(Dis)Entangling Lies and Emotion

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Abstract

Lies are frequently told. Nevertheless, researchers struggle to identify reliable cues to lying that allow for an accurate discernment between lies and truths. Especially physiological cues have been subject to debate among scientists because autonomic responses reflect the experience of emotion or stress, not deception per se. Despite that, tools like the polygraph based on autonomic responses are used to detect lies. The present study investigated if Electrodermal Activity (EDA) can be differentially elicited as a function of whether people lie or tell the truth. Further, it was tested whether this relationship depended on the valence and arousal of the emotion people experienced during lie-telling and truth-telling. A 2 (Veracity) x 3 (Valence) full factorial within-participants design was used to explore if the physiology of lying can be disambiguated from the physiology of emotion. Emotion was manipulated using short news video clips that varied in valence (negative, neutral, positive). Participants (N = 35) watched six video clips and were instructed to describe the content truthfully or untruthfully. EDA was decomposed into tonic EDA. A repeated measures General Linear Model was run to disentangle the effects of Veracity and Valence on EDA. Lying led to higher levels of skin conductance than telling the truth. Emotion did not significantly alter levels of skin conductance. Moreover, no interaction effect was found. This study formed the groundwork for further research. Despite significant differences, it was concluded that EDA is of limited practical value in discerning liars from truth-tellers.

Keywords: lie detection, emotion, autonomic responses, electrodermal activity

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People lie frequently, with indications suggesting that people lie daily (DePaulo et al., 1996). Therefore, lie detection is the subject matter of an extensive line of research. Nevertheless, a method to accurately discern truth from lie has yet to be identified (Luke, 2019). In the literature, deception detection cues range from verbal approaches such as interviewing and statement evaluations to analysing non-verbal behaviour and physiological markers (Nortje & Tredoux, 2019). Especially physiological cues have been subject to controversy (Lykken, 1981).

The physiological lie detection approach revolves around the idea that liars experience a heightened stress response which changes the activity of the autonomic nervous system. Electrodermal activity (EDA) is the most used autonomic response measure in lie detection (Vrij, 2008). EDA and other indices of autonomic responses measure the nervous system's activity. Activation of the nervous system reflects the experience of emotion or stress, which subsequently is interpreted as a cue to deception (Zuckerman et al., 1981). While EDA is an index for emotional stress, it does not directly measure deception. Although lying and autonomic responses can be theoretically related via emotion, this association is not sufficient to make arousal a reliable cue to lying. Despite that, EDA is used to make inferences about the veracity of statements. This is problematic because there is no direct link between deception and autonomic responses (Saxe & Ben-Shakhar, 1999). EDA is one of the critical components of the polygraph, which has been employed as a lie detector and has received substantial criticism up to the present day. Despite that, polygraphs are still being used by, for instance, the Federal Bureau of Investigation (FBI) to "verify information" and "determine the credibility of witnesses" (FBI, n.d.). It is unclear to what extent increased nervous system activity in lie detection reflects arousal, distress, how somebody feels, or deception. Deepening our understanding of how these processes interplay is crucial if one considers that EDA is being used to inform far-reaching decision-making by institutions such as the FBI.

The present study investigated if EDA can be differentially elicited as a function of whether people lie or tell the truth. It was tested whether this relationship depended on the valence of emotion people experienced next to the experience of emotion in general. Further, it was investigated if the physiology of lying can be disambiguated from the physiology of feeling an emotion. The remainder of this introduction briefly reviews the lie detection literature and its associated challenges. Drawing on previous research, electrodermal activity is discussed as a method to detect deception. Further, the confounding role of emotion and stress in relation to electrodermal activity and deception is emphasised. Finally, the objective of the present study is described.

The Current State of Lie Detection Research

Deception is commonly defined as "the deliberate act of conveying false information" (Nortje & Tredoux, 2019, p. 492), closely resembling the lying concept. Scholars often use the two terms interchangeably in literature (DePaulo et al., 2003). However, there are conceptual differences between the two. While lying is a deceptive act (i.e., a liar attempts to deceive), not all acts of deception are lies. For example, in order to lie, one must make a false statement. To deceive, one is not required to make any statement at all as people can deceive by remaining silent. This study focused on fabricating false statements and therefore addressed lying specifically rather than deception more broadly.

In general, research suggests that lay people are not good lie detectors. Meta-analytical findings of Bond and DePaulo (2006) suggest that lie-truth discrimination rates average around 54%, slightly above chance level. The reasons for this are multifold. First, people exhibit a truth bias. Specifically, people are more inclined to perceive that deceptive messages are truthful than that truthful messages are deceptive (Bond & DePaulo, 2006). People generally expect their interaction partners to be truthful and rarely question the credibility of what they are told (Bond & DePaulo, 2006). Second, lay people and professionals regularly hold false beliefs about cues to deception. For instance, a survey found that 65% of respondents across 63 countries believed liars often avoid eye contact, change their posture, and fidget frequently (The Global Deception Research Team, 2006). These beliefs about nonverbal cues to deception were also reported to be held by professionals such as police officers and lawyers (Sporer & Schwandt, 2007). However, research on these cues suggests that correlations are primarily weak and nonsignificant or suggest the opposite of such a belief (e.g., DePaulo et al., 2003; Sporer & Schwandt, 2007; and Luke, 2019). For instance, Mann et al. (2012) found that liars made more deliberate eye contact than truth-tellers. In sum, people may have misconceptions about deceptive cues and therefore attend to the wrong cues when assessing the veracity of a message.

Practically all nonverbal cues to deception were reported to not reliably discern liars from truth-tellers (DePaulo et al., 2003; Luke, 2019). For a good reason, deception researchers refer to the absence of a "Pinocchio's nose" as an infallible indicator of deception (e.g., Hartwig & Bond, 2011; Vrij, 2004; Vrij, 2006). While the consensus among scholars was that cues to deception are weak, Luke (2019) demonstrated that many estimated effect sizes of nonverbal cues to deception are likely to be inflated. This suggests that nonverbal cues lack reliability which motivates the need to consider an alternative type of cue. Next to nonverbal cues, an alternative means of assessing deception are physiological markers.

The Physiology of Lying

Human thinking and feeling invariably co-occur with physiological changes, as mental processes coincide with functional changes in the brain and other physiological systems (Ambach & Gamer, 2018). The psychological processes of deception are no exception. The idea of using physiological measurements to discern liars from truth-tellers dates back several millennia. In ancient China, accused liars were ordered to chew rice powder and spit it out (Vrij, 2008). If the powder was dry, the accused was deemed guilty of lying, as the fear accompanying being found lying was hypothesised to decrease salivation. The rationale was that a liar's physiological responses invariably differ from a truth-teller's. However, this idea presupposed that lying is accompanied by specific emotions (i.e., fear) that account for decreased salivation. Thus, fear would cause salivation to decrease, not lying directly.

In line with this rationale, DePaulo et al. (2003) argued that deception may be related to changes in physiology. Zuckerman et al. (1981) proposed a four-factor model to lie detection. They suggested 1) generalised arousal, 2) feelings experienced while lying, 3) cognitive effort, and 4) attempted behavioural control as cues to deception. The underlying assumption was that the expression of these four factors fundamentally differs between liars and truth tellers (Zuckerman et al., 1981). Because the factors are closely related to changes in physiology, the distinct expression of the factors in liars and truth-tellers could lead to measurable physiological differences. Ströfer (2016) categorised the four factors into two groups which are the subject of the upcoming paragraphs.

The first category, cognitive load, includes cognitive effort and attempted behavioural control. Cognitive load is commonly referred to as the total amount of cognitive resources required to solve a problem or complete a task (Sweller, 1988). This category describes cognitive processes underlying deception. According to Zuckerman et al. (1981), lying is a more complex task than truth-telling. For example, researchers found that participants took less time preparing statements in line with the truth than deceptive statements (DePaulo et al., 1980, cited in Zuckerman et al., 1981). Greater cognitive effort is required to formulate an internally consistent and logical fabrication than to describe a recollection of experienced events. Simultaneously the truth must be suppressed, which further increases cognitive load. Moreover, liars monitor themselves to examine their trustworthiness more often than truth tellers, which imposes additional cognitive load (DePaulo et al., 1988). Self-regulation refers to attempts people make to monitor their behaviours to ensure they do not compromise their ability to achieve their goals (Granhag & Hartwig, 2008). Therefore, self-regulatory processes can help explain the increased cognitive load for liars. Specifically, liars spend cognitive resources monitoring and adjusting their acts to adopt behaviours that reflect what the liar believes to align with telling the truth. This process describes the second factor, attempted behavioural control. Indeed, liars mimic the behaviour they believe to be authentic. For instance, Mann et al. (2012) found that liars deliberately made eye contact to appear more credible than truth tellers, as previously mentioned. What groups attempted behavioural control and cognitive effort together into a category is that both impose additional cognitive load. Increased cognitive effort is related to functional changes in the brain and other physiological systems (Ambach & Gamer, 2018). Accordingly, Howard et al. (2015) found that brain regions associated with working memory showed greater activation in tasks imposing higher cognitive load. However, these differences in cognitive effort were detected using fMRI, not EDA.

The second category, emotional stress, includes generalised arousal and feelings experienced while lying as factors. Both can be measured using EDA. In laboratory studies, lying and truth-telling were correlated with different autonomic responses (Lykken, 1978; Raskin & Hare, 1978). Liars showed more signs of increased nervous system activity than truth-tellers. Therefore, Zuckerman et al. (1981) suggested that liars experience higher general arousal than truth tellers. While listing several theories to interpret the difference (i.e., punishment theory, conditioned response theory, conflict theory; see Davis (1961) for more information), they also considered that this difference may merely reflect specific emotions. According to Ekman (1989), emotional stress in the context of deception originates from feelings of fear and guilt. A liar may fear their attempt to deceive is detected or feel guilty because they believe that lying is bad (Ströfer, 2016). Fear has been reliably indexed using psychophysiological markers such as heart rate, heart rate variability, fear-potentiated startle respiratory sinus arrhythmia, and skin conductance response (Hyde et al., 2019). These physiological responses can be measured, quantified, and could allow for accurate distinction between liars and truth tellers. Based on this assumption, the polygraph was devised. Polygraphs measure a multitude of channels of physiological activation, such as blood pressure, respiration rates, heartbeat, and electrodermal activity (Nortje & Tredoux, 2019). If the polygraph detects heightened physiological arousal, it is construed as a fear reaction associated with the fear of being caught in a lie. This interpretation resembles the reasoning behind the deception detection method in ancient China. While technological advancements have refined the detection method, the premise remained that the autonomic responses of truth-tellers and liars differ. Moreover, both methods strongly emphasise the role of fear in explaining these differences.

Electrodermal Activity as a Cue to Deception

EDA was first termed by Johnson and Lubin (1966) and refers to the electrical properties of the skin (Boucsein, 2012). Because EDA is an autonomic response, it cannot be controlled at will easily (Ambach & Gamer, 2018). Autonomic responses indicate the interplay between the sympathetic nervous system (SNS) and the parasympathetic nervous system (Ambach & Gamer, 2018). Heightened SNS activity is associated with several bodily signals, such as an increased heart rate, higher blood pressure, respiration, and perspiration (iMotions, 2017). Eccrine sweat glands on the skin produce sweat whenever an emotionally arousing stimulus is experienced (Caruelle et al., 2019). More sweat is produced when the stimulus is experienced as more emotionally arousing. Because sweat contains ions which conduct electrical currents, the electrical conductance changes relative to the emotional arousal experienced. EDA is considered the most sensitive compared to other psychophysiological measures of SNS activity (Boucsein, 2012). That may be because it is not altered by parasympathetic activity, which promotes relaxation and reduces arousal (Braithwaite et al., 2013). Excessive parasympathetic activity may indicate lower arousal levels, potentially masking the true activation level indicative of emotional stress. Therefore, EDA is the most repeatedly used autonomic response measure in lie detection (Vrij, 2008). Nonetheless, opinions on its efficacy in detecting lies diverge.

