Do Lie Detection Tools Really Catch Liars?
A Guide for Forensic Professionals

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Abstract. Lying is ubiquitous in every society. However, in forensic contexts lies must be revealed so that investigations/judgments can be fair and effective. Objective: For this reason, distinct tools (verbal and nonverbal) of lie detection were examined. Method: this study presents a non-systematic qualitative review of the main techniques of lie detection and credibility assessment, dividing them into verbal and nonverbal approaches. Results: CBCA and RM showed the best performance in distinguishing between truth and lie within verbal tools. Lack of empirical support made SCAN not recommended for lie detection applications. Moreover, studies have shown that people guided by BAI are less accurate in detecting lies than untrained people. Ekman's Deception Theory (EDT) showed more effective predictions about nonverbal deception cues than BAI. However, the lack of standardization in the use of EDT predictions to detect lies can be seen as a weakness of the method. Conclusion: Future efforts may be aimed at developing a tool that uses both verbal and nonverbal predictions to obtain greater accuracy in detecting lies than currently available methods.
Keywords: Lie detection; Deception; Verbal credibility assessment; Nonverbal behavior; Forensic context.

1. Introduction

Despite both intriguing and fascinating, deception is a common phenomenon in social contexts[1] Many thinkers argue that lying is not only commonplace but also strictly necessary for group life[2] see also[3]. However, there are certain contexts in which it is essential to distinguish between a false and true statement. The forensic context is one of them, which corresponds to every situation in which legal issues are raised. For

example, detecting whether a murder suspect is telling the truth about his alibi is extremely useful in a criminal investigation. Several methods suggest criteria for evaluating and detecting lies. However, professionals using these tools are not always aware of the effectiveness of them in discriminating between truth and lie. What are the strengths and weaknesses of each of these lie detection tools? Are they really capable of identifying a liar and spare innocent ones?

Due to the lack of clarity about the effectiveness of the different tools and theories of lie detection, the present work aims to review the literature about the most used lie detection tools. Dividing between verbal and nonverbal assessment tools, this paper will evaluate verbal techniques: Scientific Content Analysis (SCAN), Criteria-Based Content Analysis (CBCA) and Reality Monitoring (RM); and nonverbal techniques: Behavior Analysis Interview (BAI) and Ekman's Deception Theory (EDT). In addition, the most common (misleading) beliefs regarding deception will be presented, together with the fundamental precautions to be taken when assessing the veracity of suspects.

Since many legal practitioners are trained by unreliable sources on how to identify potential liars[4], the present study is potentially relevant to those working in judicial areas. By clearly demonstrating the efficacy evidence of lie detection methods, it will be possible to define the most appropriate procedures for distinguishing truth from lies, especially in forensic contexts. The present work is justified, therefore, by the possibility of guiding professionals about what kind of (verbal and nonverbal) behavior to evaluate during the interrogation of suspects.

2. Methods

The present work briefly discusses the main beliefs that lay people and forensic professionals about lie detection. Moreover, this study presents a non-systematic qualitative review of the main techniques of lie detection and credibility assessment, dividing them into verbal and nonverbal approaches.

3. Beliefs and myths about lie catching

"Beliefs" can be defined as a set of (strong or weak) feelings and convictions that something is true or real[5]. The beliefs that a person holds, irrespective of whether these are correct or not, are often reflected in his or her behavioral disposition[6]. Since personal convictions tend to guide future actions, it is important to identify the most

common beliefs people have about lies to better understand why they fail to identify when someone is lying.

Some researches have shown that people are not very skilled at detecting lies[7–9]. On average, participants only correctly rated about 50% of the judgments if someone was lying or not (i.e., no better than chance). To make matters worse, researchers also found that even so-called lie detection professionals – such as federal and police agents – who deal with lying situations all the time, did not perform better than laypeople[10,11]. This is an alarming result, as people usually rely on these professionals' ability to catch criminals and detect when they hide something from justice.

