Lie, Liar, Lance Armstrong
A case study of automatic detection of deception using non-verbal facial and vocal social signals

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Preface

Na mijn hbo-opleiding Technische Bedrijfskunde die ik in 2011 aan Avans Hogeschool te ’s-Hertogenbosch heb afgerond, wist ik dat hier mijn toekomst niet lag. Een tijdje heb ik nog getwijfeld; een ritme, geld, een baan en wellicht niet gelukkig met mijn dagelijkse werkzaamheden? Of zal ik toch verder studeren? Mijzelf verder ontwikkelen, nog even genieten van het studentenleven?

Uiteindelijk heb ik gekozen om door te gaan studeren. Het was een uitdaging en een nieuwe stap. In het begin even wennen, maar ik heb er geen seconde spijt van gehad. Het was een mooie tijd.

Ik wil alle mensen bedanken die mij hebben geholpen in deze tijd, maar ook de mensen die ik heb leren kennen. Familie, vrienden, mijn vriendin en ook zeker mijn studiegenoten. Zij hebben deze tijd gemaakt tot iets onvergetelijks. Dank jullie wel. Daarnaast wil ik uiteraard, en in het bijzonder mijn supervisors Prof. Dr. E.O. Postma en Dr. M. Postma bedanken die mij hebben begeleid tijdens het doen van dit onderzoek en het schrijven van deze scriptie. Dank jullie wel.

Al met al heb ik naar mijn idee een goed onderzoek neergezet, een interessant verhaal verteld, en hopelijk de wetenschap een stapje verder geholpen.

Ik wens u veel plezier met lezen, en dank u bij voorbaat dat u hier de tijd voor neemt.

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Abstract

Detecting human deception is difficult. Scientific studies showed humans to perform badly on the task of detecting lies in other humans. Distinguishing truthful from deceptive behavior is hampered by the fact that cues to deception differ from person to person. Social Signal Processing (SSP), the automatic analysis of nonverbal social signals with computers, may facilitate the discovery of deception cues. SSP software can process facial and vocal information and search for informative cues to deception, provided that sufficient samples of truthful and deceptive behavior are available. The recent case of Lance Armstrong, who admitted to have lied about his use of doping, provides a (relatively) unique sample of videotaped interviews of deceptive and truthful behaviors.

The research question addressed in this thesis reads: *to what extent is it possible to automatically detect deception using facial and vocal cues?*

To answer the research question, SSP methods were employed to analyze videotaped fragments of interviews with Lance Armstrong. The fragments were divided in two classes: truthful and deceptive. The fragments in the truthful class consisted of statements about his experiences with his illness. We assumed that these statements are truthful. Those in the deceptive class consisted of responses to questions about the use of doping. These responses are now established to be all deceptive. The SSP analysis focused on the automatic measurement of facial expressions (relying on so-called *Facial Action Units*) and vocal characteristics (measures of vocal pitch). The SSP measurements were statistically analyzed to determine which facial expressions and vocal characteristics were diagnostic for truthful or deceptive statements. For facial expressions, the intensity of a number of Facial Action Units was found to vary with the nature of the statements. Most notably, deceptive statements were accompanied by more frequent smiling and sad expressions, whereas truthful statements were often characterized by expressions of anger. The statistical analysis of the vocal measurements revealed an effect of pitch. Deceptive statements tended to have a higher pitch than truthful ones.

Finally, the measurements were used to train a classifier on the task of distinguishing between truthful and deceptive fragments. The optimal combination of measurements made use of only one measurement; a specific Facial Action Unit, called *Brow Lower* (Facial Action Unit 4). With this measurement, on average 83,1% of the fragments could be classified correctly by the classifier when trained on a balanced set of truthful and deceptive measurements (chance level 50%).

The conclusion reads that for the particular case under consideration, deception can be detected with an accuracy of 83,1%. Future work should determine on the extent to which this result generalizes to other cases.

Keywords: Deception, Non-verbal behavior, Facial expressions, Auditory features, Automatic deception detection, Lance Armstrong

Introduction

Detecting deception is considered a tough task for human perceivers. According to several studies, plain human observers only achieve slightly above chance level (Akehurst et al. 1996; Ekman and O'Sullivan, 1991; Ekman, O'Sullivan & Frank 1999; Malone & DePaulo, 2001). Nevertheless, paying attention to the proper non-verbal cues, might result in a more accurate classifying of truthful and deceptive utterances. Facial and vocal expressions have been shown to provide such cues (Ekman, 1989; DePaulo, Stone & Lassiter, 1985; Zuckerman & Driver, 1985). Still, deception detection is a difficult task since expressed cues during deception differ from person to person. Therefore, it is useful to study the detection of deception in single persons.

To date, only two studies researched the detection of deceptive behavior of one particular person. Vrij and Mann (2001) recorded video fragments in which a convict was examined on his allegations of murder. In this case there already was sufficient evidence to prove the suspects' guilt, thus the truth was already known. This made the video material suitable to compare the deceptive and truthful statements. Results of the study showed detection rates of 57% on deceptive utterances and 70% on truthful utterances. Davis and Hadiks (1995) analyzed an interview with Saddam Hussein, focusing on his non-verbal behavior during truthful and deceptive utterances. They found that a certain pattern exists in ones non-verbal behavior when it is compared to certain subjects that are discussed.

Though these studies have put great effort into detecting the deceit of one particular person, they are limited by several factors. Vrij and Mann's research is limited because they only used human observers for deception detection while most humans only achieve chance level in detecting deception (Ekman, O'Sullivan & Frank 1999; Malone & DePaulo, 2001). The case study on Saddam Hussein was limited because it used manual coding of the non-verbal behavior. Although the coders may have been trained exceptionally well, there is a reasonable chance that they made mistakes or that they did not code systematically the same way. Next to this, both studies did not use software to predict deceit based on the results. Concluding, these previous studies have their restrictions, and should therefore be extended to get more knowledge on predicting deception based on uttered cues.

The study reported in this thesis improves upon earlier work in two respects. First, cues are automatically coded by means of software, which should increase the objectivity. Second, the coded cues are automatically classified by means of machine learning. This should result in better insights in deception detection.

Field research on non-verbal behavior during deception is hard to conduct (Mann, Vrij & Bull, 2002). As a result, past research almost exclusively conducted laboratory studies. Laboratory studies have the disadvantages of the low-stakes that are involved, resulting in little involvement of the participants. Furthermore, the lack of naturalness raises a major issue, as research showed a significant difference between a natural setting and a laboratory setting (Porter & Brinke, 2010; Vrij & Semin, 1996). The present study has a higher ecological validity compared to previous laboratory research, because it relies on video recordings of Lance Armstrong in more or less natural settings.

The Lance Armstrong case undoubtedly involves high stakes as well as naturalness. Preliminary to his confessions of having used doping, in his interviews he denied ever having used performance-enhancing drugs. The competitive nature of professional cycling and the high stakes that are involved makes the Armstrong case highly suitable for the investigation of high-stake deception in a natural setting.

Literature review

As several studies have concluded, deception detection is difficult. Ekman and O'Sullivan (1991), for example, performed a study on deception detection, for which they compared the detection rate results from freshman students to those of police officers, lawyers and secret service agents. This study did not show significant differences in the accuracy of recognizing deception between these groups. Only Secret Service agents performed significantly better. Other participants only achieved chance level. Other studies also did not find significant differences between professional and non-professionals in detecting deceit. In all studies the performances on deception detecting were slightly above chance level (Akehurst et al. 1996; Ekman, O'Sullivan & Frank 1999; Kraut, 1980; Malone & DePaulo, 2001).

During attempted deception detection, verbal and non-verbal cues are important for perceivers to identify deceit (Zuckerman, DePaulo & Rosenthal, 1981). However, it is important to note that verbal communication is a less accurate predictor of deceptive behavior. One reason for this is that the tone of voice is capable of expressing information that is not in accordance with the verbal content (Bugental, Henker & Whalen, 1976; Love, 1975; Shennum, 1980; Wietz, 1972 as cited in Zuckerman, DePaulo & Rosenthal, 1981). Contrary to that, non-verbal behavior is a part of communication which lends itself for accurately detecting deception (DePaulo, et al., 1996; Ekman, 2001; Zuckerman, DePaulo & Rosenthal). This might be due to the greater cognitive load one experiences during the expression of a lie. While telling a lie, people have to control their verbal and non-verbal behavior to avoid getting caught, which leads to unnatural behavior that can be detected (Ekman; Zuckerman, DePaulo & Rosenthal). Therefore, non-verbal behavior is an accurate indicator of deception.

A study shows that all types of non-verbal behavior can in some way be predictors of deception (Nicholas et al. 2013). However, facial expressions and auditory features are the best predictors of deception (DePaulo, Stone & Lassiter, 1985; Zuckerman & Driver, 1985). Moreover, Ekman (1989) stated that the combination of facial expressions and auditory features "allows for highly accurate identification of deceptive behavior" (p. 71). Therefore, this study focuses on facial expressions and auditory features during deceptive behavior.

Although detecting deception is difficult, studies show that uttered cues during deception leak some kind of information in their non-verbal behavior. This is called leakage (Ekman et al., 1991; Warren, Schertler & Bull, 2009). Ekman et al. show that this leakage expresses itself in facial expressions, body movements and/or vocal tones. This leakage might lead to the great reliability of detecting deception based on non-verbal behavior. Leakage in facial expressions can be distinguished into two categories; subtle expressions and micro-expressions. The subtle expressions are characterized as "fragments of otherwise suppressed or masked affect displays using only part of the normally associated musculature" (Warren, Schertler & Bull, 2009, p. 61). Micro-expressions are

facial expressions, which typically last for short time intervals, between $^1/_5$ and $^1/_{25}$ of a second. This makes them difficult to discover with the bare eye (Ekman & Friesen 1969; Frank & Ekman, 1997; Porter & Brinke, 2008). These two specific types of leakage may possibly lead to the detection of deceit by means of a research on facial expressions.

DePaulo et al. (1982) proposed a fixed set of cues consisting of ten visual and nine auditory features, with which it should be capable of accurately recognizing deceptive behavior. Later research by DePaulo et al. (1997), Ennis, Vrij and Chance (2008) and Vrij and Mann (2004), though, showed that there are individual differences in cues during deceptive situations, and thus the fixed set of cues by DePaulo et al., is rejected. These differences form an additional barrier in detecting deception. Although there are differences between individuals, some cues occur more frequently during deception.

