The Bodily Movements of Liars

Natasha M. Eapen (nme@eyethink.org)
Sam Baron (sambaron@ eyethink.org)
Chris N.H. Street (chris@eyethink.org)
Daniel C. Richardson (dcr@eyethink.org)
Cognitive, Perceptual & Brain sciences, University College London
Gower Street, London WC1E 6BT, UK

Abstract

We measured the continuous bodily motion of participants as they lied to experimenters. These lies were spontaneous rather than elicited, and occurred for different motivations. In one situation, participants were given the opportunity to lie about their performance on a maths test in order to win money. In another, they witnessed one experimenter accidentally break a laptop. When asked what had happened, participants were motivated to lie and deny any knowledge. Across these situations, participants lied 61% of the time, allowing us to contrast the body movements of liars with truth tellers as they answered neutral and critical questions. Those who lied had significantly reduced bodily motion. In one case this motion appeared before the experimenter had even asked the critical question. We conclude that a person's bodily dynamics can be indicative of their cognitive and effective states, even when they would rather conceal them.

Keywords: deception; social cognition; action; body motion

Introduction

While running in between parallel sessions at the next Cognitive Science conference, you catch the eye of a colleague from your university. They smile and ask what you thought of the talk they gave that morning, the one you promised to attend. Since you know that the sessions were both crowded and dimly lit, you take a chance, smile, and say, 'Of course I was there. It was fantastic, as always." Will they believe your deliberate falsehood? What in your choice of words, gestures and behaviour will make you sound either convincing or conniving?

The good news for you is that it is very unlikely your colleague will be able to tell that you are lying. Regardless of their training or self belief, people are able to detect deception in others at only a fraction above chance levels (Bond & DePaulo, 2006, 2008; DePaulo, Stone, & Lassiter, 1985; Köhnken, 1987; Vrij 1993, 2000). The bad news for your colleague, professionals who need to know if people are lying, and those studying deception is that many researchers have found no unique and reliable behavioural signature for deception (Vrij, 2008; Ekman, 1992; Buller & Burgoon, 1996; DePaulo et al., 1985, 2003).

One reason is that deception is a daily activity and a diverse phenomenon (DePaulo et al., 1996). Sometimes a lie means making up a story, sometimes it means a simple denial. Lying can be done out of kindness or out of self interest. It can have different consequences and place different emotional and cognitive demands on the liar (Vrij & Mann, 2004).

It may not be surprising, then, that a clear link between deceit and bodily activity has proven elusive (DePaulo et al., 2003). Whilst some researchers have demonstrated increased movements of the fingers, arms, hands, legs and feet whilst deceiving (McClintock & Hunt, 1975), even if only anecdotally (Porter & ten Brinke, 2009), others report decreased limb movements (Vrij, 2008).

Set against this long tradition of deception research are more recent findings in cognitive science regarding the relationship between motor control and cognitive processing. Thinking about the past versus the future shifts the direction that your body tilts (Miles, Nind, & Macrae, 2010) moving marbles upwards rather than downwards changes the emotional content of the memories you recall (Casasanto & Dijkstra, in press), swaying in time with another person and mimicking their actions they make causes you to like each other (Chartrand & Van Baaren 2009), and how you move your mouse cursor when asked 'Do you like Black people?' reveals the influence of negative stereotypes (Wojnowicz et al., 2009). Many of these recent findings rely on fine grained, continuous measures or manipulations of motor activity, rather than discrete, categorical behaviours such as button presses (see Spivey, 2007 for a motivation). Is it possible to use these continuous methods to detect a behavioural signal to deception?

Recently, Duran, Dale & McNamara (in press) adapted a standard paradigm in deception research, and asked people to respond yes or no to certain questions about themselves. They were instructed to give false answers in some cases and truthful answers in others. In this experiment, they signalled their responses using a Wiimote-controller that translated their hand movements into movements of a cursor. They found that deceitful answers had a characteristic movement trajectory, with increased complexity and competition from other responses. This exciting evidence suffers from only one flaw - it is rare that people ask us to lie to them. Regardless, Duran et al's findings suggest that perhaps there is more in motor behaviour than has typically been measured by deception researchers.

