Review Paper

A Review Article on Layered Voice Analysis: Forensic Utility and Limitation

Shubhangi Srivastava[1]*, Afreen Alisha Hussain[2], Dr. Swapnil Gupta[3]

ABSTRACT

Layered Voice Analysis is a new technology in voice analysis. Features like *analysis of emotional cues, cognitive process and stress in voice* by *"brain trace activity"* and *"emotional signature"* makes it unique and powerful tool for various fields like criminology, forensic psychology, psychology, medicine, etc. The technology can be used for linking different psychological features with the voice. LVA also detects and analyze the unconscious emotional cues and may play an important role in screening potential deviant behavior, criminal investigation and understanding layers of emotional cues and cognitive processes. LVA can be used by rehabilitative and correctional centers to determine the underlying behavioral factors of a convict and design a rehabilitative programme according to the needs of the convict and it will also help in recording the progress and efficiency of the ongoing programmes. Few studies also highlight the limitations and chance level performance of LVA. But the issues like inducing simulated stress, controlled analysis by LVA operators and lack of any kind of ecological or real-time fear might have contributed in the final results of the studies. It is important to understand that LVA detects the current mental state of the speaker to detect the speaker's internal reaction to the lie. The LVA technology does not identify the lie.

Keywords: *Forensic Psychology, Layered Voice Analysis (LVA), Detection of Deception, Voice Analysis, Emotional Signature, Speech and Deception.*

V erbal interaction is a huge part of our daily lives. A conversation may convey multiple layers of information including the information beyond the literal meaning (Park, Lee, Brotherton, Um, Park, 2020). The verbal interaction or oral communication provide meaningful information like linguistic content or what is being said and its meaning but it also has indexical features as well.

[1]Forensic Professional (FPACT), Central Forensic Science Laboratory, Kamrup, Assam. DFSS, MHA, Government of India.
[2]Forensic Professional (FPACT), Central Forensic Science Laboratory, Kamrup, Assam. DFSS, MHA, Government of India
[3]Scientist- B (Documents) & HoD Forensic Psychology, Central Forensic Science Laboratory, Kamrup, Assam. DFSS, MHA, Government of India.
*Corresponding Author

The indexical features include information like the identity of the speaker, age of the speaker, language and dialect of the speaker and emotions (including stress) (Harnsberger, Hollien, Martin & Hollien, 2009).

Since the understanding of relationship between oral communication and emotions (including stress) and its utility, various devices were created to extract the information for different purposes. These devices were used for detecting deception in the human voice by various countries, mostly by their law enforcement agencies (Horvath, McCloughan, Weatherman & Slowik, 2013). A more contemporary approach to voice-based "lie detection" has emerged as Layered Voice Analysis (LVA), invented in 1997 by Nemesysco Ltd. in Israel (Mayew & Venkatachalam, 2012). Voice analysis has three different disciplines: voice signature, speech to text and emotional analysis. LVA deals only with emotional analysis (Kacker & Shukla, 2020). LVA technology detects and measures the emotional content of human speech by capturing it live (online mode) or by extracting it from recorded audio (Offline mode) (Conradie, 2007). LVA identifies various types of stress, emotional reactions and cognitive process as well. They together provide *"emotional signature"* of the subject at a given moment, based only on the properties of the voice of the subject.

This technology has following features:
   a) It is designed for security and screening and it also helps in police investigations, secured access control, intelligence information, hostage negotiation, etc.
   b) It helps in understanding the subject's emotional system better and provides an insight into the way subject thinks, what troubles and excites the subject or if subject is not certain about anything, etc.
   c) It allows the user to explore and understand various levels of conscious and unconscious thoughts and feelings. This technology provides additional layers of information that is not assessable easily and helps the user to find out the truth as soon as possible (Conradie, 2007).