Facial expressive cues to deception

In order to universally and objectively code facial expressions, researchers developed the FACS (Facial Action Coding System) (Ekman & Friesen 1976; Ekman & Friesen, 1978; Ekman, Friesen & Hager, 2002). This system uses action units (AU's). AU's are facial muscles that consist of single facial muscles or groups of facial muscles that play a role in facial expressions (Ekman, Friesen & Hager).

Numerous researches have focused on finding reliable facial cues during deception. O'Hair, Cody and McLaughlin (1981) found that there is less smiling during a prepared lie compared to during a spontaneous lie or a truthful utterance. Bond Kahler and Paolicelli (1985) and also DePaulo (1994) later confirmed this result. More importantly, DePaulo et al. (2003) conducted a meta-analysis on cues to deception (which is the most recent to date) in which they questioned whether or not there are general reliable indicators of deception. In their study, they reviewed 120 studies, and paid attention to verbal and non-verbal behavior in relation to deception. With regard to facial expressions, they came up with three measurable reliable indicators of deception. These are; pressed lips (AU 23, AU 24), chin raise (AU 17) and genuine smile (AU 6). The results of this study are found in the appendix, table A1.

To automatically code facial expressions, a variety of software has been developed. Computer Expression Recognition Toolbox (CERT) is capable of detecting expressions based on the FACS and the six basic emotions (Happiness, Sadness, Anger, Fear, Surprise and Disgust) as proposed by Ekman (1992). CERT runs real time on a frame of 320 x 240 on 10 fps (Littlewort et al. 2011). The advantage of using a system like CERT is that it automatically codes the expressions. Next to that, it is an objective and accurate tool. This software makes use of different classifiers based on Gabor filters and Fourier transforms. As a result, CERT is capable of detecting faces and expressions based on AU's (Shen & Bai, 2006).

Auditory features cues to deception

As stated earlier, besides facial expressions auditory cues are also accurate predictors of deception (DePaulo, Stone & Lassiter, 1985; Zuckerman & Driver, 1985). This conclusion is based on the difficulty of controlling vocal cues (Scherer, 1986). The non-verbal part of speech thus also leaks information leading to deception (Ekman et al. 1991; Warren, Schertler & Bull, 2009). Therefore, analyzing one's speech next to analyzing the facial expressions might result in an improved deception detection mechanism.

Similar to facial expressions, no fixed set of cues is available to detect deception in one's speech, as results are not consistent across studies, and individual differences are present (Greene et. al. 1985; Matarazzo et. al. 1970; Motley, 1974; O'Hair, Cody, & McLaughlin, 1981). This might partly be caused by the difference in pitch between men and women, since a men's voice generally has an overall lower pitch (Latinus & Belin, 2011). Nonetheless, just as in the case of facial expressions, some audible cues are recognized that roughly implicate deception as well. Many researchers have therefore focused on the non-verbal auditory part of deception. Rockwell, Buller and Burgoon (1997) found that deceivers tend to speak slower and have a higher intensity and a greater pitch variance in their voice. In addition to that, a higher pitch was noticed in a number of studies (Apple, Streeter & Kraus, 1979; Ekman, Friesen & Scherer, 1976; Streeter et al. 1977; Vrij, 1991; Vrij, 1995). In general, longer message duration and more speech hesitations or pauses are found as accurate indicators of deceptive behavior (Ekman, 1989; Ekman, Friesen, & Scherer; Ekman, O'Sullivan, Friesen, & Scherer, 1991; Streeter et al.; Zuckerman et al. 1981). Despite individual differences, studies showed significant differences between auditory cues during truthful and deceptive utterances, which make it possible to detect deception by means of an auditory analysis.

The differences in auditory features during truthful and deceptive utterances may be the result of the arousing experience of lying (Barland & Raskin, 1975; Streeter et al., 1977). Again, the greater cognitive load plays a role in the accidental leakage (Ekman, 2001; Zuckerman, DePaulo & Rosenthal, 1981).

Case study

The explorative study that is presented in this thesis focuses on accurately recognizing deceptive behavior of one person in particular. In contrast to a great number of earlier studies (Ekman & Friesen, 1974; Harrison, Hwalek, Raney, & Fritz, 1978; Kraut, 1978), in this study features of deceptive behavior are identified by trained computer software.

This study is conducted respecting these previous studies, as it tries to accurately distinguish deceptive from truthful utterances of one particular person. Furthermore, this study attempts to automatically predict deception in non-analyzed data by means of a trained software program.

Previous research on deception detection lacks credibility on two major issues. First, the involved stakes are important to consider. Lies in which high stake lies are involved, are easier

detectable due to emotional cues (Frank & Ekman, 1997). Further, DePaulo et al. (2003) show that cues of deception are easier to detect when the deceptive behavior is based on crimes, or when it is based on personal reasons rather then when it is set up for an incentive. Also, two other studies show that personally motivated liars are more likely betrayed by their non-verbal behavior than liars who are not personally motivated to succeed (Burgoon & Floyd, 2000; DePaulo et al., 1988). These liars without a personal motivation are better capable of controlling their facial expressions (DePaulo, Stone, & Lassiter, as cited in DePaulo). Second, the naturalness of the settings is important. As a majority of the research has been conducted in a laboratory setting, this lacks the factor of naturalness. However, Mann, Vrij and Bull (2002) found that it has been hard to conduct field research on the non-verbal behavior during deception, this case involves a more realistic setting compared to previous laboratory research, as in the Lance Armstrong case, both the high-stakes and a natural setting are involved.

The Lance Armstrong case, as analyzed in this study, involves a video, in which he confesses to have used performance-enhancing substances during his cycling career. Preliminary to his confessions, he denied ever having used performance-enhancing drugs during all of his interviews. As numerous of these interviews in which he lied were videotaped, this creates unique opportunity to analyze the non-verbal deceptive behavior of the athlete while high stakes are involved. However, to detect deception, also fragments in which he tells the truth have to be analyzed in order to make a decent comparison between truthful and deceptive behavior. As, in the interviews, also truth-based stories are considered, the video material is suitable for comparison.

In conclusion, it is possible to detect deceit by analyzing non-verbal behavior, in particular by analyzing facial and auditory cues. There are cues that, to some extent, might indicate deception. However, these cues are not a fixed set of cues due to individual differences. Nevertheless, the most important finding of this literature review is that deceptive behavior differs from truthful behavior. This literature review therefore leads to the following research question:

> *RQ: To what extent is it possible to automatically detect deception using facial and vocal cues?*

Based on previous research, the following cues, as set in table 1, are expected to indicate deceptive behavior. Table 1 shows the expectations for this case study. Two types of non-verbal behavior are distinguished; the visual cues and the auditory cues. The second column shows the cues, which at large are expressed during deception. The third column shows the size of the effect. In the fourth column the sources are found. The fifth column considers the type of study of which the cues derive from. A distinction is made between meta studies, laboratory studies and a natural setting. The meta studies rely on different types of studies, the laboratory studies are experimental in nature, and consider low stakes. Opposed to the laboratory setting, one study considers a more natural setting in which high stakes are involved.

Table 1

Expectations for this study regarding deceptive statements based on earlier research.

Visual Cues	Cue	Effect	Source	Context of the study
	Chin raise	Decrease	DePaulo et al. (2003)	Meta study
	Smiling	Decrease	Bond Kahler and Paolicelli (1985)	Laboratory / Low stakes
			DePaulo (1994)	Laboratory / Low stakes
			DePaulo et al. (2003)	Meta study
			O'Hair, Cody and McLaughlin (1981)	Laboratory / Low stakes
	Pressed lips	Increase	DePaulo et al. (2003)	Meta study
Auditory Cues				
	Pitch	Increase	Apple, Streeter & Kraus (1979)	Laboratory / Low stakes
			Rockwell, Burger & Burgoon (1997)	Laboratory / Low stakes
			Ekman, Friesen & Scherer (1976)	Laboratory / Low stakes
			Streeter et al. (1977)	Laboratory / Low stakes
			Vrij (1995)	Natural / High stakes
	Pitch variance	Increase	Rockwell, Burger & Burgoon (1997)	Laboratory / Low stakes

Method

Data collection

A total of 196 movies, which featured Lance Armstrong were watched and downloaded. The search was performed using the video search engine YouTube, entering key phrases like *Lance Armstrong – Lance Armstrong interview – Lance Armstrong press conference – Lance Armstrong lie - Lance Armstrong cancer – Lance Armstrong foundation – Livestrong*. The contents of the database so obtained, may be found in the appendix, table A2. After acquiring the data, a strict selection was made based on five different criteria; naturalness, quality, camera angle, type, and performed action.

Subsequently, duplicate fragments were deleted, and a selection was made of interviews/ press conferences in which Armstrong was present for a at least three seconds, in an up front position where his face was visible and no visual or audible noise was present, most importantly, interviews in which he was on his bike, or just got off his bike were not used. The latter selection was made due to influences of exhaustion, which could affect non-verbal behavior (Fery, et al., 1997).

After that, the videos were cut into thin slices using time duration, and were labeled with a no deception or deception label, the date of the event and a transcript of the question of the interviewer. Also, the discussed topics were taken into consideration. To analyze the no deception claims, utterances related to cancer, his cycling related opinions[1], the Livestrong foundation and his family life were used. For the deceptive utterances, only statements regarding the denial of his doping usage were used. In addition, the gender of the interviewer was listed due to rule out possible gender influences (Carli, LaFleur & Loeber, 1995). The reduced database consisted of 68 thin slices (*M*=49.21 sec, *SD*= 43.16 sec) from 25 different videos of which 52 were labeled with no deception and 16 with deception. A thin slice consists of the whole fragment of Armstrong's answer after an interviewer raised a question.

After the classification was completed, the videos were watched again, and cut into thin slices using only the parts that were recognized by CERT, as this was the most sensitive to noise as compared to the PRAAT software. The software program was unable to recognize all videos due to insufficient video quality or troublesome clothing, such as hats that were worn. The unrecognizable fragments were deleted, which resulted in a final set of 62 thin slices (*M*= 49.57 sec, *SD*= 43.70 sec) from 25 different videos of which 47 were labeled with no deception and 15 with deception. The dates of the videos ranged from 2005 till 2011.

Thereafter, two analyses were set up, as two types of non-verbal behavior were analyzed, first, the facial expressions, and second the auditory features. After these two analyses were completed in

[1] In which low stakes were involved

the SPSS software, three complementary analyses were set up, using MATLAB software for data mining developed at Tilburg University. This software was trained for automatically detecting deception.

