Accelerating the Acquisition of Intuitive Decision-Making through Expertise-Based Training (XBT)

Peter J. Fadde
Southern Illinois University
Carbondale, Illinois
fadde@siu.edu

ABSTRACT

Expert performers in many domains exhibit an uncanny ability to size up dynamic situations and to make good, fast, and largely unconscious decisions. These performers' cognitive processes can appear, to the performers as well as to observers, to be intuitive. This paper describes the instructional design theory of *Expertise-Based Training* (XBT) as a way to systematically train intuitive decision-making. XBT takes laboratory methods used in expert-novice research and repurposes them as computer-based training. In particular, XBT targets the recognition component of Gary Klein's Recognition-Primed Decision-Making (RPD) model. Recognition skills such as selective attention, pattern recognition, and situation awareness can be trained as a way of accelerating expertise in performance contexts that require quick decisions and immediate actions, including: emergency response, security screening, use-of-force, vehicle operation, interrogation, negotiation, medical and equipment diagnosis, and many others. XBT focuses solely on the recognition component of RPD, separate from skill execution, and can therefore be delivered on laptop computers and mobile devices. Despite being aimed at the still mysterious cognitive processes of intuitive decision-making XBT is in the tradition of Gagne and systematic design of instruction. XBT empowers an agile force by accelerating acquisition of the intuitive decision-making aspect of expertise that is increasingly acknowledged as both valuable and trainable.

ABOUT THE AUTHOR

Peter J. Fadde, Ph.D., is an associate professor and director of the Learning Systems Design and Technology graduate program at Southern Illinois University. Dr. Fadde earned his doctoral degree in Instructional Research and Design from Purdue University in 2002, has worked in video analysis for major sports teams, and has conducted research in the training of perceptual and decision skills in sports and other areas, including classroom teaching. Dr. Fadde can be reached at fadde@siu.edu.
Website: http://peterfadde.com

Accelerating the Acquisition of Intuitive Decision-Making through Expertise-Based Training (XBT)

Peter J. Fadde
Southern Illinois University
Carbondale, Illinois
fadde@siu.edu

INTRODUCTION

This paper describes the instructional design theory of *expertise-based training* (XBT), which draws on theories, findings, and laboratory methods of expertise research to design computer-based training (CBT) technologies that can accelerate the acquisition of expertise in the form of intuitive decision-making. XBT is in the tradition of Gagne and systematic design of instruction (SDI), but it changes the target from mass competence to individual expertise. Although expertise typically includes all five of Gagne's categories of learning (intellectual skills, cognitive strategies, verbal information, motor skills, and attitudes) it often includes a sixth category, intuitive skills, as well. As stated in the Office of Naval Research Basic Research Challenge – *Enhancing Intuitive Decision Making Through Implicit Learning*:

> Evidence is accumulating that this capability, known as intuition or intuitive decision making, enables the rapid detection of patterns in ambiguous, uncertain and time restricted information contexts, that it informs the decision making process and, most importantly, that it may not require domain expertise to be effective. (2012, p. 1).

XBT concepts can be employed to design instructional technologies that train intuitive decision-making in low cost, mobile, and flexible ways that empower an agile force by making expertise and expert performance attainable by more performers in less time – goals that Gagne would surely embrace.

In previous I/ITSEC papers, I reported on implementations of XBT methods in the widely disparate contexts of baseball batting (Fadde, 2010) and classroom teaching (Fadde, 2012; Fadde & Sullivan, 2013). Between these extremes lies a range of performance domains in which professionals as well as Warfighters rely on context-specific intuitive decision-making. While the full flower of expertise requires mastery of requisite knowledge and skills along with substantial and varied experience, XBT offers an approach to systematically training key aspects of intuitive decision-making *before* expertise is achieved. XBT builds on cognitive models of intuitive decision-making that are derived from the naturalistic study of expert performers in action (e.g., Klein, 1998). From a training perspective, naturalistic research and theory ground holistic training approaches such as workshops for intact groups (Klein, 2004). While holistic approaches can be highly effective and engaging they are inherently less efficient than instruction that is delivered on-demand to individual learners on mobile devices. XBT was developed as an instructional design theory that focuses on efficiency. So, the questions that have driven the development of XBT are:

- What can be done *earlier* in the development of expert performers to speed the process?
- What can be done *without removing* performers from the field?
- What can be produced and delivered *quickly* and *inexpensively* so it can change rapidly?
- What can be done *systematically* without undermining the implicit nature of expertise?

XBT leverages answers to these questions that have already been discovered in the research laboratories of cognitive psychologists studying expertise and expert performance. Specifically, XBT builds upon the *representative tasks* used in expert-novice research studies to reveal areas of expert advantage. Representative tasks are similar to real-world performance but are designed to be repeatable, observable, and measurable in the research laboratory. First in chess (e.g., Simon & Chase, 1973) and then in many areas, including sports, expert-novice studies have revealed a primary source of experts' performance advantage to be almost effortless pattern recognition and situation awareness (Fadde, 2009a).