Oral communication needs minimal efforts and exhibit subconscious knowledge for interaction on a daily basis. This leads to identifiable emotional cues in the voice (Park et all 2020). Out of these many emotional cues, stress has an established relationship with lying to some extent, with an understanding that vocal stress does not always indicate lying but it can be an indicator of deception in majority of cases (Harnsberger et all 2009). The ability to detect stress in oral communication has wide range of applications for law enforcement agencies, private companies, mental health applications, deep-space missions, etc., (Salganik, Vries, Intrater & Sheizaf, 2014).

Working Principle and Mechanism
According to Nemesysco the device works "upon a 'voice frequency' analysis involving the application of '8000 mathematical algorithms' to '129 voice frequencies' that are affected by '*psychological versus physiological* body reactions to the stress of telling lies'", Horvath et all (2013, p. 643).

Speech and the voice are two different phenomenons as any other complex set of behaviors. Human behaviors are the manifestations of cortical activity, which has the following functions: *any events occur and are perceived by the individual. Then these events are processed through the brain according to individual's personal experiences and/or*

behavioral hierarchies. Interpretations of these events are manifested by the individual's voice which is unique to that individual (Conradie, 2007).

The principle of LVA technology is related to the process when we speak. Initially, the brain tries to understand the situation and understand the meaning implied. The brain monitors the vocal tract resonations like throat, mouth cavity, nasal passage, and it also closely monitors voice tract articulation through tongue, soft palette, and lips. Therefore, the event in the brain leaves a *"finger print"* on the speech flow. LVA technology does not focus on the content of the speech instead its focuses on the brain activity involved when the subject speaks. It takes *"how the subject speaks"* into consideration rather than what he says to detect states of stress and emotions (Nemesysco, 2020).

LVA measures the stress, emotional cues and cognitive processes and grades them automatically. The LVA technology can also indicate the cause of stress. In its reports it indicates whether the stress experienced by the subject is due to a lie, an excitement, an exaggeration, a cognitive conflict, etc. It tries to detect multiple layers of the subject's conscious and unconscious state. It uses around 18 vocal parameters and thousands of mathematical processes to accurately analyze the state of mind, including exited, confused, stressed, aroused, embarrassed, deceptive and joking state of the subject (Nemesysco, 2020). Nemesysco has two basic formulas for LVA:
a) It uses thousands of mathematical calculations (38,000 algorithms) to extract more than 120 emotional data parameters from each voice segment and
b) It automatically analyses it further into nine major categories of emotions. The final result is then calculated and reflected in eight formulas including lie, stress, arousal level, attention level, deception and additional methods for veracity assessment (Conradie, 2007).

The LVA software performs analysis at voice segment level. A voice segment is a logical, meaningful and noiseless portion of continuous voice ranging from one word to a few words which might range in length from 4/10th of a second to 2 seconds. LVA then creates output (result) based on multiple layers of analysis like the base layer extracts and combines raw vocal attributes, the next layer creates fundamental emotion variables, and the final layer creates conclusion variables that result from combining results from prior layers (Mayew & Venkatachalam,2012).

Calibrated value of each raw base layer variable provides the four fundamental variables of the LVA software: *Emotion Level, Cognition Level, Global Stress and Thinking Level.* Emotion Level captures excitement, Cognition Level captures cognitive dissonance, Global Stress captures physical arousal and alertness, and Thinking Level captures the mental effort behind what the subject is saying (Mayew & Venkatachalam, 2012).

Understanding Forensic Utility and Limitation of LVA
There are few studies on Layered Voice Analysis technology for research purposes and testing the accuracy and efficiency of LVA. It can be employed by various fields like psychology, law, medicine, etc., to understand the relationship between voice and different aspects of these fields. As mentioned earlier, LVA detects the *"brain activity traces"* by using voice as a medium and the information gathered through this reveals the speaker's current state of mind and generate *"emotional signature"* of a person (Conradie, 2007). This feature can be used to understand about an individual's personality, traits, cognitive process, etc. A study on *"Layered Voice Analysis based determination of personality traits"* was