Both in practical use and among researchers, the polygraph is controversial. The polygraph is not widely supported among deception scientists. This is reflected in repeated declarations of the polygraph as "unsuitable" for deception detection from both the British Psychological Society and the American Psychological Association. Masip (2017) presented estimated accuracy rates in laboratory polygraph studies to detect deception between 74%-88% and truthfulness between 60%-97%. Field studies yielded similar accuracy estimates for detecting deception (42%-89%) and detecting truthfulness (59%-98%). Here, it is noteworthy that the lower ends of the estimates for detection deception are substantially lower for in-field studies compared to studies conducted in the laboratory. This may hint at challenges associated with applying polygraph lie detection to a practical setting. In presenting these estimates, Masip (2017) noted that the sample size of available field studies was small and that there is evidence of publication bias in favour of studies that show higher accuracy rates. Another limitation of many studies aiming to obtain in-field accuracy estimates of the polygraph is how ground truth is determined.

Ground truth refers to a claim's objective and verifiable classification as true or false. In field studies, ground truth is often unknown, which makes it challenging to establish. Confessions are frequently used as a criterion (Iacono, 2008). However, a substantial proportion of confessions are false (Gudjonsson, 2003). While this proportion is impossible to quantify, Gudjonsson (2003) emphasised that it may be significantly underestimated. According to Iacono (2008), one of the main objectives of a polygraph examiner is to use a failed test result as leverage to obtain a confession. As a result, in-field accuracy estimates of polygraph tests likely do not reflect its true discriminative power. This is because a proportion of confessions that match a failed polygraph test are false. Moreover, polygraphs appear effective because people have an inflated perception of its efficacy (American Psychological Association, 2004). This inflated perception may cause the suspect to confess as they believe an attempt to deceive is futile (American Psychological Association, 2004). Altogether, it appears highly unlikely that estimates of the top end of the accuracy range presented by Masip (2017) reflect the actual discriminative ability of a polygraph. Although the detection rate may be greater than chance, the polygraph is likely to be less infallible than reported in some of the literature.

The main criticism of the polygraph and EDA in the context of lie detection pertains to the underlying assumption that autonomic responses between liars and truth-tellers differ. While there is little doubt that EDA measures physiological responses reliably, an increase in nervous system activity can stem from a multitude of factors unrelated to deception (Nortje & Tredoux, 2019). The context in which lie detection often occurs (e.g., submission to an authority figure, novel setting, social isolation, coercion, being associated with a crime) gives reason enough to experience some form of distress, even if innocent (Gudjonsson, 2003). Considering what often is at stake and what detrimental consequences being judged to be lying has on the suspect of a criminal case, it does not seem surprising that an innocent truth-teller would still experience distress. Given these circumstances, a lack of a clear distinction between possible sources of increased psychophysiological activity is problematic.

To sum up, there are good theoretical reasons to question the adequacy of judging veracity based on physiological cues. Physiological changes expressed in EDA are sensitive to an array of factors unrelated to deception. This notion can also be seen in Zuckerman et al.'s (1981) four-factor deception model. Specifically, generalised stress is hypothesised to indicate lying, while the experience of emotion is presented as a potential confounder accounting for this heightened stress response. In a nutshell, there is no certainty if increased levels of emotional stress originate from deception or factors unrelated to the veracity of the given account. Because EDA is limited to measuring sympathetic nervous system activity, the mere detection of an increase in activity does not specify if the subject experiences general distress, is aroused, or fears being caught in the act of lying. Additionally, it might need to be more evident whether heightened nervous system activity indicates experiencing negative emotions rather than positive ones.

EDA and Emotion

While EDA accurately measures the strength of an experienced emotion (Boucsein, 2012), it does not provide insights into emotional valence. According to Caruelle et al. (2019), EDA measurements can only be used to assess the arousal dimension of emotion and need to be complemented with self-report measures to determine the valence dimension. However, some researchers argued that emotions translate into specific physiological response patterns (Ekman et al., 1983; Lang, 1979; Schwartz et al., 1981). Hubert and de Jong-Meyer (1990) investigated emotional response patterns in reaction to film stimuli that vary in valence. They found that while negative stimuli elicited significant rises in EDA for the entirety of the stimulus, positive stimuli elicited only an initial increase in EDA. Christie and Friedman (2004) also reported findings supporting emotional specificity in physiological response patterns. Aguado et al. (2018) conducted a study in which they obtained psychophysiological data in response to film clips. They found greater skin conductance responses to stimuli eliciting fear than neutral and happy stimuli. Further, significant differences in baseline EDA were measured between clips that varied in valence (Aguado et al., 2018).

Taken together, this raises the question if EDA may not solely differ between arousal levels but show emotion-specific patterns that differentiate distress from eustress. However, although Aguado et al. (2018) found higher skin conductance responses to fear than to happiness, this does not specify if the measure is valence specific or if the fear stimuli led to greater arousal than the stimuli eliciting happiness. Similar to how there is no certainty about the origins of increased physiological activity in the context of lie detection, there is ambiguity in whether physiological responses reflect the experience of negative/positive emotion or increased arousal in general. In sum, it is unclear if physiological responses (and

EDA) reflect deception, the subjective experience of negative emotion, or arousal. The convoluted interplay between these factors in the context of lie detection makes it difficult to determine to which extent each is reflected in EDA.

Returning to Zuckerman et al.'s (1981) four-factor model to lie detection, emotional specificity would have implications for how emotions experienced when lying could differentiate between liars and truth tellers. While fear and guilt are emotions often associated with lying (Ekman, 1989), liars are not restricted to a negative spectrum of emotions. For example, Ekman (1989) stated that liars could feel the delight of fooling someone. Moreover, liars who tell prosocial lies could experience positive emotions out of compassion (Lupoli et al., 2017). Prosocial lies are "statements told to mislead and benefit a target" (Levine & Lupoli, 2022, p. 335). This type of lie is common and often goes undetected. Hence, it is reasonable for a prosocial liar not to experience the fear of being found lying. Because prosocial lies are told in situations in which honesty would lead to increased emotional harm, people high in compassion, emotional understanding, and cognitive empathy are more likely to tell prosocial lies (Lupoli et al., 2017). As prosocial lies are motivated by the genuine desire to prevent harm in the receiver of the lie, it may be that tellers of prosocial lies experience less guilt than tellers of selfish lies or even experience positive emotions because they believe they have done a good deed. This illustrates that the valence of the lie told and the associated experienced emotion, as in Zuckerman et al.'s (1981) model, could be an essential factor to consider. This especially applies when using autonomic measures found to be emotion-specific in some studies. For example, would lies with positive emotions elicit autonomic responses differently than more negative lies? Likewise, would a neutral lie elicit the same response as a truthful recollection of an adverse event? In any case, it needed to be clarified how changes in EDA can be mapped to deception and emotion, which motivated the present study.

The Present Study

The present study investigated if EDA can be differentially elicited as a function of whether people lie or tell the truth. It was explored if this relationship depended on the valence of emotion people experienced next to the experience of emotional arousal. Further, it was investigated if the physiology of lying can be disambiguated from the physiology of feeling an emotion.

According to Zuckerman et al.'s (1981) four-factor deception model, liars inherently show increased general arousal compared to truth-tellers. Increased sympathetic nervous system activity would be reflected in EDA. Moreover, the experience of emotion is associated with the nervous system's activity, which can be measured using EDA (Boucsein, 2012). Stronger emotions, regardless of their valence, would be reflected in EDA. However, some researchers have argued for emotion-specific autonomic response patterns (Aguado et al., 2018; Christie & Friedman, 2004; Ekman et al., 1983; Hubert & de Jong-Meyer, 1990; Lang, 1979; Schwartz et al., 1981). This would translate into EDA response patterns that reflect the experience of a negative emotion being different from EDA response patterns that reflect the experience of a positive emotion.

The physiological approach to lie detection is the subject of a long and ongoing debate among scientists. Conflicting accounts on the subject were reported in the literature. This motivated the need to re-examine some foundational ideas central to physiological lie detection. Due to contradictory findings, low confidence was placed in formulating a prediction as to whether and to what extent EDA would vary as a function of manipulating veracity, emotional arousal, emotional valence, or a combination of these factors. Therefore, no a priori expectations were formulated. The study's main objective was to explore and disentangle the relationship between emotion and lying on EDA.

Methods

Design

A 2 (Veracity) x 3 (Valence) full factorial within-participants design was implemented. The dependent variable, "Skin Conductance Level" (SCL), consisted of the tonic signal of electrodermal activity. The first independent variable, "Veracity", consisted of the levels Truth and Lie. Participants were instructed to lie about the content of a news video stimulus or describe it truthfully. The second independent variable, "Valence", consisted of the levels Negative, Neutral, and Positive and was manipulated using different news video stimuli. Two stimuli belonged to each level of Valence. This served the purpose of having a lie and a truth told for every level of Valence. Every participant was exposed to all experimental conditions. Therefore, every participant told three lies and three truths. As discussed later in the Procedure, measures were taken to counterbalance how often each stimulus was used to tell a truth or lie.

Participants

The ethics committee of the University of Twente approved this research project before data collection (request number: 221449). Participants were recruited using convenience sampling. The sample size was determined based on practical considerations such as the availability of resources and participants. Anyone aged 18 years or older was eligible to participate. The test subject pool system SONA of the University of Twente was used to recruit students of the Faculty of Behavioural-, Management-, and Social Sciences. Apart from SONA, the study was advertised on various social network sites (e.g., WhatsApp, Instagram). Additionally, a recruitment poster was designed and distributed in various locations on Campus (see Appendix A).

Due to connection issues in data collection, one response had to be omitted from the data set. Three additional responses were omitted after being identified as extreme positive outliers and interpreted as the results of technical malfunctions in recording EDA signals. The final sample consisted of 35 participants between 18 and 26 years of age (M = 22.11, SD = 2.01). More than half of the participants were male (54.3%), while the remaining were female (45.7%). All participants either obtained an undergraduate degree or were enrolled in undergraduate university programs. Most participants were German (62.9%) or Dutch (20%). See Appendix B for a table of all nationalities of the sample.

Materials

Pre-Experimental Questionnaire

The questionnaire included items about the demographic data of participants. Gender, age, educational level, and nationality were measured (see Appendix C). The questionnaire included a cover story to motivate participants to produce persuasive lies. Supposedly, a second researcher named Irene would judge the veracity of the participant's accounts. The web-based survey tool Qualtrics (Qualtrics, Provo, UT, USA) was used to administer the questionnaire.

iMotions

The software iMotions 9.3 (iMotions A/S, Copenhagen, Denmark, 2022) was used to administer all materials apart from the Pre-Experimental Questionnaire. The iMotions software is a modular system in which biosensors and their modules can be integrated. Measures from sensors were synchronised with recordings from the respondent camera. Further, measures were obtained separately, allowing for accurate segmentation to distinguish measures between periods of exposure to stimuli. Additionally, iMotions allowed for the integration of Qualtrics surveys. Upon completing the study set-up in iMotions, the experiment was piloted before the start of data collection. This served the purpose of validating the study's materials, resolving technical issues, and ensuring that instructions given to participants were easy to understand.

Dynamic Affective Stimuli

Six news video clips retrieved from Samide et al. (2020) were sampled to elicit emotions of varying valence in participants. Dynamic visual and auditory stimuli were chosen over static pictures for several reasons. First, dynamic stimuli inherently provide more information than static ones and depict events embedded in reality rather than static images. This provided participants with more information to describe (dis)honestly. Second, the dynamic nature of video scenes is superior to other methods of emotion induction (e.g., Palomba et al., 2000; Simons et al., 1999) because, similar to real-life experiences, events in video clips unfold over time (Aguado et al., 2018). Together, this increased the correspondence between stimuli and real-life events. For the same reason, stimuli that depict non-fiction were adopted. Further, in the applied context of deception detection, there is greater interest in whether an account or description of an event is truthful than of a static image. Lastly, film clips were shown to elicit physiological change successfully in previous literature (Christie & Friedman, 2004; Kreibig et al., 2007).

