsen's usability heuristics. The CPI address systems that support human expertise, in allowing it to develop and allowing expertise to be used where it exists.

Q: Where did the CPI come from?

A: Thematic analysis of Cognitive Systems Engineering literature on how the design of systems impact a person's cognitive performance. Researchers whose work formed a significant contribution include:

- Dr. Gary Klein
- Dr. David Woods
- Dr. Robert Hoffman
- Dr. Mica Endsley
- Dr. Kim Vicente

Q. How do I start using the CPI?

A: The CPI are a great way to introduce and foster a cognitive orientation in a project, product or organization.

Some ways to get started with the CPI:

- conduct your own review of the product using the indicators
- have outside experts conduct a review
- evaluate a competitive or previous generation product
- observe existing evaluations and report using the indicators to structure the results and provide explanation of the results
- host a 1.5 day workshop on using the indicators for developers and SMEs
- create a Cognitive Performance Case for your product
- create a custom version of the extended indicators for your domain/product

Q: What would a small effort to conduct a review look like?

A: Outline for CPI Expert Review:

1. Domain Familiarization
   a. learn about the work the system is used for though reading and interviews
   b. define focus of evaluation and domain tasks to use in evaluation
2. Conduct the Review
   a. 2-5 reviewers independently inspect interface in the context of domain tasks using the indicators
   b. each reviewer records findings
3. Analyze and Present Results
   a. Synthesize results across all reviewers following the indicators
   b. Create report or presentation
   c. Engage stakeholders in conversation about challenges and opportunities for system

Q: What has been published about the CPI?

Wiggins, S.L, & Cox, D.A. (in preparation), System Evaluation using the Cognitive Performance Indicators. In Patterson, E.S. and Miller, J. *Macrocognition Metrics and Scenarios: Design and Evaluation for Real-World Teams.* Ashgate Publishing. ISBN 978-0-7546-7578-5.

Brown, J., Kosnick, L., & Cox, D. A. (2007). *Enhancing an application for dynamic management of system capacity using cognitive assessment indicators.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society 51st Annual Meeting, Baltimore, MD.

Long, W., & Cox, D. A. (2007). *Indicators for identifying systems that hinder cognitive performance.* Paper presented at the Eighth International Conference on Naturalistic Decision Making, Asilomar, CA.

Notes