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Clusters of nonverbal behavior differentiate truths and lies about future malicious intent in checkpoint screening interviews

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Recent research has shown that nonverbal behavior (NVB) assessed across multiple channels can differentiate truthtellers from liars. No study, however, has examined whether or not multiple NVBs can differentiate truths from lies about intent regarding future malicious behavior, or across multiple cultural/ethnic groups. We address this gap by examining truths and lies about intent to commit a malicious act in the future in brief, checkpoint-type security screening interviews. Data from four NVB channels producing twenty-one observable NVBs were coded and analyzed using different analytic strategies. Clusters of NVB were found to differentiate truthtellers from liars at statistically significant levels, and substantially beyond the ability of human observers. The findings showed that clusters of NVB can differentiate truthtellers from liars even in brief, checkpoint-type interviews.

Keywords: nonverbal behavior; veracity; deception; intent; facial expressions; gestures; voice; body movements; shrugs.

Research has examined nonverbal behavior (NVB) associated with veracity and deception for decades, with good reason: findings have theoretical implications concerning cognitions and emotions associated with truth-telling and lying, as well as practical ramifications for application in real-life investigative settings. Individuals and organizations from many such settings – including law enforcement, national security, asset protection and the business world – have interests in utilizing reliable behavioral indicators of veracity, deception and other mental states in interviews and investigations.

Almost two decades ago, a seminal meta-analysis concluded that few NVBs differentiate truthtellers from liars in low stakes lies or when suppressing emotions or pain (DePaulo et al., 2003). Subsequent research, however, has examined multiple rather than single NVBs and provided evidence that NVB clusters can make such differentiations. A meta-analysis examining NVB clusters reported that lies were detected with nearly 68% accuracy across multiple settings (Hartwig & Bond, 2014), and concluded: ‘the higher accuracy rates obtained here suggest that signals of deception are manifested in constellations rather than single cues’ (p. 667). Other studies not included in that meta-analysis have also provided such evidence (Davis et al., 2005; Dunbar et al., 2014; Duran et al., & Richardson, 2013; Ekman et al., 1991; Jensen et al., 2010; Matsumoto & Hwang, 2018a; Pennebaker & Chew, 1985; Vrij et al., 2000; Wright et al., 2014).

That multiple rather than single NVBs better differentiate veracity from deception makes...
theoretical sense. Communication involves multiple NVB channels, all of which produce multiple signals that convey multiple messages. These messages include specific emotions, general affective orientations, words and phrases, general cognitive processes, physical effort, attitudes and conversation regulation. In interaction, signals of any of these messages may be produced across any channel, with or without words, rendering the NVB system the most complex communicative system of the body.

The NVB system’s complexity is compounded by the complexity of truthtellers’ and liars’ minds and their associated cognitive and emotional loads (Ekman, 1985; Frank, 2009; Vrij, 2008). Liars lie about their thinking and think about their lying, and they need to lie about their emotions and have emotions about the fact that they are lying. All this occurs while they are attempting to manage the impressions of themselves that they give to others and maintain cognitive and emotional control (Buller & Burgoon, 1996; Hurley & Frank, 2011; Vrij, 2008).

Because people verbalize only a portion of their mental contents, and because different mental states map onto different NVB channels, truthful vs. deceptive signaling can occur in multiple channels and in different ways. Emotionally, the fear of being caught – or guilt or even thrill about lying – may be betrayed by face or voice; nervousness may be betrayed by voice and body. Cognitively, obfuscation, fabrication or omission in words may be betrayed by voice and gesture; lies about emotions and sensations experienced about an incident can range from anger or fear to shame or glee (see the Reality Monitoring perspective in Johnson, 1988; Johnson & Raye, 1981). A myriad of possibilities in cognitions and emotions combined with complexity of the NVB system to signal them suggest that analysis of single NVB channels will underestimate the potential for the NVB system to differentiate truthtellers from liars, whereas analysis of NVB clusters across multiple channels may be more predictive of differences, which is what has been evidenced in previous studies (reviewed above).

Within the deception literature, most studies have examined lies concerning an incident in the past. Some have examined lies about future intent (Granhag & Mac Giolla, 2014), but only a few were related to intent regarding future malfeasance in criminal contexts (Matsumoto & Hwang, 2018b; Matsumoto, Hwang, & Sandoval, 2015; Vrij et al., 2011). Theoretically, such lies may be different than lies about the past because they may access different domains of cognition and memory (Addis et al., 2007; Schacter & Addis, 2007; Schacter, Addis, & Buckner, 2008). Examining lies about future intent has practical implications; results of such studies may inform practitioners about behavioral indicators that can occur in brief, checkpoint-type interactions, with implications for security procedures in settings that assess future malicious intent.

However, examining lies about future intent in encounters such as checkpoint interviews is risky because they are brief and questions are not directed toward specific incidents. Thus, they may not produce cognitive and emotional loads that differentiate truthtellers from liars as do longer, investigative interviews. Moreover, NVBs tend to produce weak signals, as evidenced by the effect sizes reported for single NVBs in previous meta-analyses (DePaulo et al., 2003; Hartwig & Bond, 2014). The complexity of the NVB system is further complicated by the existence of cultural similarities and differences in the production of NVBs. Although certain facial expressions of emotion are universally expressed and recognized, the contexts, dynamics and rules that govern their usage and modification are culturally different (Hwang & Matsumoto, 2016a). Whereas speech illustrative gestures function similarly across cultures, their form, frequency and amplitude are culturally different, as are emblematic gestures (Cartmill & Goldin-Meadow, 2016).
movements – including posture, gait, proxemics and haptics – also involve both cross-culturally similar and different aspects (Matsumoto et al., 2016). Lastly, vocalics appear to be cross-culturally similar in their characteristics to signal emotion but culturally different in signals of cognition and speech articulation (Scott & McGettigan, 2016).