done to find out the connection between the individual's emotional signature and personality traits. The aim of the study was to find out whether the presence emotions in one's voice reflect on their personality traits or not (Manchireddy, Sadaf, Jospeh & Reddy, 2010). Emotional signature depends on what happens in our brain when we speak. The interpretation by brain is expressed through an individual's voice and it is unique to that individual. The study used this feature to establish a relation between voice and personality. A questionnaire, the Sixteen Personality Factor Questionnaire (16PF), which is an internationally accepted self-report personality test, was used for assessment of psychological traits. The recorded voice samples along with the results of 16PF questionnaire were statistically analyzed to find out a relationship between voice and personality. Various traits like affectogthmia, threctia, praxernia, surgency, harria, etc, were found out using 16PF. The LVA on the other hand generated emotional factor like upset, content, angry, excited, stressed, hesitation, concentrated along with emotion-cognition ratio. The statistical analysis revealed various significant findings like there was a strong correlation between emotion-cognition ratio and ego strength. Students who were more upset tend to have higher level of affectogthmia (Manchireddy et all, 2010). The findings of this study established a positive relationship between emotional factors, expressed through voice, and personality traits. As mentioned by Manchireddy et all, (2010), "There is a significant correlation between the emotional factors and certain personality traits. Thus, the emotions displayed through voice can be used as a tool to determine personality." (Manchireddy, 2010, p. 521) This study increases the utility and importance of LVA in the field of psychology and law enforcement agencies, the ability to determine personality through voice might help in interview and analysis of the subject.

LVA, along with its conscious emotional cues, also helps in understanding the unconscious thoughts and feelings. According to Prof Herman Conradie, Department of Criminology, University of South Africa in *"The Sexual Arousal Factor in Paedophiles",* "It (LVA) facilitates a better understanding of the subject's emotional structure, insights into the way he thinks, what troubles him and what excites him, what part of his story he is uncertain about, and what attracts his attention. It also enables the user to explore several levels of conscious and unconscious thoughts and feelings. This technology thus reveals additional layers of information that would otherwise be inaccessible." Conradie (2007, p. 36). The information gathered from these additional layers might help in police investigation, security screening, hostage negotiations, etc. The aim of this study was to use LVA technology to unravel the thinking process and emotions of the pedophiles. The study interviewed fifteen convicted pedophiles using LVA technology. Twelve of these convicted pedophiles were participants of PedoStop programme. PedoStop is a rehabilitation programme developed Mr. Reinier Naudé of the Department of Correctional Services at the Grootvlei Correctional Facility, in an effort to change the behavior of the pedophile convicts. It might not be a rehabilitation programme in the strict sense but rather a self-management programme (Conradie, 2007). The interview consisted of few questions and few picture questions *(half-naked pre-teens, clothed attractive men and women, erotic pictures of men and women and naked pictures of men and women)* to elicit and analyze their thinking level, emotional level, risk level and sexual arousal level and if their responses are deceptive. The emphasis of this study was on the convicts response to the picture questions. Depending upon their responses and LVA analysis these convicts were classified in different categories for analysis. The categories are as followings:
  i.   Mainline and Hardcore Pedophiles (n=2) - They reacted with the highest sexual arousal factor to the pictures of half-naked pre-teen girls. One of the examples of the important support LVA provided in identifying the mainline pedophiles can be

demonstrated by a brief response of one of the convict with real time analysis, which is given verbatim as, ""They are (truth) youngsters who are also playing (highly stressed) in the pool or the swimming (inaccuracy) … They are also swimming (inaccuracy) … and … ah … (high tension) look to be happy (probably false)"" (Conradie, 2007, p. 46).