Samide et al. (2020) examined the dynamics of emotion and memory and obtained affective ratings for 126 videos showing real-life events in television news clips from the United States. Two videos eliciting positive affect, two videos eliciting negative affect, and two neutral videos were sampled. Sampling criteria were the length of the video, mean valence ratings and standard deviations. This served the purpose of minimising individual variability in response to the video clips. Video clips were only used if they had been shown to reliably elicit a specific emotional response across participants in Samide et al. (2020). For valence ratings, standard deviations, length, and source links, see Table 1.

Table 1

Information on Dynamic Affective Stimuli Sampled to Manipulate Valence

	Positive		Neutral		Negative	
	1	2	1	2	1	2
Label	Dolphin	Puppies	Publisher	HITS	Police	Torture
Length (s)	50	42	50	50	38	48
M	8.02	8.13	5.26	5.2	1.85	1.63
SD	0.96	1.06	1.44	1.17	1.08	0.86
Source Link	https://shorturl.at/cuxNS	https://shorturl.at/fglyU	https://shorturl.at/ijFJK	https://shorturl.at/tITX4	https://shorturl.at/hwI67	https://shorturl.at/hiqCV

Note. Mean Valence and Valence SD estimates obtained from Samide et al. (2020).

The first positive video clip was about a woman who plays with a dolphin she rescued from stranding. The second positive video clip was about using dog puppies as an intervention to alleviate stress in a hospital. The first neutral video was about a book publisher in New York. The second neutral video was about a new data collection method for American football called HITS. The first negative video clip was about a teenager who was shot dead by the police. The second negative video clip was about the use of torture in prisons. For a detailed description of each news video clip, see Appendix D.

Electrodermal Activity (EDA)

EDA can be dissected into two distinct types of activity (Boucsein, 2012; Stern et al., 2000). An EDA measure comprises a stable, consistent, and slowly changing signal and a responsive, variable signal (Boucsein, 2012). The stable signal is referred to as tonic EDA and reflects overall conductance and arousal levels over more extended periods (Figner & Murphy, 2010). Tonic EDA was particularly interesting because it is modulated by continuous stimulation over time, resulting from manipulations of Veracity and Valence. According to Benedek and Kaernbach (2010), tonic EDA varies over minutes rather than seconds. It was, therefore, paramount to include longer breaks between conditions to prevent the transmittance of one state to the other. The fluctuating signal is referred to as phasic EDA and is responsive to event-related, reactive, short-term changes in conductance. Phasic responses occur 1-3 seconds after an event and show an average duration of less than two seconds (Benedek & Kaernbach, 2010). While tonic EDA resembles skin conductance level, phasic EDA resembles skin conductance responses. Skin conductance responses were not pertinent to the present study as they primarily reflect reactions to specific video moments rather than a general stress response over extended durations. Because this study aimed to measure potential differences in the activity of the sympathetic nervous system during longer periods of truth-telling and lying in different conditions of emotional valence, tonic EDA was used to compare the conditions. Generally, skin conductance is measured in microsiemens (µS). Higher measures of µS indicate a higher electrical conductance of the skin and greater arousal, respectively.

The Sensing Health with Intelligence, Modularity, Mobility, and Experimental Reusability 3 Galvanic Skin Response+ unit (SHIMMER3 GSR+ unit) was used to measure EDA and collect data. The SHIMMER3 GSR+ unit (Real-time Technologies Ltd, Dublin, Ireland) monitors skin conductance between two electrodes attached to two fingers of one hand. It is an ectodermal constant voltage measure of EDA. Because the SHIMMER3 GSR+ unit is a sensor supported by iMotions 9.3, obtained EDA measures were automatically stored separately whenever a new stimulus was presented in iMotions.

Discrete Emotions Questionnaire (DEQ)

The DEQ was used to measure participants' emotions in response to film stimuli throughout the study (Harmon-Jones et al., 2016). The DEQ is a self-report measure sensitive to discrete emotional states. It provides a short measure of happiness, sadness, anger, fear, anxiety, disgust, desire, and relaxation on 32 items (see Appendix E). The subscales of anger, disgust, fear, sadness, and anxiety were combined to measure the experience of negative emotions. The negative emotions scale yielded good reliability ($\alpha = .89$). The relaxation subscale represented the experience of neutral emotion ($\alpha = .91$) because it reflects a low state of arousal. Responses on the desire subscale were overall low and did not differ between conditions of Valence. It was concluded that the discrete emotion of desire was not manipulated by exposure to video stimuli and therefore excluded from further analyses. Because the desire subscale was omitted, the happiness scale measured positive emotions ($\alpha = .95$).

Respondents were required to indicate the extent to which they experienced a specific emotion on a 7-point Likert scale (1 = *Not at all* to 7 = *An extreme amount*). Instructions to the DEQ were slightly altered to match the present study ("While watching the latest video and describing it to the camera, to what extent do you experience these emotions?"). This instruction was deliberately formulated to be double-barrelled to capture the overall experience of the specific combination of conditions (e.g., how lying about a neutral video was experienced as a whole). While not all discrete emotions measured by the eight subscales of the DEQ were relevant to this study, the decision was made not to shorten the DEQ. This was done to increase the time gap between exposure to dynamic affective stimuli and the (un)truthful description of their content, allowing participants to regulate their emotional state and revert to baseline arousal levels. Due to the design of this study, it was paramount to decrease the possibility of distortion of EDA measures caused by interference of trials. To complete the DEQ, participants it took participants about three minutes (*M*s= 183.08, *SD*s = 42.83).

Post-Experimental Questionnaire

The Post-Experimental Questionnaire included nine items which measured agreement on a 100-point slider scale (see Appendix F). To measure participant motivation, respondents had to indicate to what extent they 1) took the task seriously and 2) were motivated to do well. To measure perceived cognitive load, participants indicated to what extent they 3) found it more difficult to lie than to tell the truth. To measure perceived arousal, participants indicated to what extent they 4) felt stressed when having to lie and 5) felt stressed when telling the truth. To measure emotional stress, participants had to indicate to what extent they 6) felt guilty about having to lie to Irene, 7) feared that Irene would believe that they were lying when having to lie, 8) feared that Irene would believe that they were lying when having to tell the truth. Lastly, it was measured if participants believed the cover story involving Irene. Participants had to indicate to what extent they 9) believed that Irene was real when describing the videos. Moreover, two open-ended questions about how to appear truthful when lying and telling the truth were included but not analysed in the present study. Additionally, respondents were asked if they would like to tell the researchers anything about their experience in the study in an open-ended text box.

Procedure

Participants were invited to the BMS lab of the University of Twente. The room in which the study was conducted was a 2.2m x 2.3m x 3m enclosed space which allowed for remote monitoring. Participants sat in a desk chair with armrests in front of a PC screen to which a webcam was attached. The Pre-Experimental Questionnaire was administered. Participants gave informed consent and were informed about the right to withdraw from the experiment at any moment. Participants were asked to disclose if they suffered from extreme cases of phobia due to one of the stimuli showing footage of dogs. Nobody indicated suffering from phobias. Not all information was disclosed at the beginning of the experiment not to bias participants. The procedural information conveyed to participants that a second researcher called Irene was watching the video recordings of the webcam and judging the veracity of their descriptions based on the stories they told. Participants were instructed that it was their goal to trick Irene into believing that they tell the truth when instructed to lie. If instructed to tell the truth, the goal of the participants was to appear truthful and not mistakenly be judged lying by Irene. Then, the SHIMMER3 GSR+ unit was introduced to the participants. Velcro strap electrodes were placed on the medial parts of the hand's index finger and middle finger, not used to use the PC mouse. The electrodes were always attached to the left hand. Upon connecting the participant to the data collection device, measures were tested for signal stability and adjusted if required. Participants were given headphones to listen to the audio of the video stimuli. Then, the iMotions slideshow was started. A calibration phase of 80 seconds took place to obtain baseline measurements of EDA. Once completed, the stimuli blocks were presented in randomised order. Before each video, participants were told if they had to truthfully describe the events shown in the video in detail or fabricate a story afterwards. This was done to increase ecological validity. Typically, people either decide to prepare a lie or tell the truth when giving an account of an event.

Participants had to lie and tell the truth about stimuli from each Valence level (negative, positive, and neutral). The order in which the stimuli were presented was randomised, and the Veracity condition assigned to each stimulus was fixed. Eight slideshows were created in iMotions, to nullify a potential effect of the Veracity condition of a specific stimulus on obtained measures of successive stimuli. The eight slideshows covered all possible event combinations. Each participant was administered one of the eight slideshows. The distribution was balanced manually. After watching each video, participants described the content of the latest video stimulus (un)truthfully. The instructions were "You may now begin! Please describe the content of the video truthfully to Irene" or "You may now begin! Please lie to Irene about the content of the video". The time limit to describe the video was 90 seconds. If done earlier, participants could proceed by clicking the mouse once. Subsequently, participants had to fill in the DEQ and indicate whether they had to lie and what the video they just saw was truly about. Watching a video clip, describing its content, and filling in the DEQ marked one trial. This procedure was repeated until all six trials were completed.

Between trials, participants were given a break of one minute to relax. This cooldown period was manually extendable by participants at will. After all six trials were completed, the Post-Experimental Questionnaire was automatically administered. The Post-Measure Questionnaire included a debriefing section in which the aim of the study was presented and disclosed that Irene was not real. Upon completion, the end of the study was marked. On average, participants took 46 minutes to complete the study.

Data Analysis

iMotions 9.3 allowed for automatic processing of collected EDA data by R-Notebook integration. The "GSR Peak Detection" R-Notebook separated tonic EDA from phasic EDA. The algorithm was based on a method by Benedek and Kaernbach (2010). This method retrieved the calibrated Galvanic Skin Response (GSR) signal for each given stimulus and respondent in µS and determined the sample rate. Then the phasic signal was extracted and calculated by applying a median filter over a fixed period and subtracting the running median from the calibrated signal. To remove powerline noises, a low-pass Butterworth filter was applied. Additional information can be found in the paper of Benedek and Kaernbach (2010). Following Braithwaite et al. (2013), a sampling rate of 257 Hz was employed to obtain enough samples to separate phasic responses from tonic levels. No down-sampling procedure was applied. As recommended by Braithwaite et al. (2013), the peak onset threshold was set to 0.01 µS. After running the algorithm, data was exported from iMotions 9.3 and further processed and analysed using the programs IBM SPSS Statistics (Version 25) and R (R Core Team, 2021).

To account for the initial latency of 1-3 seconds inherent to the signal (Braithwaite et al., 2013), data from the first three seconds following the exposure to a new condition was omitted from the dataset. The dependent variable, Skin Conductance Level (SCL), was calculated by aggregating data from the tonic signal using respondent and condition as break variables. Thus, a mean score was obtained for every participant for all 2 (Veracity) x 3 (Valence) conditions, next to a mean score serving as a baseline measure from the calibration at the beginning of the experiment.

Because some researchers have argued for emotion-specific autonomic response patterns across time (Aguado et al., 2018; Christie & Friedman, 2004; Ekman et al., 1983; Lang, 1979; Schwartz et al., 1981), an additional variable, “Time”, was created to investigate how tonic EDA changes across time within each condition. One time interval covered five seconds.

Results

Descriptive Statistics

Skin Conductance Level obtained during the baseline measure was the lowest overall mean (*M* = 1.98, *SD* = 0.99). Across stimuli, mean measures varied from 3.79 to 4.07. The highest mean of Skin Conductance Level was obtained when descriptions of the HITS (neutral) video clip were given. The lowest measure was obtained when the positive Dolphin video clip was described. The positive Puppies video clip and the negative Police video clip elicited the same Skin Conductance Level (*M* = 3.95). See Table 2 for means and standard deviations. Independent samples t-tests were conducted to check if differences between truth and lie conditions were statistically significant across all video stimuli. Results showed that SCL measures in the Publisher stimulus condition significantly differed between levels of Veracity. For all other stimuli conditions, the differences in SCL between truth-tellers and liars were nonsignificant.