**Overview of the current study**

This study addresses the possibility of using multiple NVBs to differentiate truths from lies about future malicious intent in a culturally diverse community sample that participated in a mock crime experiment about a future theft. Stakes were associated with performance, and manipulation checks ensured that participants perceived the stakes to be at moderate to high levels and were emotionally aroused. The participants were interviewed in a checkpoint-type screening interview prior to gaining access to an area where a theft could occur. The context, therefore, was analogous to real-life settings in which individuals with malicious intent need to hide their intentions, with the stakes involved regarding whether or not they were believed.

Participants’ behavior was video-recorded using two cameras, one filming straight head and shoulder shots and the other filming participants’ whole bodies at a 90° angle. We extracted data from four NVB channels: facial expressions of emotion (seven types), gestures (three types), whole body movements (four types) and vocalics (seven types). These NVBs were selected a priori because previous research has tested their ability to differentiate truthtellers from liars, although mostly when tested individually and with some contradictory findings (DePaulo et al., 2003; Ekman et al., 1991; Matsumoto & Hwang, 2018a, 2018b). To the authors’ knowledge, the current study is the first to test NVB clusters in an initial screening interview about future intent.

We tested whether or not NVB differentiated truthtellers from liars both singly (univariate analyses) and in combination (multivariate analyses). We included univariate analyses because each NVB signal by itself should be relatively weak, and practitioners in real life would not observe as many channels and signals as we assessed herein and thus could not perform complex mathematical algorithms in real time that account for the interdependencies among observed variables in the same way as multivariate statistics do. We used two criteria in the univariate analyses to determine whether or not the NVBs differentiated truthtellers from liars: null hypothesis significance testing (NHST) and effect sizes. NHST is dependent on sample sizes whereas effect sizes are less so, and findings across studies can differ depending on sample size.

We hypothesized that clusters of NVB from different source channels would differentiate truthtellers from liars. Specifically, we predicted that at least one NVB from at least two different channels would differentiate veracity from deception, as opposed to multiple NVBs from the same channel (for example, Facial Expressions of Anger and fear, which both originate in the face channel). We further hypothesized that the participants’ culture/ethnicity would moderate the findings.

**Method**

**Design**

The experiment was a two-way design involving Veracity (truths vs. lies) and Culture/ethnicity (European American, Chinese, Hispanic and Middle Eastern). Other papers have examined verbal behavior and NVB coded from a different interview in this experiment (Matsumoto et al., 2015; Matsumoto & Hwang, 2015, 2018a), as well as the timing characteristics of facial expressions from a subset of the records reported below (Matsumoto & Hwang, 2018b). The current study reports occurrence data (ignoring timing) from four sources of NVB from the initial interview of the study ($n = 226$), all of which
have not been analyzed or reported previously and are new to the literature.  

**Participants**

Community samples were recruited from the San Francisco Bay Area and Buffalo, New York. The European American participants were American born-and-raised Caucasians; the other participants were born and raised in their country of origin or in the United States (US), their first language was that of their country of origin and both parents were born and raised in their country of origin. The country of origin and first language were categorized as Chinese (People’s Republic of China, Hong Kong or Taiwan; Mandarin or Cantonese), Hispanic (any country in Central or South America; Spanish) and Middle Eastern (any country in Northern Africa or Western Asia; Arabic). The total number of participants assigned to be liars and truth-tellers, respectively, were $n_s = 40$ and $38$ European American participants, $n_s = 46$ and $36$ Chinese participants, $n_s = 28$ and $18$ Hispanic participants and $n_s = 8$ and $12$ Middle Eastern participants. Sex ratio was evenly distributed (47.4% males, 52.6% females; $M_{age} = 27.32$, range = 19–47). The experiment was administered in English.

**Measures**

Pre-session measures included a demographics questionnaire, the General Ethnicity Questionnaire (GEQ; Tsai et al., 2000), the Machiavellianism Scale (Christie, 1970), the Self-Monitoring Scale (Snyder, 1974) and an emotion checklist that included 12 emotion words (guilt, fear, anger, embarrassment, worry, contempt, excitement, disgust, amusement, nervousness, surprise and interest) rated on 9-point scales (where 0 = none, 4 = a moderate amount and 8 = extremely strong). This checklist was also administered at the end of the experiment as a manipulation check on emotional arousal.

The GEQ served as a manipulation check for ethnic/cultural differences (the target group was made applicable for each group), and was modified to refer to the participants’ culture/ethnic group. The Chinese sample had significantly higher scores on the GEQ Total than Chinese who immigrated to the U.S. before age 12 (Christie, 1970), $t(74) = 8.07, p < .001, d = .93$; and $t(74) = 1.71, p < .05, d = .20$, respectively. GEQ scores for the Middle Eastern and Hispanic participants were comparable to those of the Chinese participants in the same way, suggesting the groups were equivalently representative of their respective cultures/ethnicities.

**Procedure**

After completing the pre-session measures, participants were informed that they would be randomly assigned to either steal a US$100 check (the liars) or not (the truth-tellers), go through up to three interviews and earn a minimum of US$20. Participants were told that if they were judged as honest they would receive additional money and be allowed to leave early, but if they were judged as dishonest they would receive no additional money and would have to stay longer to complete other procedures. Participants rated these stakes on a scale from 1 = no consequence, even slightly pleasurable to 10 = maximum consequence, even slightly painful. The mean was above the midpoint ($M = 5.68, SD = 2.24$) and significantly greater than 1.00, $t(224) = 31.34, p < .001, d = 2.09$. No ethnicity or veracity condition differences were found. Participants were then randomly assigned to steal or not steal the check.

