Automatic Classification of Children’s Antisocial and Prosocial Lies Using Facial Expressions

by

Sarah Zanette

A thesis submitted in conformity with the requirements for the degree of Master of Arts
Graduate Department of Applied Psychology and Human Development
Ontario Institute for Studies in Education
University of Toronto

© Copyright by Sarah Zanette 2014
Automatic Classification of Children’s Antisocial and Prosocial Lies Using Facial Expressions

Sarah Zanette
Master of Arts
Graduate Department of Applied Psychology and Human Development
Ontario Institute for Studies in Education of the University of Toronto
2014

Abstract

Research on the nonverbal facial expressions of children during lie-telling is extremely limited. As such, it is unknown whether the nonverbal behaviours of children telling an antisocial lie are the same or different when they tell a prosocial lie. The current study is the first to concurrently examine the facial movements of children during antisocial and prosocial lying. Through the use of the Computer Recognition Toolbox (Littlewort et al., 2011), an automated computer vision program using the Facial Action Coding System (Ekman & Friesen, 1978), children’s nonverbal behaviours were shown to be significantly different in terms of 8 different facial actions. Furthermore, linear support vector machine (SVM) analysis was successful in classifying children’s lies with an average accuracy of 72.68%, significantly above chance levels. Implications and limitations are discussed.
Acknowledgments

There are many people who I wish to thank for their support in the completion of this thesis. First and foremost, I would like to express my deepest gratitude to my supervisor, Dr. Kang Lee, for his thoughtful guidance and comments and for playing a pivotal role throughout the completion of my Masters degree. Furthermore, I extend my great appreciation to Dr. Xiaoqing Gao, for teaching me how to use support vector machines and assisting me with the analyses. Additionally, I would like to thank Dr. Megan Brunet, who directed the parent project in which this work is based, as well as the members of the Child Development Research Group, in particular Sarah Bi, for their roles in data collection and preparing the videos for analysis.

Lastly, I thank the many friends and loved ones who have supported me throughout this past year and coached me through my most stressful moments. To my parents, thank you for always supporting my academic goals as I continue my journey onwards to the PhD level. To my partner, thank you for always believing in me.
Table of Contents

Acknowledgments ........................................................................................................ iii

Table of Contents ....................................................................................................... iv

List of Tables .............................................................................................................. vi

List of Figures ............................................................................................................ vii

List of Appendices ..................................................................................................... viii

Chapter 1 .................................................................................................................... 1

1 Introduction ............................................................................................................. 1

1.1 Nonverbal Behaviours During Deception ........................................................... 2

1.2 The Facial Action Coding System ....................................................................... 4

1.3 The Computer Expression Recognition Toolbox (CERT) .................................. 4

1.4 The Current Study ............................................................................................... 5

Chapter 2 .................................................................................................................... 7

2 Method .................................................................................................................... 7

2.1 Participants .......................................................................................................... 7

2.2 Setting .................................................................................................................. 7

2.3 Design and Procedure ........................................................................................ 8

2.4 Deception Scenarios ........................................................................................... 10

2.4.1 Antisocial lie-telling scenario ......................................................................... 10

2.4.2 Prosocial lie-telling scenario ......................................................................... 11

2.5 Analyzing Nonverbal Behaviour During Lie-Telling ......................................... 11

2.5.1 Computer Expression Recognition Toolbox .................................................... 12

2.5.2 Linear Support Vector Machine Classification .............................................. 14

Chapter 3 .................................................................................................................... 16

3 Results ..................................................................................................................... 16

3.1 Data Selection Criteria ....................................................................................... 16

3.2 Mean Intensity of Antisocial and Prosocial Lies ............................................... 17

3.3 Automated Classification of Antisocial and Prosocial Lies ................................ 17
# Chapter 4

## 4 Discussion

### 4.1 Summary of Findings

### 4.2 Observed Differences in Facial Expressions

#### 4.2.1 Smiling

#### 4.2.2 Expressions of Contempt

### 4.3 Automatic Classification of Lie-Type

### 4.4 Subtle Differences in Facial Movements

### 4.5 Spontaneous Expression

### 4.6 Limitations and Future Research

### 4.7 Conclusion

## References

## Appendix A

## Appendix B

## Appendix C

## Appendix D
List of Tables

Table 1. The codes and names of the AUs of FACS analyzed through CERT .........................13
Table 2. Comparing the mean intensity of each AU across lie-type. ..................................19
Table 3. Comparing the mean intensity of each Emotion across lie-type. .............................20
Table 4. Percent of times each AU and Emotion was chosen in the SVM .............................23
List of Figures

Figure 1. Room design at the research lab ................................................................. 8
Figure 2. Illustrations of linear SVM data classification .................................... 15
Figure 3. Significantly different facial movements across lie-type ...................... 21
Figure 4. Mean accuracy of the linear SVM ......................................................... 22
List of Appendices

Appendix A: Ethics Approval Letter .................................................................................. 35
Appendix B: Consent Form .................................................................................................. 36
Appendix C: Child Assent Form ........................................................................................ 38
Appendix D: Debriefing Procedure .................................................................................... 39
Chapter 1

1 Introduction

The current study investigated the effectiveness of an automated computer program, the Computer Expression Recognition Toolbox (CERT; Littlewort et al., 2011) in distinguishing between children’s antisocial and prosocial lies. Lying is known as a verbal statement made with the intention to deceive a listener (Bok, 1978). Antisocial lies, also known as “black lies”, are selfish lies told in order to conceal a misdeed. Whereas prosocial lies, or “white lies”, are lies told in order to spare another’s feelings. The ability to tell a lie is a part of typical development, with children demonstrating the ability to tell a lie as early as age 2 (Darwin, 1877; Evans & Lee, 2013; Harthshorne & May, 1928; Lewis, Stanger, & Sullivan, 1989; Newton, Reddy, and Bull, 2000; Talwar & Lee, 2002; Wilson, Smith, and Ross, 2003). Despite the fact that lying is an everyday occurrence, researchers have consistently demonstrated that adults tend to be highly inaccurate at identifying children’s lies, rarely performing above chance levels (Bala, Ramakrishnan, Lindsay, & Lee, 2005; Evans, Xu, & Lee, 2011; Talwar, Crossman, Gulmi, Renaud, & Williams, 2009; Talwar & Lee, 2002; Vrij, 2005). Even individuals who supposedly require greater lie-detection skills, such as police officers, lawyers, and social workers, as well as individuals who have a high degree of experience with children such as teachers, do not perform significantly above chance levels when identifying children’s lies (Bala et al., 2005, Bond & DePaulo, 2008; Ekman & O’Sullivan, 1991; Leach, Talwar, Lee, Bala, & Lindsay, 2004; Strömwall, Granhag, Landström, & 2007; Vrij, 2005). While there has been evidence to suggest that older children’s lies are more difficult to recognize than younger children’s lies, perhaps due to their increased cognitive development (Evans & Lee, 2011; Feldman, Jenkins, & Popoola, 1979; Talwar et al., 2009), there is a need for improved methods of identifying children’s lies using objective procedures.

In order for a liar to tell a convincing lie, they must monitor both their verbal and nonverbal behaviours, and adjust these behaviours to suit the context of the lie. Preschoolers are therefore very poor lie-tellers, and often “leak” incriminating evidence of their lie through verbal and nonverbal behaviours (Lee, 2013; Talwar & Lee, 2002). For example, a 3 year old may claim not to have peeked at an hidden object, but may then correctly identify the object during questioning, revealing that they had in fact peeked and then lied about their peeking behavior (Talwar & Lee,
2002). By school age, children’s lie-telling skills become more refined, along with the development of cognitive skills such as theory of mind and executive functioning (Lee, 2013), and children are able to tell increasingly sophisticated lies. However, research on children’s nonverbal behaviours during lie telling is limited.

1.1 Nonverbal Behaviours During Deception

In theory, telling a lie involves elevated arousal, cognitive load, and behavioral control, compared to when telling the truth (Vrij, 2008). As the speaker focuses on suppressing the truth in order to convey a lie, their attention to their nonverbal behaviors (i.e., facial expressions) is thought to decline. While telling a lie, an individual must monitor their facial expressions and body language while concurrently monitoring their language as they deliver the lie. Arguably, it is possible that this necessary “multi-tasking”, as Brinke and colleagues describe, results in the “leakage” of evidence that a lie is being told through one of these behavioral channels (Brinke, MacDonald, Porter, & O’Connor, 2012). As Ekman (1992) has theorized, nonverbal behaviours are most likely to provide cues to deception when the lie is either based on an emotion, especially the felt emotion at the time of a lie, or when the speaker experiences emotions from telling the lie itself; such as fear of getting caught in the lie or feeling guilty for being deceitful. However, it is important to note that Ekman (1992) has also argued that there does not exist a specific behavioural cue related to deceit on its own. That is, there is no such cue that is present only when a person is being deceptive and is absent in all other cases. Instead, cues to deceit will be uncovered based on the context of the situation. For example, if a person claims to like a meal prepared for them, but they do not smile when they say they are enjoying it, the absence of a smile may be the cue that they are being deceptive. Indeed, prior research has demonstrated that when adults’ lie-telling behaviors are analyzed in depth, nonverbal markers of deceit begin to emerge (e.g., Bartlett et al., 2008; Ekman, Friesen, & O’Sullivan, 1988; Littlewort, Bartlett, & Lee, 2009; Brinke et al., 2012).