ii. Slowed-down Pedophiles (n=3) – Their sexual arousal was highest when they discussed about their modus operandi. The sexual arousal was activated by children and found to be highest when they discussed about it or they described their last sexual assault. Here is one of the examples of LVA analysis of a slowed down pedophiles (translated from Afrikaan): ""It is someone that (inaccuracy) does something against (high anticipation) … that does something sexually against (stressed) women and children and (inaccuracy) …without their (inaccuracy) … without their consent (probably false)."" (Conradie, 2007, p. 47)

iii. Inactive Pedophiles (n=8) – They scored highest when they talk about how they sexually satisfy themselves now. Out of these eight convicts, two of them experienced highest sexual arousal when describing their last sexual assault. This behavior of reflecting and fantasizing about their previous victims is commonly seen in pedophiles. Since now they employ other ways to sexually satisfy themselves, it was deduced in the study that they are inactive because their sexual arousal "stopped" with their last assault.

iv. Sideline Pedophiles (n=2) – They did not react to primary pedophile questions. They responded with the highest sexual arousal when shown a picture of an attractive male or a woman with blood on her breasts. It was deduced in the study that they engaged in pedophilia as a sideline. (Conradie, 2007) They might engage in pedophilia because children were easy targets.

The LVA's ability to identify and register sexual arousal proves that LVA technology is a powerful linguistic tool and it does help in understanding the unconscious thoughts and feelings (In this case, unraveling the minds of pedophiles). Since the punishment for child sexual abuse is much severe than of an adult, the investigative techniques should use LVA unearth critical information about pedophiles (Conradie, 2007).

However, Harnsberger et all (2009) and Horvath et all (2013) in their respective studies, analyzed the accuracy and success rate of LVA through different methods and highlighted few limitations of LVA technology. In the study on *"Stress and Deception in Speech: Evaluating Layered Voice Analysis"* the Layered voice analysis was evaluated by a double-blind study using two types of examiners. Pair of scientists trained by the manufacturers and two highly experienced LVA instructors were employed as examiners (Harnsberger et all, 2009). The study was programmed into three stage model. The present study reports on the first stage, where under highly controlled laboratory settings, the utterances involving truth, deception, stress are obtained from the speakers. A very important point to note here is that these responses are experimentally induced, they are relevant to the study and their presence is verifiable through assessment. Each subject produced six different types of utterance: Low stress truth, Low stress lie, high stress lies, high stress truth, high stress lie- dual stressor and simulated stress. The subjects held strong views about some issues and the speech sample primarily involved intense contradictory statements while believing they would be heard and seen by peers. The goal was to understand the true positive rate and false positive rate of LVA. Intensive statistical analysis revealed true positive rate to be below or near chance in the range of 42-50% whereas false positive rate high and in the range of 54-63%. The comparable hit and high percentage of false positive rate indicate a lack of sensitivity.

According to the study, "The raw data and all statistical analyses suggest only chance-level performance by the LVA, which can lead to the conclusion that the LVA is insensitive to deception and stress outside the laboratory." (Harnsberger et all, 2009, p. 648). The LVA did not show the expected sensitivity to the presence of deception, truth and/or high/low stress in voice.

