Nonverbal indicators of deception: How iconic gestures reveal thoughts that cannot be suppressed*

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Abstract

This study explores the morphology of iconic gestures during deception. Participants narrated a static cartoon story twice. In one condition they provided an accurate account of the story, in the other they were instructed to introduce false details. Participants produced significantly fewer iconic gestures when describing plot-line events deceptively than when narrating comparable episode units truthfully. Deceptive gestures had significantly fewer post-stroke holds and shorter stroke phase durations than those produced alongside truthful utterances. Following Beattie (2003) three narrators in the deceptive condition produced gestures that in their morphology contradicted the semantic information encoded in their speech stream, and ultimately signaled possible deceit.

Keywords: *deception; iconic gestures; nonverbal leakage; contradictory gestures; gesture frequency; gesture-speech mismatches.*

1. Introduction

Lying is a pervasive aspect of everyday social interaction (see Lippard 1988; Metts 1989; Feldman, Forrest, and Happ 2002). In a series of diary studies, DePaulo and her colleagues (e.g., Kashy and DePaulo 1996; DePaulo et al. 1996; DePaulo and Kashy 1998) instructed participants to record the social interactions they had in a one week period. These studies have consistently revealed that, on average, people lie almost twice daily, or in a quarter of all social interactions with others. Given the high prevalence of lying in conversational exchange, it is perhaps not surprising that academics and lay people alike have, for centuries, tried to develop techniques for detecting deception (e.g., Kleinmuntz and Szucko 1984). Perhaps for as long as human beings have

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been able to deceive, the question of whether liars and truth-tellers exhibit systematic differences in their nonverbal behavior has been a locus of sustained human fascination (see Trovillo 1939). Most recently, the September 11 terrorist attacks have led to renewed scientific interest in identifying nonverbal correlates of deception, particularly in the area of face-to-face interviewers (Frank 2005).

Despite a longstanding scientific interest in developing techniques for detecting deception, research to date has been disappointing. Ekman (2001 [1985]), for instance, has argued that there is no single behavioral indicator that consistently distinguishes truth from lies. Similarly in a meta-analytic review of the literature, Vrij (2000) has reported that many nonverbal bodily actions (e.g., gaze aversion, smiling, self-manipulations, postural shifts, and blink rate) show no discernable links to deceit. Rather, these types of nonverbal behaviors have traditionally been thought of either to reflect psychological arousal and function to signal affective content, or alternatively were seen as the essential interactional signals underpinning social relationships.

In contrast, there is now a considerable body of empirical support for the idea that one type of nonverbal behavior, namely, imagistic hand movements, function to encode (e.g., McNeill 1985, 1992, 2000, 2005, Kendon 2000) and convey (e.g., Rogers 1978; Beattie and Shovelton 1999, 2002a, 2002b) significant amounts of information about objects and events in the physical world. Moreover, such gestures may be particularly applicable to a lie detection paradigm because, according to McNeill, it is with these hand movements that "people unwittingly display their inner thoughts and ways of understanding events of the world. These gestures are the person's memories and thoughts rendered visible" (1992: 12). Following Beattie (2003), our basic premise is that iconic gestures are particularly well-suited to the study of deception because they are executed with at best peripheral conscious awareness, and encode propositional content, which in its form has the potential to contradict information carried by the verbal modality and ultimately signal possible deceit.

The current study presents an experimental investigation into the impact of truth-telling and deception on the morphological structure of imagistic hand movements that accompany spontaneous speech. What is particularly striking about previous studies that have examined gestural behavior during deception is that the types of hand movements that they considered have tended to be poorly defined in the literature (see Caso et al. 2006 for a discussion). Additionally, past research is characterized by a disproportionate focus on the *frequency* rather than the *form* of liars' gestural representations (e.g., Ekman and Friesen 1972; Cody and O'Hair 1983; Feeley and deTurck 1998). The present authors will argue that this constitutes a somewhat curious approach to lie detection because it fails to acknowledge the fundamental semiotic difference that separates imagistic gestures from the behaviors that characterize nonverbal communication.

The introduction is divided into three main sections. First, we examine current understanding about the nature of speech and gesture, placing particular emphasis on both McNeill's (e.g., 1992, 2005) theoretical position and on the communicative value of imagistic hand movements in conversation more widely. Second, we critically appraise the methodological difficulties associated with examining deception under laboratory conditions, before examining the results of the meta-analytic literature. Finally, we offer a new interpretation for why gestures decrease during deception, and propose an experimental framework within which to test it empirically.

Traditionally, models of interpersonal communication have tended either to neglect the role of gesture altogether, or to marginalize those movements of the hands and arms that co-accompany real-time utterance formation as being simply another domain of nonverbal behavior. Under this rubric, gesture, along with a variety of related bodily actions (e.g., smiling, eye-gaze and demeanor), was considered both separate from and independent of language (e.g., Watzlawick, Bavelas, and Jackson 1967; Trower, Bryant, and Argyle 1978; Chomsky 1983; Noller 1984; but see Beattie 1981). Implicit within this categorization is a distinction between so-called "analogue" and "digital" modes of representation. While speech was conceived of as part of the digital domain insofar as it comprises dichotomous units arranged in a hierarchical structure (e.g., morphemes, words, sentences, discourse), bodily movements in general (and gesture by implication), were conceptualized as a form of analogical representation. The prevailing view was that speech and gesture were essentially separate systems of communication and this is perhaps most clearly captured in Bateson's well-known claim that "our iconic (i.e., analogical) communication serves functions totally different from those of language and indeed performs functions which verbal language is unsuited to perform" (1968: 614).

1.1. *McNeill's gesture production model*

Nevertheless, over the past twenty-five or so years, McNeill, building on the earlier work of Kendon (1972, 1980), has consistently theorized that gesture and speech are intimately connected in both functional and temporal terms and form a unitary system. That is, according to McNeill "[g]estures share with speech a computational stage; they are, accordingly, parts of the same psychological structure" (1985: 350). McNeill's gestural typology focuses on three principle kinds of imagistic hand movements. In iconic gestures, there is a high degree of isomorphism between gesture form and the entity that the hand represents (Kita 2000). Metaphoric gestures are analogous to iconics in that they convey propositional content, but their referent is an abstract concept as opposed to a concrete object or event. Finally, beat gestures are simplistic biphasal movements of the hands and fingers that take the same form regardless of content, and index elements of speech that the speaker considers salient in terms of the wider discourse-pragmatic context (see McNeill and Levy 1982). More recently, McNeill has warned against the use of inflexible categorization systems, arguing instead that it is preferable to conceptualize typological differences in hand movements in terms of gestural "dimensions rather than kinds" (2005: 41). This is because an iconic gesture for instance, can be in possession of both beat-like properties and metaphoricity at the same time (see McNeill 2005 for a detailed discussion).[1]

Central to McNeill's thesis is the notion that speech and gesture arise spontaneously from a single source, as different manifestations of the same underlying mental representation. Evidence for the close temporal and semantic connections between the modalities comes from experimental observations that iconic gestures only occur "during speech, are synchronized with linguistic units, are parallel in semantic and pragmatic functions to the synchronized linguistic units, perform text functions like speech, dissolve like speech in aphasia, and develop together with speech in children" (McNeill 1985: 351).