One of the most common nonverbal behaviours individuals display to try to cover up when they are telling a lie is a smile. Arguably, a smile may be used to cover up just about any negative emotion – such as fear, anger, disgust, or sadness – that the lie must conceal in order to be believable (Ekman, 1992). Furthermore, a smile is also required in many social situations for politeness purposes, and in fact is often so automatic in these contexts that they rarely undergo
scrutiny in the context of politeness (Ekman, 1992). Moreover, even elementary school-aged children recognize that they should respond with a smile during certain social situations, such as when receiving a gift. Evidence suggests that children as young as age 3 use this knowledge in order to successfully lie by telling a gift-giver they like a gift when they actually do not like it (Talwar, Gordon, & Lee, 2007). Research on nonverbal behaviours during lie telling is considerably lacking in the child populations. Furthermore, it is highly likely that the cues of deceit regarding one type of lie are not the same cues for other types of lies, as they do not take place in the same social context.

Since research on nonverbal behaviours of deceit has not considered different types of lies concurrently, it is entirely unknown as to whether the nonverbal behaviours associated with deceit in antisocial lies are the same or different in prosocial lies. As lie telling takes place in a variety of social contexts, a liar must adjust their behaviours to suit the context if they want their lie to be convincing. Thus, it is plausible that lie-tellers display different facial expressions when they tell an antisocial lie compared to when they tell a prosocial lie. For example, when a child attempts to cover-up their own transgression with a lie, they must conceal any expressions of fear of getting caught and receiving punishment (e.g., Heyman, Sweet, & Lee, 2009). Conversely, in a prosocial situation where a child lies to a gift-giver upon receiving an undesired gift, the child would have to conceal any feelings of contempt over receiving a bad gift and express gratitude towards the gift-giver through happiness instead. Thus, it is possible that the facial expressions in antisocial lies differ from that of prosocial lies.

An important consideration to make when exploring the potential for facial movements to differentiate between lie-types, is that there are two distinct neural pathways that mediate facial expressions, each of which originate in a different area of the brain (Bartlett, Littlewort, Frank, & Lee, 2014; Littlewort et al., 2009). The first pathway concerns voluntary facial movements, which originate in the cortical motor strip and are voluntarily expressed in the face through the pyramidal motor system. In contrast, the second pathway concerns spontaneous, or involuntary facial expressions, and originate in the subcortical areas of the brain: These expressions are mediated by the extrapyramidal motor system (Bartlett et al., 2014; Littlewort et al., 2009; Rinn, 1984). Not only do these two pathways influence the types of facial expressions portrayed, but they also mediate both which specific facial muscles are moved, as well as the dynamics of those movements. (Bartlett et al., 2014; Ekman, 1992; Ekman & Rosenberg, 2005; Littlewort et al.,
Given the two different neural pathways for facial expressions, it is reasonable to expect to find differences between facial expressions while telling the truth compared to a lie - especially considering lying is thought to require greater cognitive effort than telling the truth (Williams, Talwar, Lindsay, Bala, & Lee, 2014). However, it is less clear whether differences between facial expressions during antisocial and prosocial lies exist. Considering telling a prosocial lie is often viewed more favorably than antisocial lie-telling by both children and adults (Bussey, 1999; Heyman et al., 2009; Peterson, Peterson, & Seeto, 1983), it is possible that the facial expressions that take place during a prosocial lie originate in one pathway, while facial expressions during an antisocial lie may originate in the other. Thus, it is crucial that the studies examining facial behaviours occurring in different lie-types is based on spontaneous examples of real lie-telling expressions, and is coded using an objective method.

1.2 The Facial Action Coding System

The Facial Action Coding System (FACS), developed by Ekman and Friesen (1978), is an anatomically based, comprehensive, and objective technique for measuring all observable facial movements (Ekman, Friesen, & Hagar, 2002; Ekman et al., 1988). FACS is used to measure the minute changes in muscular activity that produce momentary changes in facial appearance, as well as the intensity of those changes. Ekman and Friesen (1978) have termed these muscular changes Action Units (AUs), and have identified 46 action units to occur on the face, which roughly correspond to the individual facial muscles. FACS has been widely used across the behavioral sciences to code facial expressions, as it has proven to be highly useful for the study of the facial movements associated with cognitive and affective states (Ekman & Rosenberg, 2005). However, one major limitation to this system is that it is a hand-scored method of coding. Thus, it takes up to 100 hours of self-instructed training to learn and approximately two hours for a human expert to code each minute of video (Ekman and Friesen, 1978). Considering this limitation, researchers have developed methods to fully automate FACS using computer vision technology.

1.3 The Computer Expression Recognition Toolbox (CERT)

The Computer Expression Recognition Toolbox (CERT) developed by Littlewort et al. (2011) is a fully automatic, real-time software tool for estimating facial expression. CERT provides estimates of facial action intensity for 19 of the FACS Action Units, as well as probability
estimates for the 6 universally recognized emotions; happiness, sadness, anger, disgust, surprise, and fear (Littlewort et al., 2011). Additionally, CERT provides estimates for a neutral and contempt expression, as well the intensity of smiles. This smile detector achieves an accuracy rate greater than human coding (Littlewort et al., 2011). Overall, CERT has been shown to achieve an average recognition performance of up to 90.1%, and has been used to successfully provide accurate estimates of facial expressions in real-world settings, such as in the detection of driver fatigue (Vural, Cetin, Ercil, Littlewort, Bartlett, & Movellan, 2007) and genuine versus faked pain (Littlewort et al., 2009; Bartlett et al., 2014). In the latter study, adult participants faked facial expressions of pain, as well as experienced real pain during a cold presser task. The researchers then used CERT to differentiate expressions of real versus faked pain with an accuracy of 88%, significantly higher than chance predictions (Littlewort et al., 2009). The authors note that although accuracy with the automated system was below that of human expert coders, a major strength of the automated system is that it can be applied to large quantities of data in a mere fraction of the time (Littlewort et al., 2009). Thus, the current study will employ the Computer Expression Recognition Toolbox in the classification of antisocial and prosocial lies.

1.4 The Current Study

The aim of the current study was to investigate the effectiveness of the Computer Expression Recognition Toolbox (CERT) in distinguishing between children’s antisocial and prosocial lies. The ultimate goal of this research is not the detection of lies compared to truths, but is instead an important advance in lie-detection research; determining if lies can be differentiated based on nonverbal facial cues. Children aged 6-11 years old participated in two experimental paradigms where they were given the opportunity to tell an antisocial and a prosocial lie. The first lie-telling paradigm, the antisocial scenario, involved a situation where the child was asked to not peek at a bonus prize being wrapped for them. The child was then given the opportunity to lie about their peeking behavior. Telling a lie in this situation is considered to be antisocial, because the lie was used in order to cover up a transgression committed by the child. The second lie-telling paradigm, the prosocial scenario, took place at the end of the session: Children were given an undesirable gift (bar of soap) as a prize for their participation in the study and then asked if they liked their prize. This provided an opportunity for the child to tell a white lie by saying they like the gift, when they in fact did not like it. As Heyman et al. (2009) has demonstrated, children
who lie in this scenario likely realize that if they were to tell the blunt truth, and say they do not like the gift, the gift-giver may become hurt or upset. Thus, lying in this scenario is considered a prosocial lie because the speaker uses the lie to avoid hurting the gift-giver’s feelings.

Manipulation checks before and after the gift-giving paradigm were employed to confirm that the undesirable gift was in fact a gift the child did not like. The entire testing session was recorded via hidden cameras, and the lie-telling portions of the session were analyzed using CERT to explore two main research questions:

**RQ₁**: Are the facial expressions of children telling an antisocial lie the same or different as when they tell a prosocial lie?

**RQ₂**: Can CERT be trained to correctly identify whether a child told an antisocial or prosocial lie, using facial expressions alone?

In the examination of these two research questions, I hypothesized the following:

**H₁**: The facial expressions of children telling an antisocial lie will differ in mean intensity compared to children telling a prosocial lie for some, but not all, AUs and emotions.

