Adapting a Sports Research Method to Accelerate Rapid Reaction Skills in Military and Law Enforcement

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

Mohammadreza Jalaeian
MacroCognition, LLC
Dayton, OH USA
mreza@macrocognition.com

ABSTRACT

From house clearing to carrier landings, warfighters must recognize rapidly changing aspects of the environment in order to select and execute appropriate actions in time frames that challenge simple human reaction time. Although research shows that the source of expertise in rapid reaction skills often is based more on "what you see" than on "what you do," training typically focuses solely on physical techniques. The challenge for trainers is to accelerate expertise in rapid reaction skills beyond physical components.

This paper describes a model for adapting training methods out of methods that expertise researchers use to observe and measure the perceptual-cognitive (what you see) components of rapid reaction skills. The model has worked in sports and we apply it in a law enforcement domain that maps more closely to military contexts. Like warfighters, law enforcement officers make rapid decisions and actions to protect themselves and control a situation. While different agencies teach different techniques and philosophies for use-of-force, all are enhanced by accurate and rapid recognition of potentially attacking motions made by subjects (civilians or suspects).

After identifying a rapid reaction skill, isolating a perceptual-cognitive component, and devising a representative task, the model suggests conducting an expert-novice study to verify that the target skill actually differentiates expert performers. Our study compared more and less experienced law enforcement officers on a video-occlusion test of *Attack Recognition*. Participants viewed videos of attacking and non-attacking movements by subjects. Video clips were edited to black screen (occluded) at various points during subjects' movements and test takers identified if the motion was an attack and, if so, what type (punch, kick, gun reach). Findings validated the video-occlusion task for attack recognition training that can be delivered on tablets and cell phones as a way to accelerate expertise.

ABOUT THE AUTHORS

Peter J. Fadde is a professor and director of the Learning Design and Technology graduate program at SIU. Dr. Fadde researches in expertise and expert performance, and has multiple awards and patents for sports training software. Dr. Fadde originated the Expertise-Based Training (XBT) instructional design theory that repurposes expertise research methods into expertise training methods.

Mohammadreza Jalaeian is a Postdoctoral Research Associate at ShadowBox LLC & MacroCognition LLC. He completed his Ph.D. in Learning Systems Design & Technology from Southern Illinois University. Dr. Jalaeian researches in expertise, decision making, training simulators, and human-machine interaction with a focus on explainable artificial intelligence systems.

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INTRODUCTION

Our goal is to accelerate expertise in high-speed, reactive performance skills. From house clearing to carrier landings, warfighters must recognize quickly changing aspects of the environment, then select and execute appropriate actions in time frames that sometimes challenge simple human reaction time. Yet expert performers routinely succeed, while appearing to have "all the time in the world." Although expert performers' remarkable skills are typically attributed to natural talent and/or years of experience, research suggests that expert levels of performance in reactive skills can be attained more quickly by focusing training initiatives on the perceptual side of perception-action skills, "what you see" rather than "what you do" (Fadde, 2009a).

This paper follows up on an earlier I/ITSEC paper that first proposed a model (see Figure 3) for transferring expertise research methods into practical training methods to accelerate expertise (Fadde, 2018) that traced a decades-long progression of *video-occlusion* from a laboratory research method into a technology for training the perceptual component of baseball batting. The earlier paper also described an in-progress study that applied the research-to-practice model in the domain of Law Enforcement. This paper reports the results of that study and draws implications for applying the research-to-training model to train rapid reaction skills in similar military contexts. The approach offers military trainers a way to systematically train critical components of rapid reaction skills using low-cost and portable technologies that can supplement immersive simulator and virtual reality training.

Figure 1 shows video-occlusion being used in a typical sports science research laboratory, circa 1999. Sport science researchers developed the video-occlusion method in order to study the *perceptual-cognitive* component of rapid reaction skills such as baseball batting (e.g., Paull & Glencross, 1997). Perceptual-cognitive refers to skills that involve sensory input but are largely cognitive. Over several decades, a large body of research has investigated perceptual-cognitive skills in multiple sports (e.g., return of serve in tennis, goalie play, batting in baseball, softball, and cricket) often using occlusion tasks in an expert-novice research framework. Not only has the method proven to be an effective way to reveal and measure perceptual-cognitive skills it also consistently has been shown to successfully train the same skills (Larkin et al., 2015).