Analysis 1: Facial features analysis

This first analysis made use of the visual features of Lance Armstrong, which were extracted with the CERT software, as described above. After the means for every measured action unit were determined, the basic emotion and the X, Y and Z position of the face were calculated in Matlab, the measurements were checked for normal distribution using SPSS statistics 19. Next, the means of both conditions were compared to each other, looking for significantly differentiating outcomes. Non-parametric tests with independent samples were used, as the sample sizes were to small to use t-tests. Finally, the effect sizes of the significant results were calculated using a univariate general linear model.

Analysis 2: Speech analysis

The second analysis made use of the same data set as used in the first analysis. In contrast to the first analysis, the audio was used. It was ripped of the videos using Audacity. The sound files were saved as .wav files. The auditory data was labeled with the same labels as used in the first analysis, and saved in a different folder with the same name that was used for the videos.

Next, the data files were run with an automatic script in the software PRAAT, after setting the pitch boundaries on 50 Hz for the lower boundary and 500 Hz for the upper boundary. Six different features were extracted, using scripts for; duration, maximum pitch, mean pitch, minimum pitch, SD of the pitch and finally, the slope of the pitch. The output data was saved as .txt files. Subsequently, the files were imported in SPSS and prepared for statistical analysis.

Analysis 3: Training the classifier

After analyzing the facial and vocal cues, the results of both analyses were prepared for importing in the MATLAB software. With this software, it is possible to program and train a nearest-neighbor classifier (Witten, Frank & Hall, 2011). The multi channel approach of facial expressions and speech utterances will presumably result in an even stronger classifier as these types of non-verbal behavior are both accurate predictors of deception (DePaulo, Stone & Lassiter, 1985; Zuckerman & Driver, 1985). To evaluate the prediction performance of the classifier, the leaving-one-out cross-validation method was used. In order to maintain a balanced set of deceptive and non-deceptive instances (i.e. chance level 0.5), 10.000 repetitions of training and evaluation were performed using all (15) deceptive instances against an equally sized random subset of non-deceptive instances.

The first analysis that was run in this software used the significant differentiating cues as found in earlier research for the classifier. These include, chin raising, smiling, lips presser, a higher pitch and a greater pitch variance.

The second analysis in MATLAB did use an "overtraining method" (Witten, Frank & Hall, 2011), as it is based on selected features (or cues) that were acquired from the labeled data. Moreover, an analysis of only the significant differentiating cues from the face was run, as well as a analysis of only the vocal cues.

Subsequently, the third analysis was run in MATLAB. This analysis also was an overtraining method. In contrary to the second analysis, the third analysis was automatically run, using different combinations of cues. This automatic analysis is capable of automatically generating the best combinations of cues, resulting in high detection rates.

Results

Facial expressions

The facial cues were analyzed by CERT using 40 different measurements (28 of which were action units), a smile detector, the six basic emotions as proposed by Ekman (1992), contempt and neutral. The results of the first analysis showed significant differences on ten out of the 40 measurements. Results of the non-parametric test with independent samples and the effect size may be found in table 2. The columns of the table will first be explained. The first and second columns of the table show the names for an action unit. The third shows the means of the action units. The fourth column displays the standard deviation, which indicates the size scatter of the measurements. The fifth column shows the number of videos that were analyzed, which are 62 in all of the cases. The sixth column shows the two means of the two 95% confidence intervals of the measurements, indicating the mean of a deceptive utterance (a lie) and non-deceptive utterances (truth). This indicates the differences in the two groups. The seventh column shows the U-values. These numbers show the test statistics. The eighth column shows the p-values, indicates the significance level. The lower the number, the higher the significance. The last column shows the effect level of the action units. This indicates the size of the measurements.

An image of faces with the localized action units may be found in the appendix, figure A1. The higher a score, the more an AU is used. This specifically means that a higher score on, for example blink/eye closure, is related to more eye blinking. These results implicate that a considerable amount of reliable cues of deception are present in Armstrong's face.

To systematically present the results, different facial regions are used, starting with the eye region. The first measured action unit considers eye widening and seemed to be one of the best predictors of deceptive statements. This action unit showed a higher response during a deceptive statement, also indicating more activity, which leads to overall wider eye opening during deceptive utterances. Eye widening was the only action unit in the upper area of the face that showed a significant difference between a deceptive and a truthful statement. Therefore, this region does not seem to play an important role during deception detection when regarding the case of Armstrong.

Table 2

Results of the non-parametric independent sample test and Descriptive Statistics for the cues of Lance Armstrongs face differing during truthful and deceptive utterances.

AU number	AU name	M	SD	N	95% CI for Mean Difference	U	p	df	d
AU 5	Eye Widen	-0.32	0.11	62	-0.53, -0.05	226	.038	60	.975
AU 14	Dimpler	0.68	0.54	62	-0.64, 1.68	176	.004	60	.201
AU 15	Lip Corner Depressor	2.00	0.33	62	1.47, 2.80	200	.012	60	.132
AU 17	Chin Raise	0.38	0.45	62	-0.90, 1.26	231	.046	60	.126
AU 26	Jaw Drop	0.86	0.35	62	0.07, 1.66	214	.023	60	.127
AU 28	Lips Suck	-0.10	0.98	62	-0.56, 0.27	196	.010	60	.154
AU 10 L	Lip Raise left	-3.95	0.30	62	-4.54, -3.21	180	.005	60	.163
	Smile detector	-0.75	0.29	62	-5.23, 1.30	165	.002	60	.057
	Anger	-0.53	0.32	62	0.005, 0.37	226	.038	60	.057
	Sad	0.14	0.11	62	0.02, 0.39	218	.027	60	.084

Table 3

Results of the non-parametric independent sample test and Descriptive Statistics for the cues of Lance Armstrongs voice differing during truthful and deceptive utterances.

Measurement	M	SD	N	95% CI for Mean Difference	U	p	df	d
Mean pitch	115.97	14.79	62	-0.53, -0.05	183.00	.005	60	.072
Min pitch	55.31	11.79	62	-0.64, 1.68	263.00	.141	60	.026
Max pitch	417.27	117.30	62	1.47, 2.80	234.00	.058	60	.048
SD pitch	38.81	16.30	62	-0.90, 1.26	186.00	.006	60	.097
Slope pitch	234.45	101.09	62	0.07, 1.66	175.00	.004	60	.160
Duration utterance	1799	1903	62	0.02, 0.39	344.50	.895	60	.005

The remaining measured action units are in the lower region of the face, more specifically, the mouth and the cheeks. Dimpler use was measured less in the deceptive settings compared to in the truthful settings, which resulted in the most significant effect of all action units being in the lower region of the face. Next to that, when regarding the lower region of the face, the lip corner depressor, which causes a mouth to frown, was used more often during a deceptive fragment. The 26th action unit, jaw drop, was also measured more often during the utterance of deceptive statements. Apart from that, the left part of the upper lip raise was measured more often during the utterance of a lie. The 17th and 28th action unit, the chin raise and the lips suck, then again was measured significantly more often during truthful expressions. The upper part of the face only results in one significant action unit, the lower facial regions of Lance Armstrong result in several action units to play a significant role in indicating whether Lance Armstrong is deceptive or not. Consequently, this region is probably more important than the upper facial region when detecting deception. Boxplots of the significant results can be found in the appendix, figure A2a – A2j.

The results further showed a significant difference when using the smile detector, noting down more smiling during utterances of deception than during those of no deception. In contrary, the basic emotion, Anger, was measured more often during truthful utterances than during deceptive ones. Finally, the basic emotion sadness was disclosed more often during deceptive utterances. Figure 1 presents six illustrative images of Armstrong's facial cues during a deceptive statement.

Figure 1. Six subsequent images of Armstrong's face during a deceptive statement.

Further, a trend toward significance was detected regarding several measurements; action unit 6, Cheek raise. (*M*= 0.43, *SD*= 0.18), U = 234.00, *p*= .051; *d* = .024. Also the 12th action unit (*M*= -3.67, *SD*= 0.32), Lip Corner Pull, was trending toward significance, U = 236.00, *p*= .056; *d* = .052. Finally, the left dimpler (*M*= -3.62, *SD*= 0.42), action unit 14, left showed a trend towards significance, U = 235.00, *p*= .053; *d* = .084. These three action units were measured more often higher during the utterances of Lance Armstrong of deceptive statements.

Speech characteristics

The second analysis concerned the speech characteristics, the results of which are presented in table 3[1]. This analysis showed significant effects for three out of the six measured units. First, the mean pitch shows an overall higher value during the deceptive utterances. Next to that, the standard deviation of pitch was smaller during the deceptive utterances than during the truthful ones, which implicates that there is less fluctuation of speech during the utterance of a lie. The third finding considers the slope of the pitch and indicated that there were smoother transitions of the consecutive utterances during the deceptive statements than during truthful statements, while the consecutive utterances during truthful statements differ more from each other by means of pitch. A fourth finding with regard to pitch is the higher maximum frequency during deception. This feature shows a trend towards significance, and indicates that there is a possible maximum higher pitch during statements of deception, and a lower maximum pitch during statements that are truthful. Boxplots of the significant differences regarding the speech characteristics are presented in the appendix, figure A3a – A3c. Summarizing the results, differences in speech indicates cues to deception.

Accuracy rates of the trained classifier

The results of the first test that was run, regarding the cues to deception based on the literature review resulted in a detection rate of 67.8%.

The second test that was run made use of the significant differentiating cues resulting from the statistical analysis as run in the first and second analysis. This showed an accuracy rate of 64.3%. The subsequent analysis, of only the facial cues, resulted in a detection rate of 72.9%. The vocal analysis achieved a detection rate of 63.7%.

Finally, the fourth analysis that was run made use of optimization techniques. The optimization resulted in a single feature, Action Unit 4, Brow lower. This resulted in an accuracy of 83,1%. The distribution of the detection rate over the 10.000 replications can be found in the appendix, figure A4.

[1] The content of the columns in table 3 corresponds to the ones of table 2.

Expectation testing

In the literature review, five expectations were summed up. In this part, the findings of this study are compared to the findings of previous studies. It should be noted that these expectations are only relevant for this explorative case study, as cues differ from person to person.

Chin raising

The findings regarding chin raise, action unit 17, are in line with the expectation, as described in the facial expressions part in the literature review, since Lance Armstrong's chin was raised less often during deceptive statements.

