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Training To Detect Deception: The Role Of Intelligent Tutoring Systems And Impression-Based Cues

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TRAINING TO DETECT DECEPTION: THE ROLE OF INTELLIGENT TUTORING SYSTEMS AND IMPRESSION-BASED CUES

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TRAINING TO DETECT DECEPTION: THE ROLE OF INTELLIGENT TUTORING SYSTEMS AND IMPRESSION-BASED CUES

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Abstract

Research attempting to train individuals to detect deception has demonstrated small, inconsistent effects. The methods with which previous studies have trained participants and the cues to deception used in these training programs may be partially responsible for these findings. The current study investigated the effectiveness of a novel, interactive training program for deception detection which used an interview setting with virtual humans and an intelligent tutoring system. This training program was compared to a non-interactive training program. Participants were trained on eight indirect, impression-based cues that have been empirically demonstrated to be diagnostic of deception. Results demonstrated that indirect, impression-based cues are effective in training for deception detection. Additionally, the interactive training program proved to be just as effective as the training program that was not interactive. Implications for future deception detection training studies will be discussed.

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Training to Detect Deception: The Role of Intelligent Tutoring Systems and Impression-based Cues

Deceit is a common practice in society. Lies are used in situations ranging anywhere from a son or daughter lying to his/her parents about where he/she was going that night, to a President lying to the nation about his personal relationships. Self-reporting has demonstrated that individuals tell about two lies per day (DePaulo & Kashy, 1998) and lie in one out of every four social interactions (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996). Many ordinary people are so practiced at the act of lying that they may be regarded as professional liars (Fiedler & Walka, 1993). Lies can be told for many different reasons: for materialistic gains, psychological gains, or in order to avoid punishment (Vrij, 2008). Additionally, they can be told for the benefit of one's self or for another individual to increase the predictability in social interactions to punish another person.

One area in which the implications of lying are often quite serious is in the legal system. Typically, lies told in this setting are done for the benefit of the liar and/or an individual they are trying to protect. Examples of lies told in the legal context may include criminals lying to police investigators about their whereabouts in an attempt to avoid the suspicion of the officers (Olson & Wells, 2004), lying to implicate an innocent individual and cast the suspicion away from themselves**,** or lying about their true identities (Wang, Chen, & Atabakhsh, 2004). Witnesses may also lie about what they actually saw in order to protect someone they know (Köhnken, 1987). However, police investigators are not the only ones who encounter lies in the legal system. Lawyers, judges, and jurors may also find themselves in situations where they encounter someone lying to them. There are often large amounts of money, time, and even lives at stake, when individuals (e.g. police officers) rely on whether they can correctly detect if an individual is lying or telling the truth. Their judgments regarding the veracity of statements can often form the basis for their decision to pursue certain suspects or leads, to arrest an individual, or to investigate other avenues. Once investigators form hypotheses about whom they believe is responsible, it is often difficult to change this direction of the investigation (O'Brien, 2007). While this may not be the case in every situation, confirmation biases occur frequently throughout the system (Meissner & Kassin, 2004), making it more likely that the initial suspect will remain the focus of the investigation and be prosecuted (Granhag & Ask, 2007). This initial veracity judgment, regardless of its apparent importance at the time, can have great implications in the future of each case. Therefore, the ability to successfully discriminate between truthfulness and deception would be an extremely valuable asset for those involved in the legal system.

Unfortunately, research addressing the issue of human lie detection has continually demonstrated that it is a task at which humans are not particularly adept. In recent a meta-analytic review, Bond and DePaulo (2006) demonstrated that humans perform just slightly above chance in lie detection tasks, with an overall accuracy rate of 54%. Additionally, researchers investigating the performance of professionals (e.g., law enforcement) specifically have found that these individuals are no better at lie detection than lay individuals (Ekman & O'Sullivan, 1991; Kassin, Meissner, & Norwick, 2005; Meissner & Kassin, 2002). Given these results, the present study will seek to test a method intended to train individuals to become more accurate detectors of deceit. First, the literature on human lie detection will be reviewed with a focus on research regarding cues to deception, training programs to detect deception, as well as research from domains outside of deception detection in the areas of intelligent tutoring systems and virtual humans. The methodology of the proposed training experiment will then be discussed, followed by results of the analyses testing the main hypotheses, and finally a discussion of the current study including implications for future deception detection training studies.

Human Deception Detection

As noted above, lie detection is a difficult task. The review by Bond and DePaulo (2006) demonstrated that humans perform slightly above chance level at deception detection tasks. Specifically, individuals correctly identify 47% of lies and 61% of truths. These rates are evidence of a truth bias; that is, the average individual demonstrates a tendency to believe the speaker is telling the truth across situations.

One subject that research has investigated is how individuals may differ in their lie detection abilities. In a meta-analytic review investigating individual differences in detecting deception, Aamodt and Custer (2006) demonstrated that variables such as sex, age, and personality are unrelated to the ability to detect lies. Given the importance of veracity judgments in law enforcement, the ability of professionals in this setting, as opposed to lay individual, has been studied carefully. Results overwhelmingly show that law enforcement officials perform no better than lay individuals in lie detection tasks (Aamodt & Custer, 2006; Bond & DePaulo, 2006; Ekman & O'Sullivan, 1991; Meissner & Kassin, 2002; Kassin et al., 2005). The only group of professionals research has demonstrated to perform at significantly higher levels than other groups is Secret Service agents (Ekman & O'Sullivan, 1991). While the exact reason(s) for this group's success remains unknown, the researchers speculated that it may be related to their use of nonverbal cues, or to the fact that they may not deal with base rates of lies as high as those of police officers and other groups.

Meissner and Kassin (2002) further explored the influence of experience, as well as training, on lie detection performance tasks. Using signal detection theory, they were able to break accuracy down into two separate components – discrimination accuracy and response bias. While trained or experienced individuals did not differ from lay individuals on discrimination accuracy, there was a significant difference between groups on response bias. Their analysis demonstrated that individuals who were trained or more experienced demonstrated a deceit bias, as opposed to the truth bias that lay individuals exhibited. The researchers concluded that experience and training can cause individuals to have a bias that leads them to view others as more deceptive (in comparison to lay individuals who show the opposite tendency). In addition, Meissner and Kassin demonstrated that experienced professionals and trained individuals are more confident in their abilities than lay people. This overconfidence may create situations in which law enforcement officials become over reliant on their veracity judgments despite their general inaccuracy.

Cues to Deception

Decision-making in deception detection depends to a certain extent upon cues that the decision maker believes to be associated with lying or truth-telling. There are several commonly held beliefs in society as to what some of these cues are. One study examining cues lay individuals believe to be helpful, carried out by "The Global Deception Team" (2006), found that gaze aversion (64%), nervousness (28%), incoherence (25%), and body movements (25%) were the most commonly cited cues. In a similar study, British police officers were asked which verbal or nonverbal cues they use to decide whether a person is lying or telling the truth (Mann, Vrij & Bull, 2004). Consistent with the previous study, the researchers found that gaze aversion (73%) was the most popularly held belief, followed by body movements (25%). Other commonly mentioned cues in these studies included facial expressions, verbal inconsistencies, hesitations, blinking, pauses, and facial coloration. Research conducted on cues to deception that will be discussed later shows that many of these nonverbal cues are very poor predictors of truthfulness and/or deception. Unfortunately, many of these non-diagnostic cues are taught to police investigators in the United States and elsewhere (Vrij & Granhag, 2007) and purported to be diagnostic.

For obvious reasons, it is important to determine which beliefs regarding cues to deception are true and which have no scientific merit. The most important thing that research has shown is that there is no one cue that is indicative of whether an individual is lying or telling the truth (DePaulo & Morris, 2004). Nevertheless, there are a number of cues that are more diagnostic of lies or truths than others.

Direct Cues

The most common way that cues to deception have been conceived in research has been through those cues that can be directly measured. These *direct* cues are often divided into one of three categories – verbal, nonverbal, and vocal (also known as paraverbal or paralinguistic). *Verbal* cues are cues that come from the content of the speaker's statement (e.g., admitted lack of memory, textual embedding, self-references). *Nonverbal* cues can be observed solely by the behavior of the individual (e.g., eye contact, posture, hand/arm movements). Finally, *vocal* cues are behaviors that are related to speech (e.g., speech hesitations, pitch of voice, response latency).