In deception research, bodily behaviour is usually videotaped and coded by experimenters. However, this is a laborious, costly and inaccurate method as reliability between coders must be established, extensive training can be necessary and only bodily movements discernible to the human eye can be analysed. Furthermore, because it is necessary to be selective in such a coding method, it requires an understanding of what bodily movements are potentially interesting to examine before it is possible to begin coding. As we have noted, the consensus is that there is no reliable behavioural profile for deceit. An ideal, for

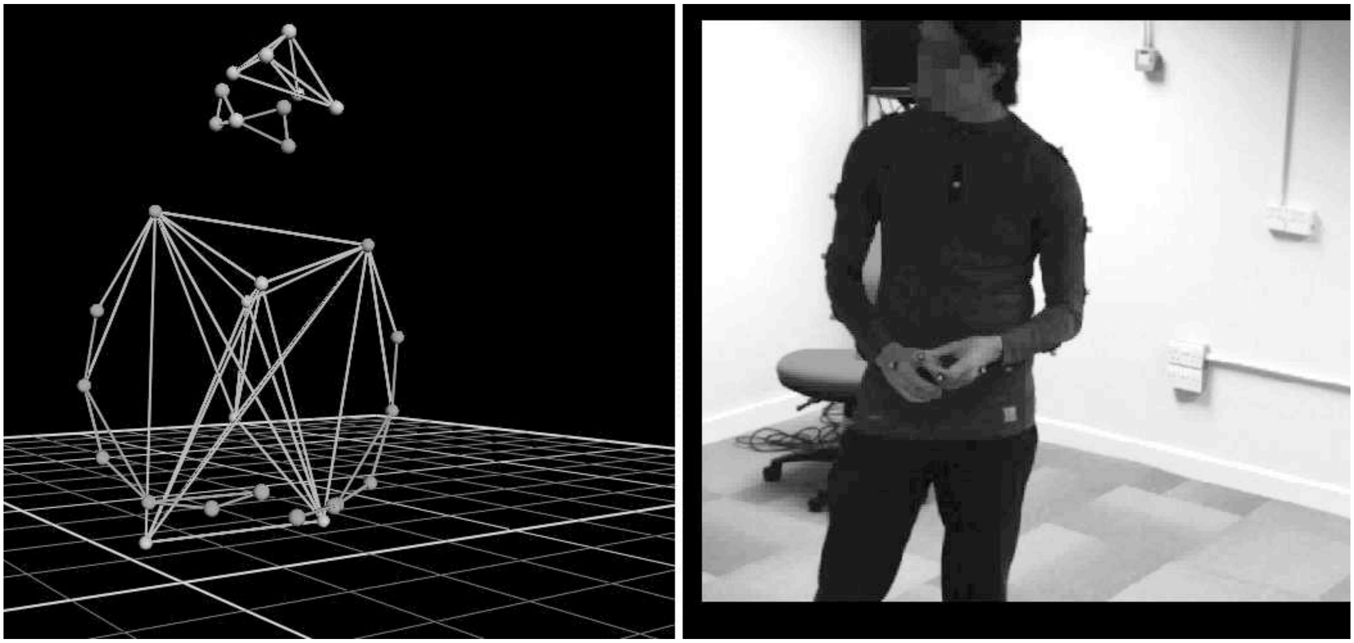

Figure 1. A participant wearing the motion tracking shirt and hat (right) and the 3D position of the markers reconstructed by the motion tracking system (left)

both practical and theoretical goals, is an automated system which will record accurate bodily changes and provide an objective approach to the study of deception (Burgoon et al., 2005; Vrij & Mann, 2004). Such a method, we believe, must be able to maintain the complexity of continuous variables.

Our goal in this experiment was to use continuous, objective measures of the bodily activity of participants who were engaged in spontaneous deceptive behaviour. Participants were told they were in a study about posture and mental arithmetic. This gave us an excuse to measure their body position at 24 locations 200 times a second. It also provided the opportunity for them to lie. We offered them £5 for improving their score in a second round of the maths test. Although the task became much harder, so that score was most likely to decrease, only the participants could know how well they had performed. Therefore, participants were given the opportunity to tell a lie for a monetary reward, without the risk of being caught out.