Smiling

Contrary to a great number of findings of other studies as described in the literature review, more smiling was measured during truthful utterances than during deceptive utterances.

Lips presser

Another finding of other studies was that lips were pressed more often during deceptive statements. In this study, we did not find evidence for a significant difference in lip pressing between a deceptive and truthful utterance. Therefore, this expectation was not met.

Pitch

The mean pitch shows an overall higher pitch during the deceptive utterances. This is in line with the findings of other studies, as described in the literature review and confirms the 6th expectation.

Pitch variance

The seventh expectation concerns the standard deviation of the pitch, which in previous studies was found to show a greater variance during deceptive statements. In this study, contrasting results were found. A smaller standard deviation was measured when regarding the deceptive statements as opposed to when regarding the truthful statements.

Discussion

Facial expressions

The results of the visual analysis implicate, that it is possible, based on several cues, to distinguish truthful from deceptive statements of one person. Fifteen out of the 40 measured cues in the facial analysis might lead to accurately distinguish a deceptive face from a truthful face. As some of the results are highly significant ($p < .005$), it could be that in this case less dimpler use, more raising of the left side of the lip and smiling may indicate that Armstrong is telling a lie. Moreover, eye widening showed a great effect size, though, this was not highly significant.. This feature may also help accurately detecting deception.

Although the results show a high significance, the effects in the action units and emotions, (AU5, AU14, AU17, AU26, AU28, AU10L, Smile, Anger and Sad) only show small to modest effect sizes. In case of exception, in eye widen, the effect sizes do not exceed $d = .201$. These modest effects indicate that no greatly reliable indicators were detected.

It further must be noted, that six out of the fifteen thin slices with a 'lie' derive from one single video. This could play an important role during the extraction of the cues. This especially might influence the facial extraction with CERT. It therefore could be argued that a wrong bias is set. Results might be influenced due to the fact that the video in which most lies were uttered is shot at one specific time. This might be problematic as faces change over time (Lanitis, Taylor & Cootes, 2002). Also, one specific face position might have influenced the results. This could be considered as one of the major disadvantages of this study. However, due to the extensive data collection, this is a relatively exceptional available, and naturally collected dataset regarding this subject.

Auditory features

The audible cues were measured on six characteristics, three of them showed significant differences. Based on these findings, it can be assumed that by means of an auditory analysis it is possible to detect deceit in Lance Armstrong's vocal utterances. Nonetheless, only half of the measurements showed a significant difference. The effect sizes of the auditory cues, even as the facial cues, do not exceed $d = .160$, which equals a modest effect at most.

The results regarding a lower fundamental pitch during truthful utterances are in line with earlier research. Here, they found that stressful situations, deriving from an arousing experience, lead to a higher fundamental frequency (Apple, Streeter & Krauss, 1979).

A smaller standard deviation was detected during the deceptive behavior. This was not concluded in earlier research. However, in a study based on the automatic detection of emotion, researchers found that adding a vector of standard deviation of the pitch did not improve the classifier (Schuller, Rigoll & Lang, 2003), and therefore did not seem important when identifying emotions.

This study, however, shows that when regarding deception in this case, standard deviation does play an important role during deception detection. Earlier research regarding the pitch slope does not show significant differences between truthful and deceptive conditions (Enos, 2009). This contradicts results from this research, as we found a highly significant difference with a modest effect, where a higher difference between consecutive utterances was measured during deceptive statements.

Though, it could be argued that the same bias problem as in the facial analysis is present, and therefore the results may give wrong indications. This, however, does not seem plausible, as it should be kept in mind that previous research did show differences between individuals. Consequently, an important finding may be that cues to deception, indeed differ per person (DePaulo et al., 1997; Vrij & Mann, 2004).

Implications of the machine learning

The results of the first test showed an accuracy rate of 67,8%. This is already an improvement compared to the accuracy of a human. The training, based on the results deriving from the statistical analysis achieves an accuracy of 64,3%. This also is an improvement on human accuracy, however it is an impairment compared to the cues as deriving from the literature review.

When only the facial cues are used for detection deceit, an accuracy of 72,9% is achieved. Therefore, the face in this case is a good predictor for deception. Vocal cues on the other hand only achieve a detection rate of 63,7%. Finally, for the optimization technique, a high accuracy rate of 83,1% was achieved. This only used one cue; the fourth action unit, brow lower.

These results conclude that the face is a good predictor of deceit. Moreover, all the analyses are an improvement on human accuracy rates.

Restrictions

It first has to be noted, as already stated in the literature review, that cues during deception vary from person to person (DePaulo et al., 1997; Vrij & Mann, 2004). Therefore, this study should not be considered as a new way to detect deception, however, rather as an explorative study that shows the possibility of accurately detecting the deception of one specific person.

The main aim of this study was to research the possibility to accurately (and automatically) distinguish truthful from deceptive behavior when regarding one particular person. The results of this explorative study show that it is possible to predict lying at a level of 83,1%. Therefore, a trained computer is better in detecting a lie than normal human beings or most of the professional lie spotters, as these only achieve levels slightly above a chance level of 50% (Aamodt & Custer, 2006; Ekman, O'Sullivan & Frank 1999; Kraut, 1980; Malone & DePaulo, 2001).

Even though this study shows interesting results, several restrictions have to be taken into consideration. Therefore, the main four restrictions are listed. First, the data collection in this study has been extensive, however, due to technical restrictions and restrictions in the nature of the videos, it was not possible to make use of all 196 videos that were downloaded. Eventually, only 62 videos

seemed suitable for analyzing. Admittedly, this might be a too small database for an accurate representation of the truth.

A second overall issue also includes the fact that this case study does not consist of the perfect data set. As previous research suggested, to increase the ecological validity, high-stakes were involved in this case. However, the naturalness and spontaneity of the utterances can be questioned, as a considerable part of the answers of the questions could be prepared. This study is, however, still an improvement on the extensive laboratory research that has been put forward in the past.

Further, it should be marked that, even though a content based speech analysis was not the scope of this research, a meta-analysis of general behavior during deception found that when a subject is ‘‘not directly answering the questions being asked’’ (Aamodt & Custer, 2006, p. 6) this indicates that the subject is telling a lie. During the manual selection of the videos, it was noted that Lance rather dodged a question regarding possible use of performance enhancing drugs, than directly answer it. Moreover, it was noticeable that he answered questions regarding this subject with mixed parts of truth and lies. As cues differ during these two situations, it could be argued that the analyzed thin slices include false classified parts of a thin slice. For example, in an interview with a Dutch sports journalist, who asked him a question on his possible doping usage, he answered:

> ‘‘Mart, they can’t say that, they can say it, but it is very hard to believe. I’m 38 years old, and I’m still here. I was 21, and I was winning stages on the tour, I was winning the world championship, and I won, and I won, and I won, and I won. And along the way, yeah, there were things here and there said, and accusations, uhmmm. Nobody, is that smart, nobody is that conniving, nobody is that good to try and get away with something for 17, 18, 19 years. No way, No…’’ (NOS Sport Document, 2010, July 14).

This answer consists of almost only truthful statements, except for the part in which he said; ‘‘Nobody, is that smart, nobody is that conniving, nobody is that good to try and get away with something for 17, 18, 19 years.’’ (NOS Sport Document). The small to modest effect sizes of the statistical analysis could be explained by these, probably, incorrect classified parts in the thin slices.

Feldman et al. (1979) indicates a change in non-verbal behavior regarding deception when a person ages. He argues that a person may get better in hiding his/her lies as he or she ages. As a significant period of time has passed, this argument could be considered valid. Still, it has been proven that deceptive behavior is accompanied with leakage (Ekman et al., 1991; Warren, Schertler & Bull, 2009).

However, several restrictions as discussed in this section, might raise issues for not being best suitable case. The analyses still show interesting results regarding both the differences in truthful and deceptive behavior on facial and auditory cues. Further, interesting results are found regarding the trained classifier, which is able to preform above an accuracy level of a human.

Conclusion

Previous research showed the difficulty in detecting deception for human perceivers. Distinguishing truthful from deceptive behavior even gets more difficult as cues differ from person to person. However, paying attention on a specific individual should make the differentiation in these two types of utterances easier. This should be even easier when the cues are analyzed by a computer. In this study, special attention was paid to the facial expressions and the non-verbal speech characteristics.

The case of the professional cyclist Lance Armstrong seemed a suitable one, as numerous of his interviews are video captured. Previous research came up short, and suggested the high stakes and naturalness that should be involved during deception detection. The research question was as follows:

RQ: *To what extent is it possible to automatically detect deception using facial and vocal cues?*

The results, leading to answer the research question derive from three analyses. The first one measured the differences in facial expressions during deceptive and truthful utterances. This resulted in ten significant differences between the two settings; AU5, AU15, AU26 and the left side of AU10, a smile and a sad face gave a higher response during deceptive statements. AU14, AU17 AU28 and an anger face were measured more during a truthful statement.

The second analysis concerned the speech analysis. This analysis resulted in three significant differences amongst the two conditions. A higher pitch, greater standard deviation regarding pitch and a greater slope difference in consecutive utterances was found during deceptive statements.

Eventually, with the input, deriving from the first and second analysis, in the third analysis, a classifier was trained. After optimization of the classifier, a detection rate of 83,1% was achievable. Therefore, the research questions for this study can be answered as follows:

It is possible with an accuracy rate of 83,1% to detect deception in one particular person, using facial and vocal cues.

Figures

Figure A1. Shows miniatures of facial expressions and the involved action units. Retrieved from http://what-when-how.com/face-recognition/facial-expression-recognition-face-recognition-techniques-part-1/

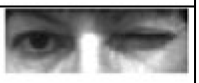
Upper Face Action Units					
AU 1	AU 2	AU 4	AU 5	AU 6	AU 7
					
Inner Brow Raiser	Outer Brow Raiser	Brow Lowerer	Upper Lid Raiser	Cheek Raiser	Lid Tightener
*AU 41	*AU 42	*AU 43	AU 44	AU 45	AU 46
					
Lid Droop	Slit	Eyes Closed	Squint	Blink	Wink
Lower Face Action Units					
AU 9	AU 10	AU 11	AU 12	AU 13	AU 14
					
Nose Wrinkler	Upper Lip Raiser	Nasolabial Deepener	Lip Corner Puller	Cheek Puffer	Dimpler
AU 15	AU 16	AU 17	AU 18	AU 20	AU 22
					
Lip Corner Depressor	Lower Lip Depressor	Chin Raiser	Lip Puckerer	Lip Stretcher	Lip Funneler
AU 23	AU 24	*AU 25	*AU 26	*AU 27	AU 28
					
Lip Tightener	Lip Pressor	Lips Part	Jaw Drop	Mouth Stretch	Lip Suck

Figure A2a. Results of the measurements presented in boxplots, Eye Widen.