Table 2

Means and Standard Deviations of Skin Conductance Level Across All Dynamic Affective Stimuli Including Sub Measures by Level of Veracity with Independent Samples T-Tests

				Veracity									
	Total			Truth			Lie			Valence	*t*(33)	*p*	*d*
Stimulus	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*				
Dolphin	3.79	2.06	35	4.22	2.30	19	3.28	1.68	16	+	-1.35	.186	0.46
Puppies	3.95	2.02	35	3.23	1.81	16	4.55	2.04	19	+	1.99	.054	0.68
Publisher	3.91	2.30	35	3.03	1.09	15	4.57	2.75	20	+-	2.28	.031	0.70
HITS	4.07	2.08	35	4.46	2.5	20	3.56	1.24	15	+-	1.39	.175	0.44
Police	3.95	2.16	35	3.79	1.90	13	4.04	2.33	22	-	0.33	.745	0.12
Torture	3.98	2.11	35	3.76	2.12	22	4.34	2.12	13	-	0.78	.443	0.27

Note. Skin Conductance Level is expressed in µS.

Mean scores of the seven subscales of the DEQ were calculated. It was noted that scores were generally low. A table shows means and standard deviations across all news video stimuli (see Appendix G). Next, the seven subscales of the DEQ were transformed into three scales that reflected feeling negative, neutral, and positive emotions. These scores were correlated with the means of Skin Conductance Level for every level of Valence (Table 3). This was done to test if greater physiological activation would co-occur with strong self-reported emotion. The self-response measures were weakly correlated with measures of skin conductance. Interestingly, correlation coefficients for the positive DEQ scale were negative. This suggested that an increase in Skin Conductance Level, regardless of Valence level, co-occurred with a slight decrease in self-reported positive emotions. However, correlation estimates were low and nonsignificant.

Table 3

Correlation Matrix of Scores on Skin Conductance Level Across Conditions of Valence and Scores on Discrete Emotions Questionnaire Across the Negative, Positive, and Neutral Sub-Scales (N=35)

			DEQ Scale		
	Valence		Negative	Positive	Neutral
	Negative	*r*	.11	-.15	.15
SCL	Positive	*r*	.29	-.17	.09
	Neutral	*r*	.17	-.17	.09
	Total	*r*	.19	-.17	.11

Note. For all correlations, $p > .050$.

Finally, the responses to the Post-Experimental Questionnaire were examined (see Appendix H). The scale measured to which extent participants agreed with statements on a scale from 0 to 100. Participants were generally motivated to do well ($M = 88.16$, $SD = 10.76$) and took the task seriously ($M = 91.57$, $SD = 7.41$). Also, participants agreed with the statement to find lying more difficult than telling the truth ($M = 75.11$, $SD = 25.45$). Moreover, participants experienced more stress when lying ($M = 60.89$, $SD = 24.32$) than when telling the truth (*M* = 30.65, *SD* = 23.05). A paired samples t-test showed that this difference was statistically significant, *t* (36) = 5.14, *p* < .001. However, participants experienced little guilt when having to lie (*M* = 19.97, *SD* = 23.13) and did not experience fear that their lie would be detected by Irene (*M* = 23.95, *SD* = 31.25). Additionally, participants were suspicious of the cover story and did not believe Irene was real (*M* = 38.59, *SD* = 31.7).

Results indicated that participants were likely aware of the negligible consequences linked to failing the lie detector test but wanted to do well regardless. However, recognising the low stakes seemed to have not prevented lying from being stressful.

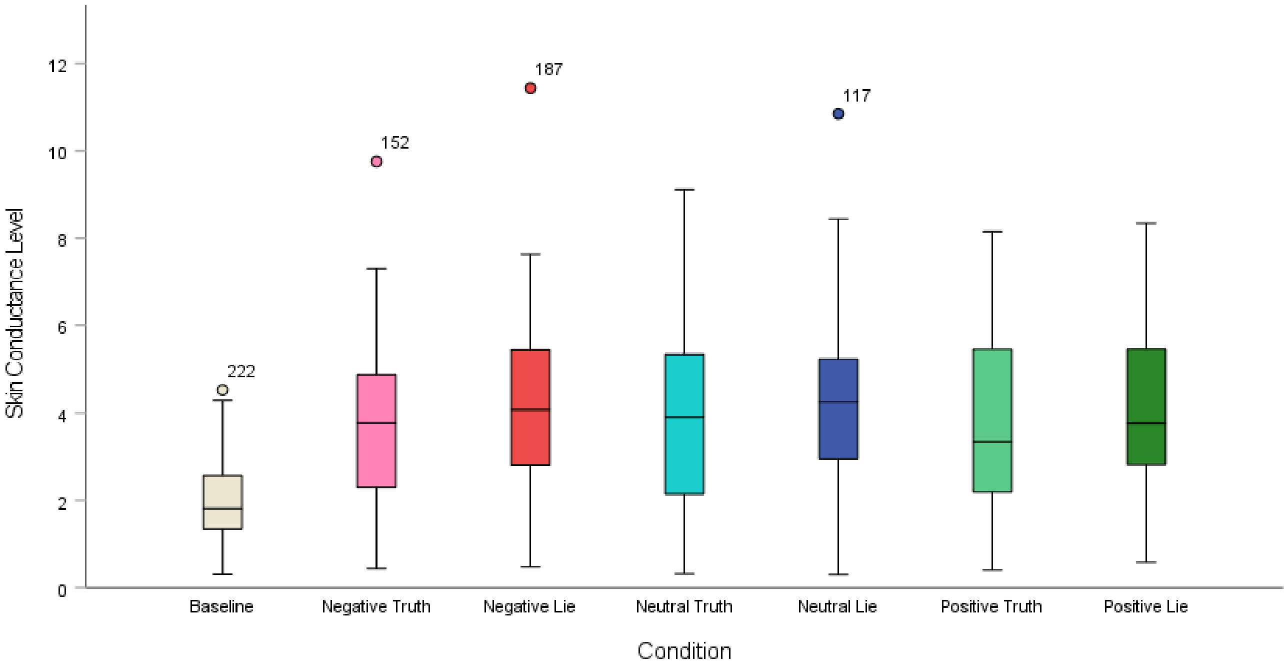
Manipulation Check

Skin Conductance Level

It was tested if Skin Conductance Level in the experimental conditions was statistically different from the baseline. A repeated measures General Linear Model with a Simple Contrast with baseline as the comparison group was run. The epsilon value for the sphericity assumption was calculated as ε = .7. Mauchly's test of Sphericity was violated with $\chi 2$ (20) = 37.17, *p* = .009, indicating that the variances of the differences between all combinations of conditions were not equal. A Greenhouse-Geisser correction was applied. A statistically significant difference was found between experimental groups, *F* (4.2, 142.99) = 28.76, *p* < .001. Simple Contrasts revealed that the baseline measure was significantly lower than all experimental conditions. In every comparison, the *F*-value was greater than 28.76, and the *p*-value was less than .001. Figure 1 shows that Skin Conductance Level was lower in the baseline condition when compared to the rest.

Figure 1

Boxplots of Skin Conductance Level Across All Combinations of Veracity and Valence Levels in Comparison to the Baseline (N=35)



Discrete Emotions Questionnaire

It was tested if the news video clips effectively manipulated experienced emotions. For instance, if participants reported experiencing more positive emotions when presented with a positive news video clip than when a stimulus from another Valence level was presented. Table 4 compares how participants felt after watching news video clips belonging to different Valence levels. Three repeated measures ANOVA with polynomial contrasts and pairwise comparisons were run to test if the manipulation was successful. Because multiple comparisons were made, Bonferroni corrections were applied. A polynomial contrast was added to capture whether emotions increased linearly.

Table 4

Means and Standard Deviations of Scores on the Negative, Neutral, and Positive Sub-Scales of the Discrete Emotions Questionnaire Across Conditions of Valence (N=35)

	DEQ Scale					
	Negative		Neutral		Positive	
Valence	*M*	*SD*	*M*	*SD*	*M*	*SD*
Negative	2.40	0.75	2.23	0.90	1.44	0.62
Neutral	1.28	0.25	3.35	1.12	2.45	0.78
Positive	1.26	0.31	3.86	0.91	3.67	1.04

Results showed that participants experienced negative emotions more strongly after seeing negative Valence video clips than neutral or positive ones. Because Mauchly's test of Sphericity was violated with $\chi2$ (2) = 22.47, $p < .001$, a Greenhouse-Geisser correction was applied. Results of the corrected model showed that the differences were significant with F (1.39, 55.64) = 75.74, $p < .001$. A significant linear trend, F (1, 40) = 25.5, $p < .001$, indicated that negative emotions increased linearly from positive to neutral to negative video stimuli. Pairwise comparisons indicated that negative emotions were significantly higher after seeing a negative video clip than after seeing a neutral video clip, $p < .001$, or positive video clip, $p < .001$.

For the neutral scale, responses were higher in the neutral Valence condition than in the negative Valence condition but lower than in the positive Valence condition. Sphericity was assumed, $\chi2$ (2) = 0.21, p =.899. The model showed significant differences with F (2, 80) = 28.64, $p < .001$, indicating that neutral emotions increased linearly from negative to neutral to positive video stimuli. Pairwise comparisons showed that differences on the neutral scale between the neutral and negative Valence conditions were significant, $p < .001$. A significant linear trend was also found, F (1, 40) = 25.81, $p < .001$. Likewise, the neutral scale differences between the neutral and positive Valence conditions were significant, $p = .047$.

Results showed that participants experienced positive emotions more strongly after seeing positive Valence video clips than negative or neutral ones. Because Mauchly's test of Sphericity was violated with $\chi2$ (2) = 9.88, $p = .007$, a Greenhouse-Geisser correction was applied. Results of the corrected model showed that the differences were significant with F (1.63, 65.37) = 85.16, $p < .001$. A significant linear trend, F (1, 40) = 101.54, $p < .001$, indicated that positive emotions increased linearly from negative to neutral to positive video stimuli. Pairwise comparisons indicated that positive emotions were significantly higher after a positive video clip than after a neutral video clip, $p < .001$, or a negative video clip, $p < .001$.

In sum, the manipulation check suggested that the news video clips successfully manipulated the extent to which participants felt positive and negative emotions. However, more neutral emotions were reported after watching positive video stimuli instead of neutral video stimuli.

Inferential Statistics

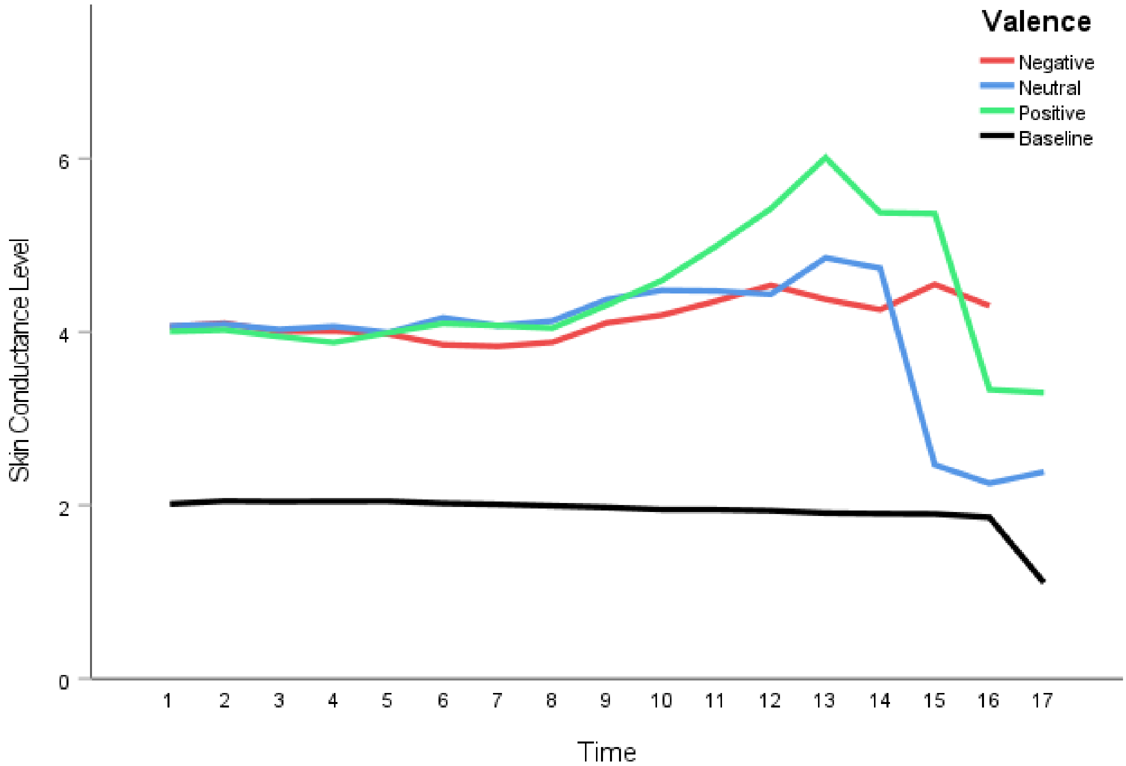
Measures of the video stimuli were aggregated across different levels of the variable Valence (Negative, Neutral, Positive) and Veracity (Truth, Lie). Line charts were created to show how Skin Conductance Level changed over time in different conditions of Valence and Veracity. The Baseline measure served as a reference point as it showed little alternation.

