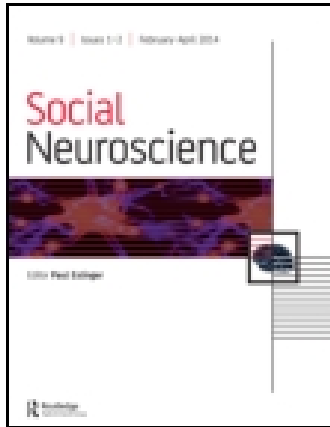


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Pants on fire: The electrophysiological signature of telling a lie

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Pants on fire: The electrophysiological signature of telling a lie

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Even though electroencephalography has played a prominent role for lie detection via personally relevant information, the electrophysiological signature of active lying is still elusive. We addressed this signature with two experiments in which participants helped a virtual police officer to locate a knife. Crucially, before this response, they announced whether they would lie or tell the truth about the knife's location. This design allowed us to study the signature of lie-telling in the absence of rare and personally significant oddball stimuli that are typically used for lie detection via electrophysiological markers, especially the P300 component. Our results indicate that active lying attenuated P300 amplitudes as well as N200 amplitudes for such non-oddball stimuli. These results support accounts that stress the high cognitive demand of lie-telling, including the need to suppress the truthful response and to generate a lie.

Keywords: Active lying; P300; N200; Deception; Cognitive demand.

Any fool can tell the truth, but it requires a man of some sense to know how to lie well.

Samuel Butler

Children are taught from early on that they always have to tell the truth; and numerous fairy tales depict drastic consequences of dishonesty and lies. A famous victim of such consequences is Pinocchio: The wooden doll tended to be dishonest now and then but, much to his chagrin, each of his lies made his nose grow a little longer. Whereas detecting Pinocchio's lies is a child's play—all it takes is two eyes, and perhaps a ruler—detecting lies of human agents is a challenging task. Even expert lie catchers such as judges are not always able to detect lies better than chance, indicating that telling the truth and lying are hard to distinguish based on observable behaviour (DePaulo et al., 2003; Ekman & O'Sullivan, 1991; Vrij, 2008; but see Ekman, O'Sullivan, & Frank, 1999).

Interestingly, the scientific study of truth and lies has traditionally adopted one of two distinct

perspectives: One being concerned with *lie detection* and one being concerned with exploring the signature of *active lying*. Both traditions have employed rather different experimental approaches that we summarize in the following sections.

LIE DETECTION

Lie detection has a long history in psychological science during which the mysterious technique of "polygraphy" continued to incite the public debate (Grubin & Madsen, 2005; National Research Council, 2003; Wolpe, Foster, & Langleben, 2005). A prominent approach is the *Guilty Knowledge Test* (GKT; Lykken, 1959; see also Verschuere, Ben-Shakhar, & Meijer, 2011): Participants view different items that are either familiar to them or not while several physiological measures are recorded for each item. It is typically assumed that familiar items elicit different physiological responses than neutral stimuli and this assumption is exploited by presenting crime-

related items that are likely to be meaningful only for a guilty subject. Specific changes in the recorded measures are used for lie detection by comparing this implicit assessment with a person's explicit response. GKT measures include peripheral physiology (e.g., Ben-Shakhar & Elaad, 2003; Gamer, Verschuere, Crombez, & Vossel, 2008; Vandenbosch, Verschuere, Crombez, & De Clercq, 2009), functional magnetic resonance imaging (fMRI; Gamer, Klimecki, Bauermann, Stoeter, & Vossel, 2012; Langleben et al., 2005) and electroencephalography (EEG; Abootalebi, Moradi, & Khalilzadeh, 2006; Rosenfeld, 2011; Van Hooff, Brunia, & Allen, 1996).

The most prominent electrophysiological marker of guilty knowledge is the P300 component of the event-related potential (ERP; Allen, Iacono, & Danielson, 1992; Farwell & Donchin, 1991). The P300 and the associated N200 are robust components of the ERP that are typically linked to stimulus evaluation and selective attention (Patel & Azzam, 2005; Polich, 2007; Verleger, 1988). More specifically, large P300 responses are triggered by significant and rare stimuli (e.g., Duncan-Johnson & Donchin, 1977; Gray, Ambady, Lowenthal, & Deldin, 2004), rendering it a prime candidate for investigating guilty knowledge.