Even motivated people fail to detect lies simply because this task is not easy[4]. There is no physiological, verbal or nonverbal response that is uniquely associated with lying[12]. There is no equivalent to Pinocchio's nose in real life[13]. In addition, most people tend to pay attention to signs that are not usually related to lies, such as putting their hand over their mouths or avoiding eye contact[14]. Studies have shown that people who regard these behaviors as lie-signals often perform even worse than other people[15,16]. Therefore, probably one of the reasons why people have low performances in lie detection is the lack of correspondence between what people *believe* to be cues to deceit and what are *in fact* indicators of deceit[4].

According to Strömwall et al.[5], laypeople usually consider that liars: 1) are more gaze aversive; 2) shift position more often; 3) make more hand illustrators; 4) make more self-manipulations (e.g., self-scratching); 5) make more arm/hand movements; 6) make more leg/feet movements; 7) blink more often; 8) have a higher-pitched voice; 9) make more speech disturbances; 10) have a slower speech rate; 11) have a longer latency period; 12) take more and longer pauses. It is notable that many of these behaviors are indicators of anxiety and nervousness. Although even innocents may feel nervous when they are under suspicion[17,18], it seems that most people believe that signs of nervousness are unique to guilty suspects. That is, since people tend to believe that liars are more anxious than truthtellers, they (mistakenly) infer that any sign of nervousness is indicative of a lie[5].

Behavioral cues that people often associate with lying tend to be less trustworthy because liars know that others tend to rely on such cues as lie indicators. Therefore, as a strategy to make a favorable impression, skillful liars avoid moving too much to appear less nervous and, in some cases, even increase the frequency of eye

contact to appear more trustworthy[12]. In other words, some deceivers avoid behaving in a liar-stereotype way and, for this reason, they often succeed in their lies[5].

It makes sense to believe that professionals who daily need to distinguish truth from deceit are better at this kind of task than laypeople. However, studies show that forensic professionals have basically the same beliefs as laypeople about behaviors that (supposedly) betray a lie. For example, in Sweden, Strömwall and Granhag examined beliefs about nonverbal cues to deception of police officers, prosecutors, and judges[19]. They found that, like laypeople, these professionals were convinced that liars avoid more eye contact and make more body movements than truthtellers. In Spain, Masip, Garrido & Herrero compared beliefs about lying to police officers and students[20]. In general, both groups expressed the same beliefs about lying behaviors. However, the most striking finding was the more pronounced confidence of the police officers on their beliefs than laypeople (e.g., police officers had a stronger belief that increased leg movements frequency are infallible indicators of lying).

Therefore, in addition to forensic professionals have similar beliefs about lying to laypeople, they are also more confident in their mistaken convictions. This is a serious fact, since many forensic professionals believe that because of their training, they can determine whether a suspect is being truthful or lying just by his/her demeanor during the interrogation[21]. It is even worse if one takes into account that some investigators, who are specially trained to take confessions, usually do not start an interrogation until they have already made an initial judgment about the suspect's guilt[22]. Consequently, this may result in innocent confessions, who admit crimes they did not commit just to get away from the high stress of a coercive interrogation[23]. This shows how training lie detection techniques that have no empirical support can be disastrous. For this reason, the effectiveness' evidence of the most used lie detection tools will be presented below. Initially discussing the verbal assessment tools and, afterward, the nonverbal assessment techniques.

4. Verbal lie detection tools

Scientific Content Analysis (SCAN) is one of the lie detection tools most used by criminal investigators from several countries (e.g., Australia, Canada, USA, UK, Belgium, Israel, Mexico, Singapore, South Africa, and the Netherlands, as it is mentioned in SCAN official website http://www.lsiscan.com). The assumption behind SCAN is that the content and quality of statements derived from the memory of an

actual (i.e., true) experience differ from those based on inventions or fantasy (i.e., false)[24]. In other words, some SCAN criteria are more likely to occur in truthful than deceptive speeches, while other criteria are more likely to occur in false than true statements. Although SCAN tries to predict differences between people telling the truth and lies, no theoretical reason has been presented so far as to why such differences would occur through these criteria – which raises doubts about the credibility of the tool[4]. Written statements are used for SCAN analysis, and can be applied by both suspects and witnesses, whether children or adults. The SCAN trained investigator judges the honesty of the suspect or witness by checking whether the testimonial contains elements that match the tool's predictions[4].

