

SOLVING A RUBIK'S CUBE

A Model for the Relationship Between HOP & Cognitive Ergonomics

By Casandra Schroeck

Human and organizational performance (HOP) asks safety professionals to reconsider how people actually think and perform work in complex systems. Rather than assuming that errors result from a lack of rules or discipline, HOP draws attention to how work is done under varying conditions and cognitive demands.

A foundational concept that supports this perspective is the distinction between knowledge-, rule- and skill-based performance, originally described by Jens Rasmussen (1983). Knowledge-based performance occurs when individuals are reasoning through a problem, actively interpreting information and forming decisions in unfamiliar situations. Rule-based performance relies on learned procedures and follows an “if this, then that” cadence, which is often developed through experience or training. By contrast, skill-based performance is largely automatic and fluid, requiring little conscious thought once mastery is achieved. While safety systems often assume that more rules will drive safer outcomes, HOP challenges us to recognize that each mode of thinking has limits and that safety is shaped not just by what rules exist, but by which cognitive mode a task demands in a given moment.

Cognitive ergonomics provides a useful lens for understanding why certain tasks push workers out of systems-level thinking and into rule-dependent focus. While traditional ergonomics emphasizes physical fit, cognitive ergonomics examines how work design affects perception, attention, memory load, decision-making and the ability to concentrate without interruption. Factors such as poor visual and auditory clarity, information overload, interruptions, multitasking demands, unclear instructions, and inadequate tools can significantly increase cognitive strain, which can create additional risk during safety-critical tasks.

Cognitive ergonomics supports removing barriers that inhibit skill-based thinking. As a safety professional, I was an early adopter of this mindset. I wanted to do less rule-based work myself. I did not enjoy writing and reviewing

programs, developing risk assessments for routine tasks or spending hours delivering training that felt disconnected from real work. I assumed that most workers, like me, wanted to see the big picture. Repetitive, rule-based work (“work done right”) felt boring, and over time, it often led to shortcuts—what is commonly described as process drift. If that was the case, why were all workers not striving for skill-based performance instead?

If we all thought in systems, I believed, the world would be a safer place—and maybe I could stop writing so many procedures and programs and tracking performance indicators. This version of safety nirvana felt clear to me for a long time—until I learned how to solve a Rubik’s Cube. Not only did I learn how to solve it, I found that I could teach others the methods, steps and thought process. Well, except for the last four corners.

The method I learned relied on a storytelling algorithm, which made it immediately clear how my brain prefers to learn. The first step involved creating a “daisy”: a yellow center with four white “petals.” For me, this was a knowledge-based process. I could orient myself around the cube and anticipate where a white tile would land with minimal instruction. I could see the system for what it was and form the daisy with essentially one guiding rule.

Next, the daisy is rotated until the perpendicular color matches its corresponding center, and that edge is rotated down to form the white cross. Again, I did not need step-by-step rules like “rotate clockwise 90°.” I could visualize the system, understand the effect of my movements, and complete the task with a single prompt.

The next story involved the “elevator move” to complete the remaining corners of the first layer. The solver finds

a white-faced cube, moves it out of the “elevator’s path,” which allows it to travel upward, and returns it home. Although this maneuver involves several steps, I only needed the story. I could still see the system, anticipate outcomes and place the cube correctly. The second layer required remembering two rules related to cube orientation, but again, with minimal prompting, I could complete the task. Errors were easy to correct by returning to the rule or shifting my perspective of the cube and making small adjustments.

For me, the last layer is where that all goes out the window. In the final layer, specific move sequences must be executed to preserve the progress made in the first two layers. While the story still helps, I found myself repeating the exact wording of the steps over and over. However, if I became distracted, I could usually recover by repeating a sequence. That is, until the final four corners.