It should be noted that the GKT approach achieves lie detection indirectly by comparing implicit measures with explicit reports of familiarity. In other words: Results that were obtained in the context of the GKT literature can have direct practical implications (Matsuda, Nittono, & Allen, 2012), but they do not directly inform our theoretical understanding of dishonest behaviour. This is specifically true for early P300-based studies on lie detection with the GKT because these paradigms exploit recognition of meaningful items rather than studying active lying (e.g., Allen et al., 1992; Farwell & Donchin, 1991; Rosenfeld et al., 1988; Rosenfeld, Rao, Soskins, & Miller, 2002). Still, active lying might have a different electrophysiological signature than truthful responses and the current study investigates this signature in the absence of rare and personally significant information. Before describing the actual experimental design, however, we briefly review findings about active lying that draw on behavioural and fMRI data.

ACTIVE LYING

Studies on the processes underlying active lie-telling typically used conditions in which participants were either instructed to tell the truth about a presented stimulus or to lie about it. For instance, participants were confronted with short sentences describing daily

routines and they were cued to respond truthfully or to lie about whether or not they had performed the action on this day (Spence et al., 2001). Lying took consistently longer than telling the truth, indicating that lying is cognitively more demanding than responding truthfully (see also Debey, Verschuere, & Crombez, 2012; Walczyk, Mahoney, Doverspike, & Griffith-Ross, 2009). This interpretation is in line with fMRI results that point towards a stronger recruitment of areas associated with cognitive control during lying (e.g., prefrontal and anterior cingulate cortices). Truthful responses, by contrast, do not seem to exhibit consistently stronger activity than lies in any region (Bhatt et al., 2009; Kozel, Padgett, & George, 2004; Langleben et al., 2002; Nuñez, Casey, Egner, Hare, & Hirsch, 2005; Spence et al., 2001).

But what is actually demanding in telling a lie? Several behavioural and fMRI findings were taken to suggest that an automatic tendency towards truthful responses needs to be inhibited actively during lying (Buller & Burgoon, 1996; Duran, Dale, & Mcnamara, 2010; McCornack, 1997; Nuñez et al., 2005; Spence et al., 2004; see also Foerster, Pfister, Schmidts, Dignath, & Kunde, 2013; Shalvi, Eldar, & Bereby-Meyer, 2012). Automatic activation of the truthful answer also lies at the heart of the Activation-Decision-Construction model (Walczyk et al., 2009; Walczyk, Roper, Seemann, & Humphrey, 2003). This model, however, highlights two additional processes: Deciding whether to lie or not (cf. also Spence, Kaylor-Hughes, Farrow, & Wilkinson, 2008) and constructing a plausible lie afterwards (Undeutsch, 1967; Vrij, Edward, Roberts, & Bull, 2000). These processes are assumed to impose a special cognitive demand, resulting in prolonged response times (RTs) and recruitment of brain areas that are associated with executive functions.

THE ELECTROPHYSIOLOGY OF ACTIVE LYING

A seminal step towards characterizing the electrophysiological signature of active lying was reported by Johnson, Barnhardt, and Zhu (2003, 2005) who had their participants either respond truthfully or lie throughout different blocks of trials. Indeed, lying had a different electrophysiological signature than responding truthfully, especially regarding an attenuated P300 component of the ERP. Such differences in the ERP, however, vanished when participants could choose whether to tell the truth or whether to lie in each trial, suggesting that lying and truthful responses cannot be disentangled when participants' intentions switch from question to question.

Yet, an alternative interpretation of these findings is that potential differences between lying and responding truthfully were overshadowed by the decision processes preceding the lie. These decision processes were, in fact, directly reinforced in the above-mentioned studies because participants were instructed to maintain a balanced frequency of both types of responses. The present study thus targeted the electrophysiological signature of lying independently of such decisions to lie (cf. also Spence et al., 2008, 2009; Walczyk et al., 2003). Furthermore, we aimed at creating a paradigm that does not involve any oddball stimuli to avoid confounding influences relating to the evaluation of differently familiar stimuli. In a nutshell, participants were asked to locate a knife for a virtual police officer (Figure 1a). At the beginning of each trial, they announced whether they would lie or tell the truth and the target appeared shortly after. The corresponding *target response* (right-hand keypress; index vs. middle finger) triggered appropriate feedback in Experiment 1—a sad officer after lies and a cheerful officer after truthful responses. Because anticipations of this feedback could drive any emerging differences between lying and telling the truth, we replicated the set-up in Experiment 2 but did not use any feedback at all.