Figure 1. Video-Occlusion in Lab and on a Tablet Computer (courtesy of *gameSense Sports*. Inc.)

In contrast to perceptual skills training, Figure 2 shows two generations of baseball batting simulators that are used to train the complete baseball batting skill. The *Pro Batter* simulator positions a pitching machine behind a video projection screen so that the video of a pitcher is projected onto the screen. The video of a pitcher is synchronized with the machine "throwing" a pitch through a disguised hole in the projection screen. The *Win Reality* virtual reality environment presents a 3D avatar of a pitcher viewed in a head mounted display. It affords a high level of immersion and control of the environment. However, while VR environments are rapidly evolving in realism and accessibility (Xie et al., 2021), the photo-realistic video used in the video-occlusion program offers authentic perceptual cues in the pitcher's motion and release of the pitch. Ideally, trainers leverage the benefits of multiple training technologies to accelerate the development of the very high-level reactive skill of baseball hitting.

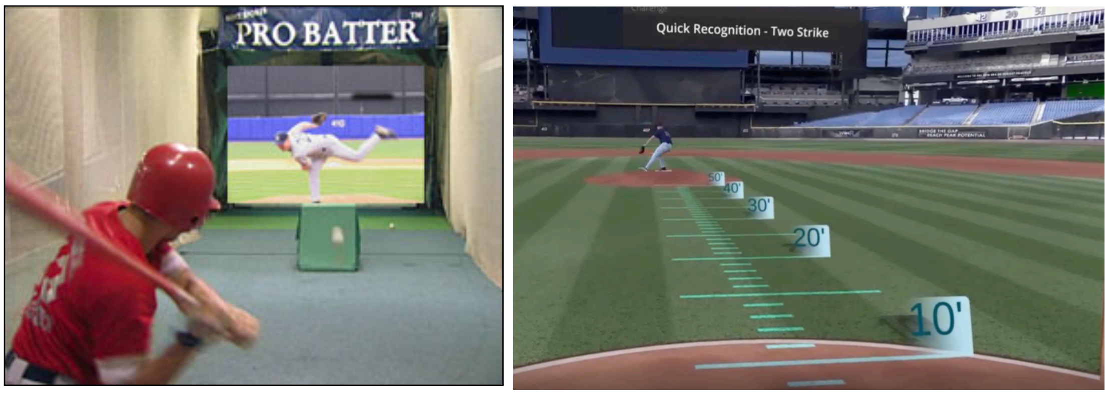

Figure 2. Video Pitching Machine (courtesy *ProBatter*) and Virtual Reality (courtesy *Win Reality*)

While sports provide a rich test bed for researching and training expertise and have a valuable role in society, the far greater value is accelerating expert reactive skills in performance domains such as medical, military, and law enforcement. Therefore, we want to draw upon what has worked in sports and transfer it to other domains (Ward et al., 2008).

The model of research-to-training shown in Figure 3 shows a sequence of phases (Fadde, 2018). In the sports of baseball and softball, the lab-to-field progression is in the DELIVER phase where youth, college, and professional athletes can train the perceptual-cognitive component skill of *pitch recognition* using commercially available video-occlusion and virtual reality products. Design of video-occlusion training was based directly on tasks devised by sports science researchers in the DISCOVER and DEFINE phases and then was validated through experimental implementation with college baseball teams (Fadde, 2006, 2013) to VERIFY it as a training method.

