# Investigating Performance of Kim's Game for Behavior Cue Detection

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**ABSTRACT**

Warfighters are expected to detect threats by quickly observing and identifying relevant pattern changes in the environment. However, little formal and adequate experiential training exists for behavior cue detection. A technique proposed to improve these pattern recognition skills, through developing an individual's capacity to observe and remember details, is Kim's game. During Kim's game, trainees must examine multiple objects for a period of time and later recall details of what was shown, by memory. Considering the U.S. Army's focus on utilizing Simulation-Based Training to bridge the gap between traditional classroom-based and live training, this research investigated a virtual simulation of Kim's game for pattern recognition training. The Kim's game task involved identifying kinesic target cues (i.e., aggressiveness and nervousness) amongst non-target cues in a virtual environment. The objective for this experiment was to compare the effectiveness of two virtual simulations, the Kim's game group and a control group, by evaluating different performance metrics of detection accuracy, response time, and false positive detection. In addition, the relationship between an Operation Span Task and performance was analyzed. A series of one-way between-groups analysis of variance revealed no significant difference in post-test performance. An examination of the percent change for the means provided insight into the post-test performance between Kim's game and the control group. The results showed that the control group performed better than the Kim's game group in detection accuracy, and differed at a statistically significant level for improved response time. The results of the percent change for the means also suggested that Kim's game had a marginally greater decrease in false positive detection. Recommendations include the use of Kim's game for enhancing memory in safety-critical domains. Ultimately, this paper seeks to explain the performance outcomes and offer insight into the advancement of human behavior cue detection research.

## ABOUT THE AUTHORS

**Crystal S. Maraj, Ph.D.** is a researcher associate at the Institute for Simulation and Training. She has attained her Bachelor's degree in Psychology, as well as her M.S. and Ph.D. in Modeling and Simulation from the University of Central Florida. Previous research and work experience focused on improving pilot training for the operation of automated aircrafts under the Federal Aviation Administration Concurrently, she also worked and gained experience in the Mental Health field. Her research interests center on Virtual Environments for training, specifically the design of technical attributes including improvement in trainee performance and training system utility.

**Jonathan Hurter** holds a Master's degree in Modeling and Simulation and a Certificate in Instructional Design for Simulations from UCF, as well as a Bachelor's degree in Digital Arts from Stetson University. While a training and simulation engineer at Science Applications International Corporation (SAIC), he employed instructional design to enhance serious games and educational simulations for a variety of audiences and disciplines. Now a research technician for the IST, Jon has contributed research and writing to multiple Simulation-Based Training efforts.

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**Stephanie J. Lackey, Ph.D.** earned her Master's and Ph.D. degrees in Industrial Engineering and Management Systems with a specialization in Simulation, Modeling, and Analysis at the University of Central Florida. Dr. Lackey has over 15 years of experience conducting innovative and high-risk research aimed at reducing the risk of a downstream acquisition enterprise. She serves as the Director of the Federal Solutions Division at Design Interactive, Inc. and leverages her experience in advanced predictive modeling and simulation-based training in order to develop methods and products that optimize human performance.

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## INTRODUCTION

The preparation of Soldiers for an operational context has often involved providing authentic tasks that situate a learner within a simulated environment or context. The application of Simulation-Based Training (SBT) is viewed as an effective bridge between live and traditional classroom training, and has been seen to improve Warfighter performance (Haque & Srinivasan, 2006; Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2011; Schatz & Bowers, 2009). The need manifested by a lack of pattern recognition skills in detecting nonverbal behavior cues has led to testing Kim's game. The latter acts as an SBT instructional strategy for enhancing a user's signal detection performance. Kim's game establishes patterns to aid in identification of object details, and strengthens memory for later detail recall. This research highlights the virtual version of Kim's game with customized scenarios for training behavior cue analysis.

A Soldier's ability to quickly read a situation and respond appropriately hinges on discerning patterns from a persistent barrage of information. Visual pattern recognition is the ability to observe a stimulus and establish types of commonalities and differences present within a visual scene. A typical theoretical construct for the recognition process includes (in order of functioning) identifying a signal, engaging in feature extraction to determine the existence of a pattern, and making a final evaluation (Pentland & Choudhury, 2000; Picard, 1995).