Consider the following gesture-speech compound in which an adult female recounts the events of a cartoon story (McNeill 1992: 14):

Example (1)

"she [chases him out again]"[2]

Iconic: Hand appears to swing an object through the air

Here McNeill points out that there is a perfect temporal correspondence between the meaningful part of the gesture (the so-called stroke phase) and the accompanying speech. The stroke phase is recognized when the morphology of the speaker's gesture most clearly expresses information about the objects or entities that are under discussion. Put simply, it is the most effortful component of the gesture and usually occurs near the apex of the movement (Bartinieff and Lewis 1980; Kendon 2004). Although the stroke phase is the only *obligatory* component of the gesture, there are up to four additional components that speakers *may* produce during on-line utterance formation. Following definitions set out in McNeill (1992), many gestures have a preparation phase in which the limb rises from the rest position (e.g., the speaker's lap) up though the gesture space in *anticipation* of the stroke. A pre-stroke hold can occur if there is a hiatus between the end of the preparation and the onset of the stroke phase. Similarly, a post-stroke hold is realized when there is a temporal cessation between the offset of the stroke and the end of the gesture (the so-called retraction phase).

In contrast to a pre-stroke hold where the hand remains momentarily static before taking on its form, in post-stroke holds the hand is frozen in the gesture space, but retains its iconicity throughout. Finally, the retraction phase marks the period in which the hand relaxes (losing its iconicity), while returning to some position of rest. Therefore, it is the stroke and any post-stroke holds that are of maximum interest to gesture theorists, because collectively they form the expressive components of the movement and "bracket a semantically complete phrase of speech" (Kendon 2004: 112).

McNeill also posits that the linguistic output in example (1) describes both the mode of action and its recurrent nature (i.e., "chases" and "again"), while the gesture displays the existence of the weapon and how it was used (i.e., "to swing object through the air"). According to McNeill it is only through an integration of *both* modalities that the speaker's message is fully conveyed. It is this dualistic attribute of the gesture-speech compound that led McNeill to advocate the notion that utterances are two-dimensional, one side is speech, "the other is imagery, actional and visuo-spatial" (2000: 139). Although the above gesture appears critical in providing details that the speech stream has omitted, McNeill's theory is not restricted to just those examples in which gesture supplies *obviously* additive information. He is equally concerned with the way in which the two communicational channels can "jointly highlight" the same content. Consider example (2) where a participant is describing a comic book scene in which a character bends back a tree (see McNeill 1992: 12):

Example (2)

"and he [bends it way back]"

Iconic: Hand appears to grip something
and pull it from the upper front space
back and down near to the shoulder.

In this example speech and gesture convey related but non-identical meanings. McNeill argues that "[i]n bending back with a single hand, the gesture *displayed* what was, at most, only implicit in speech — that the object bent back was fastened at one end. "Bends it" could equally describe bending an object held at both ends" (2000: 7; original emphasis). Again McNeill emphasizes that it is only through the listener attending to both modalities that the speaker's mental imagery can be fully conveyed.

Although McNeill's (e.g., 2000, 2005) theoretical focus has recently centered around the cognitive operations that bring about individual gesture-speech compounds (see McNeill and Duncan 2000 for an introduction to the "Growth Point"), a major tenet of his argument is that gestures are essentially communicative devices that function to transmit semantic information from speakers to listeners. Under McNeill's framework then, gestures are *part of language* and to disregard their significance in everyday interpersonal communication "is tantamount to ignoring half of the message out of the brain" (2000: 139). But how strong is the empirical argument that gestures do in fact communicate in social interaction?

1.2. *Evidence for the communicative function of imagistic gestures*

There is now considerable empirical support for McNeill's proposition that conversational gestures convey significant amounts of semantic information to respondents above and beyond that transmitted through the vocal channel (Graham and Argyle 1975; Morford and Goldin-Meadow 1992; McNeill, Cassell and McCullough 1994; Kelly et al. 1999; Beattie and Shovelton 1999, 2002a, 2002b; but see also Krauss et al. 1995 for a different interpretation). McNeill, Cassell, and McCullogh (1994), for instance, presented participants with staged mismatches between speech and gesture. For example, "mismatches of space" involved using the left hand to establish the location of a certain referent and then switching that referent to a position previously occupied by the right hand. Gestural messages that mismatched the information contained in the accompanying speech were often represented in listeners subsequent re-telling of the narrative, suggesting that hand movements do play an important role in communication, even when speakers and listeners are not actively attending to gesture.

Similar findings were obtained by Kelly et al. (1999, experiment 4). They presented participants with video recordings of a professional actress who produced ten isolated sentences describing everyday situations (e.g., "*My brother went to the gym*"; Kelly et al. 1999: 586). In the "speech-only" condition the participants watched the woman produce the ten statements in the absence of gesture. Conversely, participants in the "speech and gesture" condition not only heard the entire ten statements, but also were additionally exposed to an accompanying iconic gesture each time, which encoded information that was not expressed in the speech segments. For example, in the "*My brother went to the gym*" example, the actress was instructed to produce a gesture depicting the "shooting" of a basketball. Using a cued recall procedure, these researchers found that participants not only integrated gesturally-mediated information into memory but, crucially, were unable to determine in which modality the information had originally been presented. These researchers argued that the fact "participants were not good at monitoring the source of information in the videotapes suggests that gesture and speech may be tightly linked in comprehension" (Kelly et al. 1999: 587).

More recently, Beattie and Shovelton (1999, 2001, 2002a, 2002b) in a series of studies have developed a new experimental paradigm in which they presented participants with video-recordings of the speech segments, the gestures in isolation of the accompanying speech, or the gesture-speech combinations of a set of encoders, who had previously been instructed to narrate a comic book story to the experimenter. A variety of different procedures (e.g., multiple-choice questionnaires, simple yes/no responses and structured interviews) have subsequently been used to assess the amount of information that the participants gleaned about the original stimuli. These authors have consistently shown that when participants are presented with the gesture-speech combination (usually clause-length), they gain a greater understanding of the original comic story, than when presented with speech alone, or gesture in the absence of speech. However, it is only with respect to the semantic categories "*relative position*" (the position of the main entity with respect to something else) and "*size*" (the size of the main entity) that gesture provided significant amounts of information to decoders across the full range of the sample.