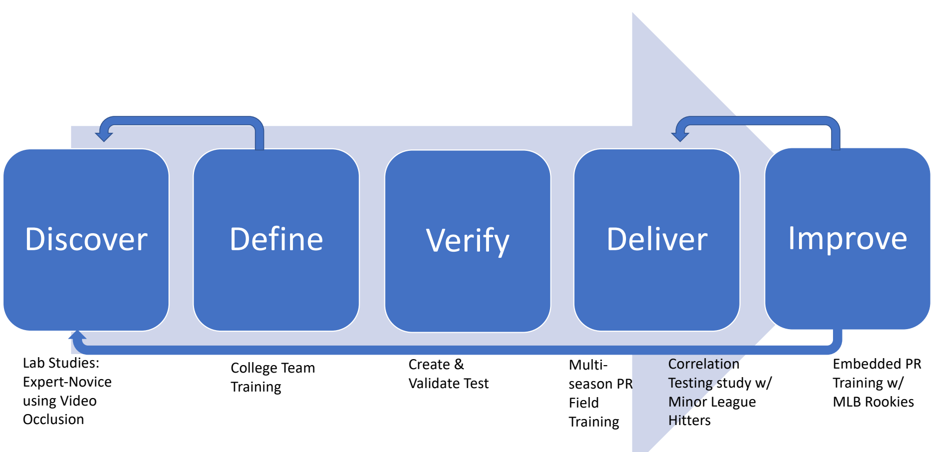

Figure 3. Phases of Research-to-Training

The study described in the body of this paper represents the VERIFY phase after the Discover and Define phases were applied to the rapid reaction skill of *defensive and control tactics* in the domain of law enforcement, focusing on the perceptual-cognitive component of *attack recognition*. The target skill of defensive and control tactics was chosen in part because of the current need for enhanced training of law enforcement officers in appropriate use-of-force and also because of the similarity of the skill to military performance skills such as security, house clearing, and other assignments that require rapid reactions in changing environments.

LAW ENFORCEMENT – DEFENSIVE AND CONTROL TACTICS

In high-stakes situations, such as police-civilian interactions, law enforcement officers (LEOs) are required to make rapid and correct decisions under constraints of time and stress. While LEOs typically receive training in skills and tactics to resolve conflict (Renden et al., 2017; Staller, Bertram, & Korner, 2017), training tends to be compartmentalized during pre-service training. Officers often are not able to practice and improve these skills, and therefore don't accumulate the amount of experience needed to become experts (Cushion, 2018). In addition, studies have shown that defensive and control tactics training availability is limited in both time and resources and often is performed in non-realistic situations (Nieuwenhuys, Caljouw, Leijsen, Schmeits, & Oudejans, 2009; Renden et al., 2017) and is predominantly instructor-centric with a basis in behavioral learning theory (Cushion, 2018; Werth, 2011), which may negatively impact officers' performance in violent situations they might face in the line of duty (Nieuwenhuys & Oudejans, 2012).

Another reason that law enforcement officers may use excessive or lethal force is slow or false interpretation, and therefore anticipation, of certain behaviors or body movements made by subjects (the term used for civilians or suspects that LEOs engage with in various settings). LEOs in different agencies may receive training in how to perform both defensive/reactive tactics such as escape, compromise, avoidance, blocking, and throwing and also offensive/proactive tactics such as takedown, firm grasp, control maneuvers, pressure-point techniques, and empty hand/leg strike. Training may involve sophisticated and expensive simulators or virtual reality to capture the full experience. More typically, training focuses on psychomotor performance (Cosma & Stanic, 2011; Summers, 2012; Vogel-Walcutt, Carper, Bowers & Nicholson, 2010) and not on the strategic and perceptual components of selecting appropriate response behaviors when attacked or threatened by a subject. Yet officers are expected to make good decisions in time-limited, high-stress situations in which the safety and health of both officers and subjects is on the line. Having identified the target skill of defensive and control tactics, the next step was to seek a perceptual-cognitive component that primes the targeted rapid reaction skill.

Perceptual-Cognitive Skill: Attack Recognition

As described in the Expert Performance Approach (Ericsson & Ward, 2007; Ford, Coughlan, & Williams, 2009) training of expert skills requires an empirical foundation that validates a particular skill as differentiating expert performers, while also providing guidance on how to potentially train the skill. As shown in Figure 4, the overall performance of defensive and control tactics includes a pivotal perceptual-cognitive component in attack recognition. That is, being able to quickly and accurately recognize whether an action by a subject potentially is an attacking movement toward the LEO and, if so, categorizing the type of attack in order to select an appropriate defensive or offensive action – and all in very short time frames. While many of the other skills represented in the chart typically are trained as targeted part-task drills, the research-to-training model positions perceptual-cognitive skills that are usually associated with whole-task practice (e.g., virtual reality), clinical placements, and accumulated domain experience as also amenable to deliberate practice approaches (Fadde & Jalaeian, 2019).