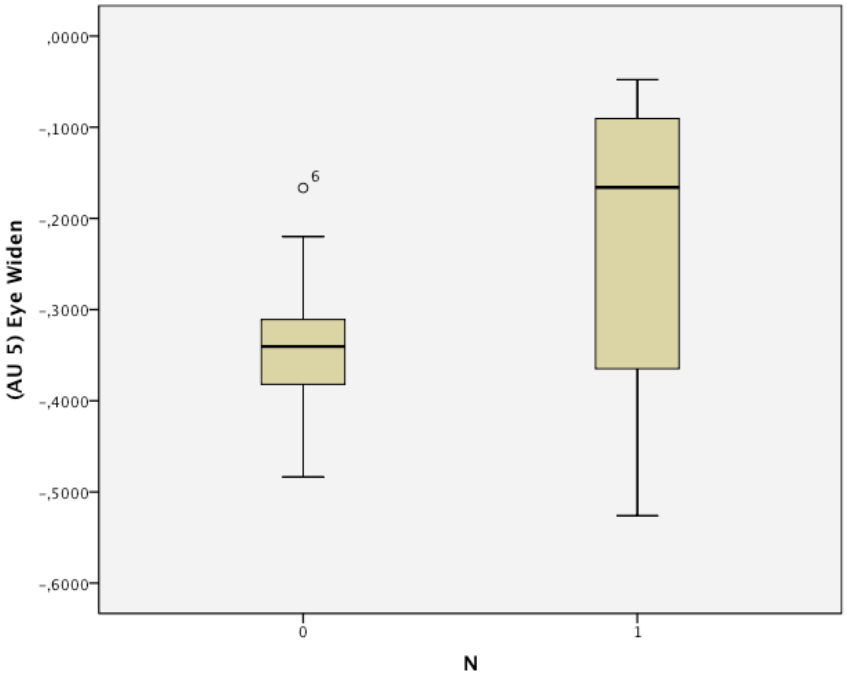


Figure A2b. Results of the measurements presented in boxplots, Dimpler.

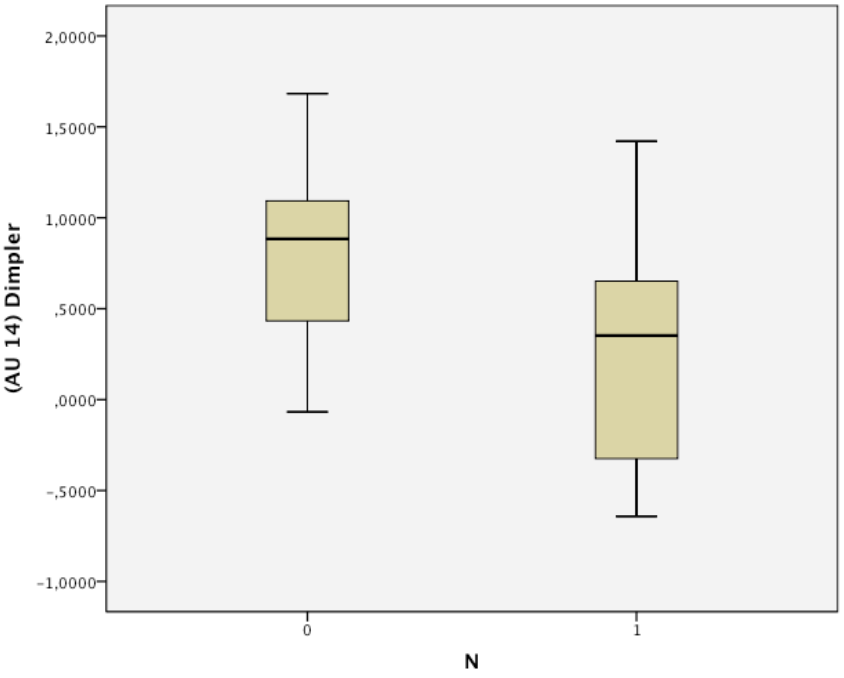


Figure A2c. Results of the measurements presented in boxplots, Lip Corner Depressor.

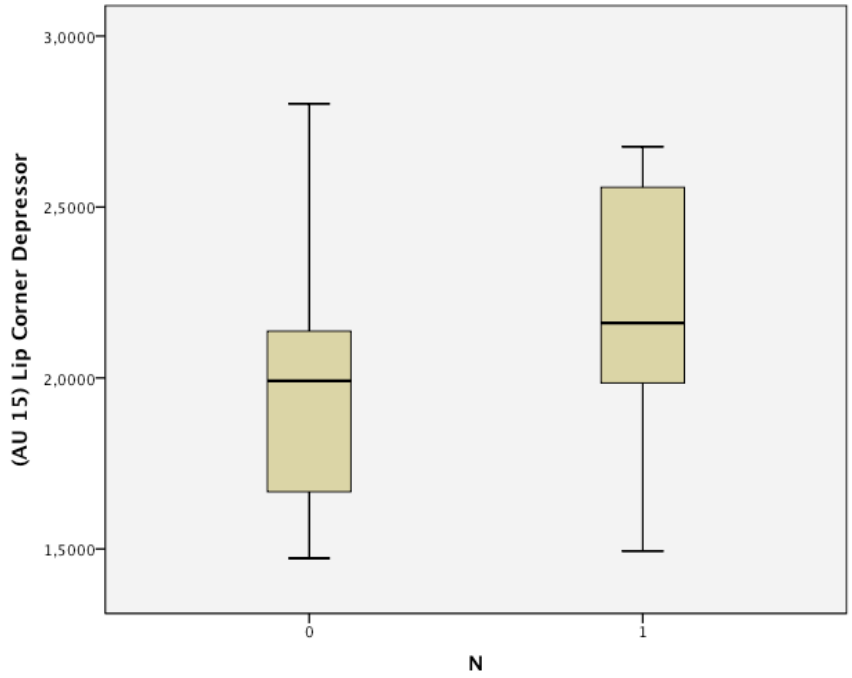


Figure A2d. Results of the measurements presented in boxplots, Chin Raise.

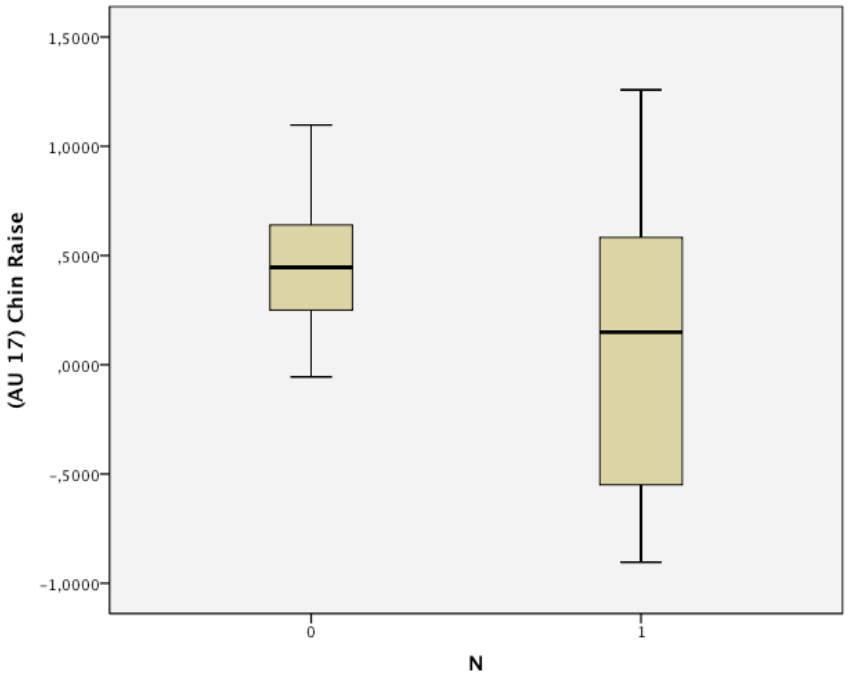


Figure A2e. Results of the measurements presented in boxplots, Jaw Drop.

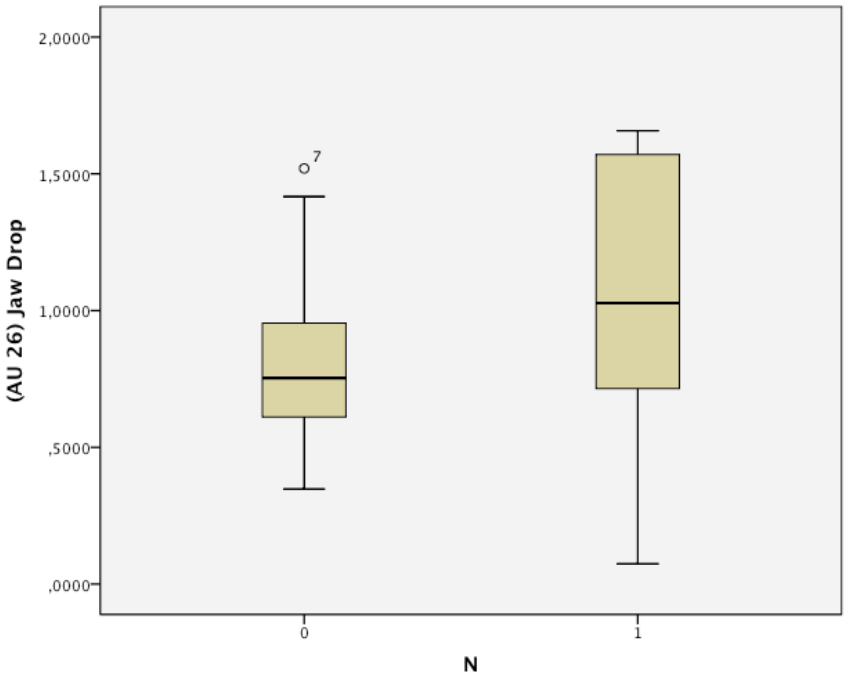


Figure A2f. Results of the measurements presented in boxplots, Lips Suck.