An initial screening interview was conducted in an area modeled after a security checkpoint. An interviewer entered the area, went to a podium and instructed the participant to go through a metal detector and step up to the podium. The screening interview included seven brief questions and lasted an average of 1 min, 56 s. Interviewers consisted of 10
males above the age of 30 years who were trained to conduct interviews neutrally. (They were predominantly European American, with one African American and one Asian American; thus, race/ethnicity of interviewers and interviewees was not counterbalanced.) Once the screening interview was completed, the interviewer left and the remainder of the experiment proceeded, consisting of a secondary interview, the mock crime, an investigative interview, the administration of post-session measures, debriefing, post-session consent and payment. All coding and analyses below focused on three questions from the initial screening interview which those assigned to steal the check had to answer dishonestly (the liars) and those assigned to not steal the check could answer honestly (the truthtellers). Coding for each channel was performed by different sets of coders.

**Coding**

**Facial expressions of emotion**

Facial expressions of seven emotions (Anger, Contempt, Disgust, Fear, Happiness, Sadness and Surprise) were coded by two coders who were blind to veracity condition. The coders used Emotion FACS (EMFACS; Hwang & Matsumoto, 2016b; Matsumoto et al., 1991), an abbreviated version of the Facial Action Coding System (FACS; Ekman & Friesen, 1978). Reliabilities were computed on a subsample of records \((n = 77)\) and were acceptable (percentage of agreement \(=.70, .91, .75, .96, .67, .68\) and \(.82\) for Anger, Contempt, Disgust, Fear, Happiness, Sadness and Surprise, respectively; \(r(76) = .97\) for total emotions coded). Analyses used the frequency of each emotion on which both coders agreed across the target questions.

**Gestures**

Head Nods, Head Shakes and Shrugs (including shoulder and face shrugs) were coded. Four raters coded one third of all videos and produced an average reliability of \(.76\). Coders then coded all remaining videos. Mid-coding reliability between the coders and authors was \(.90\) across two thirds of the total sample. Analyses used the frequency of each gesture across the target questions.

**Whole body movements**

Four types of whole body movements were coded by two coders using video from the camera that was set at a 90° angle to the interaction, through which the participants’ entire bodies could be seen (available for only \(n = 139\) interviews): Body Trembling, including trembling of the body or voice; Body Swaying, involving rocking back and forth or side to side; Fidgeting/Grooming, including any rubbing or wringing of the hands, face touching, shuffling or tapping of the feet or any other kind of grooming behavior; and Rigid Posture, involving minimal, stiff body movements with arms kept close to the sides. Reliability estimates and coder arbitration and calibration were carried out for \(n = 50\) cases and were high and acceptable for all four movements (\(\alpha = .73, .95, .96\) and \(.77\) for Body Trembling, Body Swaying, Fidgeting/Grooming and Rigid Posture, respectively). Both coders then coded all video records available. Analyses included scores for each movement averaged between coders across the target questions.

**Voice**

Vocal data were extracted using the open-source software Praat (Boersma & Weenink, 2002). The following variables were generated across the target questions: Pitch, Pitch Range, Intensity, Intensity Range, Response Latency (generated from onset/offset interview logs), Duration and Unfilled Pauses (combined into one variable) and Speech and Articulation Rates (combined into one variable).

**Interview contamination**

Two coders blind to veracity condition and hypotheses independently coded transcripts from 30 cases for participant understanding of
the questions and interviewer contamination, achieving high reliabilities ($r_s = .97$ and $.83$, respectively). The remaining cases were then coded by one coder. Analyses below included only cases that were coded as having full participant understanding and no interviewer contamination.  

Results

Manipulation check

A Pre-post (2) × Emotion (12) × Veracity (2) mixed analysis of variance (ANOVA) was computed on the self-reported emotions. The Pre-post × Veracity and three-way interactions were significant: $F(1, 186) = 18.49$, $p = .000$, $\eta^2_p = .09$; $F(11, 2046) = 4.96$, $p = .000$, $\eta^2_p = .03$. The Pre-post × Veracity simple interaction contrasts produced significant effects on seven emotions; liars exhibited increases in guilt, fear, embarrassment, worry and nervousness, whereas the truthtellers exhibited less excitement and interest, $.02 < \eta^2_p < .19$. Thus, the participants were emotionally aroused and emotions were elicited differentially in the truthtellers and the liars.

Univariate analyses

We computed descriptives ($M$s and $SD$s) on all NVB variables, followed by two initial multivariate analyses of variance (MANOVAs): one for whole body movements and another for all other NVBs because of differences in sample sizes associated with the codes available. Both were significant: Wilks’ $\lambda = .94$, $F(4, 118) = 2.45$, $p = .050$ for whole body movements; Wilks’ $\lambda = .82$, $F(17, 171) = 2.27$, $p = .004$ for all other NVBs. We then computed separate, two-tailed $t$-tests on each NVB singly to examine whether or not they differed by veracity condition. NHST indicated that three NVBs differentiated truthtellers from liars at $p \leq .05$: liars produced more facial expressions of Fear, Shrugs and Fidgeting/Grooming. Four other NVBs trended toward significance: truthtellers produced more facial expressions of Happiness and Surprise and greater Response latencies and Durations and Unfilled Pauses. (Because variables trending toward significance may have operational relevance and influence multivariate effects, they are reported.) The number of variables that differentiated truthtellers from liars was greater than that expected by chance.

We also used Cohen’s $d \geq .20$ as an effect size criterion to reduce reliance on NHST to identify NVBs that differentiated truthtellers from liars. This criterion was chosen because it is typically interpreted as an estimate of ‘small’ effects. We reckoned that any single NVB would only produce weak signals that differentiated truthtellers from liars, and therefore wanted to utilize the minimal value that would also possibly be operationally relevant to observers. Liars produced more facial expressions of Fear, Shrugs, Fidgeting/Grooming and Rigid Posture, whereas truthtellers produced more facial expressions of Happiness and Surprise and greater Response latencies and Durations and Unfilled Pauses (see Table 1). Thus, regardless of the criterion used to identify the variables, multiple NVBs from different channels differentiated truthtellers from liars.