Figure 4 places the perceptual-cognitive skill of attack recognition within a larger framework of decision making that an LEO faces when engaged with a subject. The chart is a composite of several models and includes cognitive, psychomotor, technical, and psychological skills in addition to the perceptual-cognitive skill of attack recognition. The chart illustrates how an appropriate decision made at the point of attack recognition can lead to immediate control of a suspect (i.e., arrest) or branch to a variety of trained responses. While the arrest-and-control actions are different between law enforcement and military agencies, the pivotal attack recognition skill is agnostic. Whatever type or degree of defensive and control tactics are within the policies and training of an agency, the appropriate selection of actions is primed by rapid and accurate attack recognition (Fadde, 2009b).

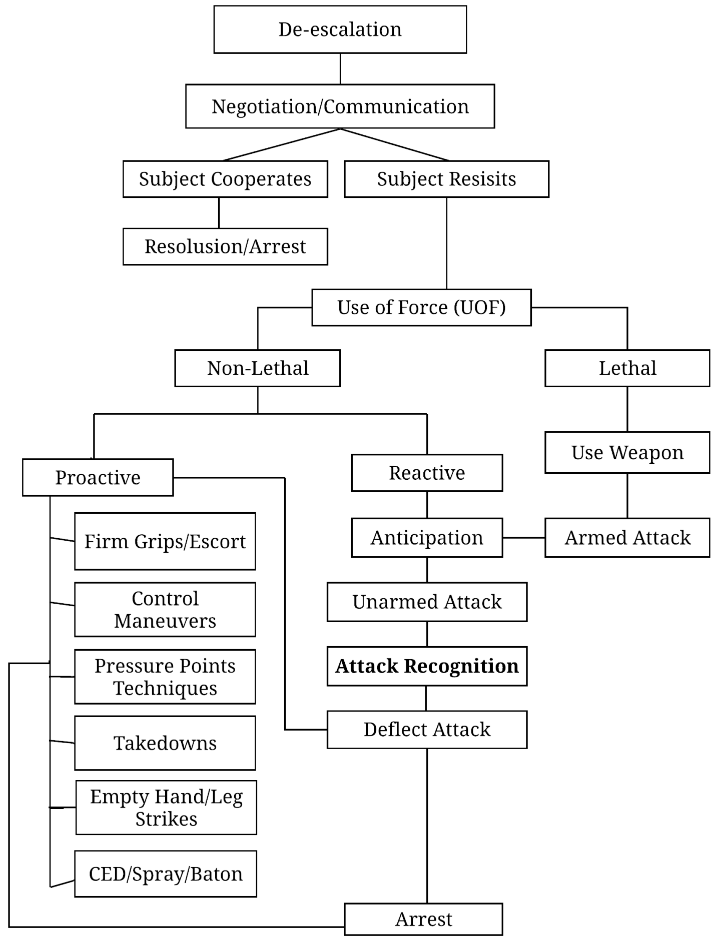

Figure 4. Arrest-and-Control Decision Chart

Modeling the defensive and control performance and identifying a perceptual-cognitive component that is both critical and addressable accomplished the DISCOVER phase. The DEFINE phase involved identifying what actions by a subject would be categorized as attacking movements. Studies on use-of-force in situations where the interactions between law enforcement officers and civilians had become violent show that hands, fists, or feet are used more frequently by either side than is deadly force (Kaminski & Martin, 2000). The Law Enforcement Officers Killed or Assaulted (LEOKA) report by Federal Bureau of Investigation (FBI) notes that 57,180 police officers were assaulted over five years between 2010–2015, a quarter of whom required treatment due to physical injuries caused by the assault (Federal Bureau of Investigation, 2016). The LEOKA report indicated only 10% of the assaults were with lethal weapons, hence, approximately in 90% of the time when police officers were engaged in violent situations facing potential attacks from subjects, no dangerous weapon was used against them.

With the Discover and Define phases having identified a target rapid reaction skill and a perceptual-cognitive component skill and occlusion method, the VERIFY phase involves conducting a small-scale expert-novice study in order to verify that the target perceptual-cognitive skills were associated with expertise.

Expert-Novice Research

Key aspects of expert-novice studies are identifying who are experts and novices, and how those levels are defined. Typically, experts are operationalized as “more experienced” or “more skilled” and novices as “less experienced” or “less skilled”. Including true novices in an analysis is not particularly meaningful since the ultimate goal is to accelerate performers from competence to proficiency, not with initial skill acquisition. Still, a novice group serves as a control group in a study.