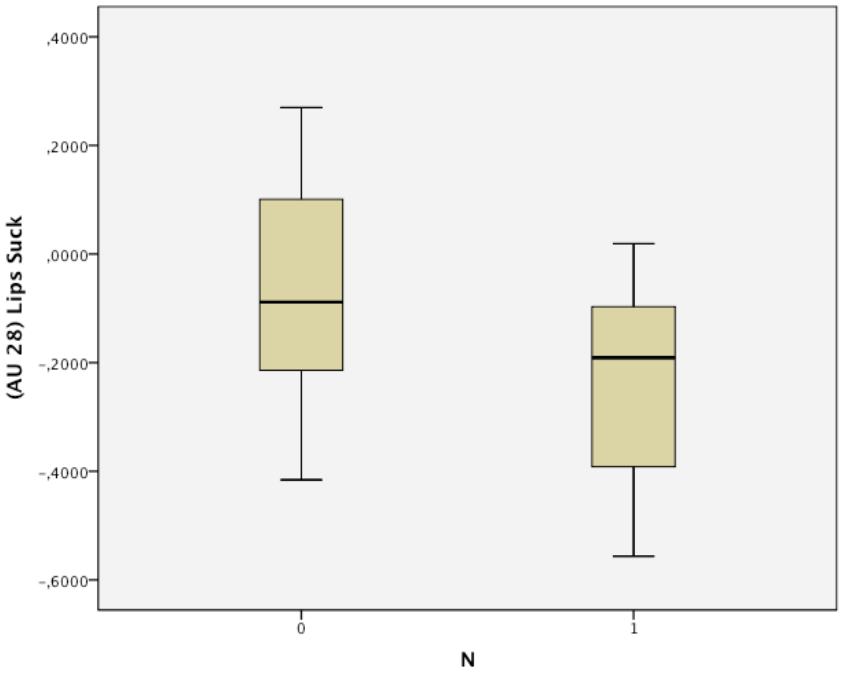


Figure A2g. Results of the measurements presented in boxplots, Left part of the Upper Lip Raiser.

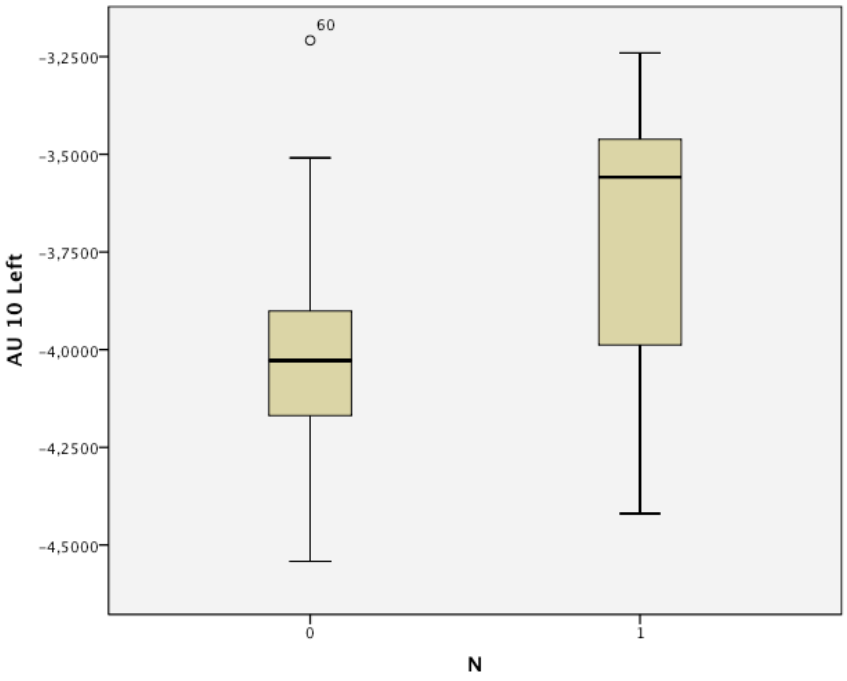


Figure A2h. Results of the measurements presented in boxplots, Smile Detector.

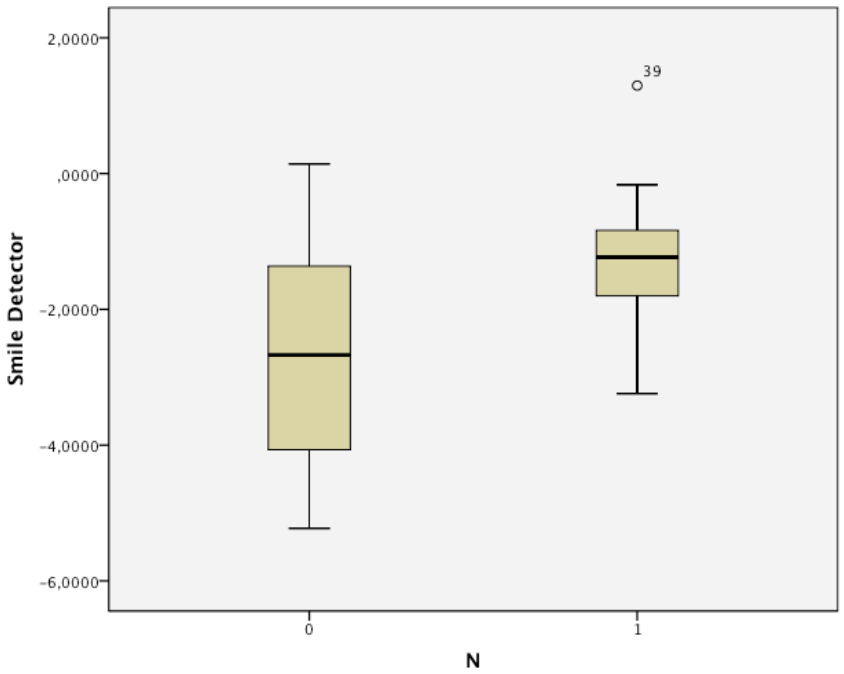


Figure A2i. Results of the measurements presented in boxplots, Anger.

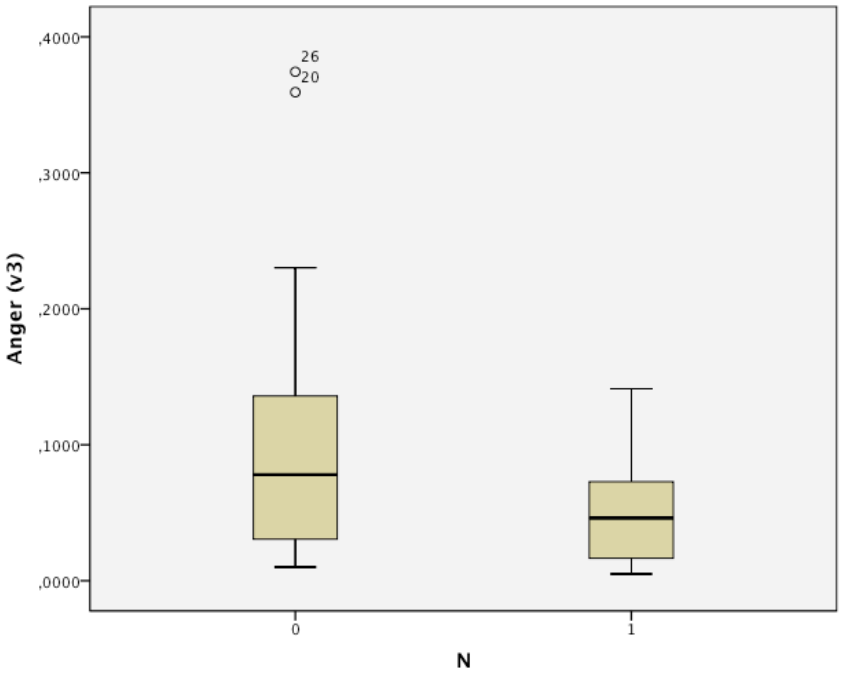


Figure A2j. Results of the measurements presented in boxplots, Sad.

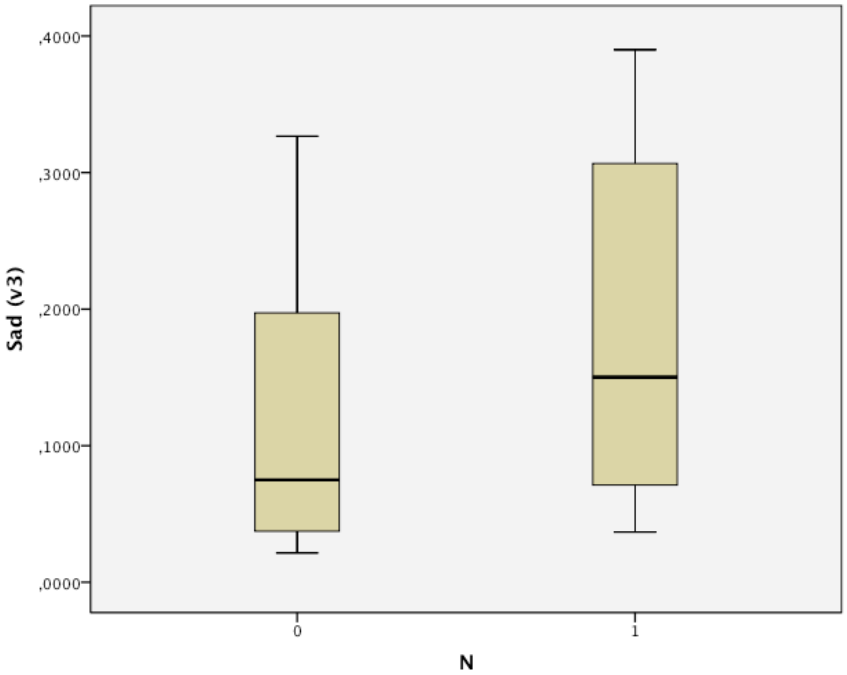


Figure A3a. Results of the measurements presented in boxplots, Mean Pitch

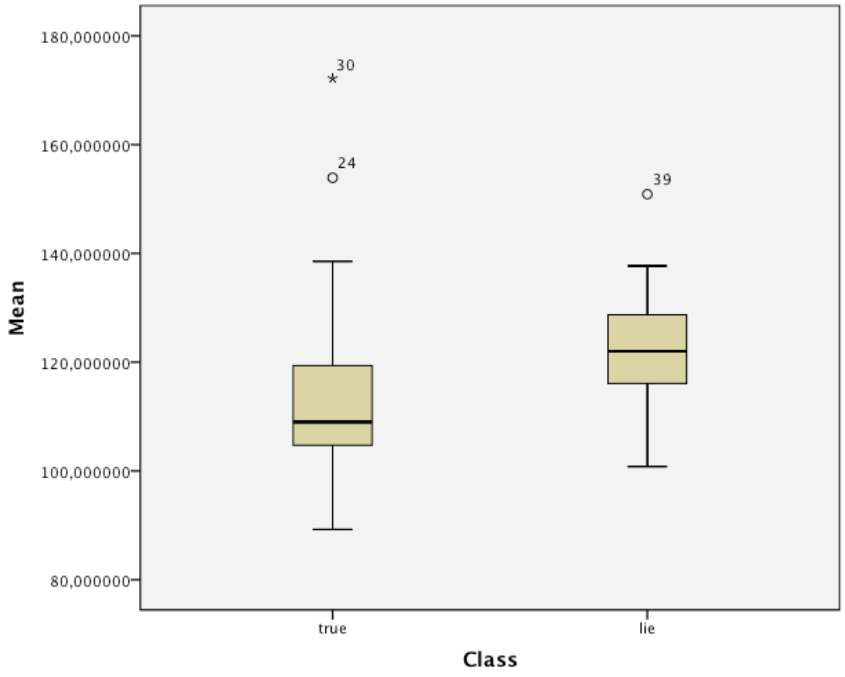


Figure A3b. Results of the measurements presented in boxplots, Standard Deviation of the Pitch