Examining for possible latent structures

To examine whether or not the NVBs were organized around latent factors, we computed principal components analyses on all variables. Kaiser criterion indicated nine factors accounting for 69.71% of the total variance. After Varimax rotation, we identified scales with variables with factor loadings $\geq .30$ and computed Cronbach’s alphas; with the exception of the first scale, all were low ($\alpha$s = .91, .63, .57, .49, .22, .41, .14, .39 and .08). The scree plot was also inconclusive and linear; the correlation between the extracted factors and the eigenvalues was $r(21) = -.97$. Analyses utilizing three-, four- and five-factor solutions and two different oblique rotation methods were also unable to produce interpretable structures. We therefore concluded that the
NVBs did not group together in an interpretable manner using factor techniques and proceeded with the analyses below using the variables separately.

**Multivariate analyses: do clusters of NVB differentiate truthtellers from liars?**

To determine whether or not multiple NVBs differentiated truthtellers from liars, we computed binary logistic regressions with backward conditional entry separately for the four NVB channels and then for all the NVBs together. We selected final models based on the lowest p-values associated with the largest classification accuracy rates. If two models had the same classification accuracies, we selected the model with the larger number of predictors.

The results are shown in Table 2. For facial expressions of emotion, Fear and Surprise were the final predictors with an overall classification rate of 57.1%. For gestures, Shrugs were a predictor with an overall classification rate of 60.1%. For whole body movements, the selected model trended toward significance with Fidgeting/Grooming as a predictor and an overall classification rate of 57.7%. The selected model for voice also trended toward significance, with Response Latency as a significant predictor and an overall classification rate of 60.2%.

When all NVBs were analyzed together, five variables were significant predictors with

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**Table 1. Descriptive statistics (Ms and SDs) and results of t-tests comparing veracity conditions separately for each NVB.**

<table>
<thead>
<tr>
<th>NVB</th>
<th>Truth</th>
<th>Lie</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p (2-tailed)</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial expressions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anger</td>
<td>99</td>
<td>0.13 (0.44)</td>
<td>113</td>
<td>0.17 (0.50)</td>
<td>−0.57</td>
<td>210</td>
<td>.573</td>
<td>−0.08</td>
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<tr>
<td>Contempt</td>
<td>99</td>
<td>0.41 (1.53)</td>
<td>113</td>
<td>0.46 (0.97)</td>
<td>−0.27</td>
<td>210</td>
<td>.791</td>
<td>−0.04</td>
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<tr>
<td>Disgust</td>
<td>99</td>
<td>0.40 (0.82)</td>
<td>113</td>
<td>0.60 (1.41)</td>
<td>1.27</td>
<td>210</td>
<td>.206</td>
<td>−0.18</td>
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<tr>
<td>Fear</td>
<td>99</td>
<td>0.15 (0.39)</td>
<td>113</td>
<td>0.37 (0.84)</td>
<td>−2.40</td>
<td>210</td>
<td>.017</td>
<td>−0.36</td>
<td></td>
</tr>
<tr>
<td>Happiness</td>
<td>99</td>
<td>0.12 (0.41)</td>
<td>113</td>
<td>0.04 (0.23)</td>
<td>1.91</td>
<td>210</td>
<td>.058</td>
<td>0.27</td>
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<td>Sadness</td>
<td>99</td>
<td>0.15 (0.41)</td>
<td>113</td>
<td>0.24 (0.63)</td>
<td>−1.18</td>
<td>210</td>
<td>.241</td>
<td>−0.17</td>
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<td>Surprise</td>
<td>99</td>
<td>0.12 (0.36)</td>
<td>113</td>
<td>0.05 (0.23)</td>
<td>1.68</td>
<td>210</td>
<td>.095</td>
<td>0.23</td>
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<tr>
<td>Gesture</td>
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<tr>
<td>Head Nods</td>
<td>98</td>
<td>4.29 (4.19)</td>
<td>111</td>
<td>3.95 (4.29)</td>
<td>0.58</td>
<td>207</td>
<td>.564</td>
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<tr>
<td>Head Shakes</td>
<td>98</td>
<td>3.68 (4.01)</td>
<td>111</td>
<td>4.36 (3.90)</td>
<td>−1.24</td>
<td>207</td>
<td>.218</td>
<td>−0.17</td>
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<td>Shrugs</td>
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<td>0.59 (1.04)</td>
<td>111</td>
<td>1.23 (1.79)</td>
<td>−3.08</td>
<td>207</td>
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<tr>
<td>Whole body mov.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Body Trembling</td>
<td>62</td>
<td>0.98 (1.58)</td>
<td>73</td>
<td>0.97 (2.71)</td>
<td>0.01</td>
<td>133</td>
<td>.993</td>
<td>0.00</td>
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<tr>
<td>Body Swaying</td>
<td>62</td>
<td>1.08 (1.33)</td>
<td>73</td>
<td>1.32 (1.78)</td>
<td>−0.85</td>
<td>133</td>
<td>.395</td>
<td>−0.15</td>
<td></td>
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<tr>
<td>Fidgeting/Grooming</td>
<td>62</td>
<td>1.21 (1.44)</td>
<td>73</td>
<td>1.83 (1.98)</td>
<td>2.10</td>
<td>133</td>
<td>.038</td>
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<tr>
<td>Rigid Posture</td>
<td>62</td>
<td>0.00 (0.00)</td>
<td>73</td>
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<td>−0.92</td>
<td>133</td>
<td>.359</td>
<td>−0.23</td>
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<tr>
<td>Voice</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Pitch</td>
<td>96</td>
<td>150.75 (40.19)</td>
<td>111</td>
<td>150.42 (38.89)</td>
<td>0.06</td>
<td>205</td>
<td>.951</td>
<td>0.01</td>
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<tr>
<td>Pitch Range</td>
<td>96</td>
<td>126.71 (80.96)</td>
<td>111</td>
<td>117.16 (63.72)</td>
<td>0.95</td>
<td>205</td>
<td>.344</td>
<td>0.13</td>
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<tr>
<td>Intensity</td>
<td>96</td>
<td>62.68 (7.79)</td>
<td>111</td>
<td>64.98 (19.54)</td>
<td>−1.08</td>
<td>205</td>
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<tr>
<td>Intensity Range</td>
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<td>22.38 (5.17)</td>
<td>111</td>
<td>25.82 (30.74)</td>
<td>−1.08</td>
<td>205</td>
<td>.281</td>
<td>−0.19</td>
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<tr>
<td>Response Latency</td>
<td>96</td>
<td>0.85 (0.83)</td>
<td>111</td>
<td>0.67 (0.48)</td>
<td>1.92</td>
<td>205</td>
<td>.056</td>
<td>0.27</td>
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<tr>
<td>Duration and Unfilled Pauses</td>
<td>96</td>
<td>5.95 (3.54)</td>
<td>111</td>
<td>5.03 (3.69)</td>
<td>1.82</td>
<td>205</td>
<td>.070</td>
<td>0.25</td>
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<tr>
<td>Speech and Articulation Rates</td>
<td>96</td>
<td>4.97 (1.84)</td>
<td>111</td>
<td>5.21 (2.03)</td>
<td>−0.89</td>
<td>205</td>
<td>.374</td>
<td>−0.12</td>
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</tbody>
</table>
an overall classification rate of 76.0%. Liars produced more facial expressions of Disgust, Shrugs, Body Swaying and Fidgeting/Grooming, whereas truthtellers exhibited larger Pitch Range. As predicted, these specific NVBs came from multiple channels. We also report the final (i.e. most parsimonious) model in the analysis. Here, five variables emerged as predictors with an overall classification rate of 65.9%. Liars produced more facial expressions of disgust, more shrugs, more Body Swaying, and more Fidgeting/Grooming, while truthtellers produced more facial expressions of happiness. Again, the final NVBs came from multiple channels rather than a single channel.