Valence

Skin Conductance Level appeared similar across different levels of Valence at the beginning of the measurement period (see Figure 2). The Positive and Neutral condition measures were similar until the 50-second mark (Time = 10). While a substantial rise in the Positive condition resulted in a global peak that rapidly declined after Time was equal to 15, there was a less pronounced rise in the Neutral condition with a comparably steep decline following. Out of the three conditions, the Negative condition was the most stable. In contrast to the other conditions, Skin Conductance Level did not rapidly decline in the Negative condition at the end of the measurement period. While the starting points were almost identical, the ending points differed vastly. Skin Conductance Level was lowest in the Neutral condition, followed by the Positive condition. The Negative condition scores highest. On average, participants spend less time (un)truthfully describing negative video stimuli, as indicated by Skin Conductance Level in the Negative condition ending before reaching the final segmenting point.

Figure 2

Line Chart Showing How Skin Conductance Level Changed as Time Passed in Response to Negative, Neutral, and Positive News Video Clips (N=35)



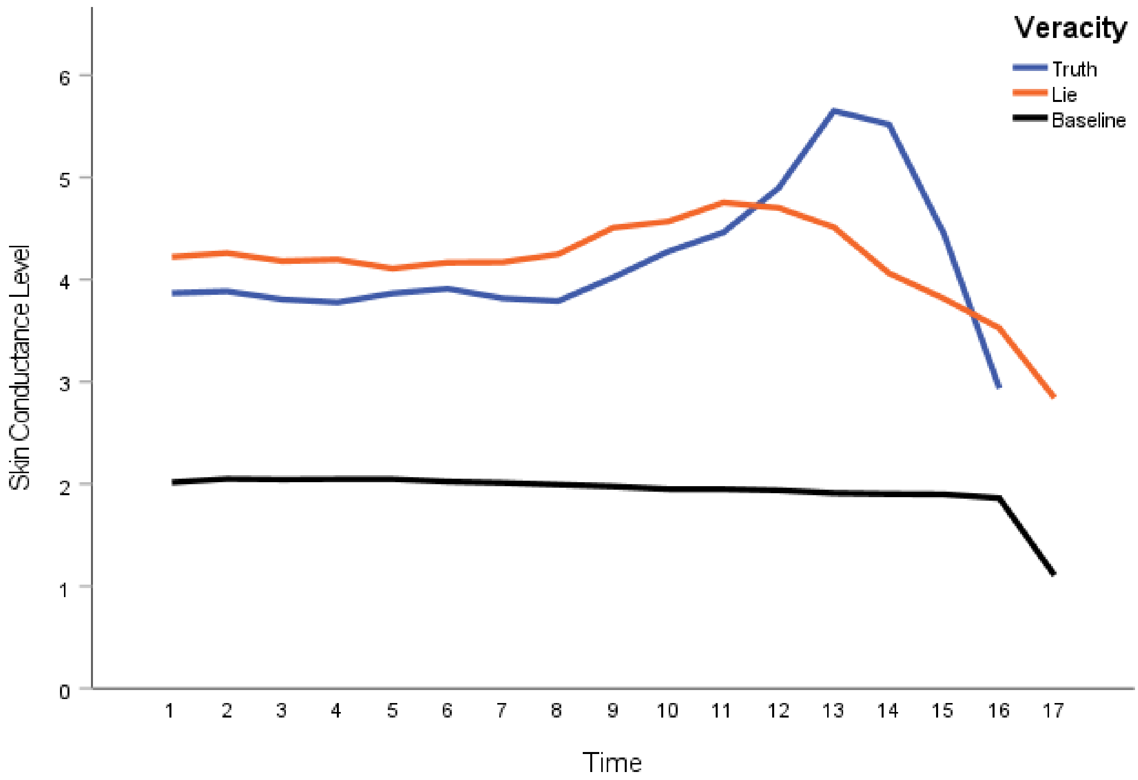
Note. One unit of Time covers an interval of 5 seconds.

Veracity

For Veracity, the starting points of the two conditions differed. Skin Conductance Level was higher in the Lie condition than in the Truth condition when the measurement period started (see Figure 3). This observation persisted until Time reached 11.5 when Skin Conductance Level measured in the Truth condition steeply rose and crossed the Lie condition. While in the Truth condition, there was a steep rise followed by a rapid fall, in the Lie condition, a less pronounced rise and a shallower decline were observed. On average, participants spend more time telling lies than telling the truth, as indicated by Skin Conductance Level in the Truth condition ending before reaching the final segmenting point.

Figure 3

Line Chart Showing How Skin Conductance Level Changed as Time Passed Across Veracity



Note. One unit of Time covers an interval of 5 seconds.

It must be noted that sample sizes decreased as time increased because participants could finish their descriptions at will. That was because there was no minimum as to how long participants should (un)truthfully describe the content of the video they saw. Only a maximum of 90 seconds was set. Naturally, fewer participants gave an account long enough to reach the final segmenting periods than participants whose accounts were long enough to reach the first segmenting periods. Due to this, estimates in the later stages of the time series are less precise. This is because they are more susceptible to the influence of extreme mean values, which can arise from individual differences.

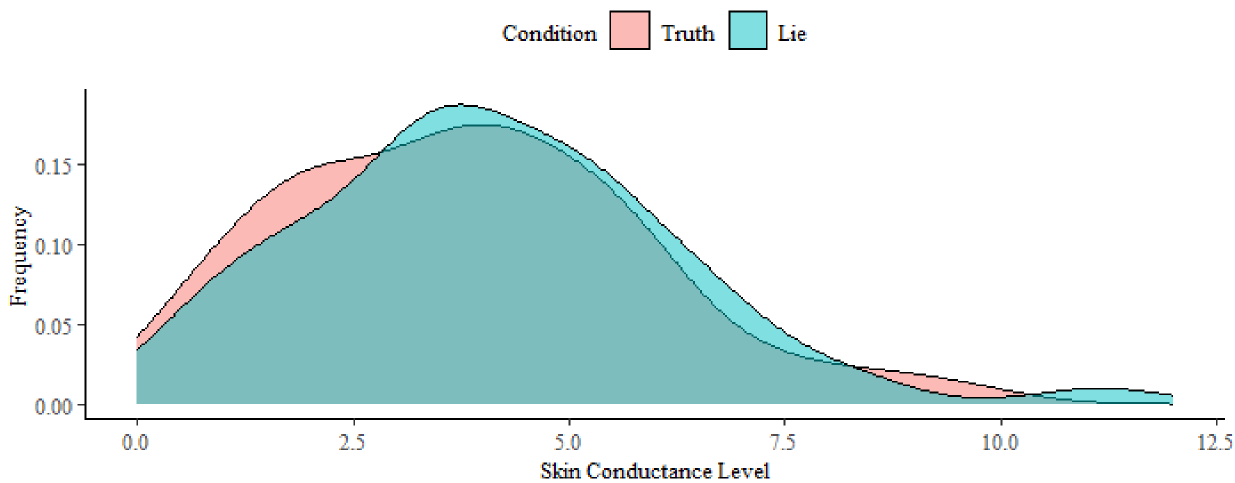
Analyses

It was tested if Skin Conductance Level differed between conditions of Veracity and Valence. Additionally, it was tested for an interaction effect between Veracity and Valence. A repeated measures General Linear Model with a polynomial contrast was run. The polynomial contrast was added to explore a potential emotion-specific pattern of Valence on Skin Conductance Level. Sphericity was assumed with Mauchly's test yielding nonsignificant results for within-subject effects, $\chi 2$ (2) = 1.41, p = .494, and $\chi 2$ (2) = 3.24, p = .198. The normality assumption was fulfilled with a Kolmogorov-Smirnov test giving a nonsignificant deviation of residuals of the model from a normal distribution D (210) = .35, p = .200.

Skin Conductance Level was lower in conditions where participants had to tell the truth than in conditions in which participants had to lie. This difference was significant with F (1,34) = 8.54, p = .006, d = 0.58. The null hypothesis was therefore rejected. Figure 4 shows the distribution of Skin Conductance Level for Truth and Lie in a density plot.

Figure 4

Density Plot of the Distribution of Skin Conductance Level between the Conditions Truth and Lie (N=35)



As can be seen in Figure 4, there are some positive outliers in the sample. It was tested if the results of the General Linear Model changed upon the exclusion of these outliers. Results of this General Linear Model were reported in Appendix I. Because removing the outliers did not alter the results, the outliers were not omitted. Skin Conductance Level was the same across conditions of Valence, F (2,68) = 0.46, p = .633. Consequently, the null hypothesis was accepted. The Valence level of the stimulus did not alter skin conductance levels significantly. Moreover, the interaction effect was nonsignificant, F (2,68) = 0.3, p = .750, resulting in accepting the null hypothesis. The effect of Veracity on Skin Conductance Level did not depend on the level of Valence. See Table 5 results of the General Linear Model, means, and standard deviations across the conditions.

Table 5

*Repeated Measures ANOVA Results for the Interaction between Variables Valence, Veracity and Valence*Veracity on Skin Conductance Level (N=35)*

Variable	**Skin Conductance Level**			
Valence			95% CI	
	M	*SD*	*LL*	*UL*
Negative	3.87	2.11	3.26	4.68
Neutral	4.00	2.18	3.26	4.74
Positive	3.87	2.03	2.30	4.55
ANOVA	$F = 0.3, p = .633, \eta_p^2 = .01$			

	Skin Conductance Level			
Veracity			95% CI	
	M	*SD*	*LL*	*UL*
Lie	4.09	2.13	3.39	4.79
Truth	3.81	2.07	3.11	4.50
ANOVA	$\mathbf{F = 8.54, p = .006, \eta_p^2 = .20}$			

	Skin Conductance Level			
Interaction Term			95% CI	
	M	*SD*	*LL*	*UL*
Negative*Lie	4.17	2.22	3.39	4.92
Negative*Truth	3.78	2.02	3.09	4.47
Neutral*Lie	4.14	2.26	3.38	4.92
Neutral*Truth	3.86	2.13	3.13	4.59
Positive*Lie	3.97	1.97	3.30	4.65
Positive*Truth	3.78	2.12	3.05	4.50
ANOVA	$F = 0.29, p = .750, \eta_p^2 = .01$			

Discussion

The present study investigated if EDA can be differentially elicited depending on whether people lie or tell the truth. Further, it explored how emotional valence and arousal are reflected in EDA. There are three key findings central to the present research. First, EDA was differentially elicited as a function of whether people lie or tell the truth. Participants had a higher level of skin conductance across trials in which they had to lie about the content of news video clips than when they had to tell the truth. However, this did not occur for all video clips. Additionally, there was substantial overlap in the distributions of both conditions. Second, EDA was not differentially elicited as a function of whether people (un)truthfully described the content of positive, neutral, or negative news video clips. Third, the finding that telling lies led to higher EDA than telling the truth did not depend on the type of news video clip presented.