To quantify differences between lying and telling the truth, we assessed RTs and stimulus-locked ERPs relating to the target. In keeping with previous behavioural data (e.g., Debey et al., 2012; Spence et al., 2001; Walczyk et al., 2009), we expected RTs to be prolonged in the lie condition. For ERP analysis, we concentrated on the P300 component due to its widespread use in studies on lie detection with the GKT (Allen et al., 1992; Allen & Mertens, 2009; Farwell & Donchin, 1991; Rosenfeld et al., 1988; Van Hooff et al., 1996). Here, we expected lying to attenuate P300 amplitudes due to increased cognitive load (Brookhuis et al., 1981; Hoffman, Simons, & Houck, 1983; Kotchoubey, Jordan, Grözing, Westphal, & Kornhuber, 1996; Pratt, Willoughby, & Swick, 2011). We further assessed the associated N200 component for which opposing predictions can be derived from the literature: Because lying likely includes response conflict between an initial impulse to tell the truth and the opposing lie, N200 amplitudes might be increased for lies as compared to truthful responses (e.g., Kopp, Rist, & Mattler, 1996; Van Veen & Carter, 2002). On the other hand, N200 and P300 are assumed to be tightly linked and, consequently, sub-components of the N200 also tend to be sensitive to general processing demands (Patel & Azzam, 2005), which would suggest an attenuated N200 for lie responses.

METHOD

Participants

Seventeen volunteers participated in Experiment 1 (mean age: 23.4 years, 4 male, 3 left-handed), and another 19 volunteers participated in Experiment 2 (mean age: 20.4 years, 3 male). All reported normal or corrected-to-normal vision and received either course credit or monetary compensation.

For statistical analyses, one participant was excluded from Experiment 1 and three participants were excluded from Experiment 2 because their small number of lie trials (<15%) did not allow for reliable estimates of the ERP for lie responses. Accordingly, all following analyses are based on equal sample sizes of 16 participants per experiment.

Apparatus and stimuli

Participants sat in front of a 17" monitor and responded on a standard German QWERTZ keyboard. They were advised to use the middle and index finger of their left hand for intention responses (keys "Y" and "X") and the middle and index finger of the right hand for target responses (keys "," and "."). Stimuli for the intention response were clip arts of two hands, one showing a victory sign and one showing crossed fingers (Figure 1a). The former gesture indicated truth responses, the latter indicated lie responses.¹ The actual target stimulus featured a shelf with three stacked compartments; the lowest compartment showed the intention stimulus according to the participant's announcement. Additionally, a knife was placed either in the middle or in the upper compartment (the other one being empty). A virtual police officer—Commissioner Clancy Wiggum of the TV series *The Simpsons*—stood in the background and waited for the participant's response. The response indicated the knife's position in the shelf (upper or middle compartment). Accordingly participants indicated the correct compartment in truth trials whereas they indicated the empty compartment when they had decided to lie. Finally, Experiment 1 featured two different feedback screens—a cheerful and a sad officer—whereas no feedback was used in Experiment 2.

We recorded EEG data throughout the session from 32 electrodes positioned in the extended 10–

¹ In German culture, crossed fingers are exclusively related to telling "white lies" and do not have the strong connotation of wishing good luck as is the case in English-speaking countries.