During the experiment, the participants witnessed the junior experimenter accidentally knock a laptop off of a table. The laptop belonged to a senior experimenter who was absent at the time. Later, when he was unable to turn on his laptop, he asked the participants if they had seen anything happen to it. The junior experimenter was very friendly and the senior experimenter quite unpleasant, and we assumed that this would provided a second motivation to deceive. We hoped that the participants would be motivated to cover up for her, and falsely deny knowledge of the incident. During these moments, when participants thought that the real experiment had finished, and when they could freely chose to tell the truth or lie, we captured their bodily motion.

Methods

Participants

32 participants took part in two experiments, run in a single session. They were UCL students or members of UCL's subject pool, and received course credit or a payment for their participation. There were 20 females and 12 males, with a mean age of 22.5 years old.

Apparatus

The experiment took place in UCL's Multimodal Lab. Six high speed infrared cameras were mounted on a rail around the perimeter of a 5m square area. Participants wore a tight, stretchable shirt and a cap which had 20 plastic markers arrayed over them (see *Figure 1*). The markers were approximately 2cm in diameter and are highly reflective in infrared light. Additional markers were attached to the hands, tips of the index fingers and the face. Image data from the cameras was passed to the Vicon Nexus motion tracking system at a rate of 200 Hz. The 3D position of each marker was reconstructed with an accuracy of 0.1mm. A digital camera recorded a view of the participants' actions, and a *ladybug 2*, 360º panoramic camera recorded all events in the lab. A ceiling mounted omnidirectional mic provided a sound recording. Participants carried out the experiment sat 50cm or stood 200cm away from a Mac laptop.

Procedure

Participants were told the study was investigating the relationship between body sway and mathematical ability. After donning the motion capture clothes, they stood in a T-pose with arms outstretched for a brief calibration recording.

The participants then took part in a simple maths test. After the experiment they were debriefed to the true aim of the study, and gave additional retrospective consent with the option to withdraw their data, which none chose to do.

Three experimenters ran the study. One operated the motion tracking systems and did not interact with the participant. The other two experimenters dealt with the participants according to a well rehearsed script. The senior, male experimenter acted in a cold and unpleasant manner throughout. The junior female experimenter, who was an undergraduate like the participants, was friendly and engaging. The experimental procedure was designed to put participants in two situations in which they might chose to lie spontaneously to the experimenters. For clarity, we will describe those two situations separately, even though the events they describe partially overlapped with each other. In each, motion is captured in two periods: as the participants reply to a neutral question, and as they reply to a question that has a motivation for deception. Participants were unaware that each of these periods were the critical portions of the experiment and that their behaviour was being recorded.

The Maths Test Following calibration, participants were seated at a table and given a maths test on a laptop. There were 30 multiplication questions with three multiple choices. Participants had a limited time to respond and were given feedback on their answer. A pilot test showed that people scored around 75% on the test.

After completing the test, participants were shown their score. The junior experimenter told them that they were now required to repeat the test, but this time standing up while the motion tracking system measured their balance. She explained that our hypothesis was that standing would improve maths performance. She said that was what we had found so far, and hoped to prove conclusively. In violation of good experimental practice, she deliberately increased the demand characteristic of the 'experiment' by telling participants how they should perform. In addition, she explained that participants would receive a £5 reward if their results followed the hypothesised pattern and they scored better while standing.

The participants were told that since they were standing out of reach of the keyboard, they couldn't enter their answer. They were instructed not to voice their answers aloud but keep count of how many they had calculated correctly. The time given for participants to respond in the standing phase gradually reduced. Norming tests confirmed that this made the test considerably harder, but since they were not inputting their answers, only the participants themselves could ever know their score on the standing phase.

Once they had completed the study, the junior experimenter asked two questions, with the order counterbalanced between participants. The neutral question was "Did you feel the second stage took more or less time to complete?" The critical question was "Did your performance improve on the second test?". Participants' body motion was captured from the time she began asking the question to the end of their reply.

Participants who answered 'yes' to the critical question received their £5 reward and were categorised as liars. Even though it is possible that the participants scored higher on the second test, the increased difficulty made this unlikely. Therefore overall, we assumed that people who said yes were more likely to be deceptive than those who said no.

The Accident At the start of the experiment, while the participant was signing the consent form, the senior researcher precariously placed a laptop down on a table saying, "I've got that report of yours on my laptop. Remind me about it at the end". After the first stage of the maths test, the senior experimenter left the lab and the junior experimenter prepared them for the standing phase. While walking backwards, the junior experimenter knocked into the laptop that had been left on the table edge, and sent it crashing to the floor. She exclaimed loudly, made eye contact with the participant and said, "Thank God the cameras were off". Therefore, only the participant witnessed this 'accident'.