Following the above study, Horvath et all (2013) conducted a study on *"The Accuracy of Auditors' and Layered Voice Analysis (LVA) Operators' Judgments of Truth and Deception During Police Questioning*"* to assess the effectiveness of LVA by determining the success rate of auditors in identifying truthful and deceptive people. The voice samples of suspects being questioned by police polygraph examiner (pretest interview) by Michigan State Police (MSP) were taken with two conditions, it should be from the examination where the examiner has determined that the examinee had been either deceptive or truthful (all inconclusive, incomplete, and other outcomes were excluded) and the examiner's judgment should be confirmed by one of the two statistical algorithms, either Polyscore (Version 1.0.01) or Objective scoring system (OSS Version-2). The samples were evaluated by two trained LVA operators and the results were compared with the results of auditors who independently audited the same data. After qualifying the conditions mentioned above, 74 samples were taken out of which 31 were truthful and 43 deceptive as reported by polygraph examiner. LVA however produced 36% inconclusive result with auditors giving a mean of 68% on correct judgment on truthful samples and a mean of 71% on correct judgment on deceptive samples and they did not render any inconclusive judgments. LVA operators on the other hand, were correct with 48% and 44% of their judgments were inconclusive for truthful samples and mean was 25% for correct judgments on deceptive samples with high percentage of inconclusive results averaging 31%. Out of these 74 samples, 18 suspects gave confirmed confession confirming their deception. The mean accuracy of auditors was found to be 70% whereas the mean accuracy of LVA operator was 42% correct judgments. On average the overall accuracy was 72%; the average of LVA operators was 48%. This data clearly shows the chance level performance of LVA with trained LVA operators (Horvath et all, 2013) According to the study, "the LVA operators produced correct calls of deception, on average, only 25% of the time when deception was verified by the polygraph examination result; when deception was not present, when persons were truthful according to the polygraph examination outcome, the LVA operators were correct only 49% of the time. When the "guilty" persons had confessed their involvement in the matter under investigation and thus had acknowledged their deception..." (Horvath et all, 2013, p. 06) These findings were in line with the research findings of Harnsberger, which also suggested chance level performance for the LVA and high false positive rates and inconclusive judgments.

Although the limitations highlighted in these studies stand correct and might raise a question on the utility of LVA but there were many important considerations while evaluating these studies and these important considerations were acknowledged in these studies as well. We shall discuss these points in the next section of this article.

Defending the Utility of LVA against Its Limitations
Layered voice analysis is a technology that uses voice as a medium to understand the current mental state of a speaker and link it with detection of deception. Although there is a wide application of LVA in forensics, there are various procedural and technical considerations that the examiner has to know before using the instrumentation for examination. The broad

classification of these concerns can be *as Ecological vs. Simulated stress, Speech Database, and role of operator in the examination.*

    i.   *Ecological vs. Simulated Stress-*

The studies done to evaluate LVA have been limited in their ability to elicit an ecological stress and deceptive speech. The researches have employed a class of experiments which can be described as "simulated field" studies. (Harnsberger, et all, 2009, p. 642) in the study mentioned, "Studies of this type ordinarily involve testing subjects in the laboratory via fairly elaborate ''games''—ones which attempt to mimic naturalistic settings where individuals produce lies that, if uncovered, would expose them to some type of jeopardy or punishment." These controlled laboratory experiments provide little to no amount of relevant information. Harnsberger et all (2009) did give counterarguments for field research setup like lack of control for basic system assessment, unrecorded various external variables, no background knowledge of speaker's actual behavior state and thus he based his model of study on these counterarguments. But there were other concerns that came into light in this study since the stress even after being highly controlled, relevant and verifiable, were not ecological and thus it might be possible that the magnitude of stress was not comparable to those induced in situations like police investigations and interrogations. As acknowledged by (Harnsberger et all, 2009, p. 648), "in such cases, the ''real-world'' levels of stress might be higher than the psychological stress that can be generated in a laboratory setting on a college campus." The study argued that the sensitivity of LVA to detect stress should be norm across all the sets of speech material and no false positive (near zero) should have been observed. But it is important to take the situation under which the stress is measured into consideration. Even though powerful contradictory utterances were made against something the speaker truly believes in, yet it is non-comparable to a stressful situation where the speaker is in trouble with the law and it's a matter of life and death. The measurement of magnitude and validity of ecological and simulated stress largely depends on the situation in which it generates. Although the argument on ecological and simulated stress is important but LVA also measures the complete emotional cues, both conscious and unconscious, and then generate results. While evaluating the results of LVA, other emotional and cognitive features should be taken into account with reference to the speaker's complete background knowledge.