Skill level is often measured by the amount of experience in combination with other factors such as recency or amount of training. Flying hours, for instance, in aviation is one measure of perceived expertise in pilots. However, flying hours as the only marker of expertise is not reliable. In one study, Endsley (2006) showed that pilots with many flying hours did not necessarily perform better than other pilots with less flying hours on a simulator task. As an alternative way to determine expertise, researchers in aviation have included situation awareness as a predictor of performance in simulator flying. Similarly, experience is not the only construct of expertise in the domain of law enforcement. The abilities to make fast and accurate decisions through situational awareness and pattern recognition skills are other constructs that define expertise in policing (Di Nota & Huhta, 2019; Suss, & Boulton, 2019).

The ability to anticipate an opponent's behavior and make decisions in complex and rapidly changing contexts is an important element of expert performance in many domains. For instances, in military combat (e.g., Pascual & Henderson, 1997) and law enforcement (Ward, Suss, Eccles, Williams, & Harris, 2011), performers are required to determine the intentions of others and to formulate an appropriate response within a severely short time (Williams et al., 2011). The need for perceptual–cognitive skill also is highlighted when decision making must be performed under rigorous time constraints in domains such as aviation (e.g., Kaempf & Orasanu, 1997), driving (Horrey, Wickens, & Consalus, 2006), and medicine (e.g., Ericsson, 2004). All these studies have shown that those who are expert at anticipating and decision making typically rely on elaborate perceptual-cognitive processes to receive and interpret complex information to make an appropriate plan of action (Williams, Ford, Eccles, & Ward, 2011).

Design of *Attack Recognition* Video-Occlusion Test

In creating a representative task for an expert-novice study, and potentially for occlusion-based training, there were numerous decisions made. Some show where an expert-novice study done as basic research differs from a similar study done to validate and calibrate a potential testing and training tool.

To verify the multiple-choice options for possible attacking motions that had been suggested by literature and subject matter experts, the Attack Recognition test was accompanied by a survey that collected information on date of last training for defensive and control tactics and other factors used to categorize participants as more-experienced or less-experienced LEOs, or non-experienced participants. LEOs also were asked if they had been involved in situations in which a subject attacked them physically using (options) Fist, Feet, Gun Reach, Other, or None. As shown in Figure 5, law enforcement officers verified that subjects had attacked them using fists, feet, and reaching for the officer's gun. Although 15% reported other types of attacks, including grappling, knife attack, resisting arrest, spit, and blunt objects attack, no individual type of attack was reported frequently enough to be added as a multiple-choice item.

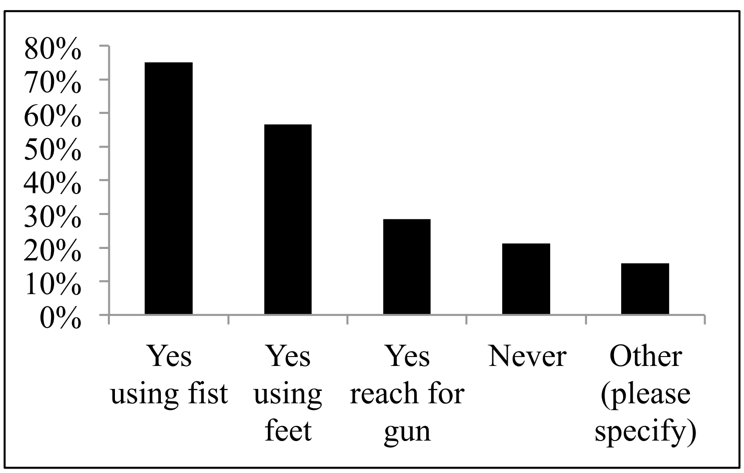

Figure 5. Types of Attacks by Civilian Subjects against Officers

As shown in Figure 6, video items for the video-occlusion test were recorded as staged scenarios of a law enforcement officer interacting with a subject. Videos captured an over-the-shoulder view.

Figure 6. Video of Staged Attacks by Subject

Since the video-occlusion test targeted recognition based on the kinematics of the subject, the video was recorded in a workout room that lacked relevant environmental cues. Law enforcement trainers acting as subjects depicted typical emotional states such as anger, confusion, and drug or alcohol impairment. These states were not intended to provide relevant cues for subjects' pre-attack (or non-attack) movements. Rather, typical movements were depicted so that attacking movements didn't "come from nowhere" but in the context of typical subject behaviors. Actors depicted about five seconds of contextual movements before initiating an attacking movement (punch, kick, or reach for officer's gun) or a non-attack movement, such as putting hands to face or stumbling.