Depaulo et al. (2003) conducted a meta-analytic review looking at 116 research studies with 158 cues hypothesized to be related to deceptive or truthful statements. Results demonstrated that verbal cues (e.g., level of detail, spontaneous corrections, admitted lack of detail, and negative statements) were most diagnostic of truth/deception. On the other hand, many of the nonverbal cues, including those commonly believed by lay persons and law enforcement personnel to be diagnostic (e.g., eye contact, posture, and blinking) were unrelated to deception. Two nonverbal cues that were significantly correlated to deception involved decreases in illustrators (i.e., hand movements that accompany speech; $d = 0.14$) and increases in fidgeting ($d = 0.16$). However, effect sizes for these cues were not as large as many of the other significant verbal cues (i.e., $0.21 < d < 0.66$). A few of the vocal cues, such as vocal tension ($d = 0.26$) and pitch ($d = 0.21$), were significantly correlated with deception as well. A separate meta-analysis conducted on nonverbal cues to deception found that increased levels of nodding, foot/leg movements, and hand movements were related to truthfulness (Sporer & Schwandt, 2007). Results of other nonverbal behaviors were not significant. Overall, these results demonstrating small-to-no relationships between nonverbal cues and lies or truths contradict popular beliefs which dictate that nonverbal cues should be observed when making veracity judgments. Research explains the non-diagnosticity of nonverbal cues with the fact that those cues are often signs that an individual is nervous (Vrij, 2008). While some claim that this nervousness is an indication that the individual is lying (Inbau, Reid, Buckley, & Jayne, 2001), in interview settings where an individual is under suspicion, nervousness could very well be a symptom of concern about perceived truthfulness as opposed to one of deceit.

Several studies using varying methodologies have provided empirical support for the need to place greater importance on verbal cues compared to nonverbal cues for lie detection. Some studies have demonstrated that individuals who pay attention to verbal cues are more accurate lie detectors than those who pay attention to nonverbal cues (e.g., DePaulo, Rosenthal, & Zuckerman, 1980). Other studies have investigated the impact of the medium by which individuals encounter lies or truths. In comparing audio, visual, and audiovisual media, studies have found that participants perform best when they use audio information only (66%) compared to audiovisual (56%) and visual only (52%; Bond & DePaulo, 2006). The best performance is found when individuals have no means by which they can observe the nonverbal behavior of the targets (see also Kassin et al., 2005).

There are two techniques of assessment that have been applied to the study of lie detection: content-based criteria analysis (CBCA) and reality monitoring (RM). Both focus on these diagnostic, verbal cues to deception. CBCA involves the assessment of 19 different criteria, all dealing with the actual content of the statement (e.g., logical structure, quantity of details, and contextual embedding; Köhnken & Steller, 1989). Reality monitoring, which was originally developed to examine cognitive processes that distinguish between actual and imaginary events, stipulates that imagined (or fictitious) accounts will contain less sensory, contextual, semantic, and emotional information. Results for DePaulo et al.'s meta-analysis provide support for both CBCA and RM through their findings that cues used in these approaches had greater effect sizes than those of vocal and nonverbal cues. While results examining the validity of these two techniques have demonstrated some of the more promising results in the literature, there is still great room for improvement in the underwhelming accuracy of human lie detection.

Indirect Cues

Whereas a great deal of the lie detection research has focused on direct verbal, nonverbal, and vocal cues to deception, recent research has demonstrated that indirect, or impression-based, cues may have a greater utility in the deception detection domain (DePaulo & Morris, 2004). For example, Vrij, Edward, and Bull (2001) compared police officers who were asked the question, “Does this person have to think hard?” to those who were asked whether they thought the person was lying or telling the truth. They determined that officers who gave their indirect judgments (i.e., Does this person have to think hard?) performed significantly better than those who were asked directly to provide their veracity judgments. A similar study, again using police officers, replicated these findings, providing additional support for the use of indirect measures. Specifically, they used the measure of having to think hard and showed that this can be more beneficial in detecting deception compared to measures looking at how tense the sender seems or simply directly asking the individual whether the sender is lying or telling the truth (Mann & Vrij, 2006). Another study by DePaulo, Rosenthal, & Rosenkrantz (1982) showed that participant ratings of ambivalence, a cue that will be discussed later in this section, significantly improved deception detection.

Many of the cues that DePaulo et al. (2003) found to be significant in their meta-analysis could be considered indirect or impression-based, including: cooperativeness, verbal and vocal immediacy, ambivalence, verbal and vocal uncertainty, nervousness, plausibility, and verbal and vocal involvement (see Table 1 for definitions and effect sizes). Specifically, a person telling the truth will provide a story that seems *more* immediate, *more* plausible, *more* involved, *more* cooperative, *less* ambivalent, *less* uncertain, and *less* nervous.

Training to Detect Deception

Given research findings that suggest people who pay attention to the more diagnostic verbal cues perform better in lie detection tasks (DePaulo, Rosenthal, & Zuckerman, 1980), it seems intuitive that training individuals to attend to diagnostic cues should lead to improved detection deception performance. Unfortunately, studies that have attempted to train individuals to be more accurate lie detectors have shown small, sometimes inconsistent, results.

One of the most common ways of developing training programs has been to base them around one or more of the three categorizations of cues (i.e. verbal, nonverbal, and vocal). Although verbal cues are clearly more diagnostic for lie detection, several studies have investigated the effects training on nonverbal cues (e.g., Vrij & Graham, 1997) or both nonverbal and vocal cues (e.g., DePaulo, Lassiter, & Stone, 1982; deTurck, 1991; deTurck, Feeley, & Roman, 1997; Fiedler & Walka, 1993). Many of these studies, such as that conducted by DePaulo, Lassiter, and Stone (1982), found no effect of training using nonverbal and/or vocal cues on deception detection performance. One study that did find an effect for training on these cues was conducted by deTurck, Feeley, and Roman (1997). They compared groups of individuals trained on nonverbal cues, vocal cues, and a combination of the two. Those in the nonverbal condition were instructed to base their judgments on their perceptions of the senders' use of adaptors, hand gestures, head movements, and hand shrugs. Those in the vocal condition were instructed to attend to speech errors, pauses, response latency, and message duration. The combined group was provided information from both nonverbal and vocal conditions. Contrary to what is now known regarding cues to deception, results actually demonstrated that training did improve deception detection accuracy from baseline, although there were no differences between groups. However, it is clear from a majority of the literature that training on these cues is not the best way to improve accuracy.

Other studies have attempted to train individuals on verbal cues to deception. They have taken verbal cues which have been empirically validated and trained individuals to use these in making their decisions (e.g., Santacangelo, Cribbie, & Hubbard, 2004). One specific method used to train verbal cues is the CBCA technique (Akehurst, Bull, Vrij, & Köhnken, 2004; Köhnken, 1987; Landry & Brigham, 1992; Ruby & Brigham, 1998; Steller, 1989). In one study assessing the impact of training on 14 of the 19 criteria, Landry and Brigham (1992) found that individuals trained on the CBCA cues (55.3%) were more accurate in a deception detection task than those who were not trained (46.9%). On the other hand, Akehurst, et al. (2004) conducted a study attempting to train lay individuals, social workers, and police officers in CBCA. None of the three groups in their study showed improvement in their lie detection abilities following the training. In fact, police officers were less accurate after the training compared to before. One weakness of these CBCA training studies is that, while the recommended training to be a CBCA expert requires a two-to-three day workshop, most of these studies have trained individuals for one-half to two hours (Vrij, 2008). In spite of this cited weakness of CBCA training studies to date, Vrij (2008) found that studies using the CBCA method tended to yield high overall accuracy rates (63.6%).

Training individuals to use reality monitoring has also been tested (e.g., Sporer & Borsch, 1996). In a review of 10 studies that have used RM as a tool for deception detection, Vrij (2008) found that RM studies produced accuracy rates slightly higher than the CBCA studies (68.8%). While these two approaches have promise in the deception detection domain individually, when combined, they may produce an even greater method. The Aberdeen Report Judgment Scales (ARJS) is the product of these two approaches and has been assessed in several training studies (e.g., Sporer, 1993; Sporer & McFadyen, 2001; Sporer, Samweber, & Stucke, 2000). Combined, these studies have produced accuracy rates greater than either approach alone (74.0%).