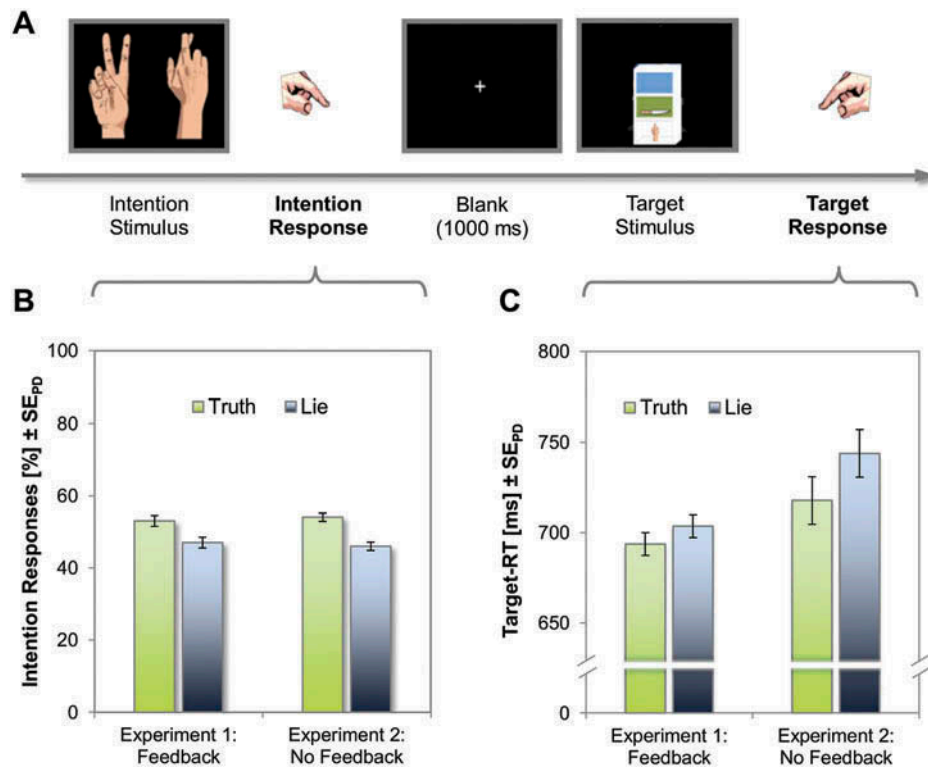


Figure 1. (a) Trial procedure in both experiments. Participants first announced their intention for the current trial with a keypress of the left hand (intention response; here: left key ► truth, right key ► lie). They then responded to the upcoming target with their right hand by either telling the truth about the knife's position or lying to the virtual officer (target response; the officer is not displayed for copyright reasons). This response was followed by feedback in Experiment 1 but not in Experiment 2. (b) Choice frequencies of the *intention response*. Participants showed a slight but consistent preference for telling the truth as compared to lying. (c) RTs of the *target response* were longer when telling a lie than when telling the truth. Error bars represent standard errors of paired differences, computed separately for each experiment (Pfister & Janczyk, 2013).

20 system: Fp1, Fp2, F7, F3, Fz, F4, F8, FC5, FC1, FC2, FC6, T7, C3, Cz, C4, T8, TP9, CP5, CP1, CP2, CP6, TP10, P7, P3, Pz, P4, P8, PO9, O1, Oz, O2, PO10. We used average reference to record the EEG signal at a sampling rate of 500 Hz, low-pass filtered at 100 Hz. The signal was amplified by a BrainVision QuickAmp amplifier with active electrodes (actiCAP; Brain Products, Germany) and impedances were below 10 k Ω before the experiment started. Ocular movements were recorded with passive electrodes on the outer canthi of both eyes and above and below the left eye (electrooculogram; EOG). Participants were encouraged to reduce eye movements and blinks during trials to minimize artefacts in the EEG data.²

² Participants were encouraged to reduce eye movements and blinks to increase data quality. In turn, however, this procedure might also have caused to shield them against arousing effects of telling a lie (Ochoa & Polich, 2000; Verleger, 1991) which renders the present design somewhat conservative. We thank Rolf Verleger for drawing our attention to this point.

Procedure

Trials started with the intention stimulus (Figure 1a). The position of the two hand stimuli varied randomly across trials and participants announced their current intention by pressing the corresponding key with their left hand. Participants were instructed to decide spontaneously between both alternatives, i.e., to respond honestly on some trials and to lie in others. They gave the intention response at leisure and the stimulus stayed on screen until participants gave a response. This intention response was followed by a fixation cross (1000 ms) and the target stimulus that featured a knife either in the upper or middle compartment of the shelf. Participants were asked to help the officer to locate the knife by indicating its position via a keypress of their right hand. The mapping of keys (“,” vs. “.”) to knife positions (upper vs. middle compartment) was counterbalanced across participants; i.e., responses with the left key informed the policeman that the knife was in the upper compartment for one half of the participants whereas the left key indicated

that the knife was in the middle compartment for the other half. The chosen intention was displayed in the lower compartment of the shelf as a reminder. The target stimulus again stayed on screen until a response was given but participants were encouraged to respond as quickly as possible. In Experiment 1, the target response triggered a feedback display (500 ms). This display showed a cheerful officer if participants had indicated the correct location (truth) whereas it showed a sad officer if participants had lied about the position (i.e., when they had pressed the key that was associated with the empty shelf). The next trial started after an inter-trial interval (ITI) of 1000 ms.

Responses with the wrong pair of keys for intention and target stimulus, as well as any response during ITI, fixation or feedback aborted the trial immediately and triggered a visual error message for 1000 ms. Each session included 9 blocks of 52 trials each; the first block was considered practice.