After the second maths test, the senior experimenter came back to the lab and told the participant that he needed to take a backup copy of the data. While the junior experimenter was stood in a corner of the lab preparing herself to leave, he asked the participant the neutral question, "Did the maths experiment run okay?" He then opened his laptop and attempted to turn it on without success. He then turned to the participant and asked the critical question, "Did you see anything happen?" During both questions and the participant's replies, their body motion was recorded. Participants were categorised as liars if they denied knowledge about the incident, and as truth tellers if they made any reference to the accident or the junior participant.

Debriefing Following the experiment, participants were fully debriefed about the true nature of the experiment and asked if they suspected that deception was being investigated. We framed all their behaviour in a positive light. For example, if they chose to deceive the senior experimenter about the accident, we referred to this as their choice to 'protect' the junior researcher. Contact details of psychological services were provided in the event that they felt concerned about deceiving or being deceived.

Data Analysis

Marker positions were reconstructed offline using the Vicon Nexus software. Standard procedures were used for identifying markers and excluding noise. For each marker we calculated the distance it moved in 5msec. We summed those values for series of 20 frames to get the total number of millimeters travelled in each 100ms period. Finally, across every marker and across every 100ms period during the data capture, we averaged those values. Our measure of general body motion is operationalized as the average distance in millimeters that a marker traveled every 100ms.

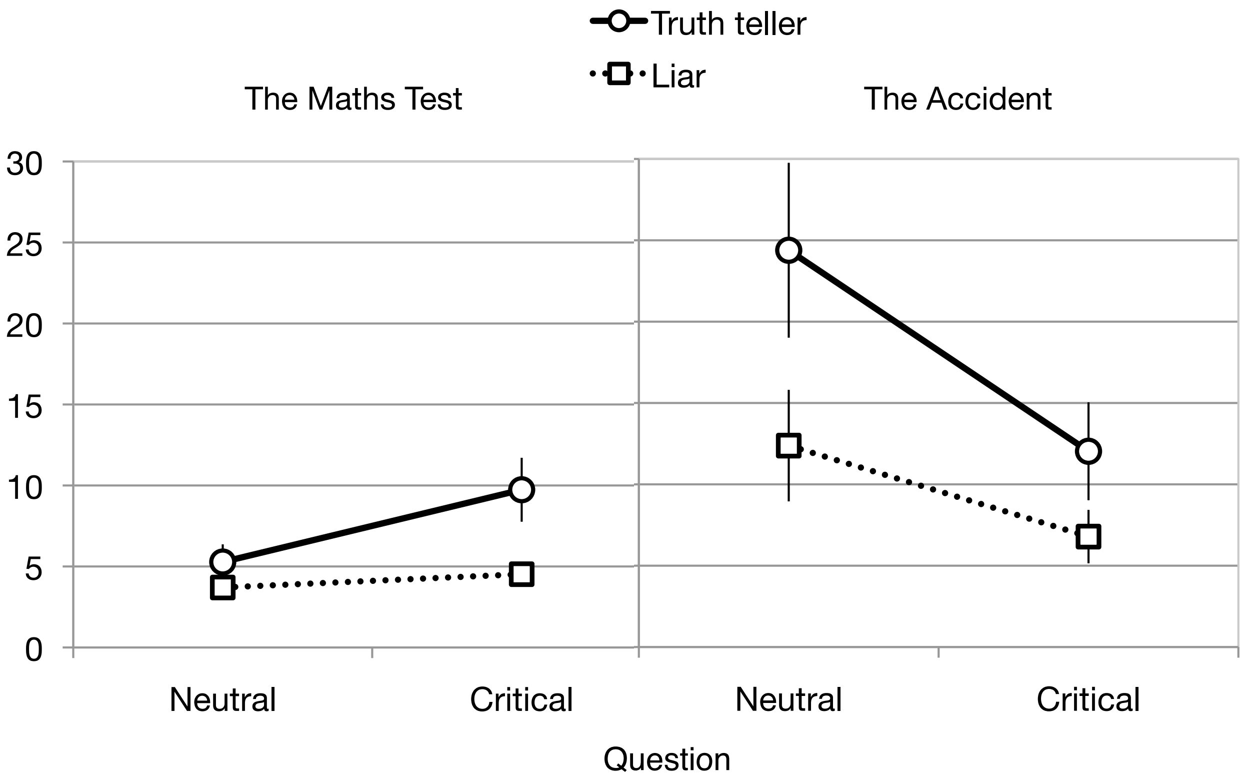

Figure 1. Total upper body motion during neutral and critical questions in the maths test and accident situations