For the military, the importance for providing pattern recognition in human training has long been established, with support for early, formal instruction that results in rapid, accurate detection and consequent decision making during deployment (Fischer and Geiwetz, 1996). According to Fischer and Geiwetz (1996), terrain training was improved by allowing participants to exercise a pattern recognition skill set (rather than simply understanding rules for the skill set), and was sought to curtail the risks associated with unreliable, downstream field experience for hardening pattern recognition skills. Continuing reflection of this importance, recent training emphasizes visual attention and target detection for improvised explosive devices (Leipold, 2009; Yang, McCauley, & Masotti, 2014); change detection during a patrol (Caldwell & Stinchfield, 2011); and target detection responses of attentiveness, recognition, and action (Durlach, Kring, & Bowens, 2008). The U.S. Marine Corps' Scout Sniper School has sought to improve detection of high-value targets with memory games (e.g., Kim's game) (U.S. Department of the Army, 1994). Practice for improving observation and memory skills is included for Special Forces' sniper field craft training, and complements marksmanship training (U.S. Department of the Army, 2003). Similarly, the U.S. Army's Every Soldier is a Sensor program has sought to ingrain Soldiers to create context-sensitive baseline models of an environment to enable detecting relevant pattern changes (Joint Staff of the Department of Defense, 2013). However, an underrepresentation of training effectiveness exists for direct behavior cue detection (i.e., human threat-pattern recognition). A Border

Hunter course involving class-based and live field training for behavior cue detection has shown performance gains, but was criticized for its lack of accessibility (Colombo, Dolletski-Lazar, Coxe, & Tarr, 2012). By implementing SBT for behavior cue detection training, accessibility may be increased, instructional strategies may be tested to determine their effectiveness, and users may practice pattern recognition skills associated with behavior cue detection. To train cue detection, the strategies must be suited to perceptual training.

Perceptual training involves processing sensory information to understand the environment; that is, perception serves as an interpretation of evidence delivered by sight, sound, touch, taste, and smell. Such training may range from a simple discrimination task (e.g., identifying an oblique line from a grouping a horizontal lines) (Kami & Sagi, 1993), to more complex tasks (e.g., radiology diagnosis). Perceptual training has shown to improve an individual's ability to respond to the environment (Goldstone, 1998). According to Vanderplas, Sanderson, and Vanderplas (1964), tests that require discrimination or recognition of a stimulus appear to have higher positive training transfer, in comparison to tasks that involve basic observation. Additionally, perceptual skills underlie more complex skills: after detecting a signal of interest, one may further interpret its meaning to inform a decision. Thus, basic perceptual training is valuable to pattern recognition and field operation decisions.

**Behavior Cue Detection**

An area of critical interest for pattern recognition is determining threats through behavior cue detection, where human behavior cues are evaluated within a dynamic and complex warfare environment (Schatz, Reitz, Nicholson, & Fautua, 2010). Intelligence, Surveillance, and Reconnaissance (ISR) tasks of observing behavior from a safe distance mirror some behavior cue detection tasks, especially tasks for detecting kinesic cues (i.e., nonverbal body movements, gestures, and postures). Kinesic cues reflect someone's true thoughts and actions (Birdwhistell, 1970), and can convey an internal emotional state (Ross, Bencaz, & Militello, 2010; Colombo, Dolletski-Lazar, Coxe, & Tarr, 2012). These cues help Soldiers interpret messages, define individuals of interest, and predict other's actions. These cues can also be portrayed within SBT as dynamic character animations. SBT is used to methodically present virtual models displaying aggressive and nervous kinesic cues, in order for the participant to enhance their real-world detection or pattern recognition skills. A full description of the model cues utilized in this experiment are mentioned later, in the experimental testbed section of this paper.