Finally, there have also been studies, such as those assessing the validity of the Reid Technique, that combine verbal, nonverbal, and paraverbal cues (Blair & McCamey, 2002; Kassin & Fong, 1999). The Reid Technique has become a very popular technique used to train police officers in interrogation tactics. The goal of the technique is to interview individuals in a manner that will elicit certain behavioral responses that are believed to indicate truthfulness or deception (Inbau, Reid, Buckley, & Jayne, 2001). The authors claim that differences in nonverbal behaviors are expected because liars will feel more uncomfortable in these interview situations as compared to individuals telling the truth. Verbal responses are also expected to vary between groups as a result of differences in attitudes – for example, liars should be less helpful and lack appropriate levels of concern for the victim. Results from Blair and McCamey's study suggest that training in this technique can not only improve accuracy, but that the training also does not affect response bias as the literature suggests training often does. On the other hand, Kassin and Fong determined that training individuals on the Reid Technique actually led to decreased judgment accuracies, although individuals did become more confident in their judgments. One criticism of the technique that is supported by the findings of this study concerns the assumption that liars will more frequently display nonverbal behaviors indicative of lower levels of comfort. As indicated earlier in this review, research has shown that very few nonverbal behaviors are correlated with deception or truthfulness. Instructing participants that nonverbal behaviors related to perceived comfort level may impede their lie detection abilities.

In a meta-analytic review of 11 training studies (20 comparisons) in the deception detection literature, Frank and Feeley (1997) determined that overall training showed a minimal effect (4% increase) in improving performance. However, the authors argued that reasons for the weak and inconsistent results may lie within the research designs and stimulus materials. Therefore, the researchers set forth six challenges for individuals studying the effects of training for deception detection to strive to achieve in their experimental methodology to discover the *true* effect. These issues included that: a) the deception situation must be relevant to professionals, b) there should be evidence of behavioral cues to deceit in the training/testing materials, c) research should create adequate training techniques executed over an appropriate period of time, d) researchers should create adequate and appropriate pre- and post-tests of deception detection ability to provide a fair test and to monitor progress in training, e) studies should show that training will generalize to new deception materials, and f) studies should show that possible gains in training persist over time. In a critique of training studies in the deception detection literature, Docan-Morgan (2006) further claims that studies to date involve passive roles for both the trainer and the trainee, where little cognitive and behavioral learning occurs. The author suggests a staircase approach where each step builds on previous steps with an end goal in mind.

Looking back retrospectively at training studies, Frank and Feeley determined that a majority of research had failed to meet many of the challenges they set forth. For example, there are several studies that either used feedback as their sole form of training (e.g., Elaad, 2003; Porter, McCabe, Moodworth, & Peace, 2007; Zuckerman, Koestner, & Alton, 1984) or simply instructed individuals to pay attention to certain cues without further definition or explanation of the cues (e.g., Feeley & deTurck, 1997). Other studies failed to investigate whether the training effect persists over any extended period time. The authors concluded that there remains no accurate estimate regarding the degree to which deception detection performance can be improved.

In a more recent meta-analytic review of the training literature (Hauch, Sporer, Michael, & Meissner, 2010), we examined the effect of training on verbal, vocal, and non-verbal cues to deception across 30 studies. Overall, there was a minimal effect of training found for vocal cues (d = .119), while effects found for training on nonverbal cues (d = .183) and the combined training of nonverbal and vocal (d = .212) were slightly larger, albeit still relatively small. A more robust, medium-sized effect was found for training involving verbal cues (d = .615). Additionally, there were several significant moderator variables. For example, the presence of an actual trainer, the use of written training materials (as opposed to audio or audiovisual), and longer durations of training sessions were found to result in larger training effects. One focus that remains absent in most of the training literature is that of indirect cues. Although there is evidence that these cues may be beneficial to lie detection, studies have been restricted to simply instructing participants to use certain indirect cues (e.g., how hard is the sender thinking?; Vrij et al., 2001) rather than providing more extensive training on the use of these cues.

Immersive Environment Training

One criticism of some of the training research is that there is often little done to engage the participants in the learning process (Docan-Morgan, 2006; Hauch et al., 2010). Research has shown that experiential learning tends to be more memorable than learning that is more passive in nature (Shute & Glasser, 1991). This is due, in part, to the fact that experiential learning is often more intrinsically motivating and involving. Additionally, instruction that addresses interesting, real world problem-solving scenarios has been demonstrated to enhance learning (Brooks, 1991, as cited in Shute & Glasser, 1991).

There have been certain deception detection studies which have sought to create a more interactive environment. Crew, Cao, and colleagues (Crews et al., 2007; George et al., 2004) recognized this need for active participation, rather than passive learning in order to create a more effective training program. They created a web-based training system called Agent99 which they tested in two studies. The program first implemented a module that allowed participants to watch a lecture on diagnostic cues to deception. A second module then enabled participants to watch real life interview segments, practice their decisions with their new knowledge of the cues, and receive feedback about the cues that could be found in each example. Agent99 was demonstrated to be effective as participants in this condition showed similar improvements in deception detection accuracy as those who were trained with the same information, using a lecture-based format. While Agent99 attempted to create a more active learning environment, the difference between this and the lecture-based comparison group lay more in the technology used, rather than novel ways of encouraging participation. The use of an intelligent tutoring system (ITS) and virtual humans is proposed in the current study to provide a more engaging context of learning.

Intelligent tutoring systems are computer-based systems designed to teach individuals about something in a particular domain without the aid of a human being (Shute & Psotka, 1991). Shute and Psotka detail several steps that are involved in training by individuals via an ITS. First, the system must assess what the learner's current knowledge of the subject matter is, as well as what the learner needs to know. The system must then determine which element should be taught next and how that element should be taught. Finally, following instruction and solutions of problems generated by the system, ITS will often provide feedback to the learners.

Intelligent tutoring systems are still relatively new, and there has been considerable debate over the effectiveness of such systems. However, in an evaluation of six different systems, Shute and Psotka (1991) found clear evidence that ITS can "accelerate learning with no degradation in final outcome" (p. 590). A subsequent analysis of ITS demonstrated that the greatest successes in training occurred when the system provided learners with detailed instructions, a problem-solving interface, and immediate feedback (Anderson, Corbett, Koedinger, & Pelletier, 1995). While there is still considerable work to be done, the current state of the field shows that ITS can be quite beneficial for learning.

Virtual humans are a recent development in technology that can clearly add value to ITS. Virtual humans are defined as "software artifacts that look like, act like, and interact with humans, but exist in a virtual world" (Swartout et al., 2006, p. 96). Combining the use of virtual humans with ITS can yield an interactive and engaging environment that facilitates learning. In recent years the utility of virtual humans in training has been demonstrated (Swartout et al., 2006). One important issue involves how individuals might respond to interacting with a virtual human compared to an actual human being. Gratch, Wang, Gerten, Fast, and Duffy (2007) show that it is possible for participants to interact and develop rapport with virtual humans in a manner similar to human beings.

With regard to training on deception detection specifically, an intelligent tutoring system using virtual human interactions may have several advantages. First, it can allow participants to receive all the information that a more didactic form of learning could provide, but in an engaging environment that encourages learning. Second, multiple interactions with virtual humans could provide individuals with opportunities to generalize their perception of relevant cues to deception in a manner consistent with conducting multiple live interviews. The ITS could also allow participants to receive feedback throughout the interaction and following veracity judgments, which research has demonstrated can improve accuracy (Porter, Woodworth, & Birt, 2000). Finally, the use of a virtual human, as opposed to actual human beings, can allow researchers to establish greater control over the information participants are presented with without losing the benefits that come along with human-to-human interactions (Gratch et al., 2007).