1.3. *Deception literature*

1.3.1. *An overview and methodological critique.* Having reviewed evidential support for the idea that iconic gestures can convey significant amounts of semantic information from speakers to listeners, we turn now to a critical appraisal of research focusing on nonverbal cues to deceit, with the aim of merging McNeill's (e.g., 1992) theoretical framework with the study of lie detection. Studies examining nonverbal cues to deception typically compare the frequency with which an individual produces a given behavior under both truthful and deceptive conditions (see Vrij 2000). However, DePaulo et al. (2003) in the most comprehensive meta-analysis of the deception literature to date, examined 120 independent samples (from 116 individual studies) and found that in 35% of cases a between-, rather than a within-subjects design was employed. Of course, the use of this sort of aggregated data prevents researchers from capturing individual variations across participants, because they are unable to calculate an individual's base-line production rate for the target behavior. This has particular implications for examining gesture usage during deception because there are significant individual differences in gesture function by participants (see Vrij, Akehurst, and Morris 1997 for a detailed discussion). Cohen, Shovelton, and Beattie (under revision), for instance, found considerable variations in how and when different speakers executed iconic gestures in a narrative production task, even though participants were describing the same basic stimulus materials.

Moreover, although researchers have acknowledged the potential importance of moving away from investigating only the frequency of hand movements during deception towards an in-depth analysis of the *meaning* they encode, progress to date has been limited. This is because even prominent theorists in the field have failed to fully exploit the idiosyncratic nature and prevalence of conversational hand gestures in spontaneous talk. Dealing specifically with deception, Ekman claims that "[h]and gestures could provide many messages, as they do in the sign language of the deaf, but hand gestures are not common in conversations among northern Europeans and Americans of that background, unless speech is prohibited" (2001 [1985]: 83). He argues that it is only when speech is of little value, such as in a noisy environment, that a more complex array of hand movements emerge, and goes on to state that "[p]ilots and landing crews for the same reason use an elaborate system of gestures" (Ekman 2001 [1985]: 83n). By placing conversational gestures alongside the conventionalized languages of the deaf, or the visual signaling system of semaphore,[3] Ekman has excluded the possibility that the *form* of such gestures may be revelatory in detecting deception, because in these cases the form is strictly controlled. His whole logic here appears to be shaped by the traditional digital-analogue differentiation of the 1950's discussed earlier.

A more generic set of criticisms associated with the deception literature concerns the low levels of ecological validity attainable in laboratory studies. Experimental investigations often fail to effectively simulate the processes liars may experience because the stakes are typically low and the participants are rarely rewarded (or sanctioned) for the quality of the lie that they tell. DePaulo et al.'s (2003) meta-analysis revealed that more than half of the published studies on deception (56.7%) did not offer participants any motivation at all for producing a convincing lie. A related point is that because participants are explicitly instructed to lie, the issue of whether they feel any emotional involvement in the deception is somewhat debatable.

On the other hand, some paradigms elicit unnaturally strong emotions among participants. Ekman and his colleagues (e.g., Ekman and Friesen 1974; Ekman, Friesen, and Scherer 1976) presented nursing students with a pleasant film designed to elicit positive feelings (e.g., depicting ocean scenes and natural landscapes), followed by a film of equal duration that aimed to evoke a powerful set of negative responses (e.g., portraying images of patients with severe burns and amputations). During the initial phase of the experiment (i.e., the showing of the pleasant film), participants were instructed to describe their feelings truthfully to the interviewer who was unable to see which film the students were watching, and to conceal their real emotions in the second phase (i.e., throughout the viewing of the unpleasant film). Based on the results of these studies Ekman made a major contribution to the literature, by demonstrating that facial micro-expressions of about a quarter of a second prior to a deceptive facial display were a frequent source of nonverbal leakage. This lead him to conclude that emotions such as guilt, detection apprehension and so-called "duping delight" (excitement associated with telling a successful lie) are often detectable in liars' affective displays. While nurses will often encounter situations in which they are required to conceal the truth (and may well feel guilty about this), a wider conceptual issue is that people typically feel only low levels of guilt during and after the more mundane lies found in everyday life (Kashy and Depaulo 1996; DePaulo and Kashy 1998). Is it really plausible then that liars in daily social interaction are sufficiently motivated to suppress the normal facial expressions that signal their deception?

1.3.2. *Gesture frequency during deception: explanatory mechanisms.* Despite these limitations, DePaulo et al.'s (2003) meta-analysis reveals that in general gesture frequency decreases when people are lying, although the effect size obtained was weak (Cohen's $d = -0.14$; see for instance, Ekman and Friesen 1972; Ekman, Friesen, and Scherer 1976; Cody and O'Hair 1983; Greene et al. 1985; Ekman 1988; Ekman et al. 1991; Vrij et al. 2000; but see also Bond, Kahler, and Paolicelli 1985 and deTurck and Miller 1985 for contradictory findings). The types of gestures that these studies investigated are termed "illustrators" (see Ekman and Friesen 1969), and are broadly comparable to the imagistic hand movements of McNeill's taxonomy. That is, like iconic gestures, illustrators occur during on-line utterance formation and function to modify or supplement information expressed though the vocal channel. Nevertheless whereas illustrators may encode both the concrete or abstract properties of an event, McNeill reserves the terms "iconic" and "metaphoric" gestures respectively to distinguish between the two types of information. In this respect, McNeill's classification scheme is more refined. Critically, McNeill's framework considers gesture to be part of the thought process and an integral aspect of "language proper."

So why do gestures decrease during deception? There are two distinct theoretical frameworks that can be used to account for the decrease in gesture frequency during deception. Central to the "cognitive load hypothesis" is the assumption that deception is a cognitively complex task (Zuckerman, DePaulo, and Rosenthal 1981; Vrij 2000). There is some empirical support that does suggest that when participants are engaged in cognitively demanding activities, they make fewer hand gestures (see Ekman and Friesen 1972); that is, the cognitive load renders a neglect of body language reducing overall animation. This view however is not entirely satisfactory. After all, if human beings are lying in a quarter of all social interaction, then deception is perhaps better conceived of as a well-practiced skill that may be only slightly more challenging than truth-telling to perform (McCornack 1997; DePaulo et al. 2003).

In contrast, the "attempted behavioral control" approach postulates that liars may be afraid that nonverbal signs of emotion or content complexity will betray them, and consequently try to suppress such signs in order to avoid getting caught (Ekman 2001 [1985]; Vrij 2000). Therefore, they tend to produce only deliberate bodily actions, and avoid those movements that are not strictly essential, ultimately resulting in an unnatural degree of rigidity and inhibition. In accordance with this explanation, Vrij, Akehurst, and Morris (1997) reported a positive correlation between decreased hand movements during deception and the extent to which the participants had attempted to control their behavior. However, one problem with the idea that liars attempt to make a credible impression by restricting those actions that they consider will make them appear suspicious, is that research into public beliefs about nonverbal behavior during deception has consistently found that people think that gestures will increase (e.g., Kraut and Poe 1980; Riggio and Friedman 1983; Akehurst et al. 1996; Vrij and Semin 1996). Therefore one might predict that liars would make a conscious effort to reduce their gesture production rate during deception. Nevertheless as pointed out earlier, studies that have found that gestures decrease during lying were associated with a weak effect size and considerable individual differences across liars. Ekman et al. (1991), for instance, examined participants' gesture frequency during deception and found that 39% of participants showed fewer hand movements when lying than when telling the truth, 26% demonstrated an increase in gestures when lying, while 35% exhibited no differences across the conditions.