Thus, the analyses of single channels of NVB produced classification rates that were only slightly above the average accuracy rate of human observers in distinguishing truths from lies (54% as reported by Bond & DePaulo, 2006). Analyzing NVB clusters across channels, however, produced substantially higher classification accuracy rates, with NVBs from multiple channels contributing to the predictions.

### Culture/ethnicity moderation

To test for culture/ethnicity moderation of the findings, we recomputed the analyses above using Culture/ethnicity (4) × Gender (2) × Veracity condition (2) MANOVAs with the 21 NVBs as dependent variables, as we reckoned that culture/ethnicity moderation of the association between NVBs with veracity condition would qualify interpretations of both sets of findings above. The Culture/ethnicity × Veracity condition was not significant, Wilks’ $\lambda = .76$, $F(51, 468.22) = 1.01, p = .455$, suggesting that culture/ethnicity did not moderate the findings above.

### Additional analyses

**Protection against Type I error**

We recomputed the multivariate analyses using data that were randomized with different ranges for different NVBs given the actual range of values that occurred in the original data set. Univariate $t$-tests produced only one significant finding at $p \leq .05$ (as would be expected for 21 tests); truthtellers produced more Shrugs, $t(225) = 2.11, p = .036$, which

<table>
<thead>
<tr>
<th>NVB analyzed</th>
<th>Model</th>
<th>$df$</th>
<th>$\chi^2$</th>
<th>$p$</th>
<th>Acc. (%)</th>
<th>Predictor</th>
<th>$B$</th>
<th>$SE$</th>
<th>$p$</th>
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</thead>
<tbody>
<tr>
<td>Facial expressions of emotion</td>
<td>3</td>
<td>5</td>
<td>13.83</td>
<td>.017</td>
<td>57.1</td>
<td>Fear</td>
<td>0.56</td>
<td>0.26</td>
<td>.033</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Surprise</td>
<td>−0.90</td>
<td>0.54</td>
<td>.094</td>
</tr>
<tr>
<td>Gestures</td>
<td>2</td>
<td>2</td>
<td>10.32</td>
<td>.006</td>
<td>60.1</td>
<td>Shrugs</td>
<td>0.36</td>
<td>0.13</td>
<td>.005</td>
</tr>
<tr>
<td>Whole body movements</td>
<td>1</td>
<td>3</td>
<td>6.93</td>
<td>.074</td>
<td>57.7</td>
<td>Fidgeting/Grooming</td>
<td>0.29</td>
<td>0.12</td>
<td>.016</td>
</tr>
<tr>
<td>Voice</td>
<td>5</td>
<td>4</td>
<td>8.06</td>
<td>.089</td>
<td>60.2</td>
<td>Response Latency</td>
<td>−0.44</td>
<td>0.26</td>
<td>.090</td>
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<td>All NVBs</td>
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<td>21</td>
<td>39.31</td>
<td>.008</td>
<td>76.0</td>
<td>Disgust</td>
<td>0.57</td>
<td>0.23</td>
<td>.014</td>
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<td></td>
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<td>Shrugs</td>
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<td>0.19</td>
<td>.025</td>
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<td></td>
<td></td>
<td>Body Swaying</td>
<td>0.33</td>
<td>0.16</td>
<td>.038</td>
</tr>
<tr>
<td></td>
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<td>Fidgeting/Grooming</td>
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<td>0.16</td>
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<td>Pitch Range</td>
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<td>Happiness</td>
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<td></td>
<td></td>
<td>Shrugs</td>
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<td>0.17</td>
<td>.007</td>
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<td>0.14</td>
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<td></td>
<td>Fidgeting/Grooming</td>
<td>0.36</td>
<td>0.14</td>
<td>.007</td>
</tr>
</tbody>
</table>

Note. *Classification accuracy.
was contrary to what would be predicted. Another variable trended toward significance; liars had shorter Durations and Unfilled Pauses, \( t(225) = 1.82, p = .070 \). At either criterion, the number of significant tests was not larger than what would be expected by chance. The same two variables were the only ones to meet Cohen’s \( d \) criterion.