**H₂**: Computerized machine learning using CERT will be able to correctly identify whether a child told an antisocial or prosocial lie significantly better than chance, using facial expressions alone.
Chapter 2

2 Method

2.1 Participants

The current sample of participants was drawn from a larger study of 134 typically developing children. However, since the study at large was not conducted for the purposes of analyzing nonverbal facial movements, video footage was only available for a subset of the sample. Thus, the present study was conducted with a total sample of 90 children between the ages of 6-11 years ($M = 105.60$ months (8 years, 8 months), $SD = 20.29$ months). Of this sample, 54.4% ($n = 49$) participants were male, and 45.6% ($n = 41$) were female. Participants were recruited from Toronto, Ontario, and the composition of ethnicity closely represented the demographics of the city of Toronto. According to parent ratings, 55.6% of the children were Caucasian, 6.7% were African Canadian, 10% were Asian, 2.2% were Latino, and 14.4% indicated another ethnicity. A total of 10 participants (11.1%) did not indicate their ethnicity.

2.2 Setting

Participants were tested at a research lab in a room containing four hidden cameras that captured the testing session from four different angles as well as sound. One camera was positioned on the table so that it focused on the child’s face, one captured their side profile, one captured the top of the table, and another captured their feet and gross body movements (Figure 1). The cameras were fed through a closed-circuit network to a control room across the hall where the video was recorded. In addition to the cameras already wired into the rooms, an additional camera was placed on the table and activated by the experimenter during key portions of the testing, in order to ensure that the child’s face was clearly captured.
One camera focused on the child’s face, one captured their side profile, one captured the top of the table and one captured their feet and gross body movements (See Figure 2.1.). The cameras were fed through a closed-circuit network to a control room across the hall where the video was recorded. At the Child Development Institute, the setup differed slightly with only two hidden cameras in the room, capturing the front and back of each child.

In addition to the cameras already wired into the rooms, an additional camera was placed on the table and activated by the experimenter during key portions of the testing in order to ensure that the child’s face was clearly captured.

Figure 2.1. Room design at the Child Development Research Lab

2.3 Design and Procedure

The current study received approval from the University of Toronto’s Ethics Review Committee (Appendix A) prior to data collection and contacting families. The study was in compliance with the ethical guidelines, and procedures were carried out in accordance with the ethics proposal. Parents were contacted by phone where the study was explained to them in full detail including the procedures, the purpose of the study, and about the use of hidden cameras. At the scheduled appointment, all parents completed a formal written consent form (Appendix B), and verbal assent was obtained from all children (Appendix C). At the end of the study session, all children were fully debriefed about the experimental procedures, including the use of hidden cameras, and were given an opportunity to ask questions about the design and purpose of the study (for details of the debriefing procedure, see Appendix D).

When parents arrived with their children to the lab, the child played with a research assistant (RA) while the main experimenter obtained written consent from the parent in a separate room. We employed this procedure for two main reasons; first, by limiting contact between the main experimenter and the child prior to testing, we were able to prevent a friendly or collegial bond from forming between the experimenter and child, as this could potentially influence the child’s truth and lie-telling behavior during the study session. Second, this gave the main experimenter an opportunity to show the parents the hidden cameras and address any of their concerns without
the child overhearing the conversation. After answering any questions the parent may have had regarding their child’s participation and obtaining consent, the main experimenter and parent proceeded to the waiting room where the RA was playing with the child. The researcher then obtained verbal assent from the child prior to beginning the study session, with the parent serving as a witness. Children were not made aware of the cameras until after the session during the debriefing period, to ensure their behaviors during the session remain as natural as possible.

The experimenter then asked the RA to show the child the testing room and the possible prizes they could win, and the parent was given several questionnaires to be completed while their child was participating in the study. As compensation for completing the measures package, parents were given a $10 gift card to one of four locations of their choosing (Tim Horton’s, Shopper’s Drug Mart, Walmart, and No Frills), and were compensated for their transportation costs (i.e., parking or public transportation fares).

In the testing room, the RA completed the first manipulation check to ensure the child did not like the gift they were to be given in the prosocial lie-telling scenario. The RA first showed the child four possible prizes they could win. Three of the prizes were seemingly desirable prizes for children (such as dolls and toy trucks), all valued at approximately $10 each, whereas one prize served as an undesirable fourth prize: a package of plain soap. The child was asked to tell the RA what gifts he/she would like, by ranking the items in order from the prize they liked the best to the prize they liked the least. The main experimenter listened to the child’s selection through the hidden cameras to be certain of the child’s ranking. Overall, 79% of the children indicated that they liked the soap the least, while 19% ranked the soap as their second to least favorite. No children listed the soap as their favorite prize. The RA then put away all prizes and asked the child to be seated at the testing table. This was the main experimenter’s cue to enter the room and begin the testing phase.

The overall study involved a series of cognitive tasks (not discussed in the current study) and two experimental scenarios (one antisocial lie-telling and one prosocial lie-telling scenario). The order of tasks remained constant for all participants so as to ensure that a comparable amount of time had passed before either of the lie-telling scenarios. This fixed order procedure is common in existing correlational studies to ensure statistical integrity (Carlson & Moses, 2001; Sabbagh, Xu, Carlson, Moses, & Lee, 2006).
2.4 Deception Scenarios

2.4.1 Antisocial lie-telling scenario

Studies using the traditional temptation resistance paradigm (e.g., Talwar, et al., 2007) have left children alone with instructions not to peek at a tempting toy while their behaviors were recorded via hidden cameras. While this paradigm has been used with children up to 11 years old, significantly fewer older children committed the transgression, potentially because it was not as motivating for them. Thus, modifications were made in the current study so that children would be more tempted to defy instructions and peek at the object, thus giving them an opportunity to tell a lie.

Approximately halfway through the testing session, children were told that they would receive a bonus prize for their hard work. The experimenter explained, “Before I give you your bonus prize, I want to wrap it up for you. I’m going to wrap it on the table. I want you to sit up straight, put your hands on the table, and close your eyes. I do not want you to peek at the prize while I am wrapping it. Ready?” The experimenter waited for the child to get in the proper position and repeated any instructions as necessary. Once the child was ready, the experimenter activated the additional hidden camera, which focused upon the child’s face in order to capture potential peeking behavior.

The experimenter then set a mug on the table in front of the child, in the middle of a piece of plain brown wrapping paper, with the handle pointing to the side so that it was clearly identifiable to the child. The mug was chosen as the prize because it is a common household item easily recognizable to the participants. The experimenter then pretended to look for tape to wrap up the gift, saying, “Where’s my tape?” to themselves, but in a voice audible to the child. The experimenter then said, “It must be over there” and walked to a bin located behind the child that contained several office supplies (See Figure 1). To reinforce the perception that they are positioned behind the child, the experimenter then created noise with the items in the bin for approximately 20 seconds ($M = 19.41$ seconds, $SD = 5.41$). This was so that the child had a sufficient opportunity to peek while the experimenter could not see their face and thus would be less likely to catch the child in the act of peeking. This also allows the experimenter to be blind to whether the child is lying or telling the truth. After 20 seconds, the experimenter then stated,
“Here’s my tape!” and walked back to the table to finish wrapping the item.

The experimenter then placed a large box over the mug to facilitate wrapping the item and help conceal its identity. The front flap of the box was cut out so that the child had a chance to see the item if they peeked while it was being wrapped for them. Once the prize was wrapped, the child was told to open their eyes, and the experimenter asked, “While I was wrapping the prize, did you peek?” After the child responded to the question, they were then permitted to open the prize. Afterwards, the mug was set aside and the testing session continued. At the end of the testing period, participants were debriefed regarding the purpose of the session and given an opportunity to exchange the mug for $1.

2.4.2 Prosocial lie-telling scenario

Similar to other prosocial deception studies, an undesirable gift paradigm was performed as the final task in the study. Children were told that for successfully completing the study, they would receive a prize. The experimenter said to the child, “I know that you selected a prize with (Research Assistant), but I picked out a prize for you before you got here.” The experimenter then gave the child a closed paper bag that contained a single bar of white soap. All children received the same prize. The experimenter then told the child, “I’m going to clean up the room, go ahead and open your prize”, and began to clean up the room without facing the child for 30 seconds. This was done to closely replicate previous studies where children were given undesirable gifts and briefly left alone in the room to allow the child to react to the prize (Talwar, et al., 2007).

Following the 30-second delay, the experimenter turned around and returned to their seat across from the child before asking the child the target question, “Do you like your prize?” Children who did not give a response, or who gave a non-committal response (e.g., “I don’t know”), were asked the question a second time. If the child still refrained from responding or giving a committal answer then the question was not asked a third time. As a final manipulation check, the experimenter asked the child if they wished to switch their awarded prize for one that they had previously selected. All children switched their prize, confirming that the original prize was something that they indeed disliked.