According to the list of SCAN criteria, true statements tend to have: 1) more direct denials (e.g., "I did not ..."); 2) more emotional reports (e.g., "I felt sad when ..."); 3) more agreement between objective and subjective time (i.e., using more lines to describe longer situations and using fewer lines to report shorter situations); 4) more use of first person singular, past tense, (because it is describing facts lived in the past); and 5) more possessive pronouns (i.e., my, his, ours). While false statements often have: 1) more corrections (such as crossing out what has been written); 2) more vague reports or lack of memory (e.g., "I think ..."); 3) more deviations of the chronological order; 4) more absence of information and temporal jumps without apparent reason; 5) more vocabulary changes (e.g., frequent word changes to refer to the same thing, such as car, automobile, vehicle, etc.); and 6) more omission of people's names (e.g., treating people as "him", "her", instead of the name itself).

Despite the (apparently) convincing SCAN criteria, the accuracy of this technique in detecting false statements was poorly tested. Previous reviews usually mention only five published studies, most with little encouraging results[25,26]. The research with the highest accuracy score, and frequently mentioned by SCAN users, was the field study developed by Driscoll that analyzed 30 statements written by suspects (of real crimes) and correctly allocated 73% of the truthful and 95% of the deceptive statements[27]. However, the author of the paper himself acknowledged that the ground truth is uncertain (i.e., it is unknown whether the suspect was actually telling the truth or lying). This fact makes this finding, at least, highly questionable.

A second field study was conducted by Smith[24]. Although his results appear promising (SCAN users correctly classified at least 80% of true testimonials and 75% of liars), it was found that SCAN users did not perform better than a group of

experienced detectives untrained in the technique – so the study, therefore, suggested no benefit in using SCAN. In addition, this study carries the same flaw of the aforementioned study, the lack of a ground truth to determine which statements were false and truthful. In a third study[28], some verbal criteria were used to verify language-based lie indicators, including some SCAN criteria (e.g., verb tense). However, as the results for the individual criteria were not discussed, it becomes impossible to point out the contribution of the SCAN criteria to their findings. The fourth and fifth study had no problems with the ground truth because they were laboratory experiments[29,30], both made to evaluate the effectiveness of SCAN. However, SCAN failed to distinguish true and false statements above the level of chance in both studies.

In addition to these five studies mentioned by previous reviews, two more recent laboratory studies also evaluated SCAN's accuracy in lie detection. One of them was conducted by Vanderhallen et al.[31], that compared the accuracy of SCAN-trained police officers, police officers untrained in SCAN, and university students in classifying four testimonials as truthful or deceptive. The SCAN group had an average accuracy of 68%, police officers untrained in SCAN 72%, and students 65%. The SCAN group did not show significantly different accuracy compared to police officers untrained in SCAN, as it was found by Smith[24]. The other study was conducted by Bogaard et al.[32]. Using the criteria derived from SCAN, they analyzed impressive 234 statements (117 fabricated and 117 true) written by students about a recent negative event that happened in their lives. Again, the results indicated that SCAN was not able to correctly classify true and fabricated statements. The authors of the study concluded that, due to the lack of empirical support, application of SCAN in the current form should not be encouraged.

Another well-used verbal lie detection tool is the ***Criteria-Based Content Analysis*** (CBCA). Admissible as evidence in legal proceedings in the United States[33] and in several Western European countries including Germany, the Netherlands, Spain and Sweden[4], CBCA is probably one of the most widely used veracity assessment technique in the world[34]. This technique arose from the need to assess the credibility of testimony made by children in sexual crimes trials, since it is often difficult to determine whether or not a child was sexually abused when there is no medical or physical evidence[25]. Users and authors (e.g.,[35]), however, argue that this technique can also be used in other criminal contexts, including between adults and adolescents.