Results

Participants data was discarded if they guessed our real hypothesis, in cases of experimenter error or deviations from the script. The complexity of the equipment and the spontaneous nature of the behaviour meant that data loss was a risk in this experiment. In the event, 34 (out of 128) trials produced unusable data. Since a full analysis of the data would require that we have data for all four periods for all subjects, we carried out planned comparisons on the maths deception and the accident data separately, giving us 18 and 23 subjects respectively. However, the same pattern of means and significance was still found when we analysed the smaller set of 16 subjects who had a full set of data for each cell.

This study is a quasi experiment, as participants placed themselves in the truth or lie conditions rather than being assigned. Overall, they chose to lie 61% of the time, allowing a between subjects comparison of the body motion of truth tellers and liars. Body motion data were analysed in a 2 (deception: truth teller/liar) x 2 (question type: neutral/critical) ANOVA.

The Maths Test

Participants moved less if they attempted to deceive the experimenter and lie about their maths score. They moved more when asked the critical question than when asked the neutral question, though the difference between truth tellers and liars was greater in response to the critical question. This pattern of results is shown in panel A of *Figure 2*, and supported by a main effect of deception ($F(1,21)=7.97$, $p=.01$), a main effect of question ($F(1,21)=9.04$, $p=.007$) and a significant interaction ($F(1,21)=6.24$, $p=.021$). Post hocs show that the participants did not significantly differ in their motion in response to the neutral question, but moved significantly more when telling the truth in response to the critical question.

The Accident

Participants moved less if they attempted to deceive the experimenter and deny knowledge of the accident. They also moved less overall in response to the critical question. This pattern of results is shown in panel B of *Figure 2*, and supported by a main effect of deception ($F(1,21)=7.97$, $p=.01$) and a main effect of question ($F(1,21)=9.04$, $p=.007$). The interaction was not significant ($F(1,21)=1.11$).

General Discussion

When people spontaneously lied to us, they reduced their bodily motion. Behind this simple finding, robustly supported by our data, lie two more nuanced stories. One concerns the directionality of the relationship between body motion and deceptive behaviour. The other concerns the difference between the two situations and the two types of lie.

In the maths test, there was no obvious negative consequence to the participants' lie. The junior experimenter gave clear signs that she would prefer a particular answer, and participants were given a monetary reward for providing it. It was clear from the situation that there was no way in which participants could be found out if they lied, since they could be the only people who knew the truth. Therefore, participants had everything to gain and nothing to lose by lying. In this situation, participants' body motion was not different in response to the neutral question, but those who chose to lie for the reward showed less motion when answering the critical question.

This result aligns with other findings (Vrij, 2000) that during cases of deception, bodily motion can decrease. One explanation is that even though there is no logical way that another person can know that we are telling a lie, we suffer from an 'illusion of transparency' (Gilovich, Medvec & Savitsky, 1998). We are prone to thinking that since our own internal mental states are highly salient to us, they must be at least partially visible to others. Therefore, when we think about something that we don't want others to know, we try to suppress our overt actions in an attempt to suppress the (nonexistent) cues to our mental states. As often happens, it is not the lie that causes people to be caught, but the cover-up.

In the accident situation, the motivation and the consequences for lying are quite different. By lying, participants are acting in the interest of another person, the junior experimenter. Our intention was that the participants would feel some affiliation with her, due to her overt friendliness to the participants and their similarity in age and position. In sharp contrast, the senior experimenter asserted his authority over everyone else in the lab, and was curt and unpleasant when speaking to the participant. By lying to him, the participants are aligning their interests with their in-group, which is a strong motivation for social behaviour. However, unlike the maths test situation, there could conceivably be negative consequences to this lie. Something did indeed happen to the laptop, and it's possible that the senior experimenter could find out what happened in the future - perhaps the junior experimenter would confess. In this case, the participants would be discovered to have lied to someone in authority.