1.4. *A third explanation: The "gestural slip"*

Beattie (2003) however adds a notable codicil to the prevailing debate in which he argues that one reason why liars use fewer hand movements is because the precise form of the iconic gesture (which has never been studied in any great detail previously in this domain) may occasionally reflect the underlying truth. Of course the conception of a "gestural slip" that inadvertently discloses the truthful properties of a given situation, forms close parallels with the well-known psychodynamic concept of the Freudian slip. Freud believed that slips of the tongue expressed something one did not wish to say, and represented a mode of self-betrayal. Hence, while the Freudian slip manifests itself in the vocal modality, the "gestural slip" uses the hands as its primary channel of expression. Freud himself appeared to acknowledge the value of studying subtle hand movements in relation to deception. This is perhaps most clearly evident in his much quoted claim that "He who has eyes to see and ears to hear, may convince himself that no mortal can keep a secret. If his lips are silent, he chatters with his finger-tips; betrayal oozes out of him at every pore" (1953 [1905]: 77–78).

The proposition that an individual's hand movements may unwittingly reveal more truthfully than words alone information that they are actively attempting to withhold has been proposed previously, at least where the concealed information is related to the *emotional state* or *feelings* of the speaker. Ekman (2001 [1985]) conducted an experiment in which psychology students were individually invited by a senior professor into an observation room for what they believed would be a discussion about their future career plans post-graduation. However, what the student volunteers did not know is that the professor had previously been instructed by Ekman to adopt and maintain a highly aggressive interview style throughout (e.g., by continually interrupting, disagreeing with and resisting the students' suggestions). The interaction between the students and the professor was video-recorded throughout using a hidden camera that was positioned behind a one-way mirror.

Although the study was originally designed to investigate changes in nonverbal behavior during stress, Ekman reports that a few minutes into the first interview following the professor's third attack, a female student gave him "the finger" gesture. This is a vulgar emblematic hand gesture in which the middle digit (usually of the right hand) extends, while the remaining fingers curl inwards to form a fist. The significations that are ascribed to this gesture generally render it an obscene expression that shows a high level of disdain towards its recipient (Kirch 1983). Although the "finger emblem" is typically executed away from the body in the lower quadrant of the gesture space, what is interesting about the student's gesture is that it appeared to be what Ekman calls a "leakage emblem" or an "emblematic slip" (see Ekman 2001 [1985]). In other words, the gesture was not performed in the conventional presentation space, but instead was lying in the rest position on the student's knee. Similarly, whereas the gesture is normally associated with a repetitive thrusting up and down motion, the student's gesture lacked a movement component. Interestingly, neither the student nor the professor was aware that the finger emblem had been enacted and Ekman claims that overall two of the five participants in his study showed "emblematic slips" (the second being a fist gesture to signify anger).

While "emblematic slips" provide a useful insight into participants' emotions during concealment, they contrast with Beattie's (2003) argument in that they are highly conventionalized movements and, unlike iconic gestures are usually performed with a degree of communicative awareness. Of course, it is the case that emblems (like speech itself) have a particular form that is only arbitrarily related to the meaning it conveys. Beattie argues that it is precisely because iconic hand movements are not constrained by a specific convention, communicate propositional content and, in their morphology, share a semantic correspondence with the source event, which makes them better candidates than emblems to apply to the deception literature. This is because there is a strong possibility that propositional content could "leak" out through these non-conventionalized movements. By examining gesture we have the potential to gain a privileged insight into the imagistic form of a speaker's sentences, as they develop during real-time utterance formation. Moreover "the speaker him-or herself may be unaware of it or think that it has been well hidden; but it is visible to those who would look at the gestures" (McNeill 1992: 109).

Currently, Beattie's (2003) hypothesis remains largely anecdotal. For instance, he reports a naturalistic observation that occurred while he was attending a meeting at a public relations company where an executive claimed that the sales of a particular product had increased following a marketing campaign. The PR director asserted that (2003: 168):

Example (3)

"the sales after that campaign [started to soar]"

Iconic: Right hand makes upward trajectory but falls fractionally at the top most part of the trajectory. The slight fall depicted in the gesture corresponding with the word "soar."

Beattie utilizes the above example to illustrate the apparent contradiction between the form of the iconic gesture (the marginal lowering of the hand) and its associated lexical affiliate (the word "soar"). When Beattie probed the executive in order to elucidate the nature of this inconsistency, she admitted that sales had in fact dipped immediately after the marketing campaign, but that they had subsequently "picked up again" (2003: 169). It is therefore evident that the "objective reality" of the situation was accurately encoded in the configuration of the iconic gesture and that critically this occurred in isolation of the speaker's conscious awareness.

Consider a second naturalistic example from Beattie's corpus in which an adult female is describing her experiences at a party where she was kissed by the boyfriend of a close friend. Below is an extract of the relevant aspects of her speech along with its accompanying iconic gesture (2003: 169):

Example (4)

"and he [kissed me] on the cheek"

Iconic: Fingers of right hand outstretched and close together, thumb curled in towards palm. Hand moves towards mouth and fingertips touch right-hand side of lips.

Once again the semantic properties contained in the speaker's vocal output ("on the cheek") and the message transmitted through the gestural channel ("fingertips touch right-hand side of lips") are seemingly incompatible with each other. Beattie indicates that here the speaker's iconic gesture unwittingly divulges revelatory information about the "*relative position*" of the two lips; information that the speaker is actively attempting to withhold. When Beattie challenged her about the events depicted in her narrative, the woman in question conceded that she had in fact been kissed on the lips, not the cheek, as she had initially stated. When Beattie pointed out the gesture that she had made, she claimed that "she didn't even realize that she had made a gesture in the first place" (Beattie 2003: 169), again demonstrating that the gestural slip operates predominantly at the sub-conscious level. Again it is because, unlike speech, these hand movements are not under a speaker's editorial control that makes them particularly appealing for lie detection research.

These sorts of isolated observations are never the best basis on which to validate (or negate) psychological theory, as Beattie (2003) admits. Franklin (2007) following an experimental procedure outlined originally by Beattie (2003: 170), instructed participants to misreport sections of a cartoon stimulus and, like Beattie, obtained evidence of gesture-speech mismatches. Nevertheless, Franklin's focus is heavily influenced by the "linguistic tradition" in which it was developed, and centers on the micro-genesis of individual gesture-speech compounds. Perhaps understandably given her perspective, Franklin uses gesture-speech mismatches as a medium with which to further elucidate the nature of Growth Point theory (see McNeill 2005), rather than to expand understanding of the processes underpinning deception *per se*. As a result key methodological details of her investigation are somewhat underspecified. For instance, it is not possible to estimate the frequency with which "contradictory gestures" might occur during deceptive discourse from Franklin's experiment, because she fails to report the number of participants who took part in the study. Furthermore, she examines only potential contradictions between modalities, rather than exploring additional properties of spontaneous hand movements occurring alongside deceptive utterances (such as their frequency or duration). Consequently, this means that we currently lack a comprehensive account of how iconic gestures function during deception.