CBCA is based on the Undeutsch hypothesis[36], which argues that statements based on experience (i.e., actually lived) show more quality than fabricated statements (e.g., they contain more details and links to external events) as they can be simply remembered rather than actively created[26]. Steller and Köhnken compiled a list of 19 content criteria to assess the quality of a statement, in which the presence of criteria enhances the probability that a statement is experience-based[37]. Therefore, CBCA is not exactly a lie detection tool, but an assessment of testimonials' veracity, a truth detection tool.

According to CBCA[25], a statement is experience-based (i.e., truth) when it has: 1) logical structure (i.e., when contains no logical inconsistencies or controversies); 2) unstructured production, that is, if the information is presented in a non-chronological order; 3) richer details about places, people, objects, and events; 4) contextual embedding (i.e., events being placed in time and location, and actions being connected with other daily activities and/or customs); 5) descriptions of interactions (i.e., information that interlinks at least the alleged perpetrator and witness); 6) reproduction of conversations in original form; 7) unexpected complications during the incident (e.g., mentioning that it took time to find the house keys); 8) unusual details, like a tattoo or scar of an aggressor; 9) superfluous details, that are not essential for the prosecution; 10) accurately reported details misunderstood (e.g., a child who describes adult sexual behavior, but attributes it to sneezing or pain); 11) related external associations, like reported events that are not actually part of the alleged offence but are merely related to the offence; 12) accounts of one's own subjective mental state; 13) attribution of perpetrator's mental state; 14) spontaneous corrections or information added to a previously provided statement; 15) admitting lack of memory; 16) raising doubts about one's own testimony (i.e., interviewee indicating that part of his or her description sounds odd, implausible, unlikely, etc.); 17) self-deprecation; 18) pardoning the perpetrator (i.e., failing to blame the perpetrator or excusing his or her behavior); and 19) details characteristic of the offense (i.e., description of elements of the crime that are known by professionals to be typical for the type of crime under investigation but are counter-intuitive for the general public).

According to a qualitative review conducted by Vrij[38], the first field study already presented to verify the effectiveness of CBCA was developed by Esplin et al.[39]. Forty testimonials of allegedly sexually abused children aged 3 to 17 years were analyzed. The results were favorable for CBCA, since confirmed statements had a

significantly higher CBCA scores than "doubtful" testimonies. However, the lack of another evaluator to check the interrater reliability and the weak ground truth in some cases (e.g., confession of the accused) made the Esplin et al.'s study heavily criticized. Similar methodological problems have arisen in other field studies[40–42].

Another field study had the ground truth been established in a more satisfactory manner[43]. Trained CBCA coders examined 14 criteria in the transcribed interviews of 60 true and 49 false cases. It was found that true cases included significantly ($p < .01$) more CBCA criteria ($M = 7.63$, $SD = 1.18$) than false cases ($M = 4.08$, $SD = 1.48$). Other field studies that established the ground truth had similarly positive results[44,45]. According to Vrij[4], in 19 laboratory studies, CBCA accuracy rates averaged 71% of correct classification, both for lie and for truth. It is worth mentioning a more recently published laboratory study conducted by Manzanero et al.[46], which examined the effectiveness of CBCA in discriminating false and true statements in people with intellectual disability. The CBCA technique did discriminate at a better level than intuitive judgements made by students, especially due to the "quantity of details" criterion. This study shows favorable results for CBCA application even in people with cognitive disabilities – although Dukala et al.[47] suggests that CBCA is flawed when enhanced cognitive interview is used in elderly witnesses.