    ii.   *Voice Sample Database*

Since voice samples play a crucial role in LVA examination, the validity of protocol used in the development of this voice sample database should be scrutinized. A careful analysis of the studies raises a question on the method of collection of the voice samples and even if these voice samples are recorded under controlled laboratory, the validity of these samples remains under jeopardy. Harnsberger et all (2009) writes, "There are some common alternate interpretations of the results that could be used to argue that the device was not adequately tested in a laboratory study. For instance, the negative results could reflect limitations in the protocols used in the development of the speech data-base."(Harnsberger et all, 2009, p. 648) Similarly, Horvath et all (2013) wrote, it is important to note that though the voice samples were verified and reliable but they weren't collected by the method that should be primarily employed for LVA interview. As mentioned in the study, "It is important to note that the audio materials used in this study were drawn from the pretest interview portion of a polygraph examination… They knew their verbal responses and statements during the interview, even though given freely, were to be followed by polygraph testing, the known purpose of which was to serve as a check on their truthfulness. It would be assumed that under such circumstances there would be, at the least, heightened anxiety,

leading perhaps to more, or different, verbal content than what might occur in another context." (Horvath et all, 2013, p. 07) The operator was not able to ask questions, control what was being asked, or probe further. The data collection method did have its own limitations.

iii.   Role of the operator

The role of an operator is crucial not only in analysis of the results but also during examination and interview. A trained and experienced operator will be able to generate better and accurate results. The study by Horvath et all (2013) examined the role of operator in the LVA examination. In his study the comparatively poor performance of LVA operators might be due to a variety of reasons. The LVA operators were given the audited voice samples and they had not other outside information to probe further or resolve a conflicting output. The real time analysis feature of LVA helps the examiner to detect emotional cues (sensitive topics, hesitation, etc.) and probe the speaker further to elicit stronger emotional responses. This technique is helped by the collected history of the speaker. If the operator is unable to access this information, it might be very difficult to analyze the result accurately. As mentioned by (Horvath et all, 2013, p. 06), "Because the operators here did not have any way to reconcile such conflicts, such as by auditing the raw audio files, they chose to report inconclusive outcomes. In real life, LVA operators have access to outside information and they may resolve conflicting LVA output by making use of that information." The makers of the LVA claim that the instrument does not point a guilty or not guilty person but gives information, which when read and analyzed carefully along with other cues in speaker's behavior and history, by an operator, will help in detection of deception (Nemesysco, 2020).

LVA in Indian Scenario

LVA is comparatively a new tool in forensic psychology in India. There are not various studies on LVA in India. The LVA was first bought in India in May, 2012 under *"MERI AWAAZ HI PEHCHAAN HAIN"* initiative by Directorate of Forensic Science, Gujarat. Since then, the instrument is bought and used by various government agencies for screening and investigation (Kacker & Shukla, 2020).

The police and various forensic science laboratories are using LVA for criminal investigation. Few major cases that used LVA include the Shakti Mill case of Mumbai. The five accused of gang rape underwent through LVA and one of the accused confessed the crime along with other crimes. LVA has been used by Anti- Corruption Bureau, Gujarat and National Investigation Agency in INS Vikrant stolen electronics case. Even the technology is new in India, it is quickly getting high acceptance from the law enforcement agencies. The major advantage of LVA is that the test does not require any legal consent because it is non-invasive in nature (Kacker & Shukla, 2020).

CONCLUSION

Layered Voice Analysis is a new technology in voice analysis. Features like *analysis of emotional cues, cognitive process and stress in voice* by "*brain trace activity*" and "*emotional signature*" makes it unique and powerful tool for various fields like criminology, forensic psychology, psychology, medicine, etc. This technology gives a confirmed link between emotional cues and deception through the medium of voice. Few of the major advantages of LVA include: Online and Offline mode analysis. The Online mode gives a quick real time analysis whereas the Offline mode enables the operator to do telephonic examination and provide an in depth analysis. It is a non invasive technique and does not require consent for examination. It is important to understand that LVA technology unlike

Voice stress analysis (VSA) does not utilize micro-tremor analysis. It uses a wide-spectrum analysis which makes it easier to analyze whatever spectrum of frequencies is received.