The Attack Recognition video-occlusion test was delivered online using the Survey Monkey platform, allowing the test to be administered to a fairly large number of LEOs in a variety of agencies and states. We ran a pilot study to determine the minimum size of computer screen on which the video test should be viewed. We also checked that videos played without interruption in typical playback situations such as weak Internet signal. Pilot study participants each completed a portion of the video-occlusion test on laptop, desktop, and tablet computers. Their scores were checked to assure there were no differences based solely on the size of the screen and other non-relevant factors. Our pilot with different screen sizes suggested that at least a 13-inch screen was desirable to take the video test without performance being affected.

In many sports-based video-occlusion studies (e.g., Paull & Glencross, 1997), especially in combat-sports (Rosalie & Müller, 2013), four occlusion points have been used to study or to train perceptual–cognitive skills. Based on these typical sports-based research tasks, the Attack Recognition video-occlusion test included four occlusion points. These temporal-occlusion conditions were constructed by editing videos to black at various points during the subjects' movements (see Figure 7). The on-screen officer was partially obscured in order to focus viewers' attention on the subjects' movements and to avoid strong identification with a specific agency or to focus on the officer's reactions. Frames of NTSC-standard 30 frames of video per second were used to determine occlusion points. Each frame of NTSC video equals 33 milliseconds.

The most severe occlusion point (O1) was the moment that the subject initiated a potentially attacking movement. The O1 clips were edited to black one frame before any discernable bodily movement, including hand or leg, to initiate an attack – as close as possible to the "moment of first movement." The second occlusion point (O2) was two frames of video after movement initiation, or about 67ms. The third occlusion point (O3) was somewhat subjective. Clips for O3 were edited to black about eight video frames (264ms) after initiation of committed movement at O1, but with some clip-to-clip adjustment to maintain the intended amount of visual information. The O3 occlusion condition was intended to present an amount of movement by on-video subjects that provided adequate visual information to judge but that did not make the type of movement obvious. The no-occlusion condition (O4) showed subjects' full attacking movements. A total of 12 video items were edited into four occlusion conditions (O1, O2, O3, and O4) to achieve a total of 48 items. The 48 trials were presented in random order to all participants. Each original video item averaged around 7 seconds in length, with occluded versions being shorter.

In the videos, the actor/subject was directed to portray affective states such as aggravated or intoxicated. The goal was that attacking movements made by the suspect would have just enough context to not "come from nowhere" on the videos. While several researchers have commented on the need for context in perceptual training (Cañal-Bruland & Mann, 2015) that is easily interpreted as meaning environmental details. For a test, however, the minimum amount of context was desired to avoid introducing non-relevant cues. Test takers were required to categorize the type of attack as a 5-option multiple choice (4 attack types plus non-attack movement).