2.5 Analyzing Nonverbal Behaviour During Lie-Telling
To analyze participants’ facial expressions while telling each type of lie, footage from the camera placed on the table during the session was used, which provided a clear image of the participants’ face during the lie-telling scenarios. The frame rate of this camera was 24 frames per second. Footage from each participant was clipped into two different video segments using Adobe Premiere Pro CC®, in order to isolate the key areas of the lie-telling scenarios. Footage from the antisocial lie-telling scenario (ASL) began immediately after the experimenter asked the child, “While I was wrapping the prize, did you peek?” Whereas footage from the prosocial lie-telling scenario (PSL) began immediately after the experimenter asked the child “Do you like your prize?” In both cases, the video clip ended right before the child gave their response. The videos were clipped so that no dialogue was present in the video. This was done so that facial movements required for speaking did not influence the data. Thus, each video began immediately after the experimenter finished asking the child the target question, and stopped immediately before the child began to give a response (either verbal or nonverbal).

2.5.1 Computer Expression Recognition Toolbox

Videos were then analyzed using CERT software, which takes a video file through a series of steps before providing a frame-by-frame analysis of each video (for images see Littlewort et al., 2011). To detect and analyze each AU, CERT first employs a face detector to locate the face of the participant in the video. Next, the program locates a set of 10 facial features within the face region using feature-specific detectors (see Eckhardt, Fasel, & Movellan, 2009). These features are located on the inner and outer eye corners, eye centers, tip of the nose, inner and outer mouth covers, and in the center of the mouth. Each of these feature detectors provides a likelihood ratio that the feature is present at the detected location, which is then refined to precise locations. The locations of the 10 facial features are then used to provide a more precise location of the participant’s face than what was generated in the initially detected face. CERT then uses a method of feature extraction using Gabor filters to string together complex filter outputs into a single feature vector. This feature vector is then analyzed using a separate linear support vector machine (SVM; described in greater detail in the next section) for 28 AU outputs (see Table 1). These outputs can then be interpreted as estimates of the AU intensities, and are significantly correlated to the intensities of the facial actions measures of FACS intensity codes (Littlewort et al., 2011). Therefore, the intensities provide information on the dynamics of each facial action that would normally be impractical using manual FACS coding. When tested on two databases
of posed and spontaneous facial expressions, the authors report an accuracy classification rate of 90.10% and 79.90%, respectively.

In order to determine which emotions are displayed, CERT employs a second layer classifier on the generated AU intensity output. By inputting the final AU estimates (generated through the procedure just described above) into a multivariate logistic regression (MLR) classifier, CERT is able to provide a probability estimate of each emotion. When tested on a database of posed facial expressions, the authors report an accuracy classification rate of 87.21%.

In order to determine if the participant is smiling, CERT contains an extension module that enables users to encode the presence and intensity smiles. In this analysis, the smile detector uses the same procedure as the AU detectors just described, up until after the face registration stage. Then, the smile detector uses a different filter system then the one described above. Instead of using Gabor filters and SVM, the smile detector uses Haar-like box filter features and GentleBoost, to classify the based on whether a smile is present or not. This method was found to be faster and slightly more accurate then the method used for AU detection (for details, see Littlewort et al., 2011). The authors report a smile detection accuracy of 97.9%, using a dataset of 20,000 images of faces representing a wide variety of imaging conditions and geographical locations, and are highly correlated with human coding of smile intensity (Littlewort et al., 2011). Linear support vector machine (SVM) was then performed using CERT output to automatically classify children’s’ lies.

Table 1.

The codes and names of the AUs of FACS analyzed through CERT

<table>
<thead>
<tr>
<th>Code</th>
<th>Description of Action Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AU1</td>
<td>Inner Brow Raise</td>
</tr>
<tr>
<td>AU2</td>
<td>Outer Brow Raise</td>
</tr>
<tr>
<td>AU4</td>
<td>Brow Lower</td>
</tr>
<tr>
<td>AU5</td>
<td>Eye Widen</td>
</tr>
<tr>
<td>AU6</td>
<td>Cheek Raise</td>
</tr>
<tr>
<td>AU7</td>
<td>Lids Tight</td>
</tr>
<tr>
<td>AU9</td>
<td>Nose Wrinkle</td>
</tr>
<tr>
<td>AU10</td>
<td>Overall Lip Raise</td>
</tr>
<tr>
<td>AU10 L</td>
<td>Lip Raise on the Left Side</td>
</tr>
<tr>
<td>AU</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------</td>
</tr>
<tr>
<td>AU10</td>
<td>Lip Raise on the Right Side</td>
</tr>
<tr>
<td>AU12</td>
<td>Overall Lip Corner Pull</td>
</tr>
<tr>
<td>AU12 L</td>
<td>Lip Corner Pull on the Left Side</td>
</tr>
<tr>
<td>AU12 R</td>
<td>Lip Corner Pull on the Right Side</td>
</tr>
<tr>
<td>AU14</td>
<td>Overall Dimpler</td>
</tr>
<tr>
<td>AU14 L</td>
<td>Dimpler on the Left Side</td>
</tr>
<tr>
<td>AU14 R</td>
<td>Dimpler on the Right Side</td>
</tr>
<tr>
<td>AU15</td>
<td>Lip Corner Depressor</td>
</tr>
<tr>
<td>AU17</td>
<td>Chin Raise</td>
</tr>
<tr>
<td>AU18</td>
<td>Lip Pucker</td>
</tr>
<tr>
<td>AU20</td>
<td>Lip Stretch</td>
</tr>
<tr>
<td>AU23</td>
<td>Lip Tightener</td>
</tr>
<tr>
<td>AU24</td>
<td>Lip Presser</td>
</tr>
<tr>
<td>AU25</td>
<td>Lips Part</td>
</tr>
<tr>
<td>AU26</td>
<td>Jaw Drop</td>
</tr>
<tr>
<td>AU28</td>
<td>Lips Suck</td>
</tr>
<tr>
<td>AU45</td>
<td>Blink/Eye Closure</td>
</tr>
<tr>
<td>Fear Brow</td>
<td>AU 1 + 2 + 4</td>
</tr>
<tr>
<td>Distress Brow</td>
<td>(1, 1 + 4)</td>
</tr>
</tbody>
</table>

### 2.5.2 Linear Support Vector Machine Classification

Support Vector Machine (SVM) analysis is a useful technique for classifying data into various groups. The goal of SVM is to create a model based on a training data set that can then predict the target value based on a set of various test data attributes or features (Chang & Lin, 2011; Hsu, Chang, & Lin, 2003; Vapnik, 1995). In the current study, CERT data reflecting the observed intensities of AU s and emotions were used to train a linear SVM to predict a target classification of one of two lie-types; antisocial or prosocial. In order to ensure authenticity, SVM analyses require the overall dataset to be split up into two groups, creating a dataset for training the SVM model, and then an additional dataset to test the model’s accuracy (Chang & Lin, 2013).
To correctly classify the data into two groups, the linear SVM algorithm seeks to locate a linear separation between the two types of data points. To illustrate, see Figure 2a. Here, there are many ways in which a linear separation can be drawn to classify the data into two groups. However, the bold green line reflects the separation with the greatest distance between the line and each of the nearest data points; this linear classifier is called the optimal separating hyperplane. However, since most real-world data would not be subject to such clean classifications as in Figure 2a, a generalized optimal separating hyperplane (Figure 2b) is used. Thus, in locating the hyperplane with the greatest margin between itself and the nearest data points, the model is taught to achieve the greatest accuracy with the fewest misclassifications.
Chapter 3

3 Results

3.1 Data Selection Criteria

First, the videos of the 90 participants were screened to see whether or not their footage from either their antisocial or prosocial scenarios were suitable for the current experiment. In order for the video to qualify for CERT analyses, the child must be facing the camera with no objects obstructing full view of their face during the answering period. Therefore, videos where children turned around, stood outside of the frame, covered their face with their body or an object, or were looking sideways (showing their profile) during the entire answering period could not be analyzed. Videos from either the ASL or PSL scenario that met these requirements were then analyzed using CERT for the next stage of screening. A child did not need to have footage from both the ASL or PSL scenario to be included.