Combining the findings and methods of expert-novice research with the theories and models of intuitive decision-making, XBT provides a theory-based approach to systematically and efficiently training recognition skills such as selective attention, pattern recognition, and situation awareness. Further, the XBT approach takes advantage of mobile devices such as tablet computers and smart phones to deliver instruction to in-service performers in the field and to pre-service trainees prior to field experiences.

In the next section I describe the theoretical foundations of XBT as an instructional design approach. I then use my baseball pitch recognition and classroom awareness training studies to illustrate key operational principles of XBT. In the final section I address several design issues and questions that instructional designers, training and simulation vendors, and those who commission training can use when assessing whether XBT is appropriate for particular performance domains, jobs, or skills.

RESEARCH AND THEORY FOUNDATIONS

Through field-based studies of expert performers Gary Klein developed the theory of Naturalistic Decision-Making (NDM) that describes the actual rather than the theoretical decision-making processes of expert performers in high-stakes, time-constrained situations, including fireground commanders, neo-natal emergency room nurses, and managers of deep-sea oil drilling platforms along with a variety of military command-and-control personnel (Klein, 1998). In such circumstances, experts don't compare alternatives in order to determine an optimal solution but instead engage in an apparently intuitive process that quickly produces a satisfying solution (Klein, 1998).

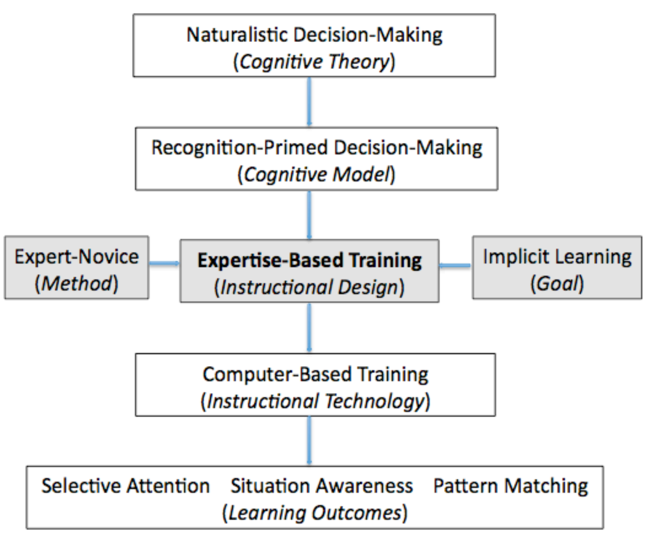

Figure 1. Theoretical Framework for Training of Intuitive Decision-Making with XBT

While NDM abstractly describes *what* expert decision makers do, Klein's Recognition-Primed Decision-Making (RPD) model depicts *how* experts are able to spontaneously generate solutions. In RPD, a situation is perceived and a solution appears to the decision-maker, who then mentally simulates execution of the solution. If the simulated result is acceptable, the decision/action is undertaken. If not, then the process is re-cycled to generate another solution (see Klein, 1998 for a full description of the RPD model).

Other theories of expert decision-making and performance are also available. In particular, John Boyd's O.O.D.A. Loop (Observation, Orientation, Decision, Action) theory, which was originally conceived in the context of air combat engagement, has been widely applied to organizational as well as individual performance in business as well as military contexts (Richards, 2004). Being aligned with Boyd's O.O.D.A. Loop theory no doubt played a role in Klein's theories being applied, especially by the Marine Corps, to re-conceptualizing military decision models (Ross, Klein, Thunholm, Schmitt, & Baxter, 2004).

Instructional design theorists consider RPD to be an expression of the highest levels of expertise, and thus not appropriate for training of novices or even competent journeymen (Jonassen, 2011). However, the word *primed* in the RPD model suggests that *recognition* is a distinct and preparatory stage of intuitive decision-making that is less complex and more appropriate for training efforts aimed at novice or journeyman performers. Modeling recognition as a separate and fairly low-level component opens a theoretical door to isolate this "low hanging fruit" and train it separately from the full RPD process. As is routinely done in the training of psychomotor performance, isolation of component skills facilitates focused and efficient training (Fadde, 2009b). XBT aims to gain similar efficiency by isolating recognition skills for targeted training. The question of *how* to train recognition skills in isolation from full performance of the skill is answered by repurposing the laboratory *methods* used in expert-novice research studies.

Expert-Novice Paradigm

Expert-novice research studies in a wide range of domains have revealed recognition skills such as *situation awareness* in aviation (Endsley, 2006) and *noticing* in classroom teaching (Sherin & van Es, 2005) to be the seat of expert performers' advantage over less skilled performers (for a rich collection of expert-novice studies in multiple domains see Ericsson, Charness, Feltovich, & Hoffman, 2006).