Reality Monitoring (RM) was developed on the hypothesis of Johnson and Raye[48], that memories based on real experiences (external sources) differ in quality of memories based on imagination (internal sources). Although not originally developed as a lie detection tool, but a method for assessing cognitive processes used to differentiate perceived and imagined events[49], RM has received attention of scientists worldwide, because of its potential in discriminating deceptive and truthful statements[4,50]. In contrast to CBCA, the RM contains both experienced-based (truth) criteria and imagination-based (deception) criteria. However, the basic idea is similar to CBCA. As real experiences are obtained through perceptual processes, truthful memories should contain more sensory, contextual, and affective information than imagination-based memories. While imagination-based memories should contain more indicators of cognitive processes, as thoughts and reasoning[25,26].

According to RM[51], a statement is experience-based (truth) when it has: 1) clarity (i.e., when it is clear and vivid, instead of dim and vague); 2) sensory/perceptual information, such as sounds, smells, tastes, visual details, and physical sensations; 3) spatial information about locations or arrangement of people and/or objects; 4)

temporal information about when an event happened or explicit descriptions of sequence of events; 5) affective information (i.e., how the teller felt during the event); 6) reconstructability of the story (e.g., is it possible to reconstruct the story based on the information given?); and 7) realism, that is, when the story is plausible, realistic and make sense. RM predicts only one criterion for statements imagination-based (i.e., deception), which is the presence of cognitive operations: that is, descriptions of inferences made by the teller at the time of the event (e.g., "It appeared to me that they didn't know what they were doing").

According to Vrij's review[4], in 10 laboratory studies that used RM to discriminate between truthtellers and liars, the tool achieved an average accuracy of 72% for truth and an average accuracy of 66% for deception. In most of those studies ($N = 8$), researchers also carried out CBCA analyses, thus allowing a direct comparison between both tools. Despite a slightly higher average total accuracy for RM (68%) compared to CBCA (64%), the findings were inconclusive. In three studies, CBCA assessment resulted in superior total accuracy rates, but in the other five studies, RM achieved the best accuracy total rate[25].

Since Vrij's review (4), at least five more recent studies about RM effectiveness have been published. Nahari et al.[52] found that by counting the frequency of occurrence of three RM criteria it was possible to achieve a 79% average accuracy at distinguishing truthful and deceptive statements through the amount of verifiable details included (truthtellers included more verifiable details than liars). Following two RM criteria, Nahari[53] found that, despite a decrease in the amount of details after a delay of two weeks between the event and the statement, truthtellers still provided more detail in their statements than liars. Elntib and Wagstaff[54] found that truthtellers had significantly ($p < .01$) higher means of RM scores ($M = 27.99$, $SD = 18.48$) than liars ($M = 16.39$, $SD = 12.94$), and that the presence of others did not affect the RM ability to distinguish between truthful and deceptive statements. Mac Giolla et al. (2019) showed that RM can be used to distinguish true and false statements not only from past facts, but also about future intentions. In addition, Nahari et al.[30] compared the effectiveness of SCAN and RM in lie detection and found that RM discriminated significantly between truthtellers and liars, but SCAN did not.

Comparing the empirical support for these three verbal lie detection tools, it has been shown that SCAN performs worse than CBCA and RM. Firstly, because CBCA and RM have underlying theoretical reason, SCAN does not. Second, because

SCAN has less studies testing its effectiveness than CBCA and RM. Third, because studies show higher rates of accuracy in discriminating truth and lie in CBCA and RM than SCAN (some studies even show that people trained in SCAN do not perform better than untrained people). In addition, SCAN and CBCA make opposing predictions about some shared criteria, as spontaneous corrections and admitting lack of memory. However, researches regarding theses individual criteria give support only to the CBCA predictions[4]. Therefore, the lack of evidence that the tool is actually effective means that SCAN cannot be recommended as a lie detection method until further studies prove its effectiveness.

Research that directly compared CBCA and RM performance showed that both tools discriminated truth and lies in very similar ways[55]. In addition, a recent meta-analysis study concluded that there is no significant difference in CBCA and RM effectiveness and that both tools are equally applicable[26]. However, there are some distinctions regarding the constraints of both tools. For instance, it is suggested that RM cannot be used with young children[25], whereas CBCA was originally developed to be applied in cases of child abuse. In addition, it may be difficult to use RM to assess statements about events that happened a long time ago, since cognitive operations may occur to facilitate remembering of the past event (Roediger, 1996). However, there are some advantages of RM over CBCA. It has been shown that RM has a higher interrater reliability than CBCA[26], and RM application is less time-consuming than CBCA[25]. Despite the limitations of each of the tools, CBCA and RM are very similar in terms of accuracy and, for that reason, both can be recommended for lie detection applications.