Logistic regressions using the randomized data and the same criteria as above produced a selected model that was significant, \( \chi^2(4, 227) = 11.03, p = .026 \), with an overall classification accuracy rate of 63.0%. The final variables in the selected model were Shrugs (direction opposite to that reported in the main analyses) and Duration and Unfilled Pauses. The final model was also significant, \( \chi^2(2, 227) = 7.26, p = .027 \), with an overall classification accuracy rate of 57.7%. The final variables in the model were once again Shrugs (opposite direction) and Duration and Unfilled Pauses.

Thus, using randomized data, the number of significant univariate results was not different from that expected by chance, the direction of the findings would not have been predicted and classification accuracies of the selected and final models in the multivariate analyses were lower than those produced with actual data and in directions that would not have been predicted.

Possible gender moderation

The Gender \( \times \) Veracity condition interaction from the overall Culture/ethnicity \( \times \) Gender \( \times \) Veracity condition MANOVA reported above was not significant, Wilks’ \( \lambda = .91, F(17, 157) = 0.91, p = .561 \), indicating that gender did not moderate the findings reported above. The gender main effect, however, was significant, Wilks’ \( \lambda = .34, F(17, 157) = 18.32, p < .001 \). Follow-up analyses indicated that gender differences existed for the following variables: Head Nods, \( F(1, 177) = 6.04, p = .015, \eta^2_p = .033 \); Body Trembling, \( F(1, 107) = 7.59, p = .007, \eta^2_p = .066 \); Pitch, \( F(1, 175) = 233.07, p \leq .001, \eta^2_p = .571 \); and Pitch Range, \( F(1, 175) = 82.24, p \leq .001, \eta^2_p = .320 \). Compared to males, females produced more Head Nods (\( M = 5.14, SD = 4.72 \) vs. \( M = 3.31, SD = 3.56 \)), higher Pitch Range (\( M = 181.97, SD = 27.31 \) vs. \( M = 118.13, SD = 16.58 \)) and greater Pitch Ranges (\( M = 167.38, SD = 73.77 \) vs. \( M = 78.05, SD = 37.47 \)). Compared to females, males produced more Body Trembling (\( M = 1.48, SD = 3.10 \) vs. \( M = 0.52, SD = 1.08 \)).

Ethnicity main effects

The Culture/ethnicity main effect from the same overall MANOVA reported above was significant, Wilks’ \( \lambda = .35, F(51, 468.22) = 3.93, p < .001 \). Follow-up tests were also significant for Facial Expressions of Anger, Body Swaying, Pitch Range, Intensity, Response Latency and Duration and Unfilled Pauses. We followed these effects using pairwise comparisons with Scheffe corrections (Table 3). Chinese participants produced more Facial Expressions of Anger than Hispanic participants and more Body Swaying and Duration and Unfilled Pauses than Hispanic and European American participants. Middle Eastern and Hispanic participants exhibited higher Pitch Ranges than European American participants and greater Vocal intensity than Chinese participants.

Discussion

The findings of this study add to a growing body of literature documenting that multiple NVBs in clusters can differentiate truth tellers from liars, in the present case by analyzing effects produced by telling lies about future malicious intent during brief, checkpoint-type interviews. Across analyses, liars produced more facial expressions of fear and disgust, shrugs, Fidgeting/Grooming, Body Swaying and Rigid Posture, whereas truth tellers produced more facial expressions of happiness and surprise, longer response latencies, greater Pitch Ranges and longer Durations and Unfilled Pauses. Clusters of NVB across
multiple channels outperformed NVB in single channels, supporting the contention that NVB represents a complex and comprehensive bodily communication system that conveys multiple messages in multiple signals across multiple channels.

The type of lie tested was unique: the intent to commit a malicious act in the future. As mentioned above, many studies have already demonstrated that NVB clusters can differentiate truths from lies about the past (summarized in Hartwig & Bond, 2014). Lies about future intentions have been considered potentially different from lies about the past because they may recruit different cognitions. However, the NVBs that differentiated truthtellers from liars in the present study were similar to those reported in previous studies, and had comparable detection accuracy rates (68% according to the meta-analysis cited in Hartwig & Bond, 2014, compared to 76.0% and 65.9% in the present study). The current findings, therefore, suggested that the cognitive and emotional processes associated with veracity and deception may be similar regardless of whether one is talking and thinking about the past or the future. Both involve lying about one’s thinking, thinking that one is lying, lying about one’s emotions and having emotions about lying; the NVBs produced may therefore be signals of these processes. This interpretation is consistent with neuroimaging studies that have demonstrated similarities between remembering the past and imagining the future (Schacter et al., 2008, 2012). Forming a better understanding of the cognitive and emotional processes that operate during the act of lying may give clues about differences in the mental complexities between truthtellers and liars that may be consistent across different types of lies and produce similarities in NVB, which is what we observed.9

The specific NVBs that have emerged as indicators provided glimpses into mindset content differences between truthtellers and liars and supported different theories about them, including emotional leakage (Ekman, 2009), impression management (Buller & Burgoon, 1996; Burgoon & Buller, 1994; DePaulo et al., 2003), cognitive load (Vrij, 2008), emotional control (Frank & Svetieva, 2013) or a combination of these theories (Zuckerman et al., 1981). For example, that liars produced more signals of fear and disgust suggested that appraisals occurred related to threat or contamination, which is linked to emotional leakage. Liars produced more shrugs, which is suggestive of doubt or uncertainty and related to cognitive load. Liars’ greater Body Swaying and Fidgeting/Grooming were suggestive of more overall nervousness (linked to emotional leakage) and their smaller Pitch Ranges were suggestive of greater vocal control (linked to emotional control and impression management). Liars also displayed less happiness and surprise, indicative of an overall negative, tense and uncertain state of mind (related to emotional leakage).

Table 3. Post hoc tests of significant ethnicity effects.