Sports expertise researchers have used expert-novice methods extensively to investigate expert performance in open sports, such as soccer and tennis, which involve reacting to an opponent (as opposed to closed sports, such as golf and gymnastics, that emphasize individual execution of skills). For example, Paull & Glencross (1997) used *video-occlusion* as a method to identify expert advantage in baseball batting. In a laboratory setting experts ("A" level Australian professionals) and novices ("B" level Australian professionals) were shown a point-of-view video display of an opponent pitcher delivering a pitch. Subjects were tasked to identify the type of pitch (fastball or curveball) and to predict the location of the pitch in the strike zone. The video display was cut to black (temporal occlusion) at various points in the flight of the ball.

When more than a third of ball flight was shown, experts and novices performed about the same on the *representative tasks* of identifying pitch type and predicting pitch location. With occlusion points earlier than moment-of-release (MOR) of the pitch both groups' performance was reduced to chance. Between those occlusion points, however, experts had a significant performance advantage. While both experts and novices suffered increasing decrement in performance as occlusion points approached MOR, the experts' advantage over the novices actually increased (Paull & Glencross, 1997). This study is typical of sports expertise research in not only affirming expert anticipation skills, but also precisely framing the window of expertise advantage. Both the findings and the laboratory methods can guide the design of highly focused recognition training.

Expert-Novice Methods in Sports Training

While sports expertise researchers are primarily interested in discovering the mechanisms of expert perceptual advantage, a number of researchers have directly applied research findings and methods to training the same skills (Ward & Williams, 2003). For example, I adapted the video-occlusion method to train baseball pitch recognition (see Figure 2).

Half of the batters on a college baseball team received video pitch recognition training. The other batters on the team acted as a control group and received extra batting practice. To create equivalent treatment and control groups the team's coaches ranked the batters by batting ability. I then paired adjacent batters in the coaches' ranking and randomly assigned one to the treatment condition and the other to the control group. Rank correlation of players' season batting statistics showed that the batters who received pitch recognition training performed significantly better ($p<.05$) on the measure of batting average (Fadde, 2010).

As depicted in Figure 3, the video-occlusion task has since been ported to a laptop computer version that I use for continuing research and training with high-performance athletes. The same research-based video-occlusion method is used in a lower-fidelity *iPad* app (Axon, 2012) that offers developing baseball players an inexpensive, self-directed, and mobile way to train an advanced batting sub-skill that has traditionally been assumed to come only with innate talent and massed experience (see Figure 4).

Figure 2. Video-Occlusion Laboratory Research

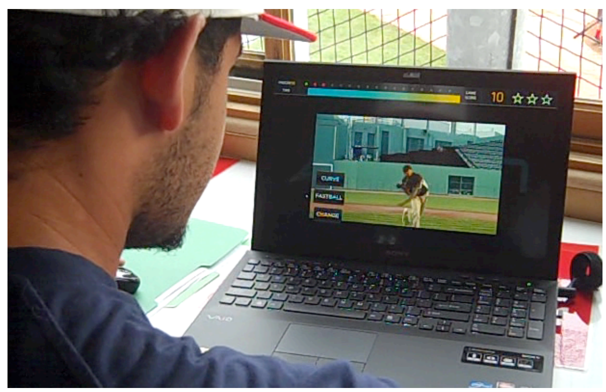

Figure 3. Video-Occlusion Research/Training

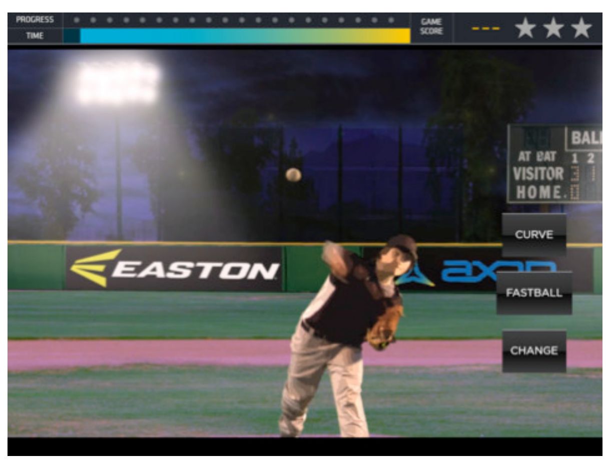

Figure 4. iPad app - Youth Training

Training baseball pitch recognition separate from psychomotor execution and improving the game batting performance of already advanced batters provides dramatic proof-of-concept for repurposing research tasks as training. Similar rapid-response sports skills such as return-of-serve in tennis and soccer goal keeping have also been successfully trained using video-occlusion methods. However, although these ballistically reactive sport skills (reaction times under one second) occur in open sports, they are much more contained in time and space than most non-sports performance skills and may not generalize widely.