5. Nonverbal lie detection tools

One of the most well-known methods of nonverbal lie detection is the **Behavior Analysis Interview** (BAI), developed by John E. Reid and Associate[56]. It is believed that the BAI technique is one of the most commonly taught interrogation methods in the USA[57]. It consists of a list of 15 questions to which liars and truthtellers are supposed to give different verbal and nonverbal responses[58]. Regarding the nonverbal responses, BAI assumes that liars feel less comfortable than truthtellers in the police interview situation and for that reason, liars would show more nonverbal cues of anxiety and nervousness than truthtellers[59]. According to BAI[56,60], liars are more likely to: 1) cross their legs; 2) shifting in chair; 3) perform grooming behaviors; 4) answer quickly;

and 5) show more anxiety-induced behaviors. While truthtellers are more likely to: 1) lean forward; 2) establish eye contact; 3) use illustrator gestures; and 4) sound more sincere.

Few studies have examined the effectiveness of BAI in discriminating truth and deception. Users of the technique often refer to a field study as support for BAI[61]. A total of 60 videotapes of suspected thefts were analyzed. Using the BAI criteria, 78% of the true statements and 66% of the false statements were correctly classified, with an average accuracy of 72%. Although these accuracy rates appear quite significant, the study has important limitations. As indicated by Vrij et al.[58] and recognized by Horvath et al.[61], there was a lack of ground truth because the researchers did not really know which suspects were lying and which were telling the truth. But other BAI studies have established the ground truth, all of them laboratory studies.

Kassin and Fong[15] compared the performance of BAI trained observers and untrained observers to distinguish true and false statements. The group of trained observers looked for cues of discomfort considered by BAI as evidence of a lie[56], while the untrained group relied only on their own intuition to make the judgment. It was found that observers trained in BAI were less accurate at detecting lies (46% accuracy) than those who had not received training (56% accuracy).

Other laboratory studies have yielded very similar results, as in Mann et al.[16], in which police officers who followed BAI's behavioral criteria had lower performances in detecting which suspects were liars and which ones were truthtellers. In other words, the more police officers relied on BAI criteria, the worse they were at distinguishing between truth and deception – this finding is consistent with another laboratory study, which found results directly opposite to BAI predictions (60). This is worrying for innocent suspects who are subjected to BAI protocols. Investigators may base their impressions about the suspects' guilt as a result of a BAI interview, and this misattribution may lead to more coercive interrogations that may result in false confessions[4]. Therefore, the use of BAI should be discouraged, especially in forensic contexts.

Paul Ekman is probably the most well-known proponent of nonverbal detection of lie. **Ekman's Deception Theory** (EDT) was first described in 1969, in which Ekman and Friesen[62] distinguished between deception cues (signs that something is being hidden) and nonverbal leakage (signs that reveal the hidden information). According to EDT[12], deception cues and nonverbal leakage can be produced by some nonverbal

behaviors that can be classified into four distinct categories: (a) facial expressions of emotions; (b) emblems, that is, symbolic gestures with precise meanings (e.g., head nods, "ok" hand-signal, etc.); (c) illustrators (i.e., hand gestures directly tied to speech); and (d) manipulators or self-touch movements. EDT predicts that manipulators and illustrators can only provide deception cues, since their meanings are not so precise. While emblems and facial expressions of emotions can produce nonverbal leakages, since these behaviors convey clearly defined messages[12].