<table>
<thead>
<tr>
<th>NVB</th>
<th>F</th>
<th>Scheffe comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Expressions of Anger</td>
<td>$F(3, 180) = 4.64, p = .004, \eta_p^2 = .072$</td>
<td>CH &gt; HI</td>
</tr>
<tr>
<td>Body Swaying</td>
<td>$F(3, 107) = 4.80, p = .004, \eta_p^2 = .119$</td>
<td>CH &gt; EA, HI</td>
</tr>
<tr>
<td>Pitch Range</td>
<td>$F(3, 175) = 8.85, p \leq .001, \eta_p^2 = .320$</td>
<td>ME, HI &gt; EA</td>
</tr>
<tr>
<td>Intensity</td>
<td>$F(3, 175) = 8.03, p \leq .001, \eta_p^2 = .121$</td>
<td>ME, HI &gt; CH</td>
</tr>
<tr>
<td>Response Latency</td>
<td>$F(3, 175) = 3.33, p = .021, \eta_p^2 = .054$</td>
<td>None</td>
</tr>
<tr>
<td>Duration and Unfilled Pauses</td>
<td>$F(3, 175) = 7.48, p \leq .001, \eta_p^2 = .114$</td>
<td>CH &gt; EA, HI</td>
</tr>
</tbody>
</table>

Note. CH = Chinese participants; EA = European American participants; HI = Hispanic participants; ME = Middle Eastern participants.
Thus, examination of NVB clusters opens the door to the possibility that multiple theories of deception may be supported because different NVBs may signal different content related to these theories.

The findings varied across analyses. Facial expressions of happiness, shrugs and Fidgeting/Grooming emerged as indicators in both univariate and multivariate analyses. Other NVBs – facial expressions of fear, disgust and surprise, Rigid Posture, Response Latency, Body Swaying, Pitch Range and duration and unfilled responses – also emerged in one or the other analysis. These differences likely occurred because of the way NVBs were handled as dependent variables. Multivariates created linear combinations of NVBs by weighting the variables depending on intercorrelations that are conditional on optimizing group classification, whereas univariates did not. Although the multivariates produced the most statistically parsimonious combination of variables relevant to category prediction, these computational differences also meant that different findings emerged depending on the analyses conducted and the criteria adopted.

Assessing NVB clusters raises methodological concerns, especially about Type I error. This problem is compounded when sample sizes do not allow for sufficient power and findings are optimized for individual data sets, which leads to concerns about replicability and generalizability (for an excellent discussion of these issues, see Luke, 2019). We attempted to mitigate this problem by reconducting analyses using randomized data, which did not produce a number of significant findings beyond that expected by chance, and those that were produced were contradictory to what would have been expected.

Another way to mitigate Type I error is to examine consistencies (and inconsistencies) in findings across other studies that have examined NVB clusters. The only other comparable study available in the literature did so in an investigative interview in the same experiment (Matsumoto & Hwang, 2018a). The interview was longer than the screening interview in the present study and included different types of questions, and analyses were computed separately for each question type. During open-ended questions, liars showed fewer Facial Expressions of Anger and happiness and more disgust, fear and surprise. Liars also exhibited fewer Head Nods, lower voice intensity and pitch, shorter Durations and Unfilled Pauses and greater Pitch Range and Intensity Range. During indicator questions, liars produced more Facial Expressions of Anger and disgust and less Head Nods. Thus, consistent with the present findings, truthtellers and liars differed on facial expressions of happiness, disgust and fear. Contradictory findings were obtained for facial expressions of surprise, Pitch Range and Duration and Unfilled Pauses. Also, several findings emerged in one study but not in the other: shrugs and Response Latency emerged in the present study but not in Matsumoto and Hwang (2018a), whereas Facial Expressions of Anger and Head Nods, pitch, intensity and Intensity Range emerged in Matsumoto and Hwang 2018a but not in the present study (Fidgeting/Grooming, Rigid Posture and Body Swaying were not measured in Matsumoto and Hwang, 2018a).

These differences may have occurred for several reasons, one being differences in context. The current study involved brief, checkpoint-type interviews with short questions asking about future intent. Matsumoto and Hwang (2018a) involved longer interviews with open-ended and indicator questions designed to accentuate differences between truths and lies about a past event. Such context differences (the type of lie and its object, the investigative design and the nature of the questions) likely contributed to differences in the findings. For example, in the present study, truthtellers exhibited longer response latencies, greater Pitch Range and longer Durations and Unfilled Pauses compared to liars, which is the opposite of the findings reported in Matsumoto and Hwang 2018a. These
differences probably occurred because of the length of the interviews and the types of questions asked. To wit, question type analyses in Matsumoto and Hwang 2018a indicated that direct questions (like those in the current study) produce less NVBs in general. Longer, open-ended questions may have allowed for greater complexity of mental states resulting in greater NVB production, thus increasing the range of NVBs that differentiated truthtellers from liars.

Another possibility, however, is that some findings are not replicable. Future reviews should compare studies that have examined NVB clusters and identify patterns of NVB that emerge consistently. Unfortunately such a volume of research does not yet exist, and we hope that the present findings and others can serve as a call for further studies to be conducted. Such an undertaking may require some consistency in the selection and measurement of NVBs across studies and investigators, which rarely occurs, rendering integrative, synthetic reviews difficult. Researchers may need to consider which NVBs to include in a more comprehensive and systematic assessment in the future.

That neither culture/ethnicity nor gender moderated the present findings was also interesting, suggesting potential for the cross-cultural/ethnic utility of NVB analyses. Although there is ample evidence for cultural/ethnic differences in NVB production (see the reviews in Cartmill & Goldin-Meadow, 2016; Hwang & Matsumoto, 2016a; Matsumoto et al., 2016; Scott & McGettigan, 2016), the checkpoint situation with brief questions may have reduced the possibility for such differences to emerge because of the focus on quick reactions and responses. Cultural/ethnic differences may occur during longer conversations that give more time for cultural factors to influence interviewees’ responses. Although there is evidence suggesting that liars take longer to respond and with less verbal volume (Newman et al., 2003; Vrij, 2008), in the current study truthtellers exhibited longer response latencies and durations, and no differences Speech and Articulation Rates were found.