The final sequence for solving a Rubik’s Cube is often called “the finisher.” This is where I could no longer see the system. Executing these moves appears to scramble the cube, creating the illusion that everything achieved so far is being undone. In that moment, I cling to the rules. I repeat: up, over, down, over, up, over, down, over. I could no longer rotate the cube to inspect it. If I stopped mid-sequence, I could not recover. This last step requires complete focus, even if only for a few seconds. That realization caused me to reflect deeply on HOP principles and cognitive ergonomics.

Everyone’s threshold is different. For some, the second layer may be where intense focus begins and rule-based thinking becomes dominant. Others, with greater experience or aptitude, may have no difficulty visualizing the system even in the final layer and may already be moving on to different or faster cubes. For me, the learning was not in mastering this puzzle, but in recognizing where my cognitive limits appeared.

This raises important questions for the workplace. When cognitive ergonomics and HOP-informed performance thinking

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are so individual, how do we know whether we are creating unnecessary rules, the right amount of structure or not enough? What about safety-critical tasks?

Safety-critical work does not need to be complex. But when it is, where do we intentionally support focus during those delicate moments? Consider an electrician working on energized equipment in full PPE, or a pipefitter working at heights while manipulating valves and reading pressure gauges. How do our risk assessments support those “third-layer” moments, when a worker may be clinging to rules because systems-level thinking is no longer available?

I am not proposing that we evaluate workers based on their ability to solve a Rubik’s Cube. However, there are existing methods worth considering. Some organizations use aptitude or ability tests, such as the Bennett Mechanical Comprehension Test (Bennett, 2008), to understand technical troubleshooting capability. These tools should not be used to exclude workers, but to inform task design, training and support strategies. Safety professionals can use this type of information to better anticipate the level of support an individual may need during complex or safety-critical tasks.

Other tools, such as lockout/tagout audits, inspections and peer-to-peer observations, could incorporate other questions that challenge the system by asking more what-if questions. These approaches help safety professionals understand how cognitive load and ergonomic stressors vary across individuals and tasks. But, where else can the individualization of work being done be examined?

As Sidney Dekker (2014) has noted, the bureaucracy of documentation and work instructions can become counterproductive and even weaponized. If workers followed every instruction exactly as written, work would rarely get done. The real process often lives in the notebook carried in a

uniform pocket. Those notes represent the third layer. They are passed down, refined through experience and relied upon in moments requiring intense focus. Safety professionals should understand where workers are most likely to cling to rules and how to support those moments.

This support may already exist in familiar forms: barricades, clear aiseways, stop work programs and housekeeping standards. But where else can cognitive stressors be reduced? That is where HOP and cognitive ergonomics meet: not in eliminating rules, but in understanding when rules are necessary, when systems thinking is possible and how to support people at the edge of their cognitive capacity. Perhaps the next evolution of HOP is not deciding whether to write rules, but learning when to step back, create space and protect focus. Especially when work enters its third layer. **PSJ**

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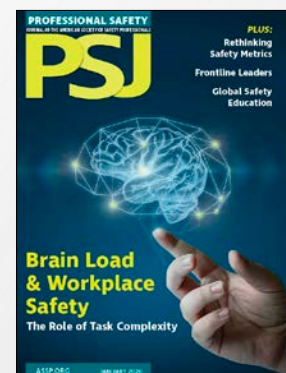
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SUPPORTING COGNITIVE PERFORMANCE

- Identify cognitive demands.** Recognize whether tasks require knowledge-, rule- or skill-based performance, and design work accordingly.
- Protect focus.** Reduce interruptions, multitasking, information overload and unclear instructions during safety-critical tasks.
- Find the “third layer.”** Use observations, audits and what-if questions to identify moments when workers must rely heavily on rules and intense concentration.
- Right-size procedures.** Provide enough structure to support safe work without creating unnecessary rules that encourage workarounds or process drift.
- Individualize support.** Use experience, aptitude and worker feedback to anticipate where individuals may need additional training, guidance or task support.
- Create cognitive space.** Apply controls such as barricades, clear work areas and stop-work practices, and look for more ways to reduce cognitive stressors.