Both the motivation (DePaulo et al., 2003) and the possible consequences of the social lie are related to affective outcomes. In contrast to the maths lie, where only money is at stake, in the accident situation, participants lie to foster an affiliation between themselves and the junior experimenter, but risk the aversive consequences of lying to an authority figure. We hypothesise that these differences produced an unusual feature of our data.

For the accident situation, the difference between liars and truth tellers emerged in responses to both the neutral and the critical questions. The neutral question was always asked before the critical question in the accident situation, as pilot studies showed that it seemed very unnatural for the experimenter to interrogate the participant about his broken laptop, and then switch to innocuous questions.

So why is it that participants who are going to lie to the experimenter in the near future already show a distinctive pattern of body motion when answering his neutral question? In looking back over the situation we constructed for participants, it seems that they may have already been thinking about the laptop and the incident they witnessed during the neutral question. While asking the neutral question, "Did the maths experiment run okay?" the senior experimenter was walking towards the table where the broken laptop was sat. This, coupled with the fact that he mentioned he was taking a backup of the data, makes it plausible to suggest that the participants realised he was about to use his laptop. At that point, perhaps they were considering the affective consequences of him discovering the accident, accusing the junior researcher, and asking them for information. In other words, even during the neutral question, participants' body motion was revealing their relation to the whole scenario of the accident and the two different researchers, and their own potential involvement.

This claim brings us to the second issue raised by these findings. Is it the case that there are some individuals, or some individuals' moods, that correlate with higher levels of bodily motion and higher levels of honesty? Or does the act of forming a lie or preparing to tell the truth produce a particular pattern of bodily motion? In the context of the accident situation, for example, it could be that during the neutral question some individuals are feeling heightened anxiety (because of what they witnessed), and that anxiety produces more bodily motion and higher rates of telling the truth. Alternatively, it could be that during the neutral question, some participants are already acting to suppress their overt behaviour as they prepare to tell a lie to the experimenter, or at least, distance themselves from the awkward situation.

In short, does body motion reveal differences between *people* who tell the truth and people who lie, or does it reveal differences in the *process* of lying and truth telling? There is some evidence for the latter proposal in our maths test situation. If it were true that some people simply move more and are more disposed to honesty, then we would expect to see truth tellers moving more in response to the neutral maths question as well as the critical question. Furthermore, supporting evidence for a direct link between motion and deception comes from experiments which instruct participants to lie or tell the truth, and thereby cause differences in bodily movements (Duran et al., in press). At present though, our data are equivocal on this point, and calls for further investigation.

Conclusion

People who spontaneously lie, or are about to lie, showed reduced body motion in our experiment. Though this pattern was found across two different types of situation, we are not rushing to make any claims to have found a unique bodily signature for deceptive behaviour. Differences in the two types of situation produced distinct patterns in degree of bodily motion and the conditions under which it emerged. We have speculated that these bodily differences are related to differences in the underlying motivations and consequences of deception in the two situations. We take this work as establishing that motion capture systems are a new telescope that we can point at deception, and reaffirming the complexity of cognitive and affective states that underlie spontaneous deceptive behaviour.

It remains the case that almost no-one is much better than a coin toss at detecting deception in others (Bond & DePaulo, 2006). A notable exception are the FBI interrogators trained and tested by Ekman and O'Sullivan (1991). In their article, 'Who can catch a liar?' they reported a deception detection rate of 64%. Recently Bond (2008) came across a passage in Ekman's (1992) book giving further details of that experiment. As it is described, the study has a striking similarity to our own maths test situation that was designed to evoke spontaneous lies:

> "Immediately after taking the test I would give the correct answers. Then I asked them to raise their hands if they got all ten correct, nine correct, and so forth. I tallied the results on a blackboard so that they could evaluate their own performance against that of their group. . . . In September 1991, our findings on these professional lie catchers were published"
>
> (Ekman, 1992; pp. 282–285)

As Bond (2008) concluded, "Who can catch a liar? It would appear to be Secret Service agents who get to score their own tests." It is an intriguing thought that these FBI agents, might themselves have displayed signature patterns of bodily movement that betrayed the fact that they were actually lying about their ability to detect liars.