1.5. *The current experiment*

In contrast, we take a much more systematic approach to studying lie detection, not only by empirically testing Beattie's (2003) contradictory gesture hypothesis to determine whether liars' hand movements really do act as hybrids, blending truth and fiction into a single global image, but also investigate the frequency and timing of such gestures. In order to achieve this it is necessary to isolate the effects of "the cognitive load" and "attempted behavioral control" approaches respectively. Following both Beattie (2003) and Franklin (2007) these objectives shall be accomplished by instructing participants to narrate a story from a comic book both truthfully and deceptively (the order of which will be fully counterbalanced) to the experimenter.

In the deceptive condition the participants will be told that three of the critical details that comprise the story are to be changed, and will be given explicit instructions on how to change them, in an attempt to simulate the cognitive operations which occur during premeditated deception. Although the implemented changes represent relatively minor modifications, they have been purposely selected to incorporate and build on events depicted in the truthful version of the comic strip, as this closely emulates real-life deception. Research indicates that "reasonably good liars are often found to base their false accounts partly on things that have actually happened to them, while changing certain core details, rather than making up a completely false account from scratch," (Beattie 2003: 170). Furthermore, the modifications were formulated specifically for their potential to evoke a range of spontaneous iconic gestures, and subsequently were largely action-based.

Participants will be provided with as much time as they require to learn the modifications to the three changed details and a projector will continually display the cartoon story (in an attempt to minimize the cognitive demands placed on the participants). Similarly, a comic book stimulus was selected precisely because its content is simplistic and is unlikely to induce high levels of arousal (be it guilt, anxiety, or duping delight) among participants. This therefore rules out any emotional or cognitive factors that may influence participants' behavior. Rather, the present study is designed to test three experimental hypotheses: First, we argue that in line with previous research there will be a significant decrease in the relative frequency of iconic hand gestures when participants are lying versus when they are telling the truth. Second, following Beattie's (2003) argument that speaker's generate fewer hand movements when lying because they are anxious that the form of the gesture may betray them, we predict that those gestures that do occur during deception will have significantly shorter durations than those produced during truth-telling. Finally, following an in-depth examination of all iconic gestures obtained in the study, any gesture produced in the deceptive condition which in its form appears to contradict the vocal output of a speaker, will contain revelatory semantic information about a truthful situation or event.

2. Method

2.1. *Participants*

Thirty students from the University of Manchester took part in the study for course credits.

2.2. *Stimulus materials*

The stimulus material consisted of a static cartoon story — (Ivy the Terrible comic taken from the Beano, October 19, 1996; see appendix 1 for a full copy of the cartoon). Each frame of the comic contained some words, which represented the speech of the main character. This particular comic was selected not only because it depicted a sequence of action-filled events, but also because it has formed the basis of many other experiments (see Beattie and Shovelton 1999; 2001; 2002a; 2002b), and has proved successful at eliciting a range of spontaneous hand movements.

2.3. *Procedure*

Each of the thirty participants were individually invited into an observation room and informed that they were taking part in an experiment that investigated "how well people tell truths and lies in order to further our understanding of how the brain processes and copes with misinformation and deceit." In accordance with McNeill's (e.g., 1992) general procedure, the background information that the participants received did not mention gestures, as this would likely have affected their gesture usage. All the participants were instructed to narrate the comic story both honestly and deceptively, with the order of lying versus truth-telling being fully counterbalanced throughout.

So as not to interfere with their gesture production rate, the comic story was projected onto a wall directly in front of the participants. This ensured that participants' hands were free to move naturally, which would not have occurred had they been required to physically hold the comic. In order to obtain as natural a sample of behavior as possible participants were filmed by an unobtrusive video camera (see Beattie 1982). One experimenter (D.C.) was present throughout and acted as the main coordinator of the tasks. Initially, the participants were instructed to carefully read through the comic story several times. In order to minimize the effects of "cognitive load," participants could take as long as they needed until they felt that they had gained a full understanding of the story. For the same reason, the projector was left on throughout both conditions. Once the participants stated that they had read through the comic several times, the experimenter (depending on the order of counterbalancing) assigned the participants to either the truthful or deceptive condition.

2.3.1. *Truthful condition.* In the truthful condition, the participants were simply instructed to describe the story in their own words "as clearly and in as much detail as possible" to the experimenter. In this respect the procedure was akin to that employed by McNeill, who instructed participants to narrate animated cartoon films to a listener "clearly and comprehensively" (1992: 374). The emphasis that both the present experiment and McNeill placed on accuracy and completeness was designed to motivate the participants to narrate the story in as complete and comprehensible manner as possible.

2.3.2. *Deceptive condition.* At the outset of the deceptive condition, the participants were informed that three critical details of the comic were about to be changed and that once these changes had been implemented, they would have to recount the altered version to another participant who had never seen the comic before. In addition they were told that at the end of the experiment the participant would have to guess whether or not they were telling the truth or lying, and, consequently, that they should try to be "as convincing as possible." In reality, the participant who was brought into the room during the deceptive condition was a confederate of the experimenter. The presence of the stooge served as a motivational cue for the "real" participants, designed both to encourage them to make a conscious attempt to lie effectively, and to validate the non-truth that they were about to tell (e.g., by providing them with an opportunity to purposefully communicate to another individual information that they knew to be untrue). As an additional motivation, all participants were told that if they managed to convince the second participant (i.e., the stooge) that they were telling the truth, they would be rewarded. In any event, at the end of the experiment all participants (irrespective of lying ability) were given a chocolate bar. In order to prevent the stooge from biasing the participants' behavior in any way, care was taken to ensure that she had restricted verbal interaction with the participants. Therefore she occupied a passive role, engaging only in formal greetings when entering or leaving the room (e.g., hello, goodbye etc).

2.4. *The three critical changes*

Presented below are the frames of the comic that comprised the three elements of the story that were to be changed, along with what they portray and how the participants were told to change them.

2.4.1. *The first critical change.* The third frame of the comic clearly depicts Ivy, the central character pushing the DJ into the boot[4] of the car, while her speech reveals her intention to "lock him in" [it]. In the deceptive condition, the participants were instructed to lie by claiming that Ivy locks the DJ in the back of the *car* (not the boot), by pushing him through the side-door.

Figure 1. *The first critical change*

2.4.2. *The second critical change.* In the seventh frame of the comic, Ivy is shown pouring the contents of a bottle of extra-strong washing up liquid into a bubble machine in an attempt to produce more bubbles. The participants in the deceptive condition were told to say that she accidentally spills some of the washing up liquid onto the floor, making a horrible, sticky mess.

2.4.3. *The third critical change.* In the final (twelfth) frame of the comic, bubbles are shown emerging from Ivy's mouth. In the deceptive condition the participants were told to say that the bubbles came out of her ears.