In the second stage of screening, the videos were screened based on frame rate. Due to the nature of the experimental paradigms, the number of available frames that CERT could analyze varied per participant, from 1 to 74 frames per video ($n_{ASL} = 55$, $m_{ASL} = 10.35$, $sd_{ASL} = 7.23$; $n_{PSL} = 58$, $m_{PSL} = 14.02$, $sd_{PSL} = 13.71$). This was due to two main reasons: First, since video was captured during a natural conversation between two people, and not time-regulated, response times for children to answer the target question varied. Second, in many cases an object partially obstructed the view of the child’s face during a portion of the answering period, or the child moved out of frame, preventing CERT analyses for some portions of the video. Since CERT conducts a frame-by-frame analysis, this meant that some participants had up to 74 data points for analyses while others had significantly fewer. Thus, in efforts to reduce variability, ASL and PSL data were each organized according to number of frames, and the middle 50% of the data from each condition was chosen for all subsequent analyses. Final data from the ASL videos ranged from 7-11 frames ($n = 28$, $m = 8.75$, $sd = 1.46$), and in the PSL videos ranged from 7-16 frames ($n = 29$, $m = 9.72$, $sd = 2.40$). A total of 47 participants make up this final dataset, as 8 participants had data from both the antisocial and prosocial lying scenarios. All children in this final sample lied during the answering period.
3.2 Mean Intensity of Antisocial and Prosocial Lies

To examine whether children display AUs and emotions with different intensity based on type of lie, CERT data from each AU and emotion was averaged to create a mean intensity score for each participant. Next, t-tests were conducted to compare the mean intensity of each AU/emotion in the ASL condition to the PSL scenarios. Of the 37 comparisons made, 8 were significant (ps < .05; See Tables 2 and 3, and Figure 3). Results show that when children tell an antisocial lie, their facial expressions show greater intensity in chin raise (AU17), lip pucker (AU18), and lip tightening (AU23), compared to when telling a prosocial lie. In contrast, children display greater intensity in upper lip raise (AU10 R), right dimpler (AU14 R), smile, and blink (AU45), and are more likely to display contempt when they tell a prosocial lie compared to when they tell an antisocial lie. Thus, an examination of each AU and emotion individually revealed support for the first hypothesis: The facial expressions of children differ based on when they tell an antisocial lie compared to when they tell a prosocial lie. However, these analyses only consider each AU and emotion individually. It is therefore beneficial to consider the 37 AUs and emotions together, as a whole, to examine whether predictions can be made regarding type of lie based on facial expressions alone.

3.3 Automated Classification of Antisocial and Prosocial Lies

Since t-tests were used to identify that ASL and PSL videos were significantly different in terms of 8 different AUs/emotions, it made sense to use t-tests to train a machine-learning program to identify antisocial and prosocial lies. A linear support vector machine (SVM; Chang & Lin, 2011) was used to perform pattern recognition on a collection of AUs and emotions, using a feature selection method. For this analysis, 80% of the data from each condition was used in the training stage, and the remaining 20% of the data from each condition was used to test the machine learning accuracy.

In the training stage, linear SVM was employed on the selected data, to identify the AUs and emotions that could be used to predict lie-type. Using t-tests, comparisons which reached significance at an average value of $p < .30$ over 10,000 iterations were selected for the testing stage. Predictive accuracy of the model was then assessed in the testing stage. Using the remaining 20% of the dataset, the linear SVM was then used to predict whether a child told an antisocial or a prosocial lie with a mean accuracy of 72.68% over 10,000 iterations. To estimate
the prediction value at chance level, the same analysis was conducted as above, but with the condition information randomized. As shown in Figure 4, results confirmed that the mean prediction accuracy of the experimental condition \((M = 72.68\%)\) was significantly greater than the randomized (or chance-level) condition \((M = 49.90\%)\), \(t(19998) = 112.0267, p < .001\), 95% CI \([22.38, 23.18]\). Thus, machine learning can predict whether a child told an antisocial lie or a prosocial lie significantly better than chance, based on facial expressions alone.

When designing the linear SVM program, certain AUs and emotions were chosen more frequently than others across the 10,000 iterations, indicating that some AUs/emotions are more important when identifying lie-type (Table 4). Several actions, such as the smile detector, right dimpler (AU14 R), chin raise (AU17), lip pucker (AU18), lip tightener (AU23), and blink/eye closure (AU45) were selected over 99% of the time, indicating that they are among the most important factors when distinguishing between antisocial and prosocial lie-telling. Conversely, other actions such as lip raise (AU10), left side lip corner pull (AU12 L), left dimpler (AU14 L), lips suck (AU28), and distress brow (AU1+2+4) were selected less than 9% of the time, indicating that they are among the least informative factors in the classification of children’s lies.
Table 2.

Results of the individual \( t \)-tests comparing the mean intensity of each AU across lie-type.

<table>
<thead>
<tr>
<th></th>
<th>ASL</th>
<th></th>
<th>PSL</th>
<th></th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
<td>( SD )</td>
<td>( t )</td>
</tr>
<tr>
<td>AU1</td>
<td>.54</td>
<td>.75</td>
<td>-.90</td>
<td>.82</td>
<td>1.72</td>
</tr>
<tr>
<td>AU2</td>
<td>.05</td>
<td>.50</td>
<td>-.27</td>
<td>.41</td>
<td>1.83</td>
</tr>
<tr>
<td>AU4</td>
<td>-.15</td>
<td>.22</td>
<td>-.07</td>
<td>.22</td>
<td>-1.31</td>
</tr>
<tr>
<td>AU5</td>
<td>-.30</td>
<td>.23</td>
<td>-.42</td>
<td>.25</td>
<td>1.78</td>
</tr>
<tr>
<td>AU6</td>
<td>.31</td>
<td>.28</td>
<td>.42</td>
<td>.38</td>
<td>-1.26</td>
</tr>
<tr>
<td>AU7</td>
<td>.17</td>
<td>.15</td>
<td>.23</td>
<td>.19</td>
<td>-1.21</td>
</tr>
<tr>
<td>AU9</td>
<td>.18</td>
<td>.06</td>
<td>.19</td>
<td>.08</td>
<td>-.71</td>
</tr>
<tr>
<td>AU10</td>
<td>-.21</td>
<td>.12</td>
<td>-.20</td>
<td>.14</td>
<td>-.28</td>
</tr>
<tr>
<td>AU10 L</td>
<td>-.37</td>
<td>.48</td>
<td>-3.46</td>
<td>.45</td>
<td>-1.94</td>
</tr>
<tr>
<td>AU10 R</td>
<td>-.41</td>
<td>.61</td>
<td>-3.80</td>
<td>.47</td>
<td>-2.13</td>
</tr>
<tr>
<td>AU12</td>
<td>-.01</td>
<td>.92</td>
<td>.22</td>
<td>1.04</td>
<td>-.90</td>
</tr>
<tr>
<td>AU12 L</td>
<td>-.37</td>
<td>.36</td>
<td>-3.72</td>
<td>.27</td>
<td>.01</td>
</tr>
<tr>
<td>AU12 R</td>
<td>-.38</td>
<td>.37</td>
<td>-3.69</td>
<td>.39</td>
<td>-.93</td>
</tr>
<tr>
<td>AU14</td>
<td>.59</td>
<td>.61</td>
<td>.74</td>
<td>.53</td>
<td>-.99</td>
</tr>
<tr>
<td>AU14 L</td>
<td>-.35</td>
<td>.62</td>
<td>-3.56</td>
<td>.51</td>
<td>.35</td>
</tr>
<tr>
<td>AU14 R</td>
<td>-.41</td>
<td>.70</td>
<td>-3.66</td>
<td>.77</td>
<td>-2.20</td>
</tr>
<tr>
<td>AU15</td>
<td>1.81</td>
<td>.61</td>
<td>1.68</td>
<td>.61</td>
<td>.83</td>
</tr>
<tr>
<td>AU17</td>
<td>1.14</td>
<td>.89</td>
<td>.53</td>
<td>.92</td>
<td>2.55</td>
</tr>
<tr>
<td>AU18</td>
<td>-.015</td>
<td>.02</td>
<td>-.025</td>
<td>.01</td>
<td>2.41</td>
</tr>
<tr>
<td>AU20</td>
<td>1.43</td>
<td>.42</td>
<td>1.58</td>
<td>.52</td>
<td>-1.15</td>
</tr>
<tr>
<td>AU23</td>
<td>1.34</td>
<td>.46</td>
<td>1.08</td>
<td>.34</td>
<td>2.38</td>
</tr>
<tr>
<td>AU24</td>
<td>-.03</td>
<td>.08</td>
<td>-.06</td>
<td>.08</td>
<td>1.49</td>
</tr>
<tr>
<td>AU25</td>
<td>.38</td>
<td>.57</td>
<td>.53</td>
<td>.63</td>
<td>-.93</td>
</tr>
<tr>
<td>AU26</td>
<td>.89</td>
<td>.40</td>
<td>.79</td>
<td>.41</td>
<td>.95</td>
</tr>
<tr>
<td>AU28</td>
<td>-.50</td>
<td>.43</td>
<td>-.46</td>
<td>.30</td>
<td>-.41</td>
</tr>
<tr>
<td>AU45</td>
<td>-.83</td>
<td>.40</td>
<td>-.23</td>
<td>.85</td>
<td>-3.43</td>
</tr>
</tbody>
</table>

Fear Brow  
-2.79  .37  -2.91  .35  1.21   .230  -.08  .31

Distress Brow  
-2.56  .40  -2.61  .40  .51   .614   -.16  .27

Smile  
-3.65  2.45  -1.32  3.40  2.98  .004*  -3.91  -.76

Note: * = Significant results, \( p < .05 \).
Table 3.