There were two main objectives of the current study that were both unique in the deception detection training literature. First, it examined the utility of an interactive training program in training individuals to detect deception. The study compared an interactive training program (i.e., virtual human intelligent tutoring system; vHITS), a didactic training program that typifies programs currently used in this field (i.e., computer-based training; CBT), and a control condition. Second, it attempted to determine the effectiveness of training individuals solely on indirect, impression-based cues, as opposed to those direct cues that have been more commonly used in the literature. Individuals in both training conditions were trained on the same eight indirect, impression-based cues (i.e., cooperativeness, ambivalence, uncertainty, immediacy, nervousness, involvement, plausibility, and cognitive demand) taken from DePaulo et al. (2003) and Vrij et al. (2001). Following a pre-test to determine each participant's baseline deception detection accuracy, participants took part in one of two training programs, or were placed in a no-training, control condition where they completed a filler task. Participants in the virtual human intelligent tutoring system (vHITS) condition were trained using a program that incorporated the use of an intelligent tutoring system, as well as interactions with virtual humans. This training program was created with the attempt to address the concerns from Frank and Feeley (1997) and Docan-Morgan (2006) regarding successful training techniques. Those in the computer-based training (CBT) program were trained using didactic, non-interactive instruction (i.e., PowerPoint presentation). Following the training program (or filler task), participants completed a post-test to determine the effectiveness of the training.

There were two main hypotheses for the study. First, it was hypothesized that across training conditions, those who were trained on these cues would display higher judgment accuracy on post-tests compared to individuals in the control condition. Second, it was hypothesized that individuals in the vHITS condition would perform better than those in the CBT condition.

Method

Participants

Ninety undergraduate psychology students (*n* = 30 per condition) from the University of Texas at El Paso participated in this study in exchange for credit in their introductory psychology courses. The necessary sample size was determined by conducting a power analysis using α = .05, power = .8, and estimated *d* = .5, which was a conservative estimate of the average effect size found by Hauch et al. (2010) when using the best cues for training. Ninety-nine individuals were originally recruited to participate; however, nine failed to return for either the second or third session.

Design

This study employed a 3 X 2 mixed factorial design where participants were randomly assigned to one of two training groups or a no-training control condition. Participants in the vHITS condition were trained using a program that allows participants to interact with a virtual human and receive training on cues to deception detection. Those assigned to the CBT condition were trained through a PowerPoint presentation on a computer supported by video and audio clips. Participants in the control group received no training and completed a filler task instead. In order to test the effectiveness of both training groups on judgment accuracy, participants completed a deception detection task prior to, and following the training program.

Materials

Videotaped stimuli. Previously collected videotaped alibi statements were used as stimuli for the pre-test and post-test in order to evaluate changes in participants' deception detection accuracy. In the alibi statements, individuals provided either a truthful or deceptive account of their whereabouts three nights prior to the interview. Participants providing their statements were randomly assigned to a truthful or deceptive condition. In the truthful condition, senders were given the following instructions:

"Three days ago a crime took place between the hours of 7:00 PM and 10:00 PM. The police have targeted you as a suspect for this crime. You will be asked to provide a detailed ***true*** alibi of where you were and what you were doing at the time of the crime. You will have ten minutes to remember as many details as you can about your whereabouts."

Conversely, senders in the deceptive condition were provided with the following instructions:

"Three days ago a crime took place between the hours of 7:00 PM and 10:00 PM. The police have targeted you as a suspect for this crime. You will be asked to provide a detailed ***false*** alibi of where you were and what you were doing at the time of the crime. We will give you a scenario for what you were doing and you will have ten minutes to create or fabricate as many details as you can about your whereabouts. Remember this is a ***false*** alibi, so don't simply relate what you actually did on another night. Make your story a false experience. For example, DO NOT just tell us what you did Thursday night instead of Friday night. Make this a novel false experience."

Participants in the deceptive condition were then randomly assigned a scenario by the interviewer (e.g., went out to dinner, went to an athletic event, etc.).

All participants were given 10 minutes to prepare their statement. Following this preparation, participants were interviewed on video camera regarding their statement. Interviews ranged from approximately one and a half minutes to seven minutes (M = 2.47 minutes). All interviews began with the following question from the interviewer: “Where were you on the night in question between the hours of 7 PM and 10 PM?” Following a free recall of this evening, the interviewer asked follow-up questions regarding specific details of the alibi.

Forty-two videos (21 truthful and 21 deceitful) were collected in total. These videos were then pilot tested by a separate group of 18 participants in order to determine the 10 truthful and 10 deceitful videos on which participants performed closest to 50% accurate. These 20 videos were divided into two sets of 10 videos, with each set containing five truthful and five deceitful accounts.

Training programs. The vHITS program was created in cooperation with the Institute of Creative Technologies (ICT) at the University of Southern California. This program was designed to provide participants with instruction on proper interviewing procedures, practice with real life interviewing and deception detection situations, as well as information and feedback on diagnostic and non-diagnostic cues to deception, in a self-paced environment. This is accomplished through participant interactions with a virtual human accompanied by a tutoring program.

The program uses several components from a variety of projects at ICT. One such project involved the tactical questioning program (TACQ). This program enabled the authors of vHITS to create two scenarios in which participants would be able to interview virtual characters with their own questions, which would in turn elicit appropriate responses from those characters. The context for the first scenario is that of a domestic terrorism event in which a bomb has just gone off in an abortion clinic and the virtual character to be interviewed is a man who either is somehow involved with the bombing or is just a witness with helpful information. In both the truthful and deceptive situations, the character claims to be an innocent witness. The participants' task is to interview the individual and determine whether he is being truthful or deceptive in his responses. The context for the second scenario is that a homicide has just occurred. A female character has apparently witnessed her boss' murder. Similar to the first scenario, the interviewer must determine whether the woman is truly just a witness as she claims, or whether she was somehow involved in the crime. The program is designed so that the participant types his or her question into a text box, and the virtual human speaks/acts-out the response. To reduce ambiguity between the questions asked by the participant and the virtual human's comprehension of these questions, a menu was created that provides the interviewer with a list of the top five closest matching questions to what is typed in the text box. This feature ensures that, in situations where the program does not have an exact match of the question asked, the participant should be able to either ask a rephrased question or one similar to the intended question.

Scenarios were authored by the creators of vHITS. Details about the characters' personal life (e.g. family, place of residence, criminal history, etc.), beliefs (political beliefs, abortion beliefs, etc.), the incident (what they claim to have seen, other witnesses, etc.), their alibis, possible responsible parties, and other information that someone conducting an actual interview might want to know were all included in the scenarios. In order for the TACQ program to successfully recognize all the different forms of one question that might be asked, numerous variations of the same question were input into the system. Additionally, individuals not involved in the project tested the system to ensure that the scenarios included all information that participants may request. Questions asked by these individuals that were not already in the system's domain were subsequently added, along with appropriate responses.

Deceitful and truthful versions were created for all responses in both scenarios. These responses were formed to include the impression-based cues described in the literature review (Table 1) that research has demonstrated to be diagnostic for deception detection. A single response does not include all of the cues available; alternatively, each one was tailored to what the authors determined was a plausible response for someone who was either lying or telling the truth in response to that question. For example, responses to questions such as "How old are you?" or "What can you tell me about your family?" may have small or no differences between truthful and deceitful responses. However, a response to a broad, open-ended question such as "What did you witness this morning?" would have more differences between truthful and deceitful scenarios.

The second component of the program, the virtual humans, were obtained from the ICT Virtual Patient project. This project provided the authors with avatars that were subsequently linked with the TACQ program. Individuals working on this project have created multiple versions of a young adult female and a young adult male. These characters were chosen because they fit the role (e.g., age) of the individuals in our scenarios.

The final component of the program was the intelligent tutor. This element was created specifically for the vHITS program to appear onscreen at specific points during the interview, either providing hints of possible questions to ask or offering feedback as to which cues to deception participants should pay attention to or ignore in the previous response. For example, if participants were unable to generate a question to ask the character, they could request a hint on what to ask. The first hint that the tutor would bring up reads as follows:

"Before jumping into issues such as that of the incident, it is a good idea to get to know the individual by asking questions about him/her and his/her background and beliefs. This allows you to learn about the individual and his/her motivations, as well as makes the individual feel more comfortable in the interview setting."

The feedback portion of the tutor appeared after each response that contained diagnostic cued-based differences between the truthful and deceitful versions. For example, if the truthful statement was more immediate and less uncertain than the deceitful version, the tutor informed the participant that he or she should consider these cues in making a veracity judgment. Following every third question asked the program prompted the participant to provide a veracity judgment on a scale of 0 to 10 (0 = *extremely deceitful*; 10 = *extremely truthful*) and a judgment of the percentage of information the participant believed he/she had obtained from the character.