Sport scientists have also used video-occlusion tasks to study anticipation in more tactical skills such as pass-dribble-shoot decision-making in basketball and soccer. Although less thoroughly researched, this type of sports decision-making is similar to more non-sports skills and may have wide applicability to the training of performance skills in military contexts (Ward, Farrow, Harris, Williams, Eccles, & Ericsson, 2008).

Comparing Figures 5 and 6 shows the similarities and differences between the video-simulation method commonly used in sports expertise research and a video-based simulation. Video-simulation involves showing research subjects video of an opponent's actions that the subject must respond with a decision. However, the video display does not change based on the decision or action made by the subject; the video-based task is interactive but not immersive.

Figure 5 depicts an experimental XBT task in which an American rules football player is viewing authentic opponent scout video that will cut to black (video-occlusion) shortly after the ball is snapped to begin the play. The player must recognize the opponent's offensive formation and predict the type of play (run or pass) based on viewing a very limited amount of the opponent's play. The goal of this recognition-only task is to improve the players' "pre-snap read" anticipation.

By comparison, the video-based use-of-force trainer shown in Figure 6 can be considered an immersive simulation because the video scenario branches based on simulated shots fired by a trainee. Clearly, recognition-only video-simulation training of use-of-force decision-making would not replace simulator training. However, recognition-only practice of use-of-force decision-making, delivered on a mobile device and using authentic field video, could provide law enforcement or military personnel with opportunities for concentrated practice prior to or in addition to simulator-based training.

Figure 5. Video-Simulation Training in Football

Figure 6. PRISim Judgment Training Simulator

As mentioned earlier, XBT is an *opportunity*-driven instructional approach. Isolating recognition skills for training, separate from skill execution, provides in-service or pre-service performers with a way to practice recognition skills using short and easily accessed training tasks. CBT technologies are limited, compared to simulators, in not responding to the psychomotor or verbal input of users by changing the visual display. Accepting this limitation, however, provides an opportunity for using authentic stimulus video rather than requiring the use of staged videos (as in Figure 6) or computer-generated visual displays that can change in response to trainees' actions.

Using Authentic Video for Training Recognition

Field video that is routinely recorded of traffic stops by highway patrol officers, interrogation of suspects, medical procedures, and myriad other performance situations can potentially be repurposed for training, adding not only efficiency but also authenticity in generating video training materials. Where video is not routinely recorded during field performance, it can often be purposefully recorded for training purposes using wearable point-of-view cameras, cameras mounted on vehicles, or remotely controlled cameras (for instance, first responders in HAZMAT settings).

An example of using authentic field video for recognition training is provided by a project in which I repurposed video of student teachers from a previous cohort to train the classroom *noticing* skills of pre-service teachers (Fadde, 2012). The construct of classroom noticing is well established in teacher education literature as an element of teacher expertise (e.g., Sherin & van Es, 2005). Expert-novice research studies also show that experienced teachers are better able to monitor student behaviors while still delivering a lesson (Feldon, 2007). The XBT design challenge was to devise a representative task that would use the available classroom video and would help novice teachers develop the classroom noticing (i.e., recognition) skills exhibited by expert teachers.

Implicit Learning Through Alignment of Novice and Expert Observations

Archived classroom videos showing student teachers were used to create a *classroom noticin*g task. Pre-service teachers (before student teaching) watched video clips (see figure 7) that were edited into short (1-2 minute) clips. The pre-service teachers then wrote a description of any behaviors they noticed that related to classroom management or student questioning, and that were significant enough that a clinical supervisor would bring them up in a 5-minute debrief with the student teacher shown in the videos. Three experienced teacher educators (experts) completed the same task and their observations were provided to trainees (novices) after the trainees had written own their observations. Trainees were directed to mentally negotiate differences between what they found to be worth noticing and what the experts had noticed before watching the next classroom video clip.

Figure 7. Student Teacher Classroom Video

This XBT method, called *video annotation with expert-model feedback*, can be used in a face-to-face teacher education course but can also be programmed as self-instructional CBT. Importantly, the learning that is cultivated in this instructional task is *implicit*, as called for in the ONR Basic Research Challenge. The trainees were not told what to look for in the classroom videos. Rather, the novice pre-service teachers worked to align what they noticed with what experts noticed.

Using Field Video as Trigger Video

Not only does video-annotation with expert-model feedback offer appropriately implicit learning, the method also addresses some of the limitations that come with using authentic field video as training material. Field video is often an impoverished depiction of complex and dynamic situations such as fires, arrests, and classrooms. However, when the field video is only used to *trigger* the observations of experts and novices then the limitations of the field video are largely circumvented. Indeed, the limitations of field video can provide both experts and novices with the opportunity to "see" what is *not* visible in the video. As Klein and Hoffman (1992) note, "Novices see only what is there; experts can see what is not there ... to visualize how a situation developed and to imagine how it is going to turn out" (p. 203).