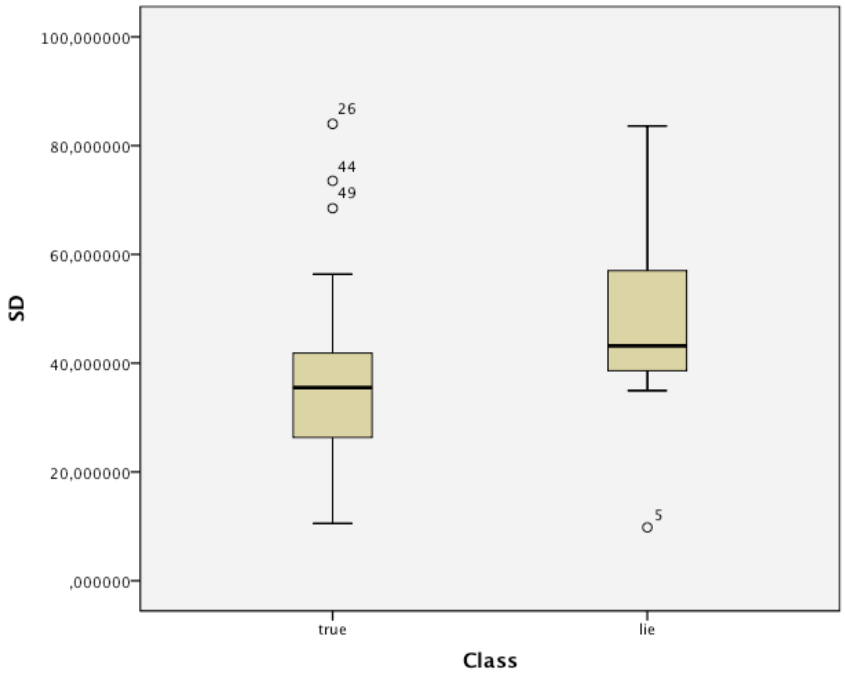


Figure A3c. Results of the measurements presented in boxplots, Slope of the Pitch

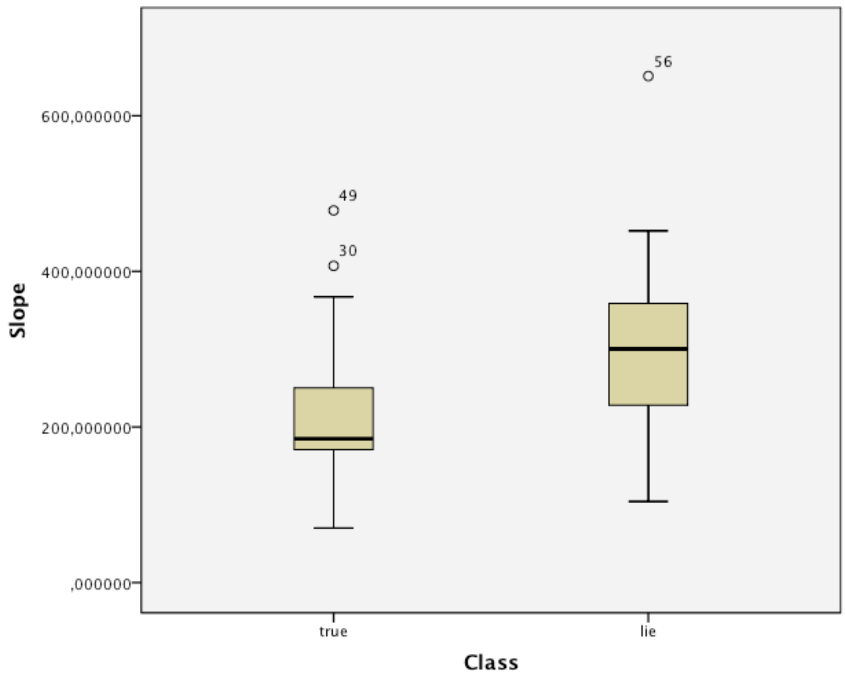
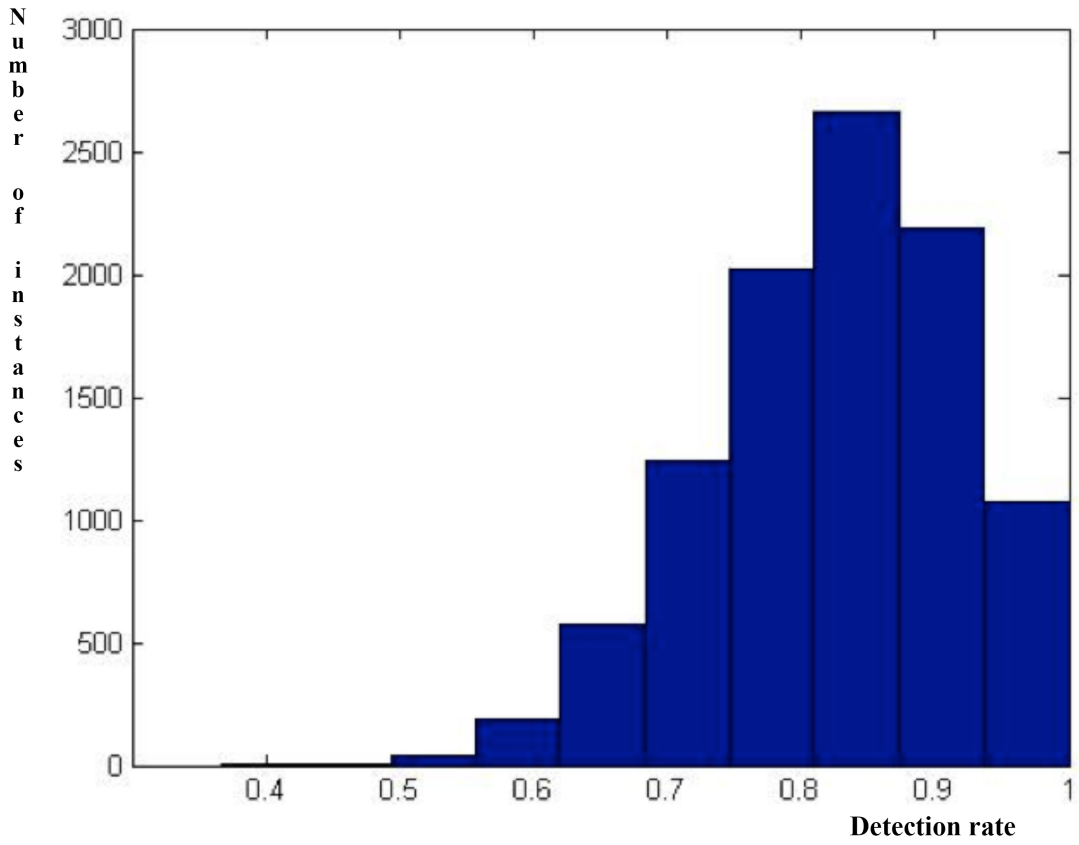


Figure A4. Results of the detection rate of Action Unit 4, Brow Lower.



Tables

Table A1.

Reliable action units in detecting deception based on the meta study of DePaulo et al. (2003).

Action Unit	Cue	N	k1	k2	D	CI	Q
AU 23/ 24	Presses lips	199	4	3	0.16*	0.01, 0.30	30.9*
AU 17	Chin raise	286	4	4	0.25*	0.12, 0.37	31.9*
AU 6	Genuine smile	?	2	2	0.70*	0.97, 0.43	?

Note. * $p < .05$.

Adapted from DePaulo, B. M., Lindsay, J. J., Malone, B. E., Muhlenbruck, L., Charlton, K., & Cooper, H. (2003). Cues to deception. *Psychological bulletin*, *129*(1), 74. pp. 91, 92 and 118.

Table A2.

Database of the thin slices that were used for training the classifier.