Results of the individual *t*-tests comparing the mean intensity of each emotion across lie-type.

<table>
<thead>
<tr>
<th>Emotion</th>
<th>ASL M</th>
<th>ASL SD</th>
<th>PSL M</th>
<th>PSL SD</th>
<th>t</th>
<th>p</th>
<th>95% CI Lower</th>
<th>95% CI Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smile</td>
<td>-3.65</td>
<td>2.45</td>
<td>-1.32</td>
<td>3.40</td>
<td>-2.98</td>
<td>.004*</td>
<td>-3.91</td>
<td>-0.76</td>
</tr>
<tr>
<td>Anger</td>
<td>.03</td>
<td>.05</td>
<td>.01</td>
<td>.02</td>
<td>1.69</td>
<td>.100</td>
<td>-0.00</td>
<td>0.04</td>
</tr>
<tr>
<td>Contempt</td>
<td>.25</td>
<td>.17</td>
<td>.36</td>
<td>.24</td>
<td>-2.03</td>
<td>.047*</td>
<td>-0.22</td>
<td>-0.00</td>
</tr>
<tr>
<td>Disgust</td>
<td>.00</td>
<td>.00</td>
<td>.01</td>
<td>.01</td>
<td>-1.98</td>
<td>.056</td>
<td>-0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>Fear</td>
<td>.04</td>
<td>.06</td>
<td>.03</td>
<td>.05</td>
<td>0.64</td>
<td>.525</td>
<td>-0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Joy</td>
<td>.04</td>
<td>.07</td>
<td>.11</td>
<td>.20</td>
<td>-1.72</td>
<td>.094</td>
<td>-0.15</td>
<td>0.01</td>
</tr>
<tr>
<td>Sad</td>
<td>.11</td>
<td>.14</td>
<td>.08</td>
<td>.15</td>
<td>0.81</td>
<td>.422</td>
<td>-0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>Surprise</td>
<td>.06</td>
<td>.13</td>
<td>.04</td>
<td>.08</td>
<td>0.80</td>
<td>.425</td>
<td>-0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>Neutral</td>
<td>.46</td>
<td>.19</td>
<td>.36</td>
<td>.22</td>
<td>1.91</td>
<td>.061</td>
<td>-0.01</td>
<td>0.22</td>
</tr>
</tbody>
</table>

*Note:* Mean values each of the emotions (anger, contempt, disgust, fear, joy, sad, surprise, and neutral) represent the average likelihood that the emotional was present. * = Significant results, *p* < .05.
Figure 3. The average intensities of each facial movement that was significantly different in the antisocial lie compared to prosocial lie. Error bars indicate standard error.
Figure 4. Mean accuracy of the linear SVM analysis compared to chance predictions. Error bars represent standard deviation.
Table 4.

Percent of times each AU and emotion was chosen in the linear SVM over 10,000 iterations

<table>
<thead>
<tr>
<th>AU/Emotion</th>
<th>% Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blink/Eye Closure (AU 45)</td>
<td>100.00</td>
</tr>
<tr>
<td>Smile Detector</td>
<td>100.00</td>
</tr>
<tr>
<td>Chin Raise (AU 17)</td>
<td>99.98</td>
</tr>
<tr>
<td>Lip Tightener (AU 23)</td>
<td>99.88</td>
</tr>
<tr>
<td>Lip Pucker (AU 18)</td>
<td>99.85</td>
</tr>
<tr>
<td>Dimpler on the right side (AU14 R)</td>
<td>99.02</td>
</tr>
<tr>
<td>Lip Raise on the right side (AU10 R)</td>
<td>98.42</td>
</tr>
<tr>
<td>Disgust</td>
<td>98.06</td>
</tr>
<tr>
<td>Contempt</td>
<td>97.74</td>
</tr>
<tr>
<td>Lip Raise on the left side (AU10 L)</td>
<td>95.82</td>
</tr>
<tr>
<td>Neutral</td>
<td>94.94</td>
</tr>
<tr>
<td>Joy</td>
<td>94.00</td>
</tr>
<tr>
<td>Outer Brow Raise (AU 2)</td>
<td>92.64</td>
</tr>
<tr>
<td>Anger</td>
<td>92.12</td>
</tr>
<tr>
<td>Eye Widen (AU 5)</td>
<td>91.72</td>
</tr>
<tr>
<td>Inner Brow Raise (AU 1)</td>
<td>88.63</td>
</tr>
<tr>
<td>Lip Presser (AU 24)</td>
<td>76.45</td>
</tr>
<tr>
<td>Brow Lower (AU 4)</td>
<td>62.32</td>
</tr>
<tr>
<td>Cheek Raise (AU 6)</td>
<td>60.86</td>
</tr>
<tr>
<td>Lids Tight (AU 7)</td>
<td>55.29</td>
</tr>
<tr>
<td>Fear Brow (1+2+4)</td>
<td>54.05</td>
</tr>
<tr>
<td>Lip stretch (AU 20)</td>
<td>48.93</td>
</tr>
<tr>
<td>Dimpler (AU 14)</td>
<td>35.07</td>
</tr>
<tr>
<td>Jaw Drop (AU 26)</td>
<td>32.52</td>
</tr>
<tr>
<td>Lip Corner Pull on the right side (AU12 R)</td>
<td>31.40</td>
</tr>
<tr>
<td>Lips Part (AU 25)</td>
<td>30.70</td>
</tr>
<tr>
<td>Lip Corner Pull (AU 12)</td>
<td>28.95</td>
</tr>
<tr>
<td>Lip Corner Depressor (AU 15)</td>
<td>25.08</td>
</tr>
<tr>
<td>Sad</td>
<td>20.44</td>
</tr>
<tr>
<td>Surprise</td>
<td>17.99</td>
</tr>
<tr>
<td>Nose Wrinkle (AU 9)</td>
<td>16.50</td>
</tr>
<tr>
<td>Fear</td>
<td>15.51</td>
</tr>
<tr>
<td>Distress Brow (1, 1+4)</td>
<td>8.46</td>
</tr>
<tr>
<td>Lips Suck (AU 28)</td>
<td>6.99</td>
</tr>
<tr>
<td>Dimpler on the left side (AU14 L)</td>
<td>4.19</td>
</tr>
<tr>
<td>Lip Raise (AU 10)</td>
<td>2.96</td>
</tr>
<tr>
<td>Lip Corner Pull on the left side (AU12 L)</td>
<td>1.71</td>
</tr>
</tbody>
</table>
Chapter 4

4 Discussion

4.1 Summary of Findings

The current study examined children’s nonverbal facial expressions while telling spontaneous antisocial and prosocial lies in two experimental paradigms. In an examination of each AU and emotion individually, results of the study revealed significant differences in the intensity of facial expressions of children when telling an antisocial lie compared to a prosocial lie, thus supporting the first hypothesis. In addition, when children’s facial expressions were examined together as a whole, CERT achieved a high success rate of 72.68% (significantly above chance-level predictions) accuracy in differentiating between antisocial and prosocial lies, supporting the second hypothesis.

4.2 Observed Differences in Facial Expressions

When the AUs and emotions of children’s facial expressions analyzed through CERT were examined individually, differences in antisocial and prosocial lies were found. Specifically, children’s facial expressions revealed that when they tell antisocial lies, children raise their chin (AU17), pucker their lips (AU18), and tighten their lips (AU23), to a greater average intensity compared to when they tell a prosocial lie. To illustrate these expressions, AU17, chin raise, is the action of pushing the skin of the chin upward, pushing on the lower lip into an inverse-U shape (Ekman et al., 2002). Meanwhile, AU18, lip pucker, takes place in the upper lip and draws the lips medially, pursing or puckering them, causing the lips to protrude, and lip tightener (AU23) occurs in the lip when the skin around the lips are tightened and thinned (Ekman et al., 2002). Each of these three actions appeared with greater average intensity during the antisocial lie. Thus, it appears that children display these behaviours as a reaction to having to cover up their undesirable behaviour of having peeked at a forbidden object.