The present findings are consistent with the claim that lying may be related to changes in physiology (DePaulo et al., 2003). Sympathetic nervous system activity was generally heightened during lie-telling as measured by tonic EDA. This pattern of results is consistent with Zuckerman et al. (1981), who argued that generalised arousal may differ between liars and truth-tellers. Past researchers have argued that generalised arousal may be accounted for by specific emotions such as fear and guilt in telling a lie (Ekman, 1989; Nortje & Tredoux, 2019; Zuckerman et al., 1981). No evidence in favour of this hypothesis was found in the present study. Specifically, lying lead to higher levels of skin conductance regardless of the emotional state. Additionally, self-reports showed that liars felt little guilt and experienced little fear of being caught lying. These findings undermine the discriminative ability of Zuckerman et al.'s (1981) second factor, feelings experienced when lying. Nonetheless, when contextualising the findings, it must be considered that the approach by which emotions in the context of deception were manipulated in the present study differs from how emotions are related to lying in the literature.

The present experiment directly manipulated the emotion of what is being lied about. That way, an attempt was made to provoke, e.g., a negative emotional response before lying or telling the truth. Nevertheless, the emotional response is not inherent to the lie itself. Specifically, the negative emotional response does not result from how one feels about lying but from what one experienced before telling a lie. This is an important consideration, as in the literature, emotional responses in the context of deception are often attributed to how the liar feels about lying (e.g., Ekman, 1989; Zuckerman et al., 1981). This notion also applies to the previously mentioned rice powder trial of ancient China. To illustrate, dry rice powder indicated lying due to the expectation that reduced salivation resulted from the fear of detection, not from the lie itself. This implies that differences in physiological responses between liars and truth-tellers would stem directly from emotional responses to the lie. Nevertheless, the present findings suggest that lying can lead to higher skin conductance levels and that this is unlikely to result from experiencing negative emotions such as fear or guilt. Considering that the distinct physiological responses observed between liars and truth-tellers are not attributable to emotional responses, what other interpretations could explain this finding?

One possible interpretation is that lying made participants feel more stressed because it was more challenging on a cognitive level. In previous research, higher perceived cognitive load (i.e., perceived task complexity) has been associated with higher perceived stress (Minkley et al., 2021). In line with that, despite low stakes, lying was rated to be substantially more stressful and difficult than truth-telling in the present study. This may support the idea that liars experience a greater cognitive load than truth-tellers (Verschuere et al., 2018). Liars have been shown to engage in more self-regulative activities than truth tellers, which imposes additional cognitive load (DePaulo et al., 1988; Granhag & Hartwig, 2008). In the present study, participants were explicitly prompted to trick Irene into believing they were telling the truth when they had to lie. Moreover, participants knew they were recorded. This may have increased self-focus and primed the subject to monitor and regulate behaviour when lying. In combination with having the task to fabricate a credible lie, lying may have required a greater total cognitive load than truth-telling. According to the Biopsychosocial Model of Threat and Challenge (Blascovich & Mendes, 2000), a greater perceived cognitive load may have led to heightened physiological activation.

The Biopsychosocial Model of Threat and Challenge is a theoretical framework that explores how people interpret and react to stress-inducing events and difficult situations (Blascovich & Mendes, 2000). According to the model, stress results from the interaction between situational demands and individual resources. The model predicts that a threat response is triggered when individuals perceive situational demands to exceed individual resources (Minkley et al., 2021). A threat response leads to immense feelings of stress accompanied by fear or anxiety. However, the situation is perceived as a challenge if situational demands match individual resources. During a challenge state, the individual may still experience heightened physiological arousal but feel motivated and excited rather than fearful and anxious. Although purely speculative, lying may have led to an emotion-independent stress response because it was perceived as a challenge rather than a threat. A higher cognitive load associated with lying may have elicited a challenge response, whereas truth-telling was not perceived as challenging. If lying was perceived as a challenge rather than a threat, it may explain why participants did not feel anxious or guilty despite indicating that lying was more stressful and difficult than telling the truth. In sum, the distinct physiological responses observed between liars and truth-tellers may be attributable to differences in cognitive load between lying and truth-telling.

Practical Implications

Lying elicited a greater physiological response than telling the truth. This effect was significant with a medium effect size ($d = 0.58$). However, does this finding demonstrate that tonic EDA can be used as an eligible tool to accurately discern who is lying from who is telling the truth? Although research can establish statistical differences between experimental groups, as in the present study, one must consider if these differences are relevant and valuable for practice (Satchell, 2019). The main objective of applied psychological research is to communicate knowledge and information to be used in an applied setting. Satchell (2019) argues that inferences from mean difference statistics in the context of lie detection have little practical value. While the average characteristics of liars and truth-tellers may differ, there can still be considerable overlap and variability between the two. Looking at Figure 4, there undoubtedly is a great deal of overlap between the two groups. This means in practice that truth-tellers may often resemble liars and vice versa. Therefore, it is unlikely that an EDA measure obtained in practice could be used to determine if that person is lying or telling the truth. In that regard, findings are consistent with the claim that accuracy estimates of the polygraph presented by Masip (2017) are unlikely to reflect its actual discriminative power. Moreover, the observed pattern was not detected for all news video clips. This is a major caveat to the external validity of the results because it implies that the observed effect is unlikely to hold under other conditions. Consequently, it is difficult to generalise findings to real-world situations beyond the specific stimuli used in the present study. A misclassification of a liar as a truth-teller or vice versa may have legal consequences and raise ethical concerns.

Another limitation to generalising the results to specific practical settings pertains to the ability of tonic EDA to detect specific lies in the context of a more extended conversation in an applied setting. Due to the slow-changing nature of tonic EDA, it may not be time-sensitive enough to detect a specific lie amidst truthful recollections in practical settings such as police interviews. In sum, the present findings are stressed to be interpreted with utmost caution.

Why Was There No Effect of Valence?

Intriguingly, no effect of Valence on Skin Conductance Level was found. EDA was not differentially elicited as a function of whether people described the content of positive, neutral, or negative news video clips. This is surprising because the manipulation check indicated that news video clips elicited their desired emotional response. Nevertheless, this difference was not reflected in levels of skin conductance. This finding is puzzling as there is consensus among scientists that EDA reliably reflects emotional arousal (Caruelle et al., 2019). Therefore, one should expect the neutral condition to differ from the rest.

A possible explanation might be that the stimuli did not elicit emotional responses to the extent they were reflected in EDA. As indicated by scores on the DEQ, emotional responses were not strong, albeit significantly different. To illustrate, no mean score for any news video clip was greater than 4 out of 7 on any scale, which could explain similar physiological responses across stimuli. This may be attributable to the emotional distance effect observed in bilingual emotional processing (Pavlenko, 2012). Although Samide et al.'s (2020) sample was comparable to the present sample in age (M = 19.01, SD = 0.85) and consisted of university students, their study was conducted in Boston, United States. Therefore, their sample likely predominantly consisted of native English speakers, whereas the present sample exclusively consisted of non-native speakers. Research found that second-language speakers show decreased automaticity of emotional processing when presented with stimuli in their second language (Pavlenko, 2012). Moreover, this effect was found to decrease electrodermal reactivity to negative valence stimuli. This suggests that non-native English speakers react less emotionally strongly to news video clips presented in English than native speakers. The weak physiological responses to the news video clips may be partly due to the emotional distance effect.

Some researchers have considered emotion-specific autonomic response patterns (e.g., Aguado et al., 2018; Christie & Friedman, 2004; Ekman et al., 1983; Hubert & de Jong-Meyer, 1990; Lang, 1979; Schwartz et al., 1981). For example, Hubert and de Jong-Meyer (1990) found significant rises in EDA across the entirety of negative stimuli, while positive stimuli only elicited an initial increase. The present study does not corroborate this finding. The patterns obtained do neither suggest that positive stimuli lead to an initial EDA increase nor that negative stimuli lead to sustained increases. No significant differences in physiological responses were found between positive and negative stimuli. Although not inferentially tested, Figure 1 shows some differences between the conditions towards the second half of the measurement period. However, one must be careful when interpreting these findings because fewer participants gave an account long enough to reach the latter segmenting periods than participants whose accounts were long enough to reach an earlier segmenting period. Consequently, the sampling error increases, and measures do not accurately represent the characteristics of the population.

Interestingly, the samples used in Aguado et al. (2018) (*N* = 38, *M*age = 19.55) and Christie and Friedman (2004) (*N* = 34, *M*age = 18.7 years) bear a striking resemblance to the one used in the present study (*N* = 39, *M*age = 21.95 years). However, their findings that EDA may be sensitive to valence were not replicated. One reason could be which phenomena of the skin were used as dependent variables. Aguado et al. (2018) used the baseline-corrected skin conductance response amplitude (phasic EDA) as the dependent measure. The present study used skin conductance level (tonic EDA) as the objective was to compare the overall affective states across different conditions of Veracity and Valence. Tonic EDA and phasic EDA are two distinct subtypes of EDA (Boucsein, 2012; Stern et al., 2000) and thus reflect different phenomena. This could explain the diverging findings.

Limitation and Strengths

After discussing the present study's findings, limitations need to be addressed. It is essential to consider the following limitations when putting present findings into perspective. The ecological validity of the study design could be improved for several reasons. First, an experimental design was used. While experimental designs eliminate the impact of erroneous variables and are more potent in establishing directional effects than correlational or descriptive research designs, they come at the cost of ecological validity. This becomes apparent when comparing the low-stakes lying scenario in the experiment to high-stakes lie detection environments in which polygraphs would be used. Additionally, self-reports showed that the participants were not convinced of the cover story. This could limit ecological validity since lie telling is a social phenomenon and involves at least a second individual. If participants believed that the veracity of their accounts was not judged, the parallels between the present study's design and real-life lie detection scenarios decreased. More ecologically valid field studies that involve real-world cases would address these shortcomings. On the other hand, field studies lack ground truth. Ground truth is crucial because it provides a benchmark against which the accuracy of the lie detection method can be assessed, as in the present study. Without a doubt, there are considerable trade-offs to both laboratory and field studies.

Another aspect worth considering is the manipulation of emotion. The present study's design allowed for controlled and equal manipulation of emotions across participants, increasing internal validity. This made it possible to directly study the effects of emotion up close while reducing the possibility of confounders. Despite the elicited emotions not being extreme, the broad direction of the observed effects generally matched the expectations. While increasing the intensity of an emotion such as fear in participants would make the study more comparable to high stakes lie detection scenarios, one must consider the ethical responsibilities of research. Exposing participants to unnecessary harm in the form of severe psychological distress by evoking intense negative emotions would violate the principle of non-maleficence.

Further, it was not specified how long participants should lie about the content of the videos. Moreover, it was not specified what these lies should be about. This marks a trade-off. On the one hand, this leads to different lengths between accounts and reduced accuracy estimates at the end of the measurement period. On the other hand, it allowed participants to determine their lie's specific characteristics (e.g., topic, length, choice of words, level of detail, mannerisms) just as the individual would do in everyday life. Consequently, participants were given the opportunity to select a deceptive approach that aligned with their typical and self-efficacious method of convincing others that they were telling the truth. This may have reduced additional stress resulting from deviations from one's self-efficacious way of lying. Such deviations may have otherwise masked the true level of stress.