There were, however, culture/ethnicity difference main effects in overall usage of Facial Expressions of Anger, Body Swaying, Pitch Range, vocal intensity, Response Latency and Duration and Unfilled Pauses when in interaction with each other. These differences pointed to the very real possibility that these NVBs could be mistakenly interpreted as deception indicators. Interpretation of these findings, however, also needs to be tempered because of the sample sizes used in the analyses, which is a limitation of the study. All findings should be replicated in the future with larger sample sizes and other cultural/ethnic groups – especially those in other nations and cultures with larger cultural distances.

Another limitation of the study was that it included no a-priori predictions. Future theoretical and empirical work should address this and will need to include theories about individual differences in emotions and cognitions related to truthtelling and lying that lend themselves to predictions of which specific NVBs will be produced when a respondent is lying. Hopefully, such studies can involve pre-registered hypotheses.

The current findings suggested the need for practitioners to be aware of multiple channels of NVB when conducting credibility assessments. These findings may be especially meaningful to practitioners who interact with people of different cultural and ethnic backgrounds in order to assess their credibility when only limited information is available from moment to moment. In these cases, discrete, nonverbal signals can be potential indicators of where to explore and in what order of priority. Even when language is a barrier and resources are limited, interactions do not have to be prohibitive as the focus can be transferred to non-linguistic approaches. Vigilant observation of multiple NVB channels in interactions is challenging because NVB signals – especially when observed singly – are weak. One way to mitigate the
challenge of leveraging weak signals in practice is to focus on validated indicators which can provide practitioners with additional insights concerning interviewees’ mindsets and be a strength for interviewers.

Another way to streamline efficiency for practitioners is to focus on relatively small clusters of NVB because different NVBs make different relative contributions to the prediction of veracity and deception (Hartwig & Bond, 2014). In the present study, this can be estimated using regression coefficients, which would give priority to facial expressions of emotions, shrugs, Fidgeting/Grooming, Body Swaying and Pitch Range – in that order. Future studies could examine whether this or any other NVB cluster may prove to be useful diagnostically; such research may also be helpful in informing practitioners about validated behavioral indicators that occur briefly, check-point-type interactions, with potential implications for security procedures across a wide variety of settings that assess malicious intent.

Notes

1. Their analyses also showed that within a cluster of NVBs, some cues were relatively more important than others and neither motivation nor strong emotion were moderators of the effects. Levine (2018) also commented in his review that arguments about the importance of stakes invoked circular reasoning.

2. Burgoon et al. (2009) was labeled as an intent study but none of the test beds used in the paper was actually about intent regarding future malfeasance; rather, multiple test beds from experiments about current or past events were used to make a case for the use of indicators for future intent.

3. Considerably more detail than is reported herein about sampling, recruitment, cultural differences among the ethnic groups, interviewers and questions, stakes, procedures and specific instructions can be found in Matsumoto and Hwang (2015) and Matsumoto et al. (2015).

4. Thus, these samples consisted of both immigrants to the U.S., and Chinese-, Hispanic-, or Middle Eastern Americans.

5. The criteria allowed us to include individuals who were members of groups that are culturally different (as exemplified by the results on the GEQ) but can read, write and speak English functionally enough to participate in the study. Interested readers are referred to Matsumoto and Hwang (2015) for more details concerning recruitment, discussion of cultural differences and citations relevant to ethnic differences in NVB.

6. The seven questions were as follows: (1) ‘Good morning/afternoon. What is the purpose of your visit today?’; (2) ‘Where will you be going?’; (3) ‘May I see a picture ID?’; (4) ‘Can you tell me in as much detail as possible what you plan to do in the file room today?’; (5) ‘Is that all?’; (6) ‘Do you intend to engage in any act that involves taking anything that does not belong to you?’; (7) ‘Is there anything else you wish to tell me about what you plan to do once you pass through this screening?’. As originally reported in Matsumoto et al. (2015), questions 4, 5 and 6 were those that are diagnostic, as those who have not been assigned to steal the check (the truthtellers) must answer them truthfully whereas those who have been assigned to steal the check (the liars) have to lie. These were the three questions which were analyzed in the present study.

7. Sample sizes for specific analyses varied because of the differing number of missing cases due to technical issues in the various methods of data extraction, differences in source record availability (for whole body movements) and differences in cases with no interview contamination.

8. Given 21 univariate tests computed, at \( \alpha = .05 \), \( 21 \times .05 = 1.05 \) tests should attain an \( \alpha \leq .05 \) by chance; in reality, 4 tests attained this; at \( \alpha = .10 \) (trending toward significance), \( 21 \times .10 = 2.10 \) tests should attain an \( \alpha \leq .10 \) by chance; in reality, 7 tests attained this.

9. However, there are also real differences in the depth and quality of memories, as memories of the past have actually occurred and involve the encoding of facts, sensations, emotions and other associations, little of which exists for future intent. Likely for this reason, cognitive load approaches to detecting lies about the future may not be as effective as lies about the past, as reported...
Acknowledgements

The data utilized in this study are available upon reasonable request to the authors for a period of five years after publication, as per the American Psychological Association (APA) guidelines. Statements of fact, opinion and analysis in this study are those of the authors and do not reflect the official policy or position of the Transportation Security Administration (TSA) or the US Government.

Ethical standards

Declaration of conflicts of interests

Both authors are employees of Humintell, a for-profit company that conducts applied research and training on the topics covered in this paper.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the University at Buffalo, State University of New York Social and Behavioral Sciences Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in this study.

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References


Matsumoto, D., & Hwang, H. C. (2018b). Microexpressions differentiate truths from