Additionally, prior to the virtual training, participants received a brief presentation on the cues that were focused on in the training. The training provided participants with definitions of the cues and their correlations with truthfulness or deceit. This was done to ensure that the participants had an idea of what they should be focusing on throughout the training. This initial presentation served as the first step to provide a foundation for the subsequent training.

To contrast the vHITS program, a computer-based training program (CBT) was also created. This program incorporated the same cues as vHITS, only they were presented through an alternative, less immersive format. This program was created on PowerPoint. For each impression-based cue the tutor discussed in vHITS, participants in the CBT condition were presented with a screen giving text and auditory information regarding the definition of that cue and how it is correlated with deception or truthfulness. Participants then viewed a video clip example of how that cue may be manifest or absent in both a truthful and deceitful statement. The statements used in the video clips came from examples from the dialogue of one of the virtual characters.

Procedure

The experiment was conducted in three sessions – a pre-test, a training session, and a post-test – within the span of five days. Participants completed all three phases individually. In session one (Monday) participants were greeted and asked to read and sign an informed consent form. They were then seated in front of a computer, which provided them with the following instructions:

"Several individuals were videotaped providing their whereabouts on a certain night. Some of these individuals are giving true statements of their actual experiences, while others are giving false accounts of events that they did not actually experience. It is your job to watch the videos of these statements and identify which individuals are lying and which individuals are telling the truth. The videos of the individuals' statements will play on the computer. At the end of each video, a new screen will appear asking you to select a button associated with your belief that the individual is lying or telling the truth. Once you have read and understood these instructions, you may continue by pressing any key on the keyboard."

Participants then viewed one set of the stimulus videos. Videos were randomized and counterbalanced across all participants to control for confounding order effects. Following each statement, participants were asked to provide judgments of veracity (*True/False*) and confidence

(0% = *not confident at all*, 100% = *extremely confident*). After giving responses to all videos, participants were asked to complete two additional measures to assess their use of the indirect cues trained in this study. First, they were prompted to respond freely to the following statement:

“Which cues did you rely on to make your judgments of truthfulness or deception for these alibi statements? Please think hard about this question and be as thorough as possible in your response, listing any thoughts that came to your mind in the previous task to help you come to the decisions you did.”

The second measure asked them to: “Please read the following cues and definitions carefully. Then rank order these cues in the order you feel they were most helpful in making your deception detection judgments.” After completing this task, participants were excused until their next session.

In session two (two days later) participants in the experimental conditions were trained either by vHITS or the CBT program, while those in the control group completed a filler task of an equal length in time to the training programs. Those in the vHITS condition were first seated in front of the computer and instructed to watch and listen to a short PowerPoint presentation regarding the cues to deception on which the vHITS portion of the training program was focused. They were then given detailed instructions on how to operate the vHITS program (see Appendix A for instructions).

Before each scenario, participants were provided with background information regarding that scenario (see Appendix B for scenarios). Participants then proceeded to interview both virtual characters. Following each interview, participants provided immediate feedback as to whether they believed the character that they interviewed was lying or telling the truth. Typical training sessions with the vHITS program lasted between 25 and 45 minutes.

Participants in the CBT training viewed the PowerPoint presentation on a computer. This session lasted approximately 32 minutes. After completing the training programs, participants in both training conditions were asked to respond to two self-report questions on an 11-point Likert scale inquiring as to how much they enjoyed the training sessions (0 = *not at all*, 10 = *very much so*) and how much they believed they learned from the training program (0 = *nothing*, 10 = *a lot*). Finally, all participants were dismissed until their final session.

To evaluate the effectiveness of the training programs, participants returned for a final session two days later to complete a post-test involving a new set of videos depicting truths and lies. They received the same instructions they did in the pre-test, and again provided veracity judgments and confidence estimates on the second set of videos. As in the pre-test, videos were randomized and counterbalanced to control for confounding effects. They also repeated the same follow-up questions regarding their use of cues. Following the post-test, participants were debriefed and thanked for their participation.

Results

Data were gathered from participants on both truth-lie judgments and confidence levels. As suggested by Meissner and Kassin (2002), signal detection estimates of discrimination accuracy (the ability to correctly detect a signal) and response bias (the tendency to respond that a signal is present or absent based upon the criterion participants adopt) were obtained from the participants' judgments of veracity. These researchers suggested that examining measures of discrimination accuracy and response bias is superior to simply reporting global accuracy as these measures provide a more complete picture of the effect that training has on individuals' veracity judgments. Whereas the purpose of many training studies is to teach individuals to correctly distinguish truth from deception, it is also important to measure the extent to which training changes the likelihood of individuals to make either truthful or deceptive judgments. Responses were first separated into hits (i.e., false statements correctly identified as deceptive) and false alarms (i.e., true statements incorrectly labeled as deceptive). These estimates were then used to compute discrimination accuracy (A_z):

$$A_Z = \Phi\left(\frac{d'}{\sqrt{2}}\right)$$

where $d' = z_H - z_{FA}$,

and response bias (c):

$$c = 0.5\,(z_{FA} + z_H)\,.$$

To assess the hypotheses that training participants on indirect cues would improve deception detection accuracy and that the vHITS training program would be more effective than the CBT program, a series of 3 (condition: vHITS vs. CBT vs. and control) X 2 (pre-test vs. post-test) mixed factorial ANOVAs were conducted on discrimination accuracy (A_z), response bias (c), and confidence (see Table 2 for mean and standard deviations of these measures). Results for A_z demonstrated a significant main effect of repeated testing (pre-test: *M* = 0.53, *SD* = 0.03; post-test: *M* = 0.65, *SD* = 0.03), $F(1,87) = 14.77$, $p < .001$, $\eta^2 = 0.15$, CI_{95} = 0.3, .28. The main effect for training condition was not significant, $F(2,87) = 0.27$, p = .767, $\eta^2 = 0.06$, CI_{95} = .00, .05. However, the training program x repeated testing interaction was significant, $F(2,87) = 3.27$, $p = .043$, $\eta^2 = 0.07$, CI_{95} = .00, .18. Follow-up pairwise comparisons showed that participants in both the vHITS, $t(29) = -3.31$, $p = .002$, $d = 0.70$, and CBT conditions, $t(29) = -3.66$, $p = .001$, $d = 0.83$, improved significantly from pre-test to post-test, whereas the control condition, $t(29) = -0.12$, $p = .905$, $d = 0.03$, showed no training effect. Figure 1 provides the mean scores for discrimination accuracy across conditions, both pre- and post-test.

For c, the measure of response bias, there was a significant main effect of repeated testing (pre-test: *M* = -0.28, *SD* = 0.07; post-test: *M* = -0.61, *SD* = 0.08), $F(1,87) = 14.43$, $p < .001$, $\eta^2 = 0.14$, CI_{95} = .03, .28. There was no significant main effect for training condition, $F(2,87) = 0.08$, p = .922, $\eta^2 = 0.00$, CI_{95} = .00, .04. Additionally, there was no significant interaction, $F(2,87) = 1.54$, $p = .221$, $\eta^2 = 0.03$, CI_{95} = .00, .12.

Finally, for the ANOVA examining participants' confidence in their judgments there was no significant main effect for repeated testing, $F(1,87) = 0.26$, $p = .613$, $\eta^2 = 0.00$, CI_{95} = .00, .06, training condition, $F(2,87) = 0.14$, $p = .870$, $\eta^2 = 0.00$, CI_{95} = .00, .04, nor was there a significant interaction, $F(2,87) = .74$, $p = .481$, $\eta^2 = 0.02$, CI_{95} = .00, .09. Across all points of measurement, participants were consistently highly confident in their decisions.