Data treatment

We focused our analyses of RTs and ERPs on the target stimulus and the following target response.³ We excluded trials with errors from the analysis (1.6%) and corrected for outliers by excluding trials with RTs that deviated more than 2.5 standard deviations from the corresponding cell mean, calculated separately for each participant in each condition (2.6%).⁴

To prepare the ERP analysis, we segmented the EEG signal into separate epochs around each target stimulus. Epochs ranged from 500 ms pre-stimulus (baseline) to 1000 ms post-stimulus. Data were pre-processed via FieldTrip (Oostenveld, Fries, Maris, &

³ Similar analyses are in principle possible for the intention response, i.e., when participants announced their intention. Such analyses come with two clear confounds, however: (1) Participants could decide before stimulus onset which intention to announce and (2) the intention response was unspedded. Therefore, RTs do not necessarily capture the decision process but might also relate partly, or even exclusively, to the announcement of the intention. ERPs relating to this stimulus cannot be interpreted directly either, because it is not clear which processes are at work at which point in time.

⁴ In Experiment 1, participants failed to act according to their intention in 5.05% of the trials ($SD = 4.22$) in which they had announced a truthful response and in 4.69% of the trials ($SD = 5.11$) in which they had announced a deceptive response. The corresponding numbers for Experiment 2 amounted to 5.69%, ($SD = 3.95$) and 5.40% ($SD = 3.18$), respectively. These percentages did not differ between conditions for either experiment, $ps > .695$. After removing data of the practice blocks, errors and outliers, there were on average 196.50 trials ($SD = 23.96$) for honest responses and 175.69 trials ($SD = 24.59$) for dishonest responses in Experiment 1 whereas there were 198.06 trials ($SD = 21.29$) for honest responses and 167.19 trials ($SD = 17.38$) for dishonest responses in Experiment 2.

Schoffelen, 2011) and custom Matlab scripts. We applied a 0.1 Hz high-pass filter and a 15 Hz low-pass filter, and eliminated trials with artefacts by using the FieldTrip outlier detection mechanism based on z-scores ($z = 20$). Ocular artefacts were addressed via independent component analysis (ICA; Makeig, Bell, Jung, & Sejnowski, 1996) and we removed components that correlated with at least one EOG channel ($r > .40$; Flexer, Bauer, Pripfl, & Dorffner, 2005).

To assess differences in ERPs between lying and telling the truth, we compared peak and mean amplitudes of both, N200 and P300, locked to the onset of the target stimulus. For analyses of the N200 component, we used the fronto-central electrodes Fz and Cz where we determined the N200 peak amplitude as the most negative peak within 100 to 300 ms post-stimulus. To determine mean N200 amplitudes, we computed the mean time to peak across both conditions and electrodes (Experiment 1: 242 ms, Experiment 2: 239 ms), and computed the mean voltage in a time window of 100 ms centred on this value. Similarly, P300 peak amplitudes were analysed for the parietal electrodes P3, Pz and P4, where they were determined as the most positive peak starting 200 ms post-stimulus until the end of the segment. Mean amplitudes were computed similarly as for the N200 by averaging the signal in a time window of 100 ms centred on the average of the different peak latencies of the conditions and electrodes (Experiment 1: 324 ms, Experiment 2: 333 ms).

RESULTS

Behavioural results

Participants showed a small but highly consistent preference for truthful responses as compared to lies, $F(1, 30) = 14.37, p = .001, \eta_p^2 = .32$ (see Figure 1b).⁵ RT analyses were done by a 2×2 analysis of variance (ANOVA) with intention (truth vs. lie) as within-subjects factor and experiment as between-subjects factor. Because Experiment 2 provides a straightforward control for any possible influences of feedback in Experiment 1, the main effect of intention is of particular interest here, whereas a significant interaction would point towards confounding effects of feedback. Consistent with previous findings, telling a lie took indeed longer than telling the truth about the knife's position, $F(1, 30) = 5.20, p = .030, \eta_p^2 = .15$

⁵ Note that these data do not involve the four participants with very low frequencies of lie choices and are thus a rather conservative measure.

(Figure 1c), whereas neither the main effect of experiment nor the interaction approached significance ($ps \geq .514$).