As there is some evidence that producing bodily actions can result in interlocutors increasing their corporeal movements accordingly, especially in the context of lie detection (see Akehurst and Vrij 1999), the experimenter did not "act out" the changes (i.e., did not gesture himself) when describing them to the participant. Instead the changes were read off a standardized script. After

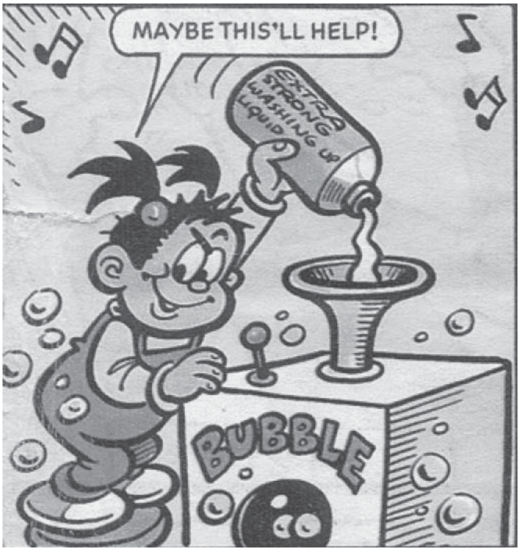

Figure 2. *The second critical change*

Figure 3. *The third critical change*

the three changes had been explained, participants were asked to confirm whether they had fully understood them and could remember those parts of the comic that required modification. Once the participants were satisfied that they could accurately perform the task, the stooge, who was always waiting directly outside the door of the observation room, was let in by the experimenter. The stooge sat with her back to the projector at all times, and so could not see the comic, which was still projected onto the wall. If the participants did not start to describe the comic spontaneously after the stooge sat down, they were prompted to do so. At the end of their narratives, the stooge always left the room independently and the participants were either thanked for their participation and debriefed, or if the deceptive condition came first in the order of counterbalancing were taken straight into the truthful condition, after which time they were de-briefed.

Seventeen of the original thirty participants produced spontaneous iconic gestures, which were the principal focus of this study and consequently were identified, counted and analyzed. This resulted in a total of thirty-four narratives (seventeen speakers by two conditions — truthful versus deceptive retelling). Although iconic gestures are according to McNeill "typically large complex movements, performed relatively slowly and carefully in the central gesture space" (1985: 359), it is important to point out that occasionally gestures were coded as iconic that were either small or fast, or that operated outside of the central gesture space, but that were nevertheless still in possession of iconic properties. Furthermore the gestures were coded in accordance with McNeill's noncombinatoric approach, which states that:

> Most of the time gestures are one to a clause, but occasionally more than one gesture occurs within a single clause. Even then the several gestures don't combine into a more complex gesture. Each gesture depicts the content from a different angle, bringing out a different aspect or temporal phase, and each is a complete expression of meaning by itself. (McNeill 1992: 21)

Where an element of doubt existed between whether a given gesture was either an iconic or a beat, McNeill's "beat filter," "a formal method of differentiating imagistic (iconic and metaphoric) from non-imagistic (beat) gestures" (1992: 81) was employed.

In total, 351 iconic gestures were recorded. In order to verify the reliability of this categorization, two independent raters categorized approximately 25% of all hand and arm movements into the categories "iconics" (operationalized as hand movements that exhibit a meaning relevant to the semantic content of speech), "beats" (simple and rapid movements that generally assume the same form regardless of the content), and "adaptors" (which encompasses both self-touching movements unconnected to speech, and object-adaptors that involve the touching or holding of an object, which again is unconnected to speech). Cohen's Kappa was employed on the data to assess the reliability of this classification as it accounts for the chance agreement that could be expected between the two raters. The Cohen's Kappa in this instance was calculated to be 0.87, which demonstrates that the classification of gestures was highly reliable.

3. Results

3.1. *Analysis 1: Investigation into the relative frequency of all iconic gestures by condition*

Before comparing the relative frequency of iconic gestures that encoded aspects of the three modified details (frames 3, 7, and 12 of the comic) across conditions, the initial analysis examined the gesture production rate of *all* iconic gestures in both the truthful and deceptive narratives. This analysis aimed to establish whether changing just three specific events in the comic had an impact on the overall frequency of iconic gestures in the deceptive condition. Of the 351 iconic hand movements that were identified across the thirty-four narratives, 169 were produced in the truthful condition and 182 in the deceptive. When the data is considered on a subject-by-subject basis, it is evident that there is considerable variation in gesture frequency by participants. Table 1 shows the frequency distribution in percentages of the participants' hand movements as a function of condition.

Table 1. *Percentage frequency of participants' hand movements by condition*

Frequency of iconic gestures	Percentage of participants
Increases during deception	41.2
No difference between conditions	5.9
Decreases during deception	52.9

Despite a greater number of gestures occurring in the deceptive than in the truthful condition, Table 1 reveals that over half of participants (52.9%) actually executed *more* iconic gestures when telling the truth than when lying, while 41.2% demonstrated the reverse response (i.e., increased hand movements during deception). Additionally, Table 1 reveals that 5.9% of participants produced the same number of gestures in both conditions. Descriptive statistics were employed on the data set and revealed that the overall mean for the frequency of iconic gestures across speakers was smaller in the truthful condition (9.9) than in the deceptive (10.7), by an average of 0.8 gestures.

However there was greater between-subjects variability in the deceptive (s.d. 8.5) than in the truthful condition (s.d. 6.1). A Wilcoxon Matched-Pairs Signed Ranks Test comparing the frequency of gestures produced by the seventeen participants found that the differences in the frequency of gestures between the conditions was not significant ($T = 66$, $n = 16$ (17–1 tie), n.s., two-tailed).

Of course, one limitation of this preliminary analysis is that it fails to account for the possibility that the participants may have spoken for an unequal length of time in the two conditions. If participants spoke for significantly longer in one condition than the other, one would expect that, on average, they would produce a greater number of gestures in that condition, as a consequence of their extended speech length. It is therefore necessary to calculate each individual participant's gesture-to-word ratio in order to ascertain whether the above differences in the frequency of iconic gestures were statistically significant. This was done by individually transcribing each participant's speech output verbatim (including all false starts, hesitations, and filled pauses) across both conditions. The number of gestures in each condition was then divided by the number of words spoken in the corresponding condition before transforming the product into a percentage. Table 2 summarizes various descriptive statistics relating to (1) the total number of words spoken in each condition, (2) the mean number of words spoken per narrative and (3) measures of the standard deviations across conditions.

Table 2. *Summary of word count data as a function of condition*

	Truthful condition	Deceptive condition
Total number of words spoken in each condition	3445.0	3981.0
Mean number of words spoken per narrative	202.6	234.2
Standard deviations across condition	87.4	88.3

The total word counts for each condition reveal that overall participants spoke for longer in the deceptive condition (3,981 words) than in the truthful condition (3,445 words). Indeed, on aggregate participants used an additional 536 words (31.5 words more per narrative) in the deceptive condition, as opposed to when describing the comic in its original form. It is also evident that there are no discernable differences in the between-subjects variability across conditions (s.d. 87.4 in the truthful condition versus 88.3 in the deceptive). The differences between conditions for the number of words spoken was not significant ($T = 52.5$, $n = 17$, n.s., two-tailed). Moreover, when the gesture-to-word ratio was taken into account, a Wilcoxon Matched-Pairs Signed Ranks Test found that the differences between the relative frequency of iconic gestures across conditions remained non-significant ($T = 51$, $n = 17$, n.s., two-tailed).