**Kim's Game as an Instructional Strategy**

Different instructional strategies may be introduced into SBT and tested to determine ideal solutions for behavior cue detection training. A group of potential strategies suitable for training perceptual skills within SBT include Massed Exposure (ME), Minimum Stimulus, Scaffolding, and Highlighting (Carroll, Milham, & Champney, 2009). This experiment focused on investigating Kim's game as an effective methodology for training pattern recognition. The research takes a novel approach by animating various kinesic cues in a virtual version of Kim's game, to further pattern recognition training. Virtual agents displayed kinesic cues that exhibited either aggressive behaviors (i.e., slapping hands or clenching a fist) or nervous behaviors (e.g., wringing hands or turning around and "checking six o'clock"). The Kim's game strategy required individuals to initially observe visual items for a period of time, and to later recall details of what was previously observed, by memory.

Kim's game has been used previously in healthcare as a task for measuring memory, such as for the effects of antidepressants on humans (Fairweather, Stanley, Yoon, & Hindmarch, 1999; Rosenblant, Kakar, & McIntyre, 2015). In the realm of education for individuals with disabilities, Kim's game has been used as an assessment of memory training for children with Down syndrome (Laws, MacDonal, & Buckley, 1996), and has been suggested as a training task for improving memory and visuospatial skills (Chivers, 2001). In relation, our use of Kim's game was also for enhancing memory and spatial abilities. However, our variant was not simply a general way to improve memory and spatial abilities per se, but a way for training detection of specific behavior cues in an ISR simulation. The research question simply asked, could the virtual version of Kim's game be applied to enhance the pattern recognition of

Soldiers? In efforts to understand the impact of the Kim's game strategy, participant performance metrics and an Operation Span Task (OSPAN) test were assessed and analyzed.

## METHOD

### Participants

The participants enlisted for this research study were recruited from the University of Central Florida. Although the student population was accessed, research showed that non-military novices (e.g., university students) had similar performance patterns and cognitive levels on perpetual training tasks when compared to novice Soldiers (Ortiz, Salcedo, Lackey, Fiorella, & Hudson, 2012). Consistent with U.S. military standards, each participant was required to be U.S. citizen who was at least 18 years old. Further, only participants with normal or corrected-to-normal vision were allowed in the study, since the experimental task demanded visual acuity. To reduce bias, participation was restricted to those who had not previously partaken in a similar series of experiments related to simulation training in virtual environments. The experimental condition included $n = 36$ participants, and the control condition included $n = 39$ participants. Combining both conditions, ages ranged from 18 to 38 ($M = 22.27$, $SD = 3.75$), with 34 males and 41 females. Participants were compensated monetarily or with class credit.

### Materials

A standard desktop computer with a 22-inch monitor and a 16:10 aspect ratio served as the display device for presenting the visual scenario tasks. Participants used a computer mouse to select icons and character models during the experimental tasks.

### Measurement Instruments

Detection accuracy scores were found by dividing the number of correctly identified targets (i.e., nervous or aggressive cues) by the total number of targets per each vignette, and converting the quotient to a percent. False positive detection scores were calculated when a non-target model was unsuccessfully identified as depicting a target behavior cue. Response time was determined by counting the seconds an operator took to react to an event, by either clicking a target to indicate a match or selecting the "No change" icon to indicate the absence of a target. Percent change was calculated as the change in value between pre- and post-test performance scores, divided by the absolute value of the pre-test score, multiplied by 100. The OSPAN test assessed the effect of working memory on performance. The OSPAN was administered as a computerized test that required participants to solve 24 problems, with each problem including a basic arithmetic calculation and a word recall task. The participant was allowed to press the spacebar only if a pre-completed calculation (e.g., "(3+3) – 1 = 5") was correct. Above the mathematical problem was a high frequency concrete noun (e.g., "Soldier") displayed in uppercase letters. Each problem was presented for 1.8 seconds with an inter-item interval of 0.2 seconds. After a set of six items was displayed, the participant was prompted to type in the order of either the six first letters or the six last letters of the noun. Participants were supplied 15 seconds to complete each set of six problems (Turner & Engle, 1989; Matthews , Joyner, Gilliland, Campbell, Huggins, & Falconer, 1999).