Target-locked ERPs

N200 peak amplitudes and N200 mean amplitudes were submitted to separate $2 \times 2 \times 2$ ANOVAs with intention (truth vs. lie) and electrode (Fz vs. Cz) as within-subjects factors and experiment as between-subjects factor (Figure 2; see Table A1 in the Appendix for descriptive statistics). The analysis of N200 peak amplitudes yielded a significant main effect of intention, $F(1, 30) = 21.42$, $p < .001$, $\eta_p^2 = .42$, with smaller amplitudes in lie trials as compared to truth trials. Furthermore, N200 peak amplitudes were more pronounced over Fz than over Cz as indicated by a significant main effect of electrode, $F(1, 30) = 33.79$, $p < .001$, $\eta_p^2 = .53$, whereas neither the main effect of experiment, $F < 1$, nor any interaction, $ps \geq .144$, was significant. A similar

pattern emerged for N200 mean amplitudes with significant main effects of intention, $F(1, 30) = 29.67$, $p < .001$, $\eta_p^2 = .50$, and electrode, $F(1, 30) = 35.42$, $p < .001$, $\eta_p^2 = .54$. Also, neither the main effect of experiment, $F < 1$, nor any interaction, $ps \geq .160$, was significant.

P300 peak amplitudes and P300 mean amplitudes were submitted to separate $2 \times 3 \times 2$ ANOVAs with intention (truth vs. lie) and electrode (P3 vs. Pz vs. P4) as within-subjects factors and experiment as between-subjects factor (Figure 3; see Table A2 in the Appendix for descriptive statistics). Violations of sphericity were corrected by the Greenhouse–Geisser method; we still report uncorrected degrees of freedom for better readability, supplemented by the corresponding ϵ estimate. Importantly, the analysis of the P300 peak amplitudes showed a highly reliable effect of intention, $F(1, 30) = 8.08$, $p = .008$, $\eta_p^2 = .21$, with P300 being attenuated in lie trials as compared to truth trials. Furthermore, P300 amplitude was highest over Pz and lowest over P3 giving rise to a significant main effect of electrode, $F(2, 60) = 21.43$, $p < .001$,

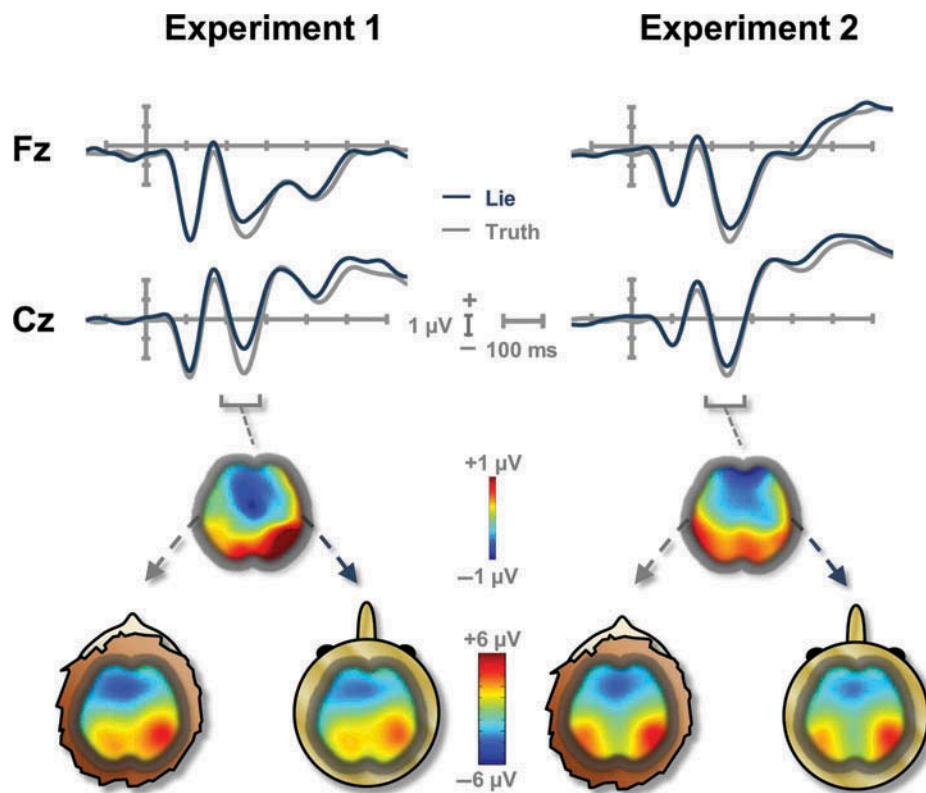


Figure 2. Mean target-locked ERPs for the electrodes Fz and Cz in both experiments, showing that N200 amplitudes differed between lying and telling the truth. Scalp maps show the mean amplitude in a 100 ms window centred on the mean time to peak of the N200 component of each experiment. Human heads show the scalp maps for truth trials whereas Pinocchio heads show the scalp maps for lie trials. Difference maps were computed as truth–lie.