3.2. *Analysis 2: Investigation into the relative frequency of iconic gestures in relation to the three critical details*

The second analysis was for the most part identical to Analysis 1, with the single exception that it examined the relative frequency of iconic gestures exclusively in relation to the *three* modified details.

3.2.1. *Overview of inclusion criteria.* In order for a gesture to be entered into the second analysis it had to satisfy a number of inclusion criteria. First, only gestures that encoded aspects of the three modified details were considered as they each had to represent a *complete* event. Recall that with reference to the first semantic event participants, depending on condition, would either have to describe a scene in which Ivy locks the DJ in the *boot* of his car (truthful version), or else claim that she locked him in the car, using the *side-door* (deceptive version). In order to be included in the analysis, participants would have to execute a gesture that depicted Ivy pushing the DJ and *explicitly* state in the verbal dimension of the corresponding clause that he entered the car through either the boot or the side-door respectively. Alternatively, the morphological structure of the gesture would need to discriminate between the act of closing a boot and that of shutting the door of a vehicle. Consider example (5) in which a speaker is describing the first critical detail in the deceptive condition.

Example (5)

"so she [locks him in the car]"

Here the gesture provides insufficient information to be entered into the analysis, as Ivy pushes the DJ into the car in *both* conditions, and the gesture only signals that an agent is pushing some object, but fails to disambiguate between the two competing possibilities (boot versus side-door). Interestingly, despite an identical clause structure the form of the gesture in example (6) explicitly reveals that the DJ has been locked in the *boot* of the car, and therefore would be coded as a "truthful gesture."

Example (6)

"so Ivy locks [him in the car]"

In relation to the second critical change participants were required either to reference the scene in which Ivy pours washing-up liquid into the bubble machine (truthful version), or to fabricate the event by claiming that Ivy accidentally spills some of the solution making a "horrible sticky mess" (deceptive

Figure 4. *Iconic: Both hands rise slightly, palms facing each other and away from speaker, while arms are bent at elbows. During stroke phase elbows rotate slightly and extend forwards pushing out into the gesture space. Palms momentarily flick outwards, before returning to rest.*

Figure 5. *Iconic: Right hand rises to above eye-level, palm faces away from speaker and is perpendicular. Entire right hand then descends rapidly, consistent with the act of shutting a boot, using a single-hand (as depicted in the original stimulus material; see figure 1). Left hand is locked in a post-hold pause from previous gesture.*

version). Very occasionally, however, participants' descriptions (2/17 speakers) of this event went beyond that which they were instructed, and consequently were not included in the second analysis, even if they did consist of a complete falsification. For instance, one participant produced the following utterance: "so she gets the bubble mix . . . mixture and pours it in. Erm but . . . but there is a . . . I think a [banana skin] on the floor . . . and she slips and . . . anyway it [spills everywhere making a sticky mess]." Here only the second hand movement was coded as being a "deceptive gesture," as the first gesture represents a confabulation that the participants were not instructed to produce. To incorporate this gesture in the analysis precludes the possibility of making a direct comparison between the truthful and deceptive narratives, and this lack of equivalence between conditions would bias the data towards an over-estimation of gesture frequency in the deceptive condition.

Recall that the final modified detail required participants to reference a scene in which bubbles contained in some sandwiches that Ivy has unwittingly eaten previously, exit her body through either her mouth (truthful version) or her ears (deceptive version). One difficulty encountered with this event is that a small number of narrators (3/17) in the truthful condition did not specifically state that bubbles came "*out of* Ivy's mouth," but rather that the bubbles had contaminated the sandwiches and so they did not "taste nice." Again in order not to violate the equivalence principle, gestures were only included in the second analysis if the participant described the target frame of the comic in speech (e.g., by saying bubbles "come out of Ivy's mouth"), so that it could be matched across both truthful and deceptive descriptions. Finally it should also be noted that in line with McNeill's non-combinatoric approach, participants could be awarded more than one gesture per modified detail. For instance if a participant produced the following utterance: "So she [pushes him into the boot], and [slams it shut]," then both hand movements would be coded as forming *two* independent gestures that represented the truthful properties of a *single* semantic event.

Out of the 351 iconic gestures that were identified throughout the study, a total of 65 gestures were directly associated with the three critical details. Of these 65 gestures, 63.1% occurred in the truthful condition, while 36.9% were produced in the deceptive condition. The most striking aspect of these results becomes evident when they are examined on a subject-by-subject basis. Table 3 shows the frequency distribution in percentages of the participants' hand movements in relation to the critical details as a function of condition.

Table 3. *Percentage frequency of participants' hand movements by condition for the three critical details*

Frequency of iconic gestures	Percentage of participants
Increase during deception	17.6
No difference between the conditions	5.9
Decrease during deception	76.5

In contrast to Table 1, which revealed an inconsistent pattern in participants gesture frequency across conditions, Table 3 demonstrates that when comparing just those three aspects of the story that were altered to form complete fabrications, the majority of participants (76.5%) produced *fewer* iconic gestures in the deceptive than in the truthful condition. Indeed, 17.6% of participants produced a *greater* number of iconic hand movements when lying than when truth-telling, while the remaining 5.9% produced the same number of gestures in both conditions.

The mean gesture rate focusing on just those three critical details revealed that, on average, participants produced nearly twice as many iconic gestures in the truthful condition (2.5) than in the deceptive (1.4). The level of between-subjects variability across the truthful (s.d. 1.3) and deceptive conditions (s.d. 1.2) was comparable. In line with the original predictions, a Wilcoxon Matched-Pairs Signed-Ranks Test revealed that participants produced significantly more iconic hand gestures when truthfully describing the three critical details, than when recounting the events deceptively (T = 18.5, n = 15 (17–2 ties), $p < 0.02$, two-tailed). A second gesture-to-word ratio was calculated to account for the unequal word length across conditions. When the gesture-to-word ratio was taken into consideration, the relative frequency of gestures between the conditions remained significant (T = 33.5, n = 17, $p < 0.05$, two-tailed).

3.3. *Analysis 3: Gesture duration during deception and truth-telling*

The penultimate analysis compared the duration of those gestures that encoded aspects of the three modified details of the story during both truth-telling and deception. However, six of the participants only gestured in one condition and consequently were removed from the analysis because they were unable to contribute to a direct comparison of gesture duration across conditions. As a result, only 53 of the original 65 gestures were included in the present analysis (of which 31 were executed in the truthful condition, while the remaining 22 occurred in the deceptive). The duration of each of the 53 gesture units (i.e., the *entire* gestures) were individually timed and broken down into their constituent phases. By definition, this included the stroke phase of each gesture, as well as any preparation, pre-stroke, post-stroke or retraction phases. Occasionally gestures were coded as having a preparation phase when the hand appeared to be returning to a period of rest, but immediately *before* arriving at the rest position suddenly rose in anticipation of a new stroke phase.