### Experimental Design

A between-groups design was employed with one independent variable: the SBT instructional strategy. The experimental condition incorporated Kim's game as an instructional strategy for identifying target cues, amongst non-target cues, in a virtual environment representing Culturally Agnostic Urban terrain. In contrast, the control condition incorporated ME as an instructional strategy. The Massed Exposure, or Massed Practice, strategy presented a high concentration of target opportunities in a short amount of time. The ME approach has been found to improve target detection accuracy and threat saliency (Mogg & Bradley, 1999; Salcedo 2014), and was selected as the control because it employed a higher target signal probability ratio (2:3) than the Kim's game condition. The results from both conditions were compared to assess differences in performance. The dependent variables, or task performance data for both groups, included detection accuracy, false positive detection, response time, and OSPAN responses.

**Experimental Testbed**

The experimental testbed for both conditions was created with Virtual Battlespace 2 (VBS2). Participants were tasked with detecting specific target behaviors of human models shown in a mock feed of an unmanned ground vehicle. Two tetrads (i.e., clusters of four) of human models were shown performing kinesic cues, and were classified as performing either target or non-target behaviors (see Table 1).

**Table 1. Target and Non-Target Behavioral Cues for Detection Task**

| | **Kinesic Behavior Cue** | **Description** | **Classification** |
|---|---|---|---|
| **Target** | Slap Hands | The back of one hand strikes the palm of the other hand. | Aggressiveness |
| | Clench Fists | Fingers are curled and squeezed into the palms. | Aggressiveness |
| | Wring Hands | Fingers and palm of one hand clasp the opposite hand and rub along the fingers. | Nervousness |
| | Check Six | The head turns to look over the shoulder followed by the body turning around 180º. | Nervousness |
| **Non-Target** | Idle Talking | Conversational behavior indicated by subtle hand and arm gestures. | N/A |
| | Check "watch" | Head angles down and one arm is raised slightly as if checking the time on a watch. | |
| | Cross Arms | Arms are bent at the elbows and overlap each other across the front of the body. | |
| | Rub Neck | Palm and fingers of one hand rubs the side of the neck. | |

*Note*. Taken from paper entitled "Assessment of Kim's Game Strategy for Behavior Cue Detection," Maraj, Lackey, Badillo-Urquiola, and Hudson (2016). Originally appeared in Doctoral Dissertation from Salcedo (2014).

Kim's game was modified to suit the SBT signal detection task. The participant was shown a total of two tetrads in a scene. Group size was based on the ideas that larger group sizes enhance the chance for individuals to exhibit aggressive behaviors (Eastin, 2007); that non-target cues act as distracters, or noise, for detecting target cues; and that an extremely large size would result in cognitive overload. The detection tasks incorporated discrete and continuous change blindness concepts for Kim's game. Change blindness occurs when a visual stimulus within a scene is altered, and the viewer of the scene does not consciously perceive the alteration. In discrete change blindness, the switch from the original to the altered image is visually masked, such as by disrupting the moment of change by a blank screen (Simons, Franconeri, & Reimer, 2000). Continuous change blindness tasks lack this masking effect. Focused attention has been suggested as a requirement for someone to notice a scene's change (Rensink, O'Regan, & Clark, 1997). The Kim's game condition had an Interstimulus Interval (ISI) of a blank screen for 1 second between task events 1a and 1b, which were each displayed for 8 seconds. Users were given 20 seconds to determine if there was a change between the two events. The Kim's game condition contained a total of 50 short video events, with a two-thirds chance of a character exhibiting a target change between events 1a and 1b. Like the control condition, the pre- and post-test scenarios were viewed continuously, without blank scenes between events.