Expert-Model Feedback

Using the observations of experts as feedback is also potentially problematic. Multiple experts with different training, experience, or disciplinary paradigms are likely to "see" different things in the same videos. But again, a limitation can serve the instructional goal of building intuitive expertise, which is not typically uniform across experts but that is (or should be) consistent within individual experts.

By focusing on recognition skills, separate from skill execution, XBT methods are able to not only work around but also to take advantage of the technological and pedagogical limitations of CBT to produce instructional activities that are appropriate for implicit learning of a key aspect of intuitive decision-making.

Referring back to the questions that drove development of the theory, XBT can:

- Be done *earlier* in the development of expert performers to accelerate the process.
- Be done on mobile devices *without removing* performers from the field.
- Be produced and delivered *quickly* and *inexpensively* so it can be changed rapidly.
- Be done *systematically*, but without undermining the implicit nature of expertise.

As an instructional design theory, XBT needs to demonstrate its utility as well as validity. Therefore, the following section considers a number of issues and questions related to design and implementation of XBT. This section does not yield a "how to" primer but rather illuminates the XBT design process in several settings in order to visualize it as a training approach.

XBT DESIGN ISSUES AND QUESTIONS

Skill Issues: ***Is the skill a good candidate for XBT?***
Sometimes recognition skills are the essence of performance, for example observation post, patrolling, and tracking skills in Marine Combat Hunter training (Carroll, Milham, & Champney, 2009). But recognition skills are also vital to the performance of trial lawyers and classroom teachers. Although these professions include considerable time spent in non-performance activities such as preparing materials they also feature a distinct stage of performance that involves situation awareness and reactive decisions.

The context of performance is also important, with Klein noting that, "An environment of high validity is a necessary condition for the development of skilled intuitions" (Kahneman & Klein, 2009, p. 524), meaning that the context of performance must have regularities that can be learned and associated with outcomes. For instance, poker, sports, and some warfare have high validity even as they feature substantial uncertainty. In my XBT studies, pitch recognition has very high validity and also fairly high certainty. Classroom teaching, on the other hand, has considerably lower validity because student behaviors are less predictable but still has enough regularity in the environment to reward training recognition skills.

An issue of particular concern in military contexts is achieving and maintaining high levels of proficiency in spite of varied assignments and redeployment (Hoffman, Andrews, & Feltovich, 2012). While just-in-time training can be used to teach or touch up on previously learned skills, the intuitive decision-making expertise than naturally comes with extensive and varied field experience may never be achieved. So, along with just-in-time learning to addresses requisite knowledge and skills, XBT can also be designed to sharpen the recognition skills that support intuitive decision-making, which may be required in a new assignment without the luxury of experience. Similarly, training of recognition skills can be incorporated into professional education programs in order to prime later acquisition of intuitive expertise after students enter into professional practice.

Task Issues: ***How do I design a representative task?***
Representative tasks devised for research purposes are small in scale and easily observed, measured and repeated. Representative tasks for expert-novice research are designed to reveal key aspects of expert performance but typically so not entail complete and authentic performance. The same characteristics guide the design of representative tasks for training. Most importantly, representative tasks are not miniatures of full performance but rather target cognitive sub-skills such as pattern recognition.

Although not exclusively making use of video stimulus materials representative XBT tasks often involve video, in part because of a focus on perceptual skills that are largely visual. And, as noted earlier, the video-simulation approach that requires learners to make decisions but doesn't require actions opens the door for using authentic field video in XBT tasks.

In some cases, as in sports, expert-novice studies provide both target skills and XBT methods. In other cases, a process of *cognitive task analysis* (CTA) may be justified to reveal experts' intuitive decision-making. CTA represents a wide range of methodologies from naturalistic inquiry (e.g., Crandall, Klein, & Hoffman, 2006)) to think-aloud protocols to deep interviewing and cross-referencing of multiple experts (Clark, Feldon, vanMerrienboer, Yates, & Early, 2007). CTA works on a much higher level than XBT in seeking to capture the overall knowledge, skills, and dispositions of experts in order to design curriculum.

If expert-novice research in an area doesn't suggest laboratory tasks to repurpose as training and full-scale CTA isn't justified then representative tasks can usually be devised that are similar to typical expert-novice laboratory tasks (Chi, 2006) that involve:

1) Recall,
2) Detection,
3) Categorization, and
4) Prediction.

The task that tends to be overlooked in simulator-based training is *detection*. As a trucker who I observed in a simulator said after being congratulated by other trainees on having executed an avoidance maneuver, "I knew something was going to happen; it's a simulator."