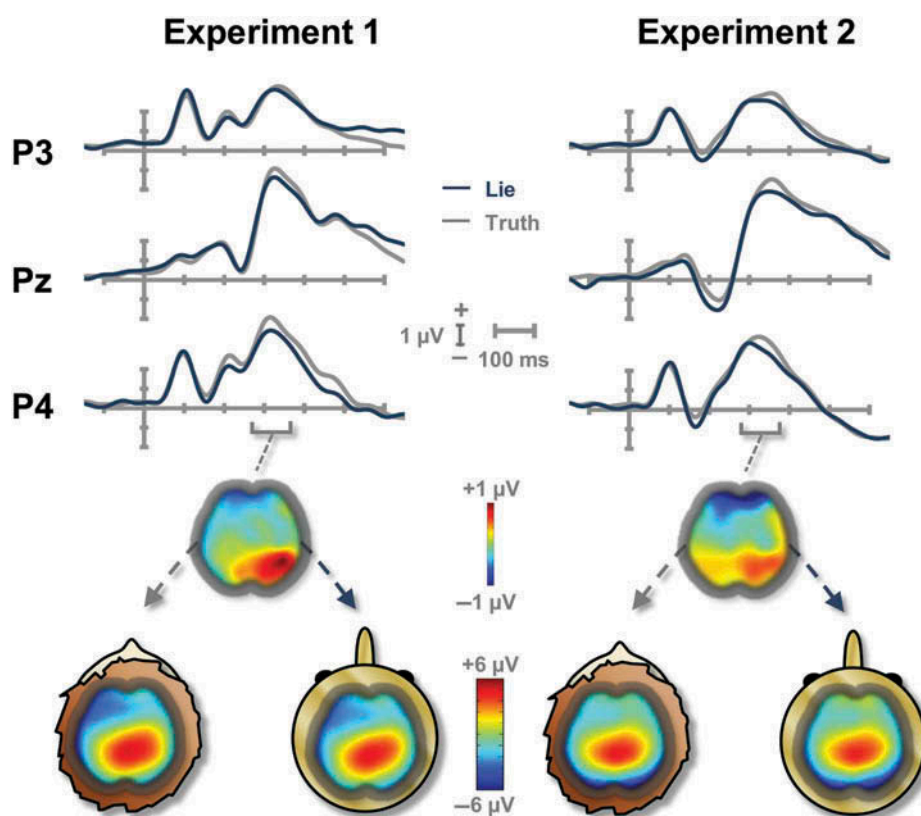


Figure 3. Mean target-locked ERPs for the parietal electrodes P3, Pz and P4 in both experiments, showing that P300 amplitudes differed between lying and telling the truth. Scalp maps show the mean amplitude in a 100 ms window centred on the mean time to peak of the P300 component of each experiment. Human heads show the scalp maps for truth trials whereas Pinocchio heads show the scalp maps for lie trials. Difference maps were computed as truth–lie.

$\eta_p^2 = .42$. Furthermore, a marginally significant interaction of intention and electrode, $F(2, 60) = 2.88$, $p = .064$, $\eta_p^2 = .09$, was driven by larger effects over Pz and P4 as compared to P3. Neither the main effect of experiment, $F < 1$, nor any interaction, $ps \geq .529$, approached significance. The analysis of P300 mean amplitudes replicated the main pattern of results: Again, a significant main effect of intention, $F(1, 30) = 5.04$, $p = .032$, $\eta_p^2 = .14$, indicated P300 to be attenuated in lie trials as compared to truth trials. The main effect of electrode was also significant, $F(2, 60) = 14.94$, $p < .001$, $\eta_p^2 = .33$, whereas the interaction of intention and electrode was not, $F(2, 60) = 1.82$, $p = .172$, $\eta_p^2 = .06$. Neither the main effect of experiment, $F < 1$, nor any interaction, $ps \geq .722$, approached significance.

DISCUSSION

Two experiments explored the behavioural and neurophysiological signature of active lying, and the results

can be summarized as follows. First, participants showed a clear preference towards truthful responses rather than lies. Second, as expected, responses to the target stimulus were slower for lies than for truthful responses. Finally, and most importantly, the ERP for the target stimulus showed an attenuated N200 and P300 component for lie trials. The effects occurred consistently across both experiments, i.e., the difference between lying and telling the truth does not seem to depend on anticipated feedback.