The characteristics of the sample of the present study are another potential limitation. The sample was homogenous as it solely consisted of students of higher education of similar age due to time and resource constraints. This feature reduces the extent to which findings can be generalised to more diverse populations, as making inferences based on a sample which merely captures a fraction of the diversity of humankind would be misleading. Further, as all participants were university students, one can assume a similarly medium/high socioeconomic background. Research demonstrates a strong association between high socioeconomic status (SES) and academic achievement (Mompremier, 2009). Moreover, research indicates that SES predicts individual differences in various skills associated with executive functioning (Last et al., 2018; Noble et al., 2005). In particular, working memory capacity is predicted by SES (Farah et al., 2006; Hackman et al., 2014; Noble et al., 2007). Because lie-telling typically involves more significant mental effort than truth-telling (Verschuere et al., 2018), the shared characteristics of the present study's sample may further prevent generalisability. That is because the sample is likely to consist of individuals whose working memory capacity is higher than an average person in their age group. As contextualised in the discussion of the main findings, physiological activity may have resulted from a situation where task demands exceed individual resources. Spontaneously fabricating convincing lies may have been more accessible to participants than it might be to the public. Therefore, this may have led to a decrease in the magnitude of the observed effect compared to the actual effect within the entire population.

Recommendations for Future Research

Lying is a phenomenon of everyday life. The invention of a tool that infallibly discerns lies from truths may be closer to fiction than science. For that reason, it is paramount to continue to research this topic. The present study's findings support the millennia-old idea that physiological responses can be differentially elicited as a function of whether people lie or tell the truth. However, the present findings have also raised questions that require further inquiry.

The emotion-independent stress response to lying suggests that cognitive factors may be worth investigating. Future research should study how different cognitive load conditions affect how people's EDA changes due to lying. Cognitive load could be manipulated by administering digit span memory tasks that vary in difficulty between trials. It would be helpful to explore whether more difficult lies lead to stronger physiological responses. The Biopsychosocial Model of Threat and Challenge (Blascovich & Mendes, 2000) was used to contextualise the finding that feelings of fear, anxiety, or guilt did not accompany stress. However, the model predicts that negative emotions accompany the stress response if the task is sufficiently complex. Therefore, future research should explore if a sufficiently high cognitive load would lead to more intense negative emotional responses in the context of lie detection and whether that would be reflected in EDA.

To improve the emotion induction approach without adopting ethically questionable practices, prosocial and antisocial lies are recommended to manipulate how people feel about lying. This would address the present study's emotion manipulation method, which does not change how people feel about lying but how they feel about what they cover with the lie. According to Lupoli et al. (2017), prosocial lies may not result in guilt or shame as prosocial liars believe they do a good deed. Further, future research should consider the implications of bilingual affective processing when designing materials to manipulate emotions.

Conclusion

The present study laid essential foundations in reevaluating physiological indicators for detecting lies, contributing to the ongoing discussion within the deception detection field. This study investigated if EDA can be differentially elicited as a function of whether people lie or tell the truth. Further, it explored how emotional valence and arousal are reflected in EDA. Results indicated that EDA can vary based on veracity, with participants displaying increased sympathetic nervous system activity when lying, regardless of emotional valence or arousal. There was no difference in EDA due to manipulating emotional valence (positive and negative) and emotional arousal (neutral). Despite the significant differences between liars and truth-tellers, differences were not large and showed substantial overlap. Hence, employing EDA to distinguish between liars and truth-tellers continues to carry significant risk, warranting a resolute note of caution.

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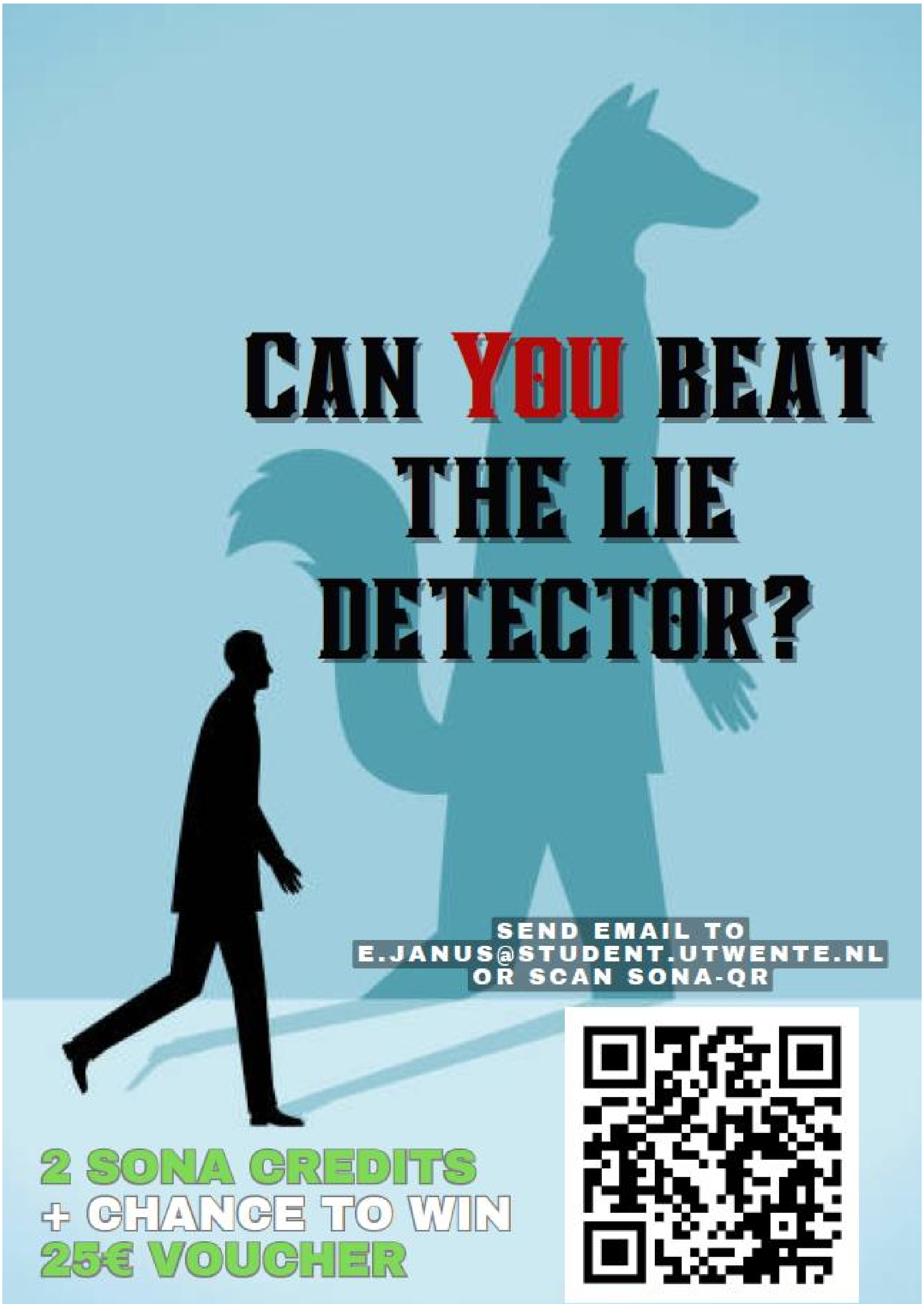
Appendix A

Recruitment Poster



Appendix B

Sample Nationalities

Table 6

Frequency and Percentage of Nationalities of the Present Sample

Nationality	Frequency	Percent
Dutch	7	20
French	1	2.9
German	22	62.9
Kenyan	1	2.9
Latvian	1	2.9
Malaysian	1	2.9
Portuguese	1	2.9
Vietnamese	1	2.9
Total	35	100

Appendix C

Pre-Experimental Questionnaire

Welcome!

You are invited to take part in a study investigating cues to deception.

This study is conducted by Erik Janus, BSc. and supervised by Dr. Steven J. Watson (Department of Psychology of Conflict, Risk and Safety, University of Twente) and Peter Slijkhuis, MSc. (Department of Psychology of Conflict, Risk and Safety, University of Twente). The study is approved by the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente (request number 221449).

Please take time to read the following information carefully before you decide whether or not to take part. It is important for you to understand what participation in this study will entail.

Who can take part?
- We are looking for participants aged 18 years and older.
- Your English language skills need to be sufficient in order to understand instructions, answer the questionnaires and give an oral verbal account.
- Participation is completely voluntary.

What is involved?
If you decide to take part, your session will consist of the following parts:
1. You enter some demographic information.
2. You are connected to a device which measures Electrodermal Activity (EDA).
3. You are being recorded (audio + video).
4. You complete six trials. Each trial consists of:
   a) Being told to either lie or tell the truth.
   b) Watching a short video (35-60 seconds).
   c) (un)truthfully describing what you saw in the video in detail.
   d) Filling in a short questionnaire.
   e) A short break.
5. You answer some additional questions.
The session takes about 60 minutes.

Will I get paid?

For participation in SONA, you will receive 2 credits.
By participating, you have the chance to win a Voucher worth 25€.

Are there any risks?
No risks are associated with participation in this study.

What happens with my data?
- Data will be stored by the researchers for at least 10 years in accordance with our requirements for ensuring research data integrity and auditability.
- Data may also be shared with the research community in accordance with the principles of open science (e.g. on osf.io). However, only anonymized versions of the data will be shared and you should not be identifiable. This is done to test if people can accurately detect lies.
- Your data will form the basis of an MSc thesis, and may also be used to create research reports or academic conference presentations.
- You have the right to terminate your participation at any time, for any reasons, and without penalty. You do not have to explain why you want to stop participating, and if you choose to withdraw we will delete any data gathered up to that point.

You may ask the researcher any questions you have before you take part in the research.

Click 'next' to proceed.

Informed Consent

By clicking 'I agree to participate' below, I agree to the following:
- I understand that my participation is voluntary.
- I also understand that I have the right to withdraw my consent at any time without needing to give a reason.
- Furthermore, the following points are clear to me:
   - During participation in this study, my electrodermal activity (EDA) is being monitored from which data will be collected.
   - During participation in this study, I will be recorded (audio and video)
   - All data that are collected by the researcher are anonymous to the extent that we collect only very limited demographic data, and so it is unlikely that my data can be traced back to me personally.
- I understand and agree that the purpose and hypotheses of the current study cannot be revealed to me because it could bias my answers. However, after completion of the study I will receive a full debriefing.

○ I agree to participate

○ I wish not to participate

Optional Consent

Additionally, I have the choice to give consent to the storage of the videos recorded during this study beyond the life of this project and further potential use of said videos in future research. The data is being ultimately retained by officials of the University of Twente. Note that this option is voluntary and optional!

○ I agree to allow storage of my data beyond this project and further potential use in research.

○ I do not want my data to be processed further!

Here, we ask you to provide some general information about yourself.

With which gender do you identify most?

- ○ Male
- ○ Female
- ○ Non-binary
- ○ Other
- ○ Prefer not to say

How old are you? (please enter the number of years)

____

What is your nationality?

____

What is the highest educational level you have achieved?

- ○ Elementary school
- ○ High school
- ○ College/University - Undergraduate degree (e.g. Bachelor of Science, Bachelor of Art or equivalent)
- ○ College/University - Graduate degree (e.g. Master of Science/Arts or equivalent)
- ○ Doctoral degree/PhD
- ○ Other

Procedural Information

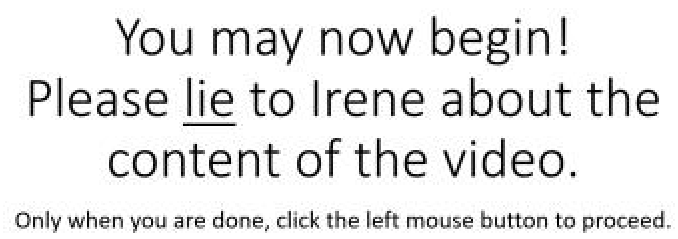
The following paragraphs contain information regarding the procedure of this study. Please read the information carefully. If you have questions, feel free to ask the researcher.

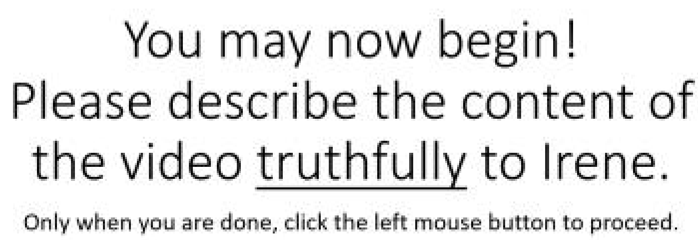
First, there will be a short calibration phase in which your base level electrodermal skin activity is measured. This is done to have a estimate of what your electrodermal skin activity looks like when you are calm and relaxed.