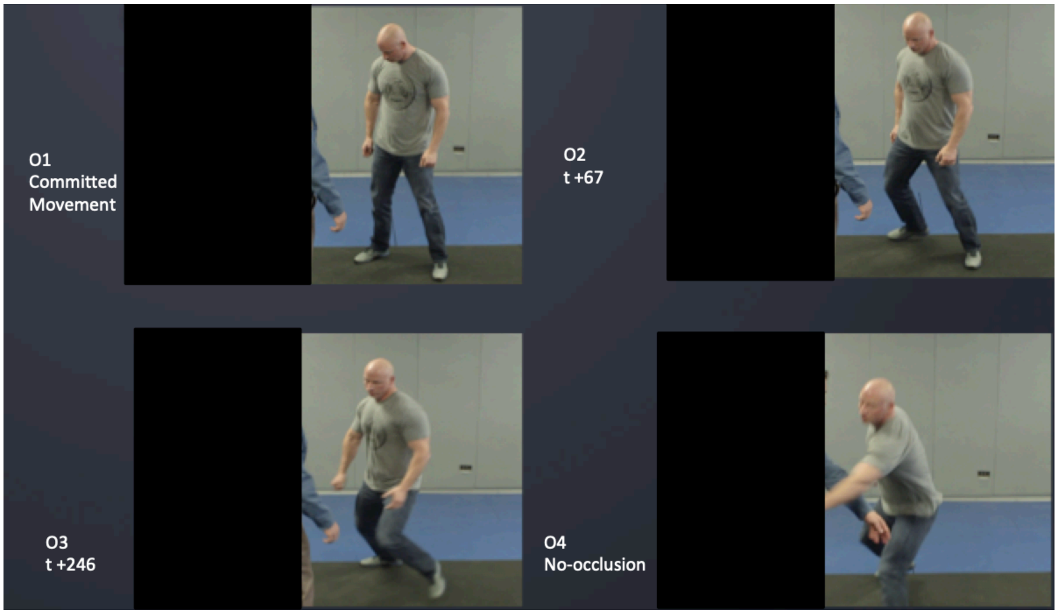

Figure 7. Video Occlusion Points: O1 = Moment of First Movement; O2 = Early Movement (about 33 ms); O3 = Later-occurring Occlusion (67ms); O4 = Observable Action (246 ms); O4 = No Occlusion.

The types of attack were designated by a state highway patrol instructor and verified by two officers as being among the most frequent types of attack by civilians against officers in the line of duty. The types of attack included do not include a firearm attack or other weapon that may involve an officer's use of deadly force in response. The five attacks that required defensive tactics responses were:

1. Overhand attack. Often made as a "punch" with closed fist but potentially with an open hand. Typically delivered at the subject's shoulder height and directed at the officer's head.
2. Underhand attack. A closed fist or open hand punch that was delivered from the subject's waist height and directed at the officer's abdomen.
3. Kick. Typically directed at the officer's knee or groin.
4. Gun reach. A movement intended to grab the officer's holstered revolver.
5. No-attack. Sudden movements that were not intended as attacks, such as a subject bringing their hands to their face, pointing at the officer, or taking out a handout of their pants pocket.

Participants were not limited in their time to respond but could respond only one time to each video. The testing interface gave feedback that their input was accepted but did not give any corrective feedback after each trial. The test was scored as the percentage of correct categorization of attack type. We calculated an overall score (percentage correct) along with a score for each occlusion point.

Participants

Participants for this study consisted of sworn law enforcement officers and non-officers. Officers were recruited from various law enforcement agencies across the country. The non-officers were university students with no law enforcement background or training in defensive tactics. Officer participants were placed into one of the two skill-level groups based on their training and field experience with defensive tactics. A second coder was recruited to code the questionnaire data and place the participants into skill-level groups and inter-rater reliability established using Cohen's Kappa. Scores of participants in each group were aggregated for analysis. Because the questionnaire and the video test were administered using the same survey instrument participants' identities did not need to be known to connect participants' demographic and experience data with video-occlusion test scores. In that way, participants' anonymity was assured, as had been promised in the recruiting email.

Results

Consistent with Rosalie and Müller (2013), the dependent measure was percentage of correct items for each temporal occlusion condition. We ran a two-way 3 (group: expert, near- expert, novice) × 4 (occlusion: O1, O2, O3, O4) mixed design factorial ANOVA with group as between-subjects factor and occlusion as within-subjects factor with repeated measures on the occlusion factor. The mean test score for 123 test takers across groups and occlusion points was 66.13 percent correct with the group mean scores shown in Table 1. The differences between groups for overall score were statistically significant at $p<.05$ level.

Table 1. Descriptive Statistics for Attack Recognition Test Scores

Skill Level	*n*	*M*	*SD*	*Mdn*	*Min*	*Max*	*Skew*	*Kurtosis*
Non-experienced	17	63.4	1.26	63.00	54.00	79.00	.846	.134
Less-experienced	57	67.2	.689	67.00	48.00	79.00	-.791	2.94
More-experienced	49	71.5	.743	71.00	63.00	81.00	.194	-.903

Of greater interest were the differences between groups, especially between the more-experienced and less-experienced groups, at each occlusion point. As shown in Table 2, while the more-experienced group scored higher than the less-experienced group at each occlusion point, the differences were significant only at occlusion point 2 and occlusion point 3. This finding provides discriminant validity for the attack recognition construct and video-occlusion test while also narrowing the window of expert advantage to those occlusion points where some movement was visible.