Illustrators (hand) gestures are thought to increase with involvement with the speech process, while decrease when the person is carefully considering each word as it is spoken[63]. EDT predicts that liars would reduce illustrators due to the higher cognitive load of lying[12]. In an earlier study of less than half the sample[64], illustrators decreased in the deceptive as compared to the honest interviews. However, in a subsequent study[65] with the total sample, there was no significant difference in the number of illustrators between deceptive and truthful conditions (despite a trend of decreasing in illustrators in the deceptive condition). DePaulo et al.[66] quantitative meta-analysis supports this trend as it was found a significant, but small effect for illustrators to decrease in deception ($d = -.14$), whereas a somewhat more substantial effect in hand/finger movements to decrease in deception ($d = -.36$). EDT asserts that manipulators are unreliable signals of deceit because liars, knowing that people think that restlessness is a deception cue, should try to control their fidget behaviors[12]. DePaulo et al.[66] support that hypothesis since the effect for manipulators as deceptive cue was almost null ($d = -.01$). As predicted by Ekman (12), this finding suggests that manipulators are not very good indicators of deception.

Although recognizing that emblems are almost always made deliberately, Ekman[12] states that there are also emblematic slips – symbolic gestures that, unintentionally, leak information that the person is trying to hide. Thus, a head shaking, for instance, could contradict a spoken statement because of its "no" message[67]. Another emblematic slip, mentioned by Ekman[12], which could contradicts a statement and potentially betray a lie is the shrug – gesture in which the shoulders are raised and/or the chin is lifted, which transmits the message of uncertainty (e.g., "I don't know"). There was a tendency for an increase in shrugs ($p < .10$) in deceptive condition[64], however, this result was shown in a study considering only less than half of the sample. In deceptive conditions, a meta-analysis showed a medium effect for raised chin increasing ($d = .25$), which can be interpreted as face shrugs[66].

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Despite these predictions about body cues and lies, most of the EDT focuses on hidden information that is leaked by facial expressions[12]. For instance, EDT show evidences for several predictions about false (deceptive) smiles: 1) false smiles shows more asymmetry than true (enjoyment) smiles[68]; 2) false smiles are too long or abrupt in their onset/offset[69,70]; 3) false smiles have no activity of the *orbicularis oculi, pars lateralis* muscles[70–72]; 4) false smiles could also include traces of negative emotions simultaneously[72]; and 5) false smiles are more frequently shown in deceptive conditions than genuine smiles[70,72].

EDT also claims that deceptively hidden emotions can leak through microexpressions, fleeting facial expressions that reveal the emotion felt despite the person's attempt to hide it[12]. Laboratory studies have shown a positive correlation between the ability to detect lies and the ability to recognize facial micro-expressions of emotions[73,74]. Despite increasing popularity in the media[75], empirical evidence is divided on whether microexpressions can distinguish liars from truthtellers[76]. Porter & ten Brinke found that microexpressions were too rare (exhibited by only 21,92% of participants) and were not just shown by liars[77]. Similar results were found in other studies[78,79]. These discouraging findings led Vrij and Granhag to concluded that there is little supporting evidence for the assumption that microexpressions are useful lie detection cues[80].

However, more recent studies provided new evidences about the possibility that micro-expressions may be indicators of deception. Analyzing micro-expressions that occurred in several distinct durations (i.e., 0.04–0.20, ≤ 0.30, ≤ 0.40, and ≤ 0.50 s), during both deceptive and truthful conditions, Matsumoto and Hwang found that micro-expressions of negative emotions occurring ≤ 0.40 and ≤ 0.50 s differentiated truthtellers and liars (81). Matsumoto and Hwang concluded that the weak findings of past studies can be explained by the lack of detailed assessment of (micro)expressions at different durations, as they did in their study[81]. Furthermore, Su and Levine provide evidence that, through a machine learning analyzing a combination of micro and macroexpressions (normal duration expressions), they achieved a 76.92% accuracy in distinguishing liars and truthtellers[82]. However, there was a lack of ground truth in Su and Levine's study, and their machine learning approach showed that macroexpressions have much more predictive value than micro-expressions[82].