In order to determine the perceived importance of the indirect cues to participants, a 3 (condition: vHITS vs. CBT vs. control) X 2 (pre-test vs. post-test) mixed factorial MANOVA was used. There was no multivariate main effect for training conditions, $F(14,81) = 1.33$, $p = .194$, $\eta^2 = 0.10$, $CI_{95} = .00, .21$. However, there was a significant main effect of repeated testing, $F(7,81) = 9.96$, $p < .001$, $\eta^2 = 0.46$, $CI_{95} = .26, .55$, and a significant interaction, $F(14,162) = 2.78$, $p = .001$, $\eta^2 = 0.19$, $CI_{95} = .04, .23$. An analysis of the univariate effects revealed significant interactions on cooperativeness, $F(2,87) = 8.73$, $p < .001$, $\eta^2 = 0.17$, $CI_{95} = .04, .29$, nervousness, $F(2,87) = 4.61$, $p = .013$, $\eta^2 = 0.10$, $CI_{95} = .00, .21$, and cognitive demand, $F(2,87) = 4.89$, $p = .010$, $\eta^2 = 0.10$, $CI_{95} = .01, .22$. For the perceived importance of the cue, participants rated cooperativeness as *more* important at post-test compared to pre-test in both the vHITS (pre-test: $M = 5.83$, $SD = 0.46$; post-test: $M = 3.17$, $SD = 0.43$) and CBT conditions (pre-test: $M = 5.57$, $SD = 0.46$; post-test: $M = 2.93$, $SD = 0.43$), whereas those in the control condition displayed no shift in their perceived importance of this variable (pre-test: $M = 5.60$, $SD = 0.46$; post-test: $M = 5.60$, $SD = 0.43$). Participants rated nervousness cue as *less* important at post-test compared to pre-test in both the vHITS (pre-test: $M = 4.00$, $SD = 0.45$; post-test: $M = 6.53$, $SD = 0.40$) and CBT conditions (pre-test: $M = 4.73$, $SD = 0.45$; post-test: $M = 6.30$, $SD = 0.40$), whereas those in the control condition did not rate the importance of nervousness any differently (pre-test: $M = 4.93$, $SD = 0.45$; post-test: $M = 5.30$, $SD = 0.40$). Finally, participants rated cognitive demand as *more* important at post-test in comparison to pre-test in the vHITS (pre-test: $M = 3.67$, $SD = 0.37$; post-test: $M = 5.03$, $SD = 0.36$) and CBT conditions (pre-test: $M = 3.70$, $SD = 0.36$; post-test: $M = 5.53$, $SD = 0.36$), while those in the control condition did not rate this cue differently (pre-test: $M = 4.13$, $SD = 0.37$; post-test: $M = 3.90$, $SD = 0.36$).

The free response question regarding the cues participants used most in making their veracity judgments was also included in order to further examine how individuals may have changed the way they approached these decisions as a function of training (e.g., using cues that they were trained to use more often in the post-test). Two research assistants were trained on the indirect cues to deception in order to code these responses. These coders both watched the CBT training program and interacted with vHITS. Additionally, they were provided with a list of the eight indirect, impression-based cues and their definitions to refer to throughout the coding process. The research assistants then independently coded the responses. Responses indicating use of cues that had been addressed in the training were separated from those not included in training. This first category was then further divided into each of the eight aforementioned cues to determine the frequency with which each cue was mentioned. Disagreements between the two coders were resolved by a third coder. Cohen's kappa was calculated for the eight indirect cues in order to determine the inter-rater reliability. Reliability for all cues fell in the range of substantial to outstanding agreement ($0.667 \leq K \leq 0.832$), with the exception for cognitive demand on which the coders had a moderate agreement rate ($K = 0.499$).

To determine if there were differences in the number of indirect cues that participants mentioned using, a 3 (condition: vHITS vs. CBT vs. control) X 2 (pre-test vs. post-test) mixed factorial ANOVA was conducted with the total number of indirect cues mentioned as the dependent variable. There was a significant repeated testing main effect, $F(1,87) = 21.40$, $p < .001$, $\eta^2 = 0.20$, $CI_{95} = .07, .33$, as participants used more cues at post-test ($M = 2.31$, $SD = 0.15$) in comparison to pre-test ($M = 1.51$, $SD = 0.12$). There was no main effect for training condition, $F(2,87) = 0.45$, $p = .638$, $\eta^2 = 0.01$, $CI_{95} = .00, .07$, nor was there a significant interaction, $F(2,87) = 0.05$, $p = .001$, $\eta^2 = 0.00$, $CI_{95} = .00, .01$.

Pearson's chi square tests were also used with each cue to examine potential differences between conditions at both pre- and post-test, separately. As would be expected, there were no differences between the frequencies of cues cited among conditions at pre-test (all *p*'s > .05). At post-test, the only cue that displayed significant between-group differences was nervousness, $\chi^2(2, N = 90) = 11.52$, $p = .003$. Nervousness was mentioned 70.00% of the time in the control condition, compared to just 43.33% in vHITS and 26.67% in CBT. See Table 3 for the percentages of each cue mentioned at both pre- and post-test.

Lastly, results regarding participants' level of enjoyment of the training program and the amount they believed they learned through the training program were analyzed with independent samples t-tests comparing the CBT and vHITS training programs. There was a significant difference between conditions on level of enjoyment, $t(58) = 2.53$, $p = .014$. Participants in the vHITS condition ($M = 8.03$; SD = 1.22) rated the training program as more enjoyable than those in the CBT condition ($M = 6.93$; $SD = 2.05$). For the measure of how much the participants believed they learned throughout the training session, participants in the CBT condition ($M = 8.07$; SD = 1.60) reported that they learned just as much as those in the vHITS condition ($M = 8.13$; SD = 0.94), $t(58) = 0.20$, $p = .884$.

Discussion

There were two main goals of the current study. The first was to determine the efficacy of training individuals for deception detection using indirect, impression-based cues as opposed to the more commonly used verbal, non-verbal, and paraverbal cues to deception. The second goal was to test the effectiveness of the vHITS training program, which encourages active involvement on the part of participants, in comparison to a more typical, didactic training program.

Indirect Cues

Toward the first goal, results demonstrated that training individuals on the indirect cues used in this study improved the quality of decisions made by lie detectors. Individuals in both training conditions showed improvements on discrimination accuracy (A_z), whereas individuals in the control condition showed no such change. After being trained on these cues, regardless of the form of training, participants were better able to correctly distinguish truths from lies, as compared to before the training session.

While research training individuals in deception detection has become more common in recent years, very few of the studies found in meta-analyses by Frank and Feeley (2003) or Hauch et al. (2010) used any kind of indirect, impression-based cues. They tended to focus on cues that have been labeled *direct* cues. While the current study did not directly compared the effectiveness of training individuals on these indirect cues to direct cues, the results do provide a precedent for continuing to investigate the role of these indirect, impression-based cues.

As this was the first study to exclusively address the helpfulness of these types of cues, it may be that some of these cues are more effective than others. The training program in this study used all of the indirect cues that had been identified by DePaulo et al. (2003), as well as - Vrij et al. (2001). Different combinations of these cues may lead to superior results. It may be helpful to examine a smaller set of cues based on those that DePaulo et al. demonstrated to have greater effects, in combination with those that participants seem to be able to identify most effectively. The results from the free response question can also provide insight for future research utilizing these types of cues. These results demonstrated that in the experimental conditions after training, plausibility (43.33%), involvement (41.67%) nervousness (35.00%), and ambivalence (33.33%) were the cues that participants mentioned being most helpful in their veracity judgments. While these results are not evidence that these are the most effective cues out of the eight included, combining these findings with our knowledge of the effect size of each cue from Depaulo et al. may be a logical place to start. A smaller set of cues to learn may make it easier for individuals to handle the information provided to them and transition their use into successful practice.

Another issue that is sometimes used to criticize the deception detection training literature is the extent to which the training effects will last over the course of an extended period of time. One benefit of the current study was that the design employed a two-day delay between the training session and post-test. As documented in Hauch et al. (2010), many of the previous studies have used between-subjects designs in which those in the training condition were tested immediately following the training. The demonstration of a training effect with the two-day delay is a testament to the effectiveness of the training programs used in the current study. However, the question of the longevity of the training effect may still remain an issue as in real world contexts the hope would be that this effect would remain visible over the span of months and years. While this is a legitimate concern, one must also take into consideration the length and intensity of the training program. Longer sessions would likely improve the effectiveness of such training programs. While this issue would be true for any training study, this may especially be the case when using indirect cues. Some of the indirect cues used in the current study (e.g., ambivalence, immediacy) likely introduced new vocabulary, if not new concepts altogether, to participants. Whereas it may be relatively easy for individuals to learn and identify many of the direct cues (e.g., negative statements, spontaneous corrections, etc.), the indirect cues may be more difficult for participants to conceptualize and subsequently recognize in practice. The training session for the current study may not have allowed participants the optimal amount of time to familiarize themselves with these potentially unfamiliar concepts. A longer training session could go a long way toward improving their success in using these cues. So while a criticism of this research could be that we do not know how long the training effect will last, given the significant effect that was achieved with the current training duration, even longer training periods over the course of multiple sessions could alleviate this concern regarding the longevity of the effects.