Obviously, it is not cost-effective to turn high-cost simulator time over to things *not* happening. Yet the reality for professional truck drivers, and performers in many other domains, is that the vast majority of time nothing that requires high cognitive engagement is happening. Indeed, one of the typical characteristics of expert performers is that they recognize when changing circumstances call for heightened awareness. Detection, then, is particularly appropriate for XBT specifically because it is not appropriate for simulator-based training. Indeed, in my classroom noticing task almost one-third of 20 video clips had *no* behaviors coded by any of the three experts as worthy of noticing.

One of the key design attributes of detection tasks is that they include not only target behaviors but also *thresholds* for selective attention, as represented by the instructions in the classroom noticing task to "note instances that are important enough to mention in a 5-minute debrief." Thresholds are especially important in performance domains such as security screening and radiology where giving full attention to any level of detection effectively shuts down the process. Performance of trainees versus experts on detection tasks can be judged using a *signal detection* paradigm: see what an expert sees (hit), don't see what an expert doesn't see (correct non-detection), see something that an expert doesn't (incorrect detection), or not see something that an expert did see (miss). In sophisticated XBT, a trainer may manipulate scoring schemes in order to emphasize maximizing hits or minimizing misses. For instance, training of intuitive decision-making by forward observation personnel may include being able to adjust their signal detection parameters based on circumstances or orders.

Expertise Issues: *How are experts designated?*
The name of the expert-novice paradigm suggests a distinction that can be vague or even misleading. In practice, XBT tasks that involve expert-model feedback, the experts should be advanced performers but not necessarily authorities. For examples, in an influential study of music conservatory students Ericsson, Krampe, and Tesch-Römer (1993) ranked the students according to performance measures used in the music school and divided the students at mid rank to set comparison groups of "experts" and "novices".

How do I "extract" expertise?
A key challenge in training expertise is extracting expert performers' knowledge, skills, attitudes and, especially, intuitions in ways that can be trained. Experts typically miss up to 70 percent of their cognitive processes when teaching a novice (Clark et al., 2007). As noted earlier, cognitive task analysis offers rigorous approaches to revealing, and crosschecking the cognitive processes of multiple experts. When targeted performance skills are both important and common conducting CTA and designing curricula based on it can produce substantial return on front-end investment in CTA by delivering instruction that is faster, for instructors and learners, as well as better (Clark et al., 2007).

In more circumscribed situations that don't justify full CTA having experts complete representative tasks reveals at least a portion of their expert processes and is not overly taxing on the experts, compared to CTA or having them act as Subject Matter Experts in designing training. Indeed, as Warfighters with highly valuable field expertise leave active roles, asking them to complete a set of representative tasks may provide a low impact method of extracting their expertise.

Platform Issues: *How do I deliver implicit training?*
Sports expertise studies have shown that *implicit* learning results in longer retention and better transfer to performance than explicit instruction. For example, in a study that involved training tennis players to recognize opponents' strokes subjects in an explicit learning condition who were told what cues to look for had less retention and transfer than subjects in an implicit training condition who were given immediate feedback on their task performance but were not given direct instruction on what to look for (Smeeton, Williams, Hodges, & Ward, 2005).

That implicit learning can be cultivated through "old fashioned" systematic design of instruction strategies seems counter-intuitive. Indeed, calls for implicit training of intuitive decision-making skills look first to immersive experiential learning and virtual environments (Cohn, Squire, Estabrooke, & O'Niell, 2013). However, while intuitive decision-making is naturally acquired as implicit learning through experience, instruction is an inherently unnatural activity. XBT methods such as *video-annotation with expert model feedback* are designed to cultivate implicit learning by having trainees continually compare and align their observations with those of experts, rather than having an instructor directly tell trainees what to look for in trigger video clips (Fadde & Sullivan, 2013).

Assessment Issues: How do I measure the effectiveness of recognition-only training?
My baseball pitch recognition training study enjoyed a unique opportunity to measure transfer of learning to full-context performance because baseball batting performance is routinely and thoroughly measured statistically (Fadde, 2010). However, such direct performance measures aren't usually available in other sports, much less in non-sports performances such as firefighting or classroom teaching.

Another way to determine the effectiveness of a recognition training program is through *quasi-transfer* of performance gains from one simulated environment to a higher fidelity simulated environment (Farrow, Chivers, Hardingham, & Sasche, 1998). In medical, military, and law enforcement contexts where simulator-based training is common, the simulator performance of trainees who completed XBT recognition training can be compared to the simulator performance of trainees who had not completed XBT.

Another method, again drawn from sports science, is to devise an *in situ* version of the laboratory task in order to measure near transfer of performance gains in the laboratory task to performance of the same task "live." For example, cricket batsmen have been fitted with occlusion spectacles that block subjects' vision of an actual cricket bowler delivering a ball, replicating the laboratory video-occlusion method and demonstrating transfer of learning (Mann, Abernethy, Farrow, Davis, & Spratford, 2010).