In contrast, children raise their upper lip on the right side (AU10 R), dimple the right side (AU14 R), blink (AU45), smile, and show contempt with greater average intensity when they tell a prosocial lie compared to when they tell an antisocial lie. Upper lip raiser (AU10) occurs when the skin above the upper lip is pulled upwards and towards the cheek. This raises the upper lip
and may expose the teeth as well (Ekman et al., 2002). In this case, the action was only performed with a greater intensity on the right side of the lip. Dimpler (AU14) is the action when the skin beyond the lip corners is pulled inwards towards the lip corners, which are they themselves somewhat drawn towards the ears, tightening the lip corners. This can make the corners of the mouth appear turned upwards (Ekman et al., 2002). Once again, the action was only performed with a greater intensity on the right side of the lip during the prosocial lie. Blink (AU45) occurs when the upper lid is lowered and the upper lid is raised so that the two meet, but only for a brief period of time. This movement is different form eye closure (AU43 – not computed by CERT), which involves only the lowering of the top lid for more than half a second, while the bottom lid does not move (Ekman et al., 2002).

It is important to note that these results do not suggest that all of these actions necessarily occur at once in each individual, but that they appear with greater overall intensity in one type of lie over the other. Furthermore, recall that while comparing each facial movement individually can provide useful information regarding the average intensities of each action displayed between lie-types, this method does not take into account the entire face as a whole.

4.2.1 Smiling

As previously discussed, smiling is a common nonverbal behaviour during deceit, as individuals may use a smile to conceal a lie in a variety of social contexts (Ekman, 1992). Children in the current study displayed smiles with greater average intensity during the prosocial lie compared to in the antisocial lie. Yet, not all smiles are presented in the same way, and we were not able to examine whether the children displayed genuine felt smiles, or false smiles (Ekman & Friesen, 1982). As a result, our results may be interpreted in one of two ways. First, perhaps children’s increased smiling in the prosocial context reflects their understanding that a smile is often required in politeness contexts, and they use this knowledge to try and convince the gift-giver that they in fact like their gift, using a faked smile. Conversely, another explanation could be that even though the child may have been disappointed that they did not receive a desirable gift, they were still grateful to have received any gift at all, and their smile may in fact be genuine. Considering evidence from the $t$-test, where happiness was not found to be significantly different between lie-types, the former explanation seems more likely. However, results of the linear SVM analysis noted that when the entire face was examined as a whole, happiness was useful in the
classification of lie-type 94% of the time (Table 4), indicating that perhaps the overall pattern of happiness in combined with other features is more informative than its average intensity levels alone.

4.2.2 Expressions of Contempt

Contempt is defined as showing lack of respect or reverence for something, and is synonymous with feelings of distain (Merriam-Webster’s, n.d.). Research on the expression of contempt has provided strong evidence to suggest that the facial action of tightening and slightly raising the corner of the lip on one side (unilaterally; AU10 R), or more strongly on one side than the other, is a universal expression for contempt (See Ekman & Friesen, 1986 for images; Ekman & Heider, 1988; Matsumoto, 1992). When excluding a neutral expression and examining each of the 7 coded emotions, children displayed contempt the most frequently on average during each of the lie-telling scenarios. Prior research has consistently shown that children judge overall lie-telling as a morally wrong behaviour, yet, consistent with prior research, their actual lie-telling behaviours often did not match these standards (Bussey, 1999; Lee, 2013; Evans & Lee, 2010; Lewis et al., 1989; Peterson et al., 1983; Polak & Harris, 1999; Poplinger, Talwar, & Crossman, 2011; Talwar, Lee, Bala, & Lindsay, 2002). Thus, the contemptuous facial expression displayed by children while lying likely reflects their distain for being in a situation where know what they are doing is considered morally wrong. However, a contempt expression was more likely to occur when children tell prosocial lies (36%) compared to antisocial lies (25%), suggesting that children experience greater contempt when they claim to like a bad gift than when they try to cover up their own misdeed. Considering children, like adults, have been shown to judge antisocial lies as more negative than prosocial lies (Poplinger, Talwar, & Crossman, 2011), this pattern does not seem in line with the previous argument. Thus, instead of contemptuous emotions being directed inwards, to the children themselves, the greater contempt in the prosocial lie may reflect distain towards the experimenter. When a child is told they are to receive a gift, they are likely to get excited in the anticipation of receiving a new exciting item for them to enjoy. Thus, when they open up the wrapping to reveal a less-than satisfying object that they do not like, the child may experience feelings of contempt towards the gift giver for falsely getting their hopes up. This feeling of disappointment, when combined with feelings of distain for committing a morally corrupt behaviour, may explain why children displayed greater contempt in the prosocial lie compared to the antisocial lie.
4.3 Automatic Classification of Lie-Type

Using linear SVM, we were able to consider each facial movement at the same time, and classify videos of children telling antisocial and prosocial lies significantly above chance-level accuracy. As mentioned above, certain facial movements were more important than others when determining the correct lie-type classification (See Table 4). Unsurprisingly, the 8 actions that were found to be significantly different individually were useful in the SVM analyses over 98% of the time. A key strength of automated expression analysis is that, unlike the manual scoring of FACS, CERT can process large quantities of video data in a matter of minutes. Statistical pattern recognition on large quantities of data such as this would normally require hours of coding by human experts, and would be unattainable by the non-expert (Littlewort et al., 2009).

4.4 Subtle Differences in Facial Movements

The observed differences that differentiate antisocial and prosocial lies were discovered using a very small amount of data. Recall that each video clip analyzed through CERT lasted a mere 7-16 frames: At a frame rate of 24 frames per second, this meant that children lied within a mere fraction of a second of being asked the question. Remarkably, that small fraction of time was enough to determine the nonverbal differences in facial expressions during antisocial and prosocial lies with substantial accuracy. Though, it should be noted that the differences found between antisocial and prosocial lies were very few and subtle. These differences in facial expressions were only detected by an automated computer vision program the fine-grained analysis of FACS: Thus, the differences observed through this system may not be detectable by the average observer, and is unknown as to whether CERT would achieve an accuracy greater than human classification through observation. Future research should examine adult laypersons’ lie-type classification accuracy on children’s antisocial and prosocial lies, in order to determine the effectiveness of the automated program compared to adult laypersons’ judgments.

4.5 Spontaneous Expression

The lies told by the children in the current study were spontaneous. That is, children did not know the study was examining lie-telling behaviours, and their decision to tell a lie to the experimenter was an entirely unregulated and voluntary behaviour. This is an important strength considering the facial muscles associated with voluntary and involuntary movement originate in
different areas of the brain, which influence both the types of facial movements portrayed and their dynamics (Bartlett et al., 2014; Ekman, 2001; Ekman & Rosenberg, 2005; Littlewort et al., 2009). However, the spontaneous nature of the experimental lie-telling paradigms also presents a problem in regards to response times. That is, while the majority of children answered the experimenters question by lying within a fraction of a second, others took several seconds to respond. Though from a real-world perspective that is a short period of time, in a frame-by-frame analysis each second represents 24 data points, and thus the children who took longer to respond would have a greater influence on the results than the children who answered extremely quickly. To control for this variance we only the middle 50% of the dataset, eliminating the participants with the least and the most data points, which limited our sample size considerably. Future research would greatly benefit from a larger sample size, as this would expand the potential to discover patterns in lie telling considerably.

4.6 Limitations and Future Research

There are several limitations to discuss regarding the current study that will be addressed in future research. One major limitation was that we had to exclude a large amount of participants from the analyses. This was due to several reasons, one of which is that the camera placement was not ideal, and resulted in many cases where the child’s face was not in full view during the lie-telling portion of the experiment. Future efforts to analyze facial expressions during lie telling in experimental paradigms will use mobile cameras, hidden in the experimenter’s eye glasses, that can be inconspicuously adjusted by the experimenter during conversations with the child. In this way, the experimenter will be able to adjust the view of the camera so that objects do not block the camera’s view, and so that the child’s face remains in the frame of the camera during the entire lie-telling portion of the session. This would dramatically reduce the number of unusable videos in future studies.

Considering the remarkable success the current study had in differentiating between antisocial and prosocial lies though nonverbal facial expressions, despite its limitations, there exists tremendous potential for future research on nonverbal behaviours of deceit using automated systems. An important avenue to explore is how the age of the lie-teller may influence nonverbal behaviours during antisocial and prosocial lying. Considering the ability to tell a lie improves with age, it is likely that the facial behaviours of young children lying would differ from older
children, either in specific AUs or in overall intensity (Evans & Lee, 2011; Lee, 2013). By obtaining a larger sample size, machine learning may be conducted on various age groups to see if younger children’s lies can be distinguished from older children’s lies with the same level of accuracy. Furthermore, future research should examine adult populations telling antisocial and prosocial lies, to see if the same nonverbal cues emerge in each type of lie in adulthood as they do childhood. It is possible that adults may be so sophisticated in their lie telling abilities that CERT may not be able to recognize the differences between their antisocial and prosocial lies.

Future research is also needed to see if the nonverbal cues differ when applied to a lengthier lie. Since the current study merely required a child to make a single yes-or-no statement regarding whether they peeked at the prize or if they like their gift, the current findings may not extend to situations involving lengthier lie-telling statements, just as in child-witness testimony. Considering witness testimony requires one to answer several questions in an interview or to give a narrative account (Williams et al., 2014), the nonverbal cues present in these lie-types may differ than those in yes-no statements. Thus, future research is needed to determine whether CERT may be used on children’s testimony in courtroom situations.