Source video	Number	Gender interviewer	Date	Time	Lie/ Truth	Transcript question
2. Armstrong Defends Himself Against Doping Allegations	1	Male	June 26, 2006	0.21 - 1.19	Lie	Lance; I would like to begin with the allegations made in the sworn testimony of Betsy Andreu, she has given a sworn testimony the allegations that 10 years ago she was present in a doctors room and in respons to a doctors question, sad that you admitted to using cortisone, EPO, growth hormone, steroids and testosterone, this was a sworn testimony. What do you say to her account?
2.	2	Male	June 26, 2006	3.37 - 3.55	Lie	He sais, that you said, 'I'm prepared to spend a lot of money to make your life miserable'.
2.	3	Male	June 26, 2006	4.13 - 4.45	Lie	I would like to ask you Emma O'Reilly, she kept what she claims as a detailed diary that formed a lot of the bases of David Walsbrouck LA confidential, she has, she tells an incident where your team, she sais asked her to carry pills from Spain into France and personally deliver to you pills in Nice, was that accurate?
2.	4	Male	June 26, 2006	5.12 - 6.04	Lie	He told me of a phone call that he said he received from you after he had criticized your involvement with dr. Ferrari, the Italian doctor who was subsequently convicted of being involved with doping, and in that phone call, LeMond sais that you said to him, in a threatening tone; I can produce ten people to say that you took EPO
2.	5	Male	June 26, 2006	6.22 - 7.26	Lie	When you look at the scope of some of the things we've talked about; Betsy Andreu, Andreu, Steven Swords and Doctor Steven and Emma O'Reilly and Greg LeMond, taken as a group. Why would independent largely of each other? Why would they say these things that you say are not true.
2.	6	Male	June 26, 2006	7.37 - 8.30	Lie	Let me ask you about; you've made news with the international Olympic committee, you're not happy with the world anti doping agency, you've written a lot on the IRE, essentially asking that Dick Pound be fired; why?
3. Lance Armstrong before the 2009 Tour de France						
	7	Male	Summer 2009	1.05 - 2.26	True	So you would disagree, you don't feel like there is any change here? Sorry to interrupt
	8	Male	Summer 2009	3.40 - 4.48	True	The question everybody wants, the repeating question over and over again, is how is Astana gonna sort of puzzle out the pie at the Tour, and I'm just gonna simply ask you. How is this thing gonna shake out, where Alberto is sorted 2 tot 1

						and you sorted 5 to 1.
	9	Male	Summer 2009	5.04 - 6.00	True	Could you sit here with a straight face and say you don’t wanna win the 2009 Tour the France?
	10	Male	Summer 2009	7.52 - 8.38	True	Lets talk about aspin here, training here, how has it been going?
	11	Male	Summer 2009	9.55 - 10.29	True	Tell me about number four, another experience for you, I don’t have any on my own, but I’m sure everybody is different and special. (The expected baby)
	12	Male	Summer 2009	11.31 - 12.25	True	This guy who won the Giro; Estano macho?
9. Lance1	13	Male	2009	2.44 - 3.25	True	Do you mind telling that story (cancer)?
11. Lance1a	14	Male	2009	0.03 - 0.47	True	No question - story on cancer
	15	Male	2009	0.49 - 1.48	True	No question - story on cancer
22. NOS Studio Sport Document; Lance Armstrong [20100714]	16	Male	July 14, 2010	4.13 - 4.22	True	Reason for coming back in the sports
	17	Male	July 14, 2010	4.38 - 4.51	True	Reason for coming back in the sports
	18	Male	July 14, 2010	5.05 - 5.20	True	Did you wanted to proof something?
	19	Male	July 14, 2010	5.37 - 5.55	True	Did you wanted to proof something?
	20	Male	July 14, 2010	6.17 - 6.45	True	No question, why he started training again
	21	Male	July 14, 2010	7.59 - 8.04	True	Story on his return in the tour down under
	22	Male	July 14, 2010	8.14 - 8.41	True	Story on his return in the tour down under
	23	Male	?	12.09 - 13.15	True	What is it about those dopers that you seem to admire so much?
	24	Male	?	15.18 - 15.47	True	How was your time without cycling?
	25	Male	July 14, 2010	16.23 - 16.49	True	No question - Story on photo's in a race
	26	Male	July 14, 2010	22.17 - 22.32	True	No question - Story on ceasing a race (while already riding it)
	27	Male	July 14, 2010	29.20 - 29.47	True	Did you talk to him before this year? So you started to really speak now?
	28	Male	July 14, 2010	32.38 - 32.40	True	No question - time trial in his return in the Tour de France
	29	Male	July 14, 2010	37.47 - 38.31	True	No question - Mont Ventoux

	30	Male	July 14, 2010	38.43 - 38.51	True	No question - Mont Ventoux
	31	Male	July 14, 2010	40.29 - 41.07	Lie	No question - doping usage
	32	Male	July 14, 2010	57.03 - 57.19	True	Do you feel yourself comfortable in a situation like that? Are you always yourself (talking to ministers and presidents)
	33	Male	July 14, 2010	1.00.46 - 1.01.14	True	If we play cards, you wanna win?
	34	Male	July 14, 2010	1.01.25 - 1.01.40	True	No question - Story on cycling
39. 2010 Amgen Tour of California - Lance Armstrong Pre-race Interview	35	Male	May 14, 2010	0.16 - 1.10	True	Lance, could you talk a little about the role helping the vio, the fitness and who you think the riders are that …. Trouble, what did you see?
42. Armstrong Denies New Doping Accusations	36	Male	(He already was 7 time tour the France winner, so after that	0.33 - 0.37	Lie	No question - could be something like; Have you ever doped?
46. Booking Lance Armstrong Speaking Engagement Sports Speakers Bureau	37	Male	After announcing his return	0.16 - 0.48	True	Why coming back to the sport, after what I thought was be the best possible way to retire, from the sport of cycling Champs-Élysées, 7 tours, goodbye everybody.
	38	Male	After announcing his return	1.06 - 1.12	True	Why coming back to the sport, after what I thought was be the best possible way to retire, from the sport of cycling Champs-Élysées, 7 tours, goodbye everybody.
	39	Male	After announcing his return	1.24 - 1.46	True	Why the tour down under? I mean, you could have started with the tour of California, which would have been a huge impact, but you've actually decided to come to Australia?
	40	Male	After announcing his return	1.57 - 2.25	Lie	Obviously, the doping questions always come up, and you are doing more than anybody as an individual to proof to the world; This is what I am, this is what I can do.
	41	Male		4.07 - 4.35	True	Racing is about the start, are you starting to get a little bit nervous now? I mean, it has been a long time, how many days is it by the way
48. Charlie Rose - Lance	42	Male	After his cancer	0.04 - 0.50	True	If you could get them agree on an agenda; what would that agenda be?

Armstrong						
	43	Male	After his cancer	0.55 - 1.08	True	If you could get them agree on an agenda; what would that agenda be?
50. David Letterman, Lance Armstrong 09_26_08	44	Male	September 26, 2008	0.59 - 1.40	True	First of all, tell me your connection to the Clinton Global Initiative
	45	Male	September 26, 2008	1.49 - 1.54	True	Good for you, it's a huge commitment, I think, it seems like it is even greater and beyond what you already committed to do isn't it?
	46	Male	September 26, 2008	2.01 - 2.15	True	Good for you, it's a huge commitment, I think, it seems like it is even greater and beyond what you already committed to do isn't it?
	47	Male	September 26, 2008	2.21 - 2.39	True	Proposition 15, what is that?
	48	Male	September 26, 2008	3.07 - 3.31	True	How did this work, because we and everybody we talked to, we were pretty well convinced that you were done riding professionally competitively, so how did you think, hmm this is a good way to come back or reason to come back. Did you think, how can I expand this, make it global, can I do that to riding or was it how can I tie something to the riding to make it significant.
	49	Male	September 26, 2008	3.36 - 3.56	True	How did this work, because we and everybody we talked to, we were pretty well convinced that you were done riding professionally competitively, so how did you think, hmm this is a good way to come back or reason to come back. Did you think, how can I expand this, make it global, can I do that to riding or was it how can I tie something to the riding to make it significant.
	50	Male	September 26, 2008	4.27,5 - 5.03	True	What comes to my mind immediately is one, it will be great for cycling, to have as high a profiled champion back in the sport, that will be great. And two, more importantly, people, who have family and friends who suffer from cancer, will now get an inestimable, emotional boost from watching you competing the race all over the world.
	51	Male	September 26, 2008	7.21 - 7.50	True	Now, will you form your own team to compete, or is there a team you want to work with or how is that?
	52	Male	September 26, 2008	8.07,5 - 8.12	Lie	And what about the dynamic of, and it probably will occur, just given the way people tend to be, especially in this sport, they will say: 'oh sure, he is doing well four years later because he is using some mysterious chemical we cant test for', are you prepared for that?
	53	Male	September 26, 2008	8.59 - 9.10	Lie	It is crazy, it is sad, but it could likely happen

53. Interview with Lance Armstrong at the Radio Shack Camp	54	Male	Somewhere mid 2010 before the tour	0.25 - 2.46	True	A year ago, the comeback was sort of a theory, it hadn't actually happened yet, and you had something to proof after years of the bike and away from racing. I'm just wondering, a year later. Haven't been on the podium of the Tour, now a team is build around you, what the hunger is like, what the mentality is like and were you are mentally compared to a year ago.
	55	Male	Somewhere mid 2010 before the tour	3.46 - 5.12		You did not win the Tour de France, but you managed to become very popular here in France, what do you feel about that? Because it is an event.
65. Lance Armstrong - The Man Behind The Legend - Part 2_5	56	?	In his early early career	1.40 - 1.51	True	No question
70. Lance Armstrong & David Agus at TEDMED 2011	57	Male	2011	3.45 - 4.01	True	You started Lance Armstrong foundation, which evolves in Livestrong, and you do that for what reason?
95. Lance Armstrong interview pre-Oprah Winfrey on drug rumors (1999 unseen interview)	58	Male	1999	3.59 - 4.57	Lie	What about some of the statements that are written in Le Monde newspaper, that must have been really crazy with you.
110. Lance Armstrong Returns - Las Vegas Press Conference	59	None	September 25, 2008	4.30 - 4.50	Lie	No question - On doping usage in general in sports.
114. Lance Armstrong ride of a lifetime 2005 part 4	60	Male	2005	5.45 - 6.05	True	You said it a time before, what went through your mind; I lost the tour, I lost the tour…
115. Lance Armstrong ride of a lifetime 2005 part 5	61	Male	2005	5.15 - 5.26	True	No question - How much he loves the sport

	62	Male	2005	9.10 - 9.18	Lie	No question - On his speech after his Tour de France win
122. Lance Armstrong Statement At Tour of California On Floyd Landis Doping Accusation Part 1	63	Male	?	1.10 - 1.14	Lie	No question - 'We have nothing to say, we have nothing to hide' on his doping usage.
123. Lance Armstrong stumped at Team Radio Shack press conference	64	Male	?	0.38 - 0.44	True	Are you happy to be on an American team again?
124. Lance Armstrong talks about his battle with cancer	65	?	Just after hearing he has cancer	0.19 - 0.31	True	No question - Were you scared when you heard you got cancer?
163. Outside the Lines/ Was Lance Clean? (1 of 2)	66	Male	?	1.02 - 1.10	Lie	No question - Have u or your team ever used doping?
177. TribLive/ Lance Armstrong on the Doping Investigation	67	Male	?	0.30 - 1.18	Lie	What is going on with the doping allegations
196. Outside the Lines/ Was Lance Clean? (2 of 2)	68	Male	?	3.36 - 4.03	Lie	Do you worry about that yourself? (His performances are so outstanding that it is like 'giving birth to an alien baby').

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