The first observation, i.e., the consistent preference for truthful responses seems to indicate that even lying about arbitrary stimuli is rather aversive. This interpretation is in line with diary studies about lies that people tell in their everyday lives (DePaulo & Kashy, 1998; DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996; Kashy & DePaulo, 1996). Here, even minor lies were found to cause slightly uncomfortable feelings during lying and directly after having lied (see also Abe, Suzuki, Mori, Itoh, & Fujii, 2007).

A clear picture also emerges for the RT data relating to actual lying or responding truthfully. Here,

telling lies took longer than telling the truth even though the decision component of telling a lie was completed before the target stimulus appeared. This confirms previous results and indicates that the decision component alone cannot explain the higher RTs for lying that are typically observed (e.g., Debey et al., 2012; Spence et al., 2001, 2008; Van Bockstaele et al., 2012; Walczyk et al., 2009). To lie “accurately” requires two steps, namely finding out what is true, and making sure that the actual response is different from the truthful response. Conceivably, this second process (negating the truth) contributes to the extra processing time in the present set-up.

The most important result of the present experiments relates to the effects of active lying on the stimulus-locked ERP. In contrast to previous designs in which decision and response were confounded (Johnson et al., 2003, 2005), P300 amplitudes were clearly attenuated for lies as compared to truthful responses even though participants chose whether to lie or whether to tell the truth on each trial. Furthermore, we also found N200 amplitudes to be attenuated for lying as compared to telling the truth. These findings support accounts that link N200 and P300 to different facets of the same process (e.g., Patel & Azzam, 2005; Ramautar, Kok, & Ridderinkof, 2004). By contrast, the current operationalization of lying does not seem to inflict a notable degree of response conflict, which would have been evident in N200 amplification rather than attenuation (Kopp et al., 1996; Van Veen & Carter, 2002).

Thus, a distinct electrophysiological signature of lies can also be found on a trial-to-trial basis. The observed attenuation effects are most likely caused by the increased complexity of active lie-telling as compared to responding truthfully, because the present paradigm ensured that the decision whether to lie or not had been finished beforehand (cf. Kok, 2001, for a general discussion of P300 amplification and attenuation). This finding supports an emerging view of P300 function that assumes P300 to reflect the retrieval of canonical responses to stimuli in the environment (Verleger, 2008; Verleger, Jaśkowski, & Wascher, 2005). Clearly, dishonest responses require the lie-teller to suppress the truthful response that is activated rather automatically (e.g., Spence et al., 2004), and the corresponding P300 attenuation for lying can be seen as reflecting exactly this process.

Our results thus reveal a straightforward picture of the electrophysiological signature of active lying that is mainly composed of attenuated responses for the P300 component. This attenuation is clearly driven by increased cognitive demand for active lying than for

telling the truth; it really seems to take a man (or woman) of some sense to lie well.

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APPENDIX: MEAN AMPLITUDES OF THE TARGET-LOCKED ERPS

TABLE A1

Descriptive statistics for the N200 component (in μV) at the electrode locations Fz and Cz. Peak amplitudes were determined as the most negative value from 100 to 300 ms post-stimulus whereas mean amplitudes were computed as the average voltage in a time window of 100 ms, centred on the average peak latency across both conditions and electrodes

Electrode	<i>N200 peak amplitudes</i>				<i>N200 mean amplitudes</i>			
	<i>Experiment 1 (Feedback)</i>		<i>Experiment 2 (No feedback)</i>		<i>Experiment 1 (Feedback)</i>		<i>Experiment 2 (No feedback)</i>	
	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>
Fz	-5.69	-5.06	-5.40	-4.77	-3.92	-3.25	-3.79	-3.25
Cz	-3.36	-2.38	-3.21	-2.80	-1.37	-0.43	-1.70	-1.27

TABLE A2

Descriptive statistics for the P300 component (in μV) at the electrode locations P3, Pz and P4. Peak amplitudes were determined as the most positive value occurring later than 200 ms, post-stimulus whereas mean amplitudes were computed as the average voltage in a time window of 100 ms, centred on the average peak latency across both conditions and all three electrodes

Electrode	<i>P300 peak amplitudes</i>				<i>P300 mean amplitudes</i>			
	<i>Experiment 1 (Feedback)</i>		<i>Experiment 2 (No feedback)</i>		<i>Experiment 1 (Feedback)</i>		<i>Experiment 2 (No feedback)</i>	
	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>	<i>Truth</i>	<i>Lie</i>
P3	3.95	3.78	3.77	3.51	2.90	2.82	2.75	2.49
Pz	6.35	5.97	5.71	5.29	4.86	4.60	4.44	4.11
P4	5.46	4.67	4.40	3.85	4.10	3.60	3.41	2.98