The technology can be used for linking different psychological features with the voice, like Manchireddy et all, (2010) study where a relationship between different personality traits and emotional cues in the voice was established. Such studies provide an insight on the utility of voice I understanding human psychology better. Along with this, LVA's features to detect and analyze the unconscious emotional cues may play an important role in screening potential deviant behavior, criminal investigation and understanding layers of emotional cues and cognitive processes. The study on pedophile along with the use of LVA in understanding the pedophilic behavior also highlighted a major progress. LVA can also be used by rehabilitative and correctional centers to determine the underlying behavioral factors of a convict and design a rehabilitative programme according to the needs of the convict and it will also help in recording the progress and efficiency of the ongoing programmes.

On contrary the studies evaluating the LVA technology highlight the limitations and chance level performance of LVA along with its incongruence with the other lie detector tool-Polygraph. The findings of these studies are important in understanding the working and analysis of LVA but the issues like inducing simulated stress, controlled analysis by LVA operators and lack of any kind of ecological or real-time fear might have contributed in the final results of the studies. It is important to understand that lying is a phenomenon directly related to motives and intention and LVA detects the current mental state of the speaker to detect the speaker's internal reaction to the lie. The LVA technology does not identify the lie. There are two key points to remember: The LVA examination and analysis of the results are majorly dependent on the LVA operator or the examinee and for more accurate and efficient results it is important to understand the behavioral attributes of the speaker or the examinee. Asking the right questions, eliciting more emotional responses, probing further on a topic and observing the subject is an essential part of all and any forensic psychology examination. Also, it is important to remember that relying solely on voice or just one kind of any evidence is unrealistic in any assessment. As highlighted in a study, "It is unrealistic to rely completely on the voice to detect deception and hostile intent for all people and all situations. But, by exploring the vocal variables used by the software, we are able to correspond and fuse them with other detection technologies for higher prediction reliability and accuracy" (Elkins, Burgoon, & Nunamaker, 2012, p. 03).

Future Implication

Due to the newness of the LVA technology there are many unexplored features of LVA that might highlight its capabilities and shortcomings. This technology holds a lot potential and might have its use in various fields. Some of the major and immediate steps to be taken in order to increase its utility are as followings:

  i. ***Research and Evaluation***

There are only a few research works on LVA which limits the knowledge of the potential and limitations of the instrument. There is an increase in acceptance and utility of LVA but further researches on different aspects of the technology and examination shall be done in order to make better use of the instrument. Here are few of the many possible areas to study:

  a) the role of operator in the examination and analysis,
  b) Find out a connection between LVA and typology of crime
  c) the effect of different questioning techniques on the results,
  d) its utility in investigating hardened criminals,
  e) Compatibility with other psychological tools, etc.

In order to make the best use of the LVA technology, studies evaluating the technology against its limitations and utility is important. It gives a clearer picture of procedure, methods and might work as a guideline for any research work in the future.

ii.   Training the Operators
Operator or the examinee plays a key role in the LVA examination. A well trained operator will not only conduct a successful examination but also accurately analyze the emotional cues, cognitive process and stress. However, it was seen in various studies that people were specially trained for the research purpose only or were trained and experienced operators of other forensic psychology instruments. This highlights a major problem of not having highly trained operators to conduct examination and analyze the results. A more formal and proper training should be provided to the operators or examinees working on LVA.

iii.   Other than Forensic Psychology
As much as this technology is helpful in criminal investigation, it can be used by other fields as well. For example, in corporate offices, LVA can be conducted as a part of recruitment process as a screening tool. It can also be used in recruitment of teachers in schools to analyze their compatibility. LVA can also be used by various security centers like airport security checks whenever a threat is suspected.

The LVA technology, like any other technology has its own advantages and disadvantages. There is a lot more to LVA than what is known to us right now. There might be a shift in the paradigm of voice analysis once we are fully aware of LVA's potential and limitation.

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