The virtual settings for the Kim's game and control conditions were modeled after a Culturally Agnostic Urban environment (Lackey, Salcedo, & Hudson, 2013). This type of setting overlaps with various urban environments expected in future warfare, and includes buildings, vehicles, terrains, and animated models. Models were given various skin tones of fair, light, and dark (Fitzpatrick, 1988; Lackey, Badillo-Urquiola, & Ortiz, 2014) to reduce bias and maintain authenticity. Similar considerations were made by including male and female models. Target cue models were created with Autodesk Motionbuilder software and imported into VBS2, and non-target cue models were selected from the VBS2 animation catalog. The character's attributes (gender, skin tone) and chosen classification (non-target or target) were randomized and counterbalanced. Six different model types were applied in the conditions (i.e., males: fair, light, and dark; and females: fair, light, and dark) for the Culturally Agnostic Urban environment, versus twelve model types in the pre- and post-test scenarios (due to the addition of six males of medium skin tones representing a Middle Eastern environment). The differences in geographic terrain were selected due to variations in the projected future state of warfare.

### Procedures

Each participant was randomly assigned to one of the conditions. Informed consent was obtained by the experimenter for all participants. Following the participant's signing of informed consent, the Ishihara Test for Color Blindness (Ishihara, 2013) was administered by the experimenter. The participant's failure to pass this test was grounds for dismissal. If the test was completed successfully, the experimenter continued by asking the participant to complete a demographics questionnaire and an OSPAN test.

Upon completion of the initial questionnaire and OSPAN test, the participant was provided their first interface training on the computer. This training familiarized the participant with the navigation and detection techniques expected within the pre-test virtual environment. A 75% score on the interface training was needed for the participant to continue the experiment. Training was re-administered if the passing score was not met.

For participants in the Kim's game condition, a second interface training was administered after the pre-test scenario. This provided the participant the opportunity to prepare for the forthcoming experimental scenarios through a discrete change blindness task of pattern recognition. A scene was presented with four barrels of uniform color, followed by a blank screen, and then a final set of four barrels. The participant was to detect if one or none of the barrels changed color on the final screen, by either clicking on the desired target (i.e., a changed barrel) or selecting the "No change" icon. The passing score and retesting procedure were identical to the first interface training.

After completing the interface training, the experiment continued with the continuous pre-test scenario. The scenario directed the participant to use their previous experience for detecting aggressive and nervous kinesic cues on screen. Next, the participant received a five-minute break, followed by a PowerPoint presentation for showing exemplar target behavior cue photos, and then completion of their assigned task (i.e., Kim's game or control condition task).

Following another five-minute break, the experimenter delivered a short PowerPoint as interface training for the post-test, and administered the subsequent continuous change blindness post-test scenario. The experiment lasted up to 3 hours. Finally, the participant was thanked, debriefed, and dismissed by the experimenter.

## RESULTS

An Analysis of Variance (ANOVA) was performed to reveal any significant performance differences between the experimental group (i.e., Kim's game) and the control group (Massed Exposure). According to a series of one-way between-groups ANOVAs, there were no significant differences in post-test performance between the Kim's game group and the control group. However, various significant differences were found between pre-test performance measures.

A series of one-way between-groups ANOVAs showed statistically significant differences for participant's pre-test detection accuracy: $F(1, 74) = 12.06$, $p = .001$. Detection accuracy scores were higher in the Kim's game group ($M$ = 58.68, $SD$ = 19.96) than the control group ($M$ = 44.59, $SD$ = 14.99). Additionally, there were statistically significant differences in pre-test responses time between the Kim's game group and the control group: $F(1, 73) = 11.11$, $p$ = .001. Specifically, the Kim's game group ($M$ = 5.98, $SD$ = .94) had a slightly faster response time than the control group ($M$ = 6.70, $SD$ = .89) for the pre-test scenario. The results from this experiment showed no significance in post-test performance, the percent change in post-test performance provide further insight into the results of the Kim's game and control strategies.

ANOVAs for percent change were calculated to investigate the success of Kim's game, in light of the non-significant differences found in post-test performance. A greater percent change decrease in response time was found in the control group ($M$ = -15.12, $SD$ = 1.55), in comparison to the Kim's game group ($M$ = -3.21, $SE$ = 2.00), $F(1, 73)$ = 22.61, $p < .05$. No significant differences in percent change were found in either detection accuracy or false positive detection.