These new findings give some support that micro-expressions, and even macro-expressions, are able to distinguish lies and truths. However, more research is

needed to investigate whether these findings can be replicated, especially in field studies. Findings regarding false smiles and deception seem to be more consistent, but evidence of emblematic slips as cues to deception are still scarce and inconclusive. EDT prediction that illustrators decrease during deception is supported by an independent meta-analysis study[66]. However, despite significant, the effect between illustrators and lies is relatively small, although there is a greater effect between hand/finger movements and deceptive conditions.

Comparing the empirical support of both nonverbal lie detection methods, it has been shown that BAI is less effective at discriminating lies and truth than EDT. Of the few studies that have examined the effectiveness of BAI, most of them showed that BAI-trained observers were less accurate at detecting lies than those who did not receive training[15,16]. While those studies that showed average accuracy above the level of chance failed to establish reliable ground truth in their deceptive and truthful cases[61].

Despite some inconsistent findings and lack of support for some hypotheses, EDT provides more effective predictions about nonverbal cues and deception than BAI, especially those involving differences between false and truthful smiles. It is worth noting, however, that EDT is not a "tool" for detecting lies. Ekman's deception theory has not yet been systematized nor standardized as a lie detection tool, although it is used as the basis for a training program on deception[83]. The lack of standardization in the use of EDT predictions to detect lies can be seen as a weakness of the method. Therefore, future efforts should draw the most empirically supported predictions of EDT and create a standardized nonverbal lie detection tool. Besides that, almost all the evidence in favor of EDT comes from the same research group, this raises the question if these findings can be reproduced by independent groups. Therefore, EDT predictions need to be interpreted with some cautions as well.

6. Discussion

Since studies show that most people are not so good at detecting lies, several professionals, especially forensic ones, look for lie detection training. However, not always these professionals know how accurate those current available lie detection techniques are. For this reason, the present work presented the strengths and weaknesses of the most used verbal and nonverbal lie detection tools.

Despite being one of the most widely used lie detection tools by criminal investigators in several countries, studies have shown that SCAN does not

discriminate false and true statements above the level of chance. While CBCA and RM showed more empirical support and similarities in terms of accuracy. Therefore, both CBCA and RM can be equally recommended for lie detection applications. However, both CBCA and RM have the disadvantage of requiring training and consuming time to master the coding and analysis of statements using these tools.

Regarding nonverbal lie detection tools, few studies have examined the effectiveness of BAI. However, most of these studies have shown that BAI-trained people are less accurate in lying detection than untrained people. Whereas EDT provides more effective predictions about nonverbal cues and deception. However, the lack of empirical support for some hypothesis and absence of standardization of its predictions are considerable weaknesses of EDT. Creating a standardized tool following EDT predictions is a task for future efforts.

Although most research has focused on nonverbal deception cues, recent studies have shown the effectiveness of verbal lie detection tools. Despite this (supposed) preference for nonverbal signals, there are currently more verbal (than nonverbal) lie detection tools. One of the possible reasons for the lack of nonverbal tools is the inadequacy of scoring systems on how to measure nonverbal cues (4). Another reason may be the difficulty of individual nonverbal cues to detect deceit. It has been shown that clusters of behaviors are better at diagnosing lies than individual cues. For instance, Vrij et al. found that based on a combination of four nonverbal behaviors (i.e., illustrators, hesitation, latency period, hand/finger movements) they achieved above than chance levels in discriminating truthtellers and liars, but none of these behaviors alone achieved similar results[84]. Matsumoto and Hwang[85] also found that clusters of nonverbal behaviors differentiated truthtellers from liars, accuracy rates ranging from 62.6% ($p = .026$) to 72.5% ($p = .027$).

Future works may aim to develop a tool that uses both verbal and nonverbal criteria and predictions. It has been shown that those who rely on verbal plus nonverbal cues are more accurate in detecting lies than those who rely solely on verbal cues[73]. Therefore, a lie detection tool with verbal and nonverbal predictions would potentially have higher levels of accuracy than those currently available. However, future research should be done to confirm (or not) this hypothesis.

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