Next, you will be presented a series of videos. Some of the videos may elicit mild distress in some participants. If you suffer from any phobiae, please notify the researcher now.

Before watching each video, you will receive instructions on whether to lie, or tell the truth about the content of the video later. Whether you have to lie or tell the truth changes from video to video, so make sure to carefully read the specific instruction before proceeding to watch each video. After watching the video, you can proceed to the next page, on which you will (un)truthfully describe the content of the video just seen for up to 90 seconds to Irene (a second researcher).

When you see one of the following two images, you can begin describing the video.





Your goal is to convince Irene who is watching the recordings of your descriptions that you are telling the truth. This means that if you are instructed to lie, your mission is to trick Irene into believing that you tell the truth. Regardless of the condition, your description should allow Irene to imagine what you just saw.

When you (un)truthfully describe the content of the video to Irene, your electrodermal skin activity will be measured. To avoid contamination of measures, please keep your hand still during these periods and lay it on the arm rest of your chair. Refrain from moving this hand.

After describing each video, you will fill in a questionnaire and afterwards have at least one minute to relax.
This relaxation period is aimed at establishing base levels of electrodermal

skin activity before moving on to the next video.

This procedure is repeated six times.
Lastly, there will be some final questions concerning this study. If you have any questions, you can ask the researcher.

Otherwise, click 'next' to proceed.

Appendix D

Detailed Description of News Video Clips Samples as Dynamic Affective Stimuli

The first positive video clip showed a blonde woman reuniting with a dolphin she believed had died on the shores. The woman reported she had received a phone call from a sea rescue organisation and was invited to see the dolphin again. During the reunion, it is emphasised that the dolphin recognised the woman and showed her new tricks, appearing "healthy", "strong", and "vibrant". The woman was shown to be very happy about seeing the dolphin again.

The second positive video clip showed a hospital station where rescued dog puppies were used to relax workers and patients. The staff was shown to pet and cuddle the puppies repeatedly, address the positive effects of the puppies, and emphasise the importance of the puppies to alleviate day-to-day stress. The puppies were shown to be petted on a worker's arm. Further, the creche of the puppies was shown. It was laid out with colourful blankets and toys.

The first neutral video clip showed a New York City publication house, "Simon & Schuster". The commentator informed viewers about the steps involved in the publication process. Then, the CEO of Simon & Schuster was interviewed about the founders of Simon and Schuster. She briefly introduced Simon and Schuster and how they founded a publication house.

The second neutral video clip showed a scientist collecting data on football players using Head Impact Telemetry System (HITS) technology. HITS collects data from sensors placed in the football players' helmets and can create real-time models of the angle and the impact acceleration whenever players make contact on the football field. This allowed the researcher to collect vast data throughout the season and training sessions. The system was explained to the viewer and shown in an applied setting on the field. Finally, the reporter and the scientist talked about the merits of HITS.

The first negative video clip showed a psychologist who works with torture victims and initially informed viewers about contingent shock therapy's use in prisons. After the psychologist talked for a couple of seconds, achromatic camera footage of one person holding another down was shown and complemented by muffled screams. Then, a naked man in an electric chair was shown. A man in military wear administered shocks to the naked man, who screamed, twitched, and squirmed in pain while a woman desperately tried to undo the chair's ties to free the man. Next, a news reporter listed torture methods used in jail while more footage of people receiving electric shocks was shown. The news reporter quoted a correctional officer who has admitted to enjoying torturing inmates.

The second negative video clip showed dashcam footage of the back of a person in a hoodie walking past a police car with some police officers on a motorway. The news reporter said that the footage was about to become graphic so that the dashcam footage would halt. Further, the reporter said the person in the hoodie was 17 years old and shot by the police. Despite the boy falling to the ground when shot, one police officer reportedly shot 16 additional bullets in 15 seconds. Then an excerpt from a press conference in which a woman addressed the case was shown. Lastly, an angry crowd of protesters shouting in front of the police department was shown. The demonstration physically escalated, as the crowd clashed with members of the police, which resulted in a chaotic situation in which people were shoved around and shouted at each other.

Appendix E

Discrete Emotions Questionnaire

Next, please fill in the questionnaire below.

Please indicate your response using the scale provided.

While watching the latest video and describing it to Irene, to what extent did you experience these emotions?

	Not at all (1)	Slightly (2)	Somewhat (3)	Moderately (4)	Quite a bit (5)	Very much (6)	An extreme amount (7)
Anger	○	○	○	○	○	○	○
Wanting	○	○	○	○	○	○	○
Dread	○	○	○	○	○	○	○
Sad	○	○	○	○	○	○	○
Easygoing	○	○	○	○	○	○	○
Grossed out	○	○	○	○	○	○	○
Happy	○	○	○	○	○	○	○
Terror	○	○	○	○	○	○	○
Rage	○	○	○	○	○	○	○
Grief	○	○	○	○	○	○	○
Nausea	○	○	○	○	○	○	○
Anxiety	○	○	○	○	○	○	○
Chilled out	○	○	○	○	○	○	○
Desire	○	○	○	○	○	○	○
Nervous	○	○	○	○	○	○	○
Lonely	○	○	○	○	○	○	○

Scared	○	○	○	○	○	○	○
Mad	○	○	○	○	○	○	○
Satisfaction	○	○	○	○	○	○	○
Sickened	○	○	○	○	○	○	○
Empty	○	○	○	○	○	○	○
Craving	○	○	○	○	○	○	○
Panic	○	○	○	○	○	○	○
Longing	○	○	○	○	○	○	○
Calm	○	○	○	○	○	○	○
Fear	○	○	○	○	○	○	○
Relaxation	○	○	○	○	○	○	○
Revulsion	○	○	○	○	○	○	○
Worry	○	○	○	○	○	○	○
Enjoyment	○	○	○	○	○	○	○
Pissed off	○	○	○	○	○	○	○
Liking	○	○	○	○	○	○	○

This question is a manipulation check. Truthfully describe in one sentence what the video you just saw was about. (e.g., "the video was about sales of headphones")

____

Did you have to lie or tell the truth about the video you just described?

- ◯ I had to tell the truth
- ◯ I had to lie

Appendix F

Post-Experimental Questionnaire

Thank you!

Lastly, we ask you to fill in a couple of questions concerning this study. Please read the questions below carefully.

Please indicate to what extent you agree or disagree with the following statements.

Strongly disagree, Disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Agree, Strongly agree

I took the task seriously	
I was motivated to do well on the task	
I found it more difficult to lie than to tell the truth	
I felt stressed when having to lie	
I felt stressed when telling the truth	
I felt guilty about having to lie to Irene	
When lying, I feared that Irene would find out I was lying	
When telling the truth, I feared that Irene would believe that I was lying	
I believed that Irene was real when describing the video	

What was your strategy when lying to Irene? What did you do to trick Irene into believing that you were telling the truth?

____

What was your strategy when telling the truth to Irene? What did you do to make Irene believe that you were telling the truth?

____

Is there anything that you would like to tell the researchers about your experience in this study?

____

End of the Study

Thank you for your participation!

Debriefing:

This study investigated changes in electrodermal activity as cues to deception. Electrodermal activity is often used as a measure of deception while it measures constructs that may only be associated with deception (i.e., stress, arousal, how somebody feels).

This study's aim was it to untangle the confounding effects of stress, emotional arousal, and deception on electrodermal activity. This was done by evoking emotional states that differed in arousal (neutral vs positive and negative) and valence (negative vs positive) using video clips for different conditions of veracity (truth vs lie).

Irene does not exist. The veracity of your descriptions was not assessed.

Results from this study might add to our understanding of the mechanisms underlying deception and their spurious expression in electrodermal activity.

Your participation was deeply appreciated!

Appendix E

Scores on Subscales of the DEQ Across News Video Stimuli

Table 7

Means and Standard Deviations of Scores on Subscales of the Discrete Emotions Questionnaire Across News Video Stimuli Prior to Self-Response

Stimulus		Anger	Disgust	Fear	Sadness	Anxiety	Relaxation	Happiness
Dolphin	*M*	1.18	1.19	1.22	1.31	1.57	3.82	3.51
	SD	0.50	0.59	0.45	0.49	0.60	1.50	1.75
Puppies	*M*	1.06	1.08	1.14	1.67	1.58	3.91	3.73
	SD	0.22	0.22	0.48	0.43	0.81	1.32	1.62
HITS	*M*	1.07	1.11	1.24	1.19	1.66	3.42	2.57
	SD	0.22	0.24	0.43	0.28	0.75	1.44	1.26
Publisher	*M*	1.04	1.10	1.30	1.19	1.84	3.28	2.37
	SD	0.21	0.24	0.62	0.37	0.87	1.48	0.96
Police	*M*	3.02	2.20	2.04	2.19	2.39	2.38	1.54
	SD	1.84	1.28	1.15	1.11	1.15	1.25	0.99
Torture	*M*	2.85	2.41	2.49	1.99	2.49	2.12	1.35
	SD	1.60	1.26	1.37	0.83	1.37	1.28	0.80
Total	*M*	1.70	1.51	1.92	1.51	1.92	3.16	2.51
	SD	1.34	0.96	1.02	0.77	1.02	1.53	1.56

Note. Scores are on scale of 1 to 7.

Appendix H

Descriptive Statistics of Responses to the Post-Experimental Questionnaire

Table 8

Descriptive Statistics of Responses to the Post-Experimental Questionnaire (N=37)

	M	Min	Max	*SD*	Skewness	Kurtosis
I took the task seriously.	91.57	78	100	7.41	-.19	-1.38
I was motivated to do well on the task.	88.16	66	100	10.76	-.45	-1.00
I found it more difficult to lie than to tell the truth.	75.11	10	100	25.45	-1.15	.62
I felt stressed when having to lie.	60.89	14	100	24.32	-.38	-.89
I felt stressed when having to tell the truth.	30.65	0	85	23.05	.44	-.72
I felt guilty about having to lie to Irene.	19.97	0	100	23.13	1.65	2.89
When lying, I feared that Irene would find out I was lying.	36.43	0	88	31.25	.20	-1.58
When telling the truth, I feared that Irene would believe that I was lying.	23.95	0	87	29.28	1.04	-.42
I believed that Irene was real when describing the video.	38.59	0	100	31.7	.46	-.94

Note. Scores on a scale up to 100.

Appendix I

Results of an Alternative General Linear Model Excluding Outliers

Table 9

*Repeated Measures ANOVA Results for the Interaction between Variables Valence, Veracity and Valence*Veracity on Skin Conductance Level without Outliers (N=35)*

Variable	**Skin Conductance Level**			
Valence			95% CI	
	M	*SD*	*LL*	*UL*
Negative	3.51	1.78	2.82	4.20
Neutral	3.56	2.00	2.79	4.34
Positive	3.59	1.96	2.81	4.29
ANOVA	$F = 0.09, p = .913, \eta_p^2 = .01$			

	Skin Conductance Level			
Veracity			95% CI	
	M	*SD*	*LL*	*UL*
Lie	3.69	1.91	2.94	4.41
Truth	3.41	1.86	2.68	4.13
ANOVA	$\boldsymbol{F = 9.20, p = .005, \eta_p^2 = .25}$			

	Skin Conductance Level			
Interaction Term			95% CI	
	M	*SD*	*LL*	*UL*
Negative*Lie	3.75	1.96	2.99	4.51
Negative*Truth	3.28	1.69	2.62	3.94
Neutral*Lie	3.63	2.00	2.85	4.40
Neutral*Truth	3.50	2.06	2.70	4.30
Positive*Lie	3.65	1.89	2.92	4.39
Positive*Truth	3.44	2.00	2.67	4.22

ANOVA	$F = 1.68, p = .195, \eta_p^2 = .06$