Table 2. Differences in Percent Correct by Groups (Statistically Significant Differences in Bold)

	Occlusion Points			
	O1	**O2**	**O3**	**O4**
More v. Less Exp.	3.78	**5.57**	**6.56**	2.44
More v. No Exp.	**7.08**	**9.27**	**9.23**	**5.65**
Less v. No Exp.	3.30	3.70	2.66	3.21

Figure 8 shows the mean attack recognition scores of each group at each occlusion point. As expected, the scores of all groups improve at successive occlusion points, from no discernable movement (O1) to full view of subjects' movements (O4). Also as expected, the more-experienced group scored higher than both other groups at each occlusion point.

The results are generalizable only to the task, which involved several design factors: 1) temporal-occlusion using 2) photo-realistic video showing a 3) over-the-shoulder (OTS) view of 4) staged attack motions with 5) non-physical response input, and 6) viewed on laptop or desktop computer. Each of the six factors of the Video-Simulation task was a decision that had alternative choices.

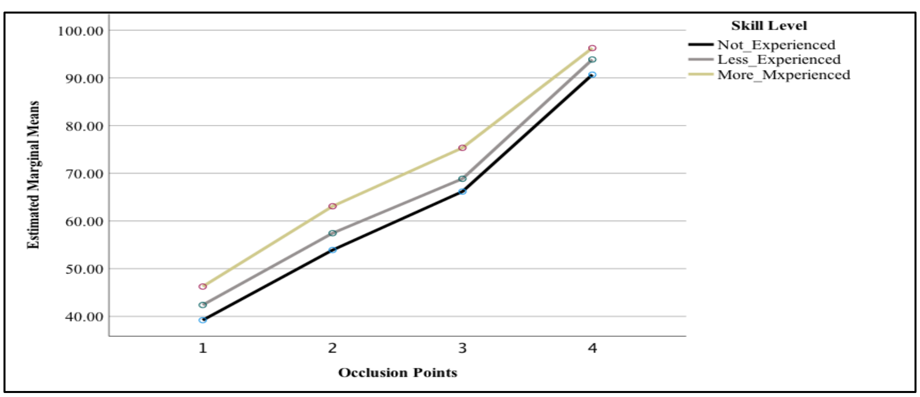

Figure 8. Correct Response Percentage for 3 Groups at 3 Occlusion Points

IMPLICATIONS FOR TRAINING DESIGN

Working within the research-to-training model, the expert-novice study was conducted for two reasons. The first was to verify that the video-occlusion attack recognition task did differentiate more and less experienced members of the intended training group (LEOs). The second reason was to calibrate the video-occlusion task for future use as a screening test, as a dependent variable for training interventions, and as a training method that trainers can be confident in including in a defensive and control tactics training program.

An attack recognition testing/training task could have used spatial-occlusion, where parts of the opponent's body were masked. The question would then be which area of the opponent's body was most predictive, revealed by when expert advantage diminished or disappeared when that area of the opponent (lower body, hands, or chest and head) was masked. A choice of 3D computer-generated display in a virtual reality environment could provide true point-of-view rather than over-the-shoulder view, and also could include participants executing an physical response in addition to recognizing the opponents' movements. Real attacking (and non-attacking) movements of subjects recorded by body-worn cameras could be used rather than staged video footage. Participants could have taken the video test in a computer room, thereby viewing monitors of appropriate and consistent size and resolution.

Ideally, trainers, training designers, and training command administrators will seek opportunities to apply simple, safe, and scientifically sound methods, such as video-occlusion, inspired by expertise research methods. The process starts by targeting a performance of appropriate type and scale. For example, piloting a jet fighter appropriately is addressed with whole-task simulators and virtual reality. However, landing a jet on an aircraft carrier is a well-defined skill that involves perceptual-cognitive components that potentially can be trained with methods such as temporal occlusion (Stacy, Beubien, & Wiggins, 2017).

We encourage military trainers to look at the various performances in terms of the framework (Fadde, 2013):

- Skill Issues: Does the performance include a perceptual-cognitive recognition skill?
- Task Issues: What type of representative task have expertise research used to measure the skill?
- Expertise Issues: How are experts designated and are they accessible?
- Platform Issues: Can recognition training be delivered in efficiently and effectively on mobile devices?
- Assessment Issues: How do I measure the effectiveness of training and transfer to performance?

Even as the momentum of modeling and simulation is with increasingly immersive and realistic training environments, looking to expertise research methods can guide the design and validation of targeted, low-cost training methods that can contribute to accelerating expertise.

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