Two separate paired-samples t-tests were implemented to examine the effectiveness of each intervention strategy, in terms of pre- and post-test performance variables. From pre- to post-test, mean scores for detection accuracy increased by 25% in Kim's game, and by 37% in the control; false positive detection decreased by 492 non-targets in Kim's game, and by 384 non-targets in the control; and response time decreased by .26 seconds in Kim's game, and by 1.08 seconds in the control.

Utilizing the OSPAN test, a series of Spearman's rank correlation coefficients were computed to investigate the relationship between working memory and the Kim's game condition. Results indicated a moderate, positive association between the number of letters the participant left blank ($r = .43$, $p < .01$) and the Kim's game condition response time.

## DISCUSSION

Performance measures (i.e., detection accuracy, false positive detection, and response time) for the Kim's game group were not significantly different than the control group. Further insight between the groups, however, was revealed through a review of percent change means from pre- to post-test performance. The decrease in control group's response time was significantly greater than the Kim's game group, and the control outperformed Kim's game in detection accuracy. In contrast, Kim's game percent change for false positive detection had a slightly greater decrease than the control group. This decrease may be explained by the Kim's game group being prepared for the final change detection task adequately through experiencing the Kim's game condition. The emphasis on properly focusing attention for visual changes is supported by Rensink, O'Regan, and Clark (1997). The control condition informed users that the scenario presented two target events per every three events for detection, and this may have had an influence on user's post-test performance. Also, the higher number of items requiring attention tends to increase complexity, and thus can negatively affect performance (Van Gerven, 2003). This distinction elaborates on a possible reason for higher false positive detections in the control group.

The control group response time was significantly less than the Kim's game group by 11%, in terms of percent change. This point may be explained by the time limit imposed in the Kim's game condition (i.e., the discrete task), which possibly conditioned the participants to scan the visual scene efficiently in the post-test.

The familiarity of post-test content may have been heightened through the control group's pre-test scenario. The latter contained a pre-exposure of stimuli that could have enhanced the ability to complete the subsequent discrimination task (Goss, 1953; Gibson & Gibson, 1955). Both control scenarios contained the dynamic examination of the virtual agents and terrain.

A moderate positive relationship was found between the number of letters left blank on the OSPAN test and the response time in the Kim's game condition, suggesting that an increase of blank letters was related to slower response time. This relation may be tied to the process of maintenance rehearsal (i.e., participants briefly repeating information) in both cases, which supports why the Kim's game response time was slower than the control in post-test performance.

## CONCLUSION

The results suggest a few items of practical transferability for training. Both ME and Kim's game have viable applications for training behavior cue detection. Findings from this investigation confirm the efficacy of the Kim's game approach for training memory recall tasks (e.g., flash recognition). Performance benefits associated with the Kim's game approach are directed to Operators in high-stakes and safety-critical disciplines, due to reduced false positives. Operationally, these findings point to fewer detection and identification mistakes, thus reducing the risk of Soldiers facing complex decisions in high-threat environments. As with any training strategy or tool, the selection of Kim's game must be applied where most appropriate. The advantage of ME in an ISR context is demonstrated by faster response times, which promote early identification of threats and safer operations. Based upon the experimental results, a layered approach represents the ideal combination of strategies for combatting barriers of behavior cue detection. Here, the control condition strategy for developing detection skills could be augmented with a Kim's game strategy to reduce false positives, increase accuracy, and improve percent change in speed.

The instructional strategies compared were intra-environmental, where both involved virtual environments for training. Further research should consider traditional (i.e., non-virtual) forms of training, especially in terms of training effectiveness. The goal, here, is to collect evidence that supplies recommendations for the role of virtual training in a behavior cue detection task curriculum (e.g., whether virtual training may supplement or replace traditional forms), as well as virtual training's broader role in applications for signal detection tasks, working memory, and unmanned systems.

Also, future studies may include user traits, such as attention (and its relation to a task) and demographic data. These studies would include comparing experienced and novice Soldiers, in terms of their detection abilities. These considerations are appropriate for determining the placement of instructional strategies across audiences in a continuum of training.

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