It's unlikely that those who design or commission training programs would go to the trouble and expense of using highly precise and instrumented assessment tools such as occlusion spectacles. However, the XBT approach of adapting expert-novice research methods for training purposes can include *in situ* assessment. For example, I have developed *attention occlusion* as a technique to both assess and facilitate near transfer of computer-based pitch recognition training to a live version of the same tasks. Attention occlusion involves a batter standing in the batter's box while a real pitcher practices pitching. The batter does not swing his bat but rather attempts to call out loud the type of pitch (e.g., fastball or curve) or location of the pitch (e.g., ball or strike) *before* the ball hits the catcher's mitt. With less than one-half second elapsing from release of a pitch to its arrival in the hitting zone, verbalizing the type or location of the pitch forces the batter to recognize the pitch within the tight temporal window of expert advantage. Although the technique is much less precise than occlusion spectacles, and therefore not appropriate for basic research, attention occlusion provides a simple way to affirm (if not precisely measure) transfer from a CBT environment to psychomotor performance.

CONCLUSION

As described by Herb Simon (1992): "The situation has provided a cue: This cue has given the expert access to information stored in memory, and the information provides the answer. Intuition is nothing more and nothing less than recognition" (as cited in Kahneman & Klein, 2009, p. 520).

Simon alludes to a level of recognition that includes both perceiving of cues in a situation and also making sense of the cues, *observation* and *orientation* in Boyd's OODA Loop model. Endsley's conception of *situation awareness* in aviation and *classroom noticing* as theorized by Sherin and van Es also include both perception and sense making. However, Klein's Recognition-Primed Decision-Making model opens a theoretical door to conceiving of a basic level of pattern recognition and selective attention that is a distinct perceptual-cognitive stage that is not truly part of the process but rather *primes* the process. This basic recognition component of intuitive decision-making is much less complex, and much more trainable, than the full RPD or OODA-Loop processes. Even trainees or early-stage performers who are not yet capable of executing the sort of automatic and intuitive decision-making displayed by expert performers can advance in their development by building a "piece of expertise."

XBT is an opportunity-driven instructional design approach that focuses on the relatively modest target goal of practicing recognition skills, early in the development of performers, without removing performers from the field (or before field internships), and using instructional strategies and technologies that are easy to change and that cultivate implicit learning.

The insight that underlies XBT is that the design of instructional strategies and technologies can be guided by the representative tasks that cognitive psychologists devise for expert-novice research studies. Perhaps because cognitive psychologists generally have limited funds, the representative tasks that they develop are not only repeatable and measureable but also affordable. Methods such as *video-simulation* represent a positive confluence of constraints and opportunities that force us to focus on those aspects of expert performance that can be observed and trained without eliciting the full performance.

Can XBT replace immersive simulator-based training? Certainly not. But the relationship between XBT and simulator-based training needs to be studied. They would seem to be complimentary technologies: low fidelity but portable methods such as video-simulation can target basic recognition skills and high fidelity simulator-based training can ensure transfer of learning. Essentially, XBT may have a role in *priming* trainees' performance in a simulator, leveraging more and higher level learning from valuable simulator time.

In summary, XBT concepts can be employed to design instructional strategies and technologies that train key recognition aspects of intuitive decision-making in low cost, mobile, and flexible ways that empower an agile force by making expertise and expert performance attainable by more performers in less time.

REFERENCES

Axon Sports (2012). Axon athletic brain trainer. Retrieved from https://itunes.apple.com/us/app/axon-athletic-brain-trainer/id543764969?mt=8

Carroll, M., Milham, L., & Champney, R. (2009). Military observation: Perceptual skills training strategies. *Proceedings of the Interservice/ Industry Training, Simulation, and Education Conference, 2009.*

Chi, M. T. H. (2006). Laboratory methods for assessing experts' and novices' knowledge. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), The Cambridge handbook of expertise and expert performance (pp. 167-184). Cambridge: Cambridge University Press.

Clark, R. E., Feldon, D., van Merriënboer, J. J. C., Yates, K, and Early, S. (2007). Cognitive Task Analysis. In J. M. Spector, M. D., Merrill, J. J. G. van Merriënboer, & M. P. Driscoll, M. P. (Eds.) *Handbook of research on educational communications and technology* (3rd ed., pp. 577-593). Mahwah, NJ: Lawrence Erlbaum Associates.

Cohn, J., Squire, P., Estabrooke, I., & O'Niell, E. (2013). Enhancing intuitive decision making through implicit learning. In D. D. Schmorrow & C. M. Fidopiastis (Eds.), *Foundations of augmented cognition*, proceedings of the 7th international conference on Augmented Cognition, July 2013. 401-409.

Crandall, B., Klein, G., & Hoffman, R.R. (2006). *Working minds: A practitioner's guide to cognitive task analysis.* Cambridge, MA: MIT Press.