Acknowledgments

We would like to thank Geoff Bird, Rick Dale, Natasha Kirkham and Michael Spivey for many insightful discussions. This research was carried out as part of NME and SB's undergraduate dissertations, and authorship is equal.

References

Bond, C.F. (2008). A few can catch a liar, sometimes: Comments on Ekman and O'Sullivan (1991), as well as Ekman, O'Sullivan, and Frank, (1999). *Applied Cognitive Psychology, 22*, 1298-1300.

Bond, C.F., & DePaulo, B.M. (2006). Accuracy of deception judgments. *Personality and Social Psychology Review, 10*(3), 214-234.

Bond, C.F., & DePaulo, B.M. (2008). Individual differences in judging deception: Accuracy and bias. *Psychological Bulletin, 134*(4), 477-492

Buller, D. B., & Burgoon, J. K. (1996). Interpersonal deception the- ory. *Communication Theory, 6,* 203–242.

Burgoon, J., Jensen, M.L., Meservy, T., Kruse, J., & Nunamaker, J.F. (2005). Augmenting human identification of emotional states in video. *Proceedings of the International Conference on Intelligent Data Analysis.*

Casasanto, D., & Dijkstra, K. (in press). Motor action and emotional memory. *Cognition*.

Chartrand, T.L., & Van Baaren, R. (2009). Mimcry. In M.P. Zanna (Ed.), *Advances in Experimental Social Psychology, Volume 41*. Ocford, UK: Academic Press.

DePaulo, B. M., Kashy, D. A., Kirkendol, S. E., Wyer, M. M., & Ep- stein, J. A. (1996). Lying in everyday life. *Journal of Personal- ity and Social Psychology, 70*, 979–995.

DePaulo, B. M., Lindsay, J. J., Malone, B. E., Muhlenbruck, L., Charlton, K., & Cooper, H. (2003). Cues to deception. *Psycho- logical Bulletin, 129,* 74–118.

DePaulo, B. M., Stone, J. L., & Lassiter, G. D. (1985). Deceiving and detecting deceit. In B. R. Schenkler (Ed.), The self and social life (pp. 323-370). New York, NJ: McGraw-Hill.

Duran, N. D., Dale, R., & McNamara, D. S. (accepted). The action dynamics of overcoming the truth. *Psychonomic Bulletin & Review*.

Ekman, P. (1992). Telling lies: Clues to deceit in the marketplace, politics and marriage. New York: Norton.

Gilovich, T., Savitsky, K., & Medvec, Victoria H. (1998). The illusion of transparency: Biased assessments of others' ability to read one's emotional states. *Journal of Personality and Social Psychology, 75*(2), 332-346.

Kohnken, G. (1987). Training police officers to detect deceptive eye-witness statements:Does it work? *Social Behaviour, 2 ,* 1-17.

McClintock, C. C., & Hunt, R. G. (1975). Nonverbal indicators of affect and deception in an interview setting. *Journal of Applied Social Psychology,* 5, 54-67.

Miles, L.K., Nind, L.K. & Macrae, N.C.(2010). Moving Through Time. *Psychological Science,* published online January 8, 2010

Porter, S., & ten Brink, L. (2009). The truth about lies: What works in detecting high-stakes deception. *Legal and Criminological Psychology, 00,* 1-21.

Spivey, M.J. (2007). *The Continuity of Mind*. Oxford: OUP.

Vrij, A. (1993). Credibility judgements of detectives: The impact of nonverbal behavior, social skills, and physical characteristics on impression formation. *Journal of Social Psychology, 133*(5), 601-610.

Vrij, A. (2000). *Detecting Lies and Deceit: The Psychology of Lying and Implications for Professional Practice*. Chichester: John Wiley & Sons.

Vrij, A. (2008). *Detecting Lies and Deceit: Pitfalls and Opportunities*. Chichester: John Wiley & Sons.

Vrij, A., & Mann, S. (2004). Detecting deception: The benefit of looking at a combination of behavioral, auditory and speech content related cues in a systematic manner. *Group Decision and Negotiation, 13*(1), 61-79.

Wojnowicz, M.T., Ferguson, M.J., Dale, R., & Spivey, M.J. (2009). The self-organization of explicit attitudes. *Psychological Science, 20*(11), 1428-1435.