Training program

The second goal of the study was to test the effectiveness of the vHITS program in comparison to the CBT condition. While the results comparing the training programs did not support the hypothesized differences, this should not be taken as a failure of the vHITS program. It is clear that vHITS has potential as a method of training for deception detection. The lack of significant differences between training programs demonstrates that there are multiple ways that individuals can be trained to become better detectors of deceit.

While this was the first study the author is aware of that focuses solely on indirect, impression-based cues, it was not the first study to examine the efficacy of the vHITS training program. Albrechtsen (2010) conducted a study similar to the current study, but with two exceptions. First, he used directly measurable cues, which are more typical in deception detection research (e.g., spontaneous corrections, level of detail). Second, he included an interview component in which he attempted to train individuals on interviewing skills along with deception detection. Albrechtsen demonstrated similar findings in regards to how the training programs improved discrimination accuracy. In considering the two studies together, they provide a strong case for the usefulness of the vHITS training program. These similar results imply that, at the current stage of research, training for deception detection should be successful regardless of the specific cues used, provided that those cues have been established to be diagnostic of deception.

One of the goals of vHITS was to create a training program that would enable participants to become more involved in the training, therefore providing a more effective environment for learning. The results from the self-report questions on levels of enjoyment and learning reveal that this goal was partially accomplished. Individuals who participated in the vHITS training program reported a greater level of enjoyment, but the same level of perceived learning in comparison to those who participated in the CBT program. The fact that the vHITS program was rated as more enjoyable supports the notion that it was more engaging for the participants. This finding has implications beyond learning. Given the choice between two equally effective programs, if participants enjoy one program more than another, this more enjoyable program may be preferable to the alternative. If implemented in the real world, individuals will most likely choose to participate in the program that they will enjoy.

On the other hand, the absence of significant differences on the self-ratings of learning, as well as between conditions on performance, indicates that the expectation that a more involving and enjoyable training would translate into a more effective, memorable program was not completely fulfilled. This does not correspond to what researchers have found demonstrating experiential learning to be more memorable than passive learning (Shute & Glasser, 1991). One possible reason for this difference is that the stimuli used in the deception detection tasks involved little interaction on behalf of the participant. This is similar to the examples used in the CBT program, in which participants passively watched examples of cues being portrayed. Those in the vHITS condition practiced deception detection using an interactive format. So, when completing the deception detection post-test, participants in the CBT condition were tested using a more familiar method than those in the vHITS condition. The vHITS program could potentially show greater effectiveness in comparison to the CBT program in an environment in which they are required to interact with individuals telling the truth or lying.

Limitations of vHITS

One limitation of vHITS training program, and another possible reason that it was not more successful, is that this computer program was the first of its kind developed. As such, the time and resources dedicated to the project were limited. While the goal of creating a more interactive training program was successful to a certain extent, there are several changes and additions that could be made to the program to increase its effectiveness.

First, the program's overall ease of use for both participants and the experimenter could be improved. The computer program involved multiple, distinctly separate components. This complicated both the access and use of the program. It was necessary for the experimenter to go through several steps to open the program and, once opened, to change the parts of the programming in between virtual human interview sessions. For the participant, it was important to closely follow specific instructions of use in order to avoid complications with the programs. Second, the nonverbal behaviors of the virtual humans were limited. A wide array of behaviors exists in other programs using some of the same components of vHITS, so this is not an issue of a lack of resources. Instead, there should be a relatively simple way for experimenters to insert desired behaviors at their discretion. Given access to a greater variety of non-verbal behaviors would allow researchers to train participants better on how to ignore non-diagnostic cues to deception. Third, both the audio quality of the virtual humans' speech and the visual quality of their physical features could be improved. Improving these would create a more realistic interview environment for the participants. This is something that will come with time as computer programmers improve these features and the ease with which they can be implemented into programs such as vHITS. Fourth, it would be ideal to eventually move from having participants type the questions into the computer to utilizing speech-to-text recognition capabilities that this computer program has available. Again, this would create a greater level of realism. However, at its current capabilities, this feature is not advanced enough to warrant use in vHITS. Finally, if vHITS were to be implemented down the road, additional characters and scenarios should be created in order to provide potential participants with more opportunities to see how these indirect cues may exist in an interview setting and to practice the deception detection skills that they learn.

Training to Detect Deception

Overall, the current study provides ample evidence that using both indirect, impression-based cues to deception and training programs that encourage greater levels of involvement on the part of the participant are promising directions for future deception detection research. However, as researchers, we must also consider the fact that there may be a limit to human deception detection accuracy. In their meta-analysis, Frank and Feeley (2003) found just a 4% increase in deception detection accuracy. Similarly, Hauch et al. (2009) found relatively small effects of training, with the exception of a medium-sized effect in training that focused solely on verbal cues. While some studies did demonstrate substantial increases in accuracy, such as deTurck (1991) who found a 14% increase, these studies seem to be rare. One reason for this is that the cues themselves are limited in their diagnosticity of deception. The meta-analysis by DePaulo et al. (2003) demonstrated that even the most diagnostic cues had medium-sized effects. Cooperativeness and immediacy had the largest effect sizes of all the cues analyzed in this study (d = -.66 and d = -.55, respectively). Many of the other cues demonstrated what would be classified as small effects. Given these findings, it should not be surprising that there seem to be certain limitations on training for deception detection.

However, it is not suggested that researchers abandon all training research due to this possibility of a ceiling effect. One recent trend in the research has been to examine methods of improving deception detection accuracy using interviewing techniques. Whereas the typical deception detection training studies focus on teaching individuals to use the most diagnostic cues to deception effectively, some researchers are trying to find interview techniques that may elicit diagnostic cues of deception at higher rates. Using interview techniques that amplify these cues would in turn make it easier for those who have been trained in lie detection to successfully pick these cues out. Although the current study did not have an interviewing component, Albrechtsen (2010) did use the vHITS program to attempt to train participants in basic interviewing skills. The program effectively taught participants proper interviewing techniques, although they were unable to appropriately apply most of them in an actual interview setting. This flexibility of vHITS to approach the issue of deception detection from different angles (e.g., using different types of cues, teaching interviewing techniques) is another reason to continue working to improve its capabilities and overall effectiveness.

Conclusions

As noted above, the literature regarding deception detection has demonstrated that it is possible to successfully train individuals to detect deception better. However, much of the existing literature has approached this issue from one direction. Training individuals on direct (i.e., verbal, nonverbal, and paraverbal) cues in a manner that involves little interaction on behalf of the participant has become standard practice. The current study offers two alternatives to this form of training. First, in regards to what individuals are being trained with, cues that require individuals to rely on their overall impressions served as a useful tool for training to detect deception. These cues may also have practical benefits in comparison to the direct cues. In daily interactions, people (e.g., law enforcement officials) may be more likely to rely on their impressions as opposed to, for example, how many sensory details an individual included in their statement. Second, in thinking about how individuals are being trained, creating a program with which participants will be engaged and will enjoy may be helpful as well. While there are several limitations to the vHITS program used in this study, results still demonstrated a positive training effect. Further development of both indirect cues, as well as programs such as vHITS should be strongly considered in the field of deception detection.