### 4.7 Conclusion

The present study revealed for the first time that the facial expressions of children telling an antisocial lie are not the same as when telling a prosocial lie, and have demonstrated the ability for computer vision technology to correctly classify children’s lies based on facial expressions alone. While the differences observed in the current study were few and subtle, establishing that the facial expressions of children during deceit differ according to lie-type provides an important step in research on children’s nonverbal behaviours during deceit.
References


Appendix A

Ethics Approval Letter

UNIVERSITY OF TORONTO

OFFICE OF THE VICE PRESIDENT, RESEARCH

PROTOCOL REFERENCE # 25864

October 20, 2011

Dr. Kang Lee
DEPT OF HUMAN DEVEL. & APPL PSYCHOLOGY
OISE/UT

Dear Dr. Lee,

Re: Your research protocol entitled, “Deception in Children with Disruptive Behaviour Disorders”

ETHICS APPROVAL

| Original Approval Date: November 3, 2010 |
| Expiry Date: November 2, 2012 |
| Continuing Review Level: 2 |
| Renewal: 1 of 4 |

We are writing to advise you that you have been granted annual renewal of ethics approval to the above-referenced research protocol through the Research Ethics Board (REB) full board review process. Please note that all protocols involving ongoing data collection or interaction with human participants are subject to re-evaluation after 5 years. Ongoing research under this protocol must be renewed prior to the expiry date.

Please ensure that you submit an Annual Renewal Form or a Study Completion Report 15 to 30 days prior to the expiry date of your protocol. Note that annual renewals for protocols cannot be accepted more than 30 days prior to the date of expiry as per our guidelines.

Any changes to the approved protocol or consent materials must be reviewed and approved through the amendment process prior to its implementation. Any adverse or unanticipated events should be reported to the Office of Research Ethics as soon as possible. If your research is funded by a third party, please contact the assigned Research Funding Officer in Research Services to ensure that your funds are released.

Best wishes for the successful completion of your research.

Yours sincerely,

Margaret Schneider, Ph.D.,
C.Psych
REB Chair

Dean Sharpe, Ph.D.
REB Manager

OFFICE OF RESEARCH ETHICS
McMurrough Building, 12 Queen’s Park Crescent West, 2nd Floor, Toronto, ON M5S 1S8 Canada
Tel: +1 416 946-3273 • Fax: +1 416 946-5763 • ethics.review@utoronto.ca • http://www.research.utoronto.ca/for-researchers-administrators/ethics/
Appendix B

Consent Form

Dear Parent/Legal Guardian,

You and your child are invited to participate in a study looking at why children may lie that is being conducted by the Child Development Research Group at the University of Toronto and the Child Development Institute. This study involves a 1-hour session with your child as well as your participation in providing information on your child’s behaviour. Our goal is to gain a better understanding of how your child thinks, uses his/her memory, processes and organizes information during various situations in which some may lead to a possible lie-telling.

In this study, your child will participate in interactive games with our researchers and will be informed that for some games they will receive a prize for completing the task and for others they will not. Your child will also be encouraged to take part in an activity that they were previously asked not to do. Your child’s behaviour and responses to questions about this activity will be recorded with several hidden cameras. Your child will also participate in a variety of memory, organization and language activities. We would also like to gain an understanding of your child’s behaviour in multiple settings. Thus, in addition to your ratings of their behaviour at home, we would like to send a brief questionnaire to his/her teacher.

Participation in the study is completely voluntary. You or your child may withdraw from the session at any time, for any reason, without loss of compensation, which will be given to all children regardless of performance or completion of tasks. Risks to participants are considered. We will explain the study in more detail to your child at the end of the session. In addition to keeping this consent form, you will also receive a form that includes a detailed explanation of the study’s purpose and our contact information should you have any questions or concerns.

The information gathered for the study is confidential, except as required by law and is secured at the Institute of Child Study. All gathered information will be combined with data collected from other participants and only group norms will be reported. Please feel free to call Dr. Kang Lee at (416) 934-4597 if you have any questions about the study. You may also call the Ethics Review Office at (416) 946-3273 to inquire about your child’s rights as a research participant, or to report research-related problems.

Sincerely,

Dr. Kang Lee
Professor & Director
OISE/University of Toronto
Phone: 416-934-4503
Email: kang.lee@utoronto.ca

Megan Brunet
Graduate Research Assistant
OISE/University of Toronto
Phone: 416-934-4503
Email: megan.brunet@utoronto.ca
Having read the enclosed materials, I (check one):

____ Allow my child to participate  ____ Do not allow my child to participate

Child’s name: ______________________  Child’s birth date: ____________ (day/month/year)

Mailing Address: __________________________  Phone # ____________________

_________________________  Email: __________________

In order to gain a complete understanding of my child’s behaviour, I understand that my child’s teacher will be contacted to complete a questionnaire. I understand that my child’s teacher will not be informed of how my child performs in this study.

____ I consent to my child’s teacher being contacted  ____ Do not contact my child’s teacher

Teacher Name: __________________________________________

Contact info (email address, phone number, school name, etc):
________________________________________________________________________

Parent/Guardian signature: ___________________________  Date: _________________

I would like to ask your permission to use your child’s video tape in a future study. This study will involve adults viewing many video clips from the present study and attempting to determine if the child is lying or telling the truth. The following standards apply to these videos:
1) No identifying information about me or my family will be available to viewers or published without my permission.
2) Recordings are available for my viewing and will be erased at my request.
3) Recordings will NOT be used for television or internet broadcasts.
4) Videos are kept on password protected electronic storage and will be destroyed in 7 years.

Please feel free to ask us for more information about this study.

___ Yes, my child’s video may be used in a future study  ___ No, my child’s video may not be used in your future study

Parent’s/Guardian’s signature: ___________________________  Date: _________________

Please provide your contact information if you would like a summary of the results:

c) Same as above

Mailing Address: ___________________________  Email: __________________

Would you be willing to have us contact you at a later time for related research?

_____ YES  _____ NO

If yes, please provide your contact information (if not provided above)

c) Same as above

Mailing Address: ___________________________  Phone #: ____________________

_________________________  Email: __________________
Appendix C

Child Assent Form

You understand that you are being asked to help with a study where you will play many different games, like games with numbers, words and pictures. You do not have to participate if you do not want to. Being in this study is up to you and no one will be upset if you don’t want to participate, or if you change your mind and want to stop. You know that you can ask any questions, take a break if you need to, or you can stop participating at any time for any reason.

Signature of an adult witness ________________________ Date _______________
Appendix D

Parent and Child Debriefing Procedure

Parents and children will be debriefed separately, given an opportunity to ask questions, and then be reunited. Once together, parents and children will have an additional opportunity to ask questions. Though they will be debriefed separately, both debriefings will follow the same general format and be developmentally appropriate:

**Purpose of the study**

Children and parents will be informed of the purpose of the study. We will explain that we asked the other research assistant to play with games in the red bin that the child was not supposed to play with. We will state that we want to know what children would do when they break a rule and think that there might be consequences, like not getting a prize. We will explain that some of the boys and girls who break the rules tell us the truth, and some do not. We will assure the child that no one did anything wrong; these games were for fun and this was a special situation.

**Video cameras**

We will show children the video cameras and discuss the purpose of them. We will reassure participants that no one will be able to see these videos without permission. We will also inform participants that we will erase the DVD recording within seven years.

**Previous findings**

The experimenter will explain to children (and their parents) the general findings of earlier studies using the same procedure. For example, we will tell children that sometimes boys and girls do not tell the experimenter that they played with the games and sometimes boys and girls tell the experimenter that they did. We will also tell the child that the games we play are special, because we are only playing games. However, we will also tell children that it is not always a good idea to pretend they didn’t do something they really did. Noting the difference between our experimental situation and the child’s life outside the laboratory will allow us to begin discussing situations in which lie-telling may be a good/bad idea. We will also discuss with the children (and their parents) about the contexts in which truth-telling is expected. For example, we may talk with the child about how lying about doing something bad might get them into more trouble; they might get into trouble for committing some kind of transgression and also for lying about it. Historically, this discussion is difficult to script exactly the same for each child, as parents often contribute by providing examples of the child’s life at home and situations in which the child’s lie-telling or secret-keeping may have been a good decision or a bad decision.

**Contact information**

We will give a debriefing document to parents (see brochure following this page). Parents will be informed of the person and phone number to contact should there be any concerns or questions. Parent will also be asked for their oral permission to include their names and information (i.e., contact information, name, date of birth, and sex of child(ren), languages spoken) in our participant database.