Endsley, M. R. (2006). Expertise and situation awareness. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 633-651). Cambridge: Cambridge University Press.

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.) (2006). *The Cambridge handbook of expertise and expert performance*. Cambridge: Cambridge University Press.

Ericsson, K. A., Krampe, R., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, *100*(3), 363-406.

Fadde, P. J. (2009a). Instructional design for advanced learners: Training expert recognition skills to hasten expertise. *Educational Technology Research and Development*, *57*(3), 359-376. DOI: 10.1007/s11423-007-9046-5

Fadde, P. J. (2009b). Training complex psychomotor skills: A part-task approach. In K. H. Silber & R. Foshay (Eds.), *Handbook of training and improving workplace performance. Volume 1: Instructional design and training delivery* (pp. 468-507). San Francisco: Pfeiffer (International Society for Performance Improvement).

Fadde, P. J. (2010). Look 'Ma, no hands: Part-task training of perceptual-cognitive skills to accelerate psychomotor expertise. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference, 2010.*

Fadde, P. J. (2012). What's wrong with this picture? Video-annotation with expert-model feedback as a method of accelerating novices' situation awareness. *Proceedings of the Interservice/ Industry Training, Simulation, and Education Conference, 2012.*

Fadde, P., & Sullivan, P. (2013). Using interactive video to develop preservice teachers' classroom awareness. *Contemporary Issues in Technology and Teacher Education*, *13*(2). Retrieved from http://www.citejournal.org/vol13/iss2/general/article1.cfm

Farrow, D., Chivers, P., Hardingham, C. & Sasche, S. (1998). The effects of video-based perceptual training on the tennis return of serve. *International Journal of Sports Psychology*, *23*, 231-242.

Feldon, D. F. (2007). Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist*, *42*(3), 123-127.

Hoffman, R. R., Andrews, D. H., & Feltovich, P. J. (2012). What is "accelerated learning"? *Cognitive Technology*, *17*(1), 7-10.

Jonassen, D. (2011). Learning to solve problems: A handbook for designing problem-solving learning environments. New York: Routledge.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: a failure to disagree. *American Psychologist*, *64*(6), 515-526. DOI: 10.1037/a0016755

Klein, G. (1998). *Sources of power: How people make decisions*. Cambridge, MA: MIT Press.

Klein, G. (2004). *The power of intuition*. New York: A Currency Book/Doubleday.

Klein, G. A., & Hoffman, R. R. (1992). Seeing the invisible: Perceptual-cognitive aspects of expertise. In M. Rabinowitz (Ed.), *Cognitive science foundations of instruction* (pp. 203-226). Mahwah, NJ: Erlbaum.

Mann, D. L., Abernethy, B., Farrow, D., Davis, M., & Spratford, W. (2010). An event-related visual occlusion method for examining anticipation skill in natural interceptive tasks. *Behavior Research Methods, 42*(2*)*, 556-562. DOI: 10.3758/BRM.42.2.556

Office of Naval Research (2012). Enhancing intuitive decision making through implicit learning. *Naval Research Basic Research Challenge* (Special Notice 12-SN-0007). Retrieved from http://www.onr.navy.mil/~/media/Files/Funding-Announcements/Special-Notice/2012/12-SN-0007.ashx

Paull, G., & Glencross, D. (1997). Expert perception and decision making in baseball. *International Journal of Sport Psychology*, *28*, 35-56.

Richards, C. W. (2004). *Certain to win: The strategy of John Boyd, applied to business*. Philadelphia: Xlibris Corporation.

Ross, K. G., Klein, G. A., Thunholm, P., Schmitt, J. F., & Baxter, H. C. (2004). The recognition-primed decision model. *Military Review*, July-August, 6-10.

Sherin, M. G., & van Es, E.A. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of Technology and Teacher Education, 13*(3), 475-491.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist*, *61*, 394–403.

Smeeton, N. J., Williams, A. M., Hodges, N. J., & Ward, P. (2005). The relative effectiveness of various instructional approaches in developing anticipation skill. *Journal of Experimental Psychology: Applied*, *11*(2), 98-110.

Ward, P.**,** Farrow, D., Harris, K. R., Williams, A. M., Eccles, D. W., & Ericsson, K. A. (2008). Training perceptual-cognitive skills: Can sport psychology research inform military decision training? *Military Psychology, 20*, S71–S102.

Ward, P., Williams, A. M., & Hancock, P. A. (2006). Simulation for performance and training. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 243-262). Cambridge: Cambridge University Press.

Williams, A. M., & Ward P. (2003). Perceptual expertise: Development in sport. In J.L. Starkes & K.A. Ericsson (Eds.), Expert performance in sports: Advances in research on sport expertise (pp.219-247). Champaign, IL: Human Kinetics