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Table 1

Definition and Effect Sizes of Cues to Deception

Cue	Definition	Effect Size (*d*)
Cooperativeness	the degree to which the speaker seems cooperative, helpful, positive, and secure	-.66
Verbal and vocal immediacy	whether the speaker responds in ways that seem direct, relevant, clear, and personal rather than indirect, distancing, evasive, irrelevant, unclear, or impersonal	-.55
Ambivalence	the extent that the speaker's communications seem internally inconsistent or discrepant, if information from different sources seems contradictory, or if the speaker appears to be ambivalent	.34
Verbal and vocal uncertainty	how uncertain, insecure, or not very dominant, assertive, or empathic the speaker sounds, as well as whether or not the speaker seems to have difficulty answering the question	.30
Nervousness	the extent to which the speaker seems nervous or tense, or how the speaker's body movements may make him or her seem nervous	.27
Plausibility	the degree to which the message seems plausible, likely, or believable	-.23
Verbal and vocal involvement	whether the speaker describes personal experiences or events in a personal, revealing way	-.21

Table 2

Mean and standard deviation estimates for deception detection performance

	vHITS		CBT		Control	
Measure	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
A_z	0.50 (0.29)	0.68 (0.23)	0.52 (0.22)	0.69 (0.20)	0.57 (0.22)	0.57 (.28)
C	-0.18 (0.62)	-0.72 (0.92)	-0.31 (0.57)	-0.52 (0.64)	-0.36 (0.70)	-0.60 (0.80)
Hits	0.61 (0.23)	0.72 (0.27)	0.62 (0.16)	0.71 (0.22)	0.65 (0.23)	0.71 (0.25)
False Alarms	0.50 (0.21)	0.59 (0.22)	0.56 (0.27)	0.58 (0.23)	0.57 (0.22)	0.58 (0.24)
Confidence	85.53 (13.73)	84.83 (13.45)	83.50 (10.85)	85.63 (10.92)	83.67 (9.52)	83.73 (12.21)

Table 3

Percentages of citations for each cue

	vHITS		CBT		Control	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Immediacy	6.67	16.67	10.00	20.00	6.67	23.33
Uncertainty	12.50	16.76	43.33	33.33	40.00	33.33
Nervousness	43.33	43.33	40.00	26.67	33.33	70.00
Cog. Demand	6.67	13.33	10.00	6.67	10.00	3.33
Ambivalence	30.00	33.33	10.00	33.33	23.33	20.00
Cooperative	6.67	20.00	3.33	40.00	3.33	10.00
Plausibility	16.67	53.33	16.67	33.33	13.33	33.33
Involvement	20.00	43.33	26.67	40.00	6.67	23.33

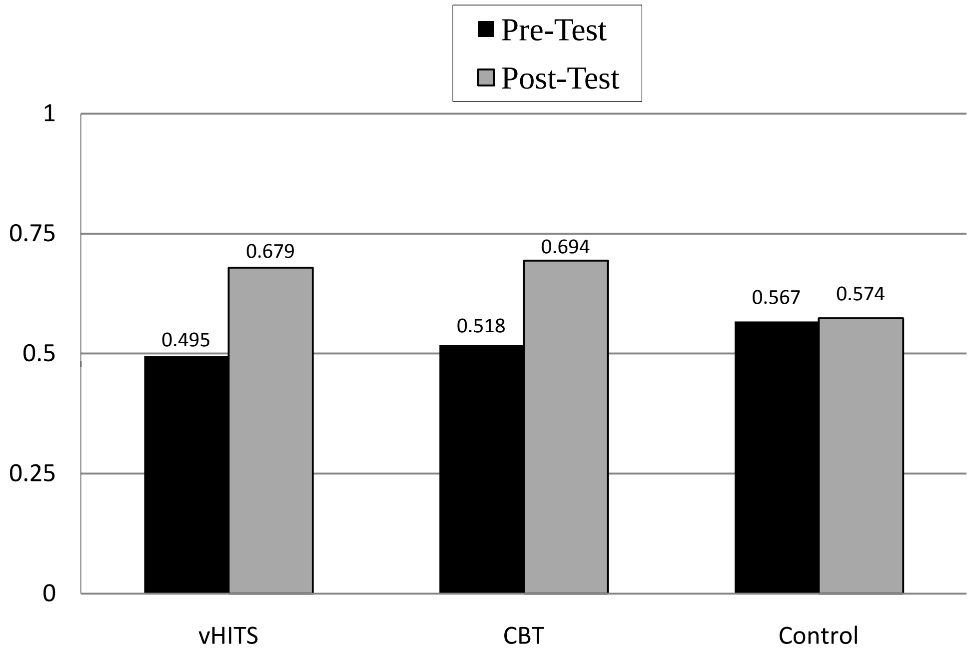

Figure 1: Mean discrimination accuracy (A_z) scores at both pre-test and post-test for all conditions.

Appendix A: vHITS Instructions

On the computer screen you can see two windows. In the window on the right you can see the suspect. The window on the left will be where you will ask the suspect your questions and see the transcript of the suspect's responses. There are several things you need to know in order to proceed through the interview. First, you will type what you would like to ask the suspect in the text box, below the words "Enter question here." After typing your question, press the send button. A list of five questions will then appear, which are the five best matches for your question in our system. Click on the question that is closest to the question you asked and click the send button. Sometimes the five questions that are generated as matches to your question won't be very good matches. When this happens, simply pick the question that you like best out of the five and press the send button. If you are not sure about what question you should ask next, press the "Hint" button in the upper right corner of the left window. You should only use this button when you can't think of a question to ask. *Please try hard to think of your own questions before resorting to using this "Hint" button.* Do you have any questions about this portion of the program? **(Have participant recap what you've said in his/her own words)**

After you have chosen your question, the suspect will respond to it. For the suspect's longer responses, it may take several seconds before he/she responds. This is normal. Please be patient and wait for the response before asking another question. In addition to seeing and hearing the suspect's responses in the window on the right, a transcript of your questions and the suspect's responses will appear in the window on the left. The transcript is there so that you can go back and read the suspect's responses any time you want. Sometimes the suspect's voice is difficult to understand. If at any point you don't understand what the suspect said, simply read the transcript of the interview. Do you have any questions about this portion of the program? **(Have participant recap what you've said in his/her own words)**

Throughout this interview, you should be thinking about whether the suspect's responses indicate that he/she is lying or telling the truth. In addition, at various points during the interview, windows will pop up on your screen. Some of these windows will contain hints to help you decide whether the suspect is lying or telling the truth. *When a hint window pops up, you should first listen to the response from the suspect, and then read the hint*. After reading the hint, think about how it may relate to the suspect's response. You can even think about the hint and look back through the transcript of the suspect's response, to better decide if he/she is lying or telling the truth. These hints are very important. *The point of this program is to make you better at detecting lies and conducting interviews. These hints are what will help you to become better*. *So when a hint pops up, pay attention to it.* The second type of window that will pop up on your screen contains questions. At various points during the interview, windows will pop up on your screen asking you the following two questions: "On a scale from 0 to 10, how truthful do you think the person is being?" and "On a scale from 0% to 100%, how much of this person's information about the event do you think you have learned so far?" You must respond to these questions before continuing on with your interview. When you are done with your interview, click the "End Interview" button. *You should only end the interview after you have asked at least 10 questions.* Ten questions is a minimum but you can ask as many questions as you want.

You control when the interview ends by pressing the “End Interview” button. Once the interview is over, open the door and tell us that you have finished. We will then give you further instructions. Do you have any questions about this portion of the program? **(Have participant recap what you’ve said in his/her own words)**

At no point should you click anywhere on the screen besides the window on the left. Don’t click on the window on the right and don’t click on any of the windows that are minimized at the bottom of your screen. Only work in the window on the left. If you do accidentally click somewhere other than the window on the left, don’t worry. Simply inform us of what happened, and we will fix it. *Don’t try and fix the problem yourself.* Take your time and try and learn as much as you can during this training. You may now begin the interview. Remember, it is always good to keep an open mind in an interview. Let’s begin by asking the individual his/her name. **(Type “Tell me your name” and walk the participant through giving the first question)**

Appendix B: Interview Scenarios

Victor's Scenario

A bomb has just gone off in an abortion clinic and a man was picked up on the road a block from the explosion. He may either be involved somehow with the attack or just an innocent witness with information that can help with the investigation. Your job is to interview this man to determine whether he is lying or telling the truth.

Amber's Scenario

The police have been called to a pawn shop where the owner has just been murdered. An employee of the shop was at the scene and has been retained by police for questioning. She may either be involved somehow with the murder or just an innocent witness with information that can help with the investigation. Your job is to interview this woman to determine whether she is lying or telling the truth.

Curriculum Vita

Stephen Michael was born in Conover, North Carolina. The third child of Douglas and Miriam Michael, he graduated from Newton-Conover High School in Newton, NC in the spring of 2004 and entered Elon University in the fall of the same year. While pursuing his bachelor's of arts degree in psychology, Stephen had the opportunity to work on a variety of research projects in the areas of Health and Legal psychology. It was his interest in research that ultimately led him to pursue a graduate degree in psychology after graduating in the spring of 2008. In the fall of 2008, Stephen entered the Legal Psychology graduate program at the University of Texas at El Paso.

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