Before presenting the timing data, it is useful at this juncture to consider the *relative frequency* of the different gesture phases for each of the 53 target gestures. Table 4 presents both the mean percentage distribution of the various gesture phases across the corpus, as well as the proportion of time they occurred in each of the two conditions. As stroke phases are by definition obligatory components of gestural movement they necessarily occurred in each of the 53 gestures, and so have not been reported here.

Table 4. *Mean percentage frequency of gesture phases across the truthful and deceptive conditions*

Gesture phase	Overall incidence	Percentage of time occurred in truthful condition	Percentage of time occurred in deceptive condition
Preparation	94.3%	96.8	90.9
Pre-stroke hold	9.4%	9.7	9.1
Post-stroke hold	30.2%	38.7	18.2
Retraction	67.9%	67.7	68.2

Table 4 reveals considerable variation in the frequency of gesture phases across the corpus. While most of the 53 gestures had both a preparation (94.3%) and a retraction phase (67.9%), the incidence of pre- and post-stroke holds were comparatively small, occurring in 9.4% and 30.2% of cases respectively. While the relative proportion of preparation, pre-stroke holds and retraction phases were comparable across the conditions (preparation: 96.8% versus 90.9%; pre-stroke hold: 9.7% versus 9.1%; retraction: 67.7% versus 68.2%), post-stoke holds were more than twice as likely to occur in the truthful than the deceptive condition (38.7% versus 18.2%). In total, 16 post-stroke holds were identified across the 53 gestures, of which 12 occurred in the truthful condition and 4 were observed in the deceptive. Ostensibly then the data suggests that liars systematically avoid producing gestures with post-stroke holds. What is particularly interesting here is that the preparation, pre-stroke and retraction phases can to some extent be considered "auxiliary" components of the gesture unit, which at best make only a very limited semantic contribution to the speaker's message. Conversely, in both its form and manner of presentation the post-stroke hold is likely to encode a good deal about the target semantic event. In line with Beattie's (2003) prediction, liars may well avoid producing them as they have the potential to index information that is incompatible with the accompanying speech (see Analysis 4). Moreover, there is some evidence that post-stroke holds lead to decoder fixation (Gullberg and Holmqvist 2002: 209). Again consistent with Beattie's hypothesis is the idea that liars attempt to suppress the frequency of post-stroke holds because this might well direct listener attention to their gestures, and increase the probability that their deception will be detected.

In order to ascertain whether the differences in the frequency of the various gesture phases across conditions were significant a set of Wilcoxon-Matched Pairs Signed Ranks Tests were performed on the data. However, as the frequency of gesture was lower overall during deception, observed increases of a particular gesture phase in the truthful condition could be accounted for simply because of the unequal distribution of gestures across the corpus. In order to correct for this bias, the raw data were converted into percentages and it was on these transformed scores that the statistical analysis was conducted. The results revealed that there were no significant differences in the percentage frequency of preparation (T = 24.5, n = 11, n.s., two-tailed) or retraction phases (T = 33, n = 11, n.s., two-tailed)[5] during truth-telling and deception. In contrast, it was found that participants were significantly more likely to produce gestures with post-stroke holds when telling the truth, than when lying (T = 6, n = 10 (11–1 tie), $p < 0.05$, two-tailed).

3.3.1. *Gesture duration by condition.* We turn now to a comparison of the duration of the gestures across conditions. The basic procedure for timing the data was as follows: Each of the 53 gesture-speech compounds were edited onto a separate video-tape and a frame-by-frame analysis was conducted in which the onset and offset times of the various gesture phases were recorded. Gesture phase duration was measured in terms of the number of recorded frames per second that elapsed between the onset and offset of the target phase. As each second of recorded material consists of 25 individual frames, one frame corresponds to 40 ms (25 frames × 40 ms = 1000 ms). In order to verify the reliability of gesture phase identification, two raters independently reviewed the tape, and using slow-motion playback facility (to the nearest frame) categorized approximately 45.0% of the gestures into the categories "stroke-only," "preparation and stroke," "retraction and stroke," "pre-stroke hold and stroke," "stroke and post-stroke hold." A Cohen's Kappa was employed on the data to assess the reliability of this classification. The Cohen's Kappa yielded an inter-rater reliability coefficient of 0.79, which demonstrates that the classification was highly reliable. Table 5 compares the mean duration (in ms) of the various gesture phases by condition.

Table 5. *Mean duration of gesture phases across the truthful and deceptive conditions*

Gesture phase	Mean duration in truthful condition	Mean duration in deceptive condition
Preparation	498.0 ms	440.5 ms
Pre-stroke	506.7 ms	450.0 ms
Stroke	830.3 ms	372.1 ms
Post-stroke	1380.0 ms	605.0 ms
Retraction	459.0 ms	398.7 ms

Although it is evident that all gesture components were longer in the truthful than in the deceptive condition, Table 5 reveals that the differences in the duration of the preparation (57.5 ms), pre-stroke (56.7 ms) and retraction phases

(60.3 ms) are at best negligible. In contrast, a marked decrease in gesture phase duration during deception was observed for the remaining two phases that are thought to form the "nucleus" of the gestural message (see Kendon, 2004; i.e., the stroke and post-stroke hold phases). That is, the stroke phases of the gestures were on average 458.2 ms longer when they occurred in the truthful rather than the deceptive condition, while post-stroke holds were 775.0 ms longer when executed as part of the truth than during deception. A Wilcoxon-Matched Pairs Signed Ranks Test revealed that no significant differences in the duration of the preparation (T = 25, n = 11, n.s., two-tailed) or retraction phases (T = 7, n = 8, n.s., two-tailed)[6] across conditions was observed.[7] In contrast, it was found that participants produced significantly longer stroke phases when telling the truth than when lying (T = 6, n = 11, $p < 0.02$, two-tailed). Finally, given that participants produced gestures with significantly longer stroke-phases when they occurred during truth-telling than deception, we now examine stroke duration by individual speakers across the two conditions.

Table 6. *Duration of stroke phases (in ms) by participants across truth-telling and deception*

Participant	Truthful condition	Deceptive condition	Difference between conditions
1	1100.0	400.0	700.0
2	720.0	400.0	320.0
3	1120.0	260.0	860.0
4	490.0	306.3	183.7
5	740.0	220.0	520.0
6	1460.0	240.0	1220.0
7	710.0	546.7	163.3
8	510.0	860.0	−350.0
9	793.3	200.0	593.3
10	330.0	400.0	−70.0
11	1160.0	260.0	900.0

Table 6 reveals that while the majority of participants (81.8%) produced gestures with longer stroke phases when telling the truth than during deception, there is nonetheless considerable variation in stroke phase duration across speakers. Overall, the mean difference between the conditions was 458.2 ms. What is interesting here is that while most participants (54.5%) did produce gestures that were *at least* 458.2 ms longer in the truthful than the deceptive condition, two speakers actually generated gestures with longer stroke phases when lying, than when telling the truth (see speakers 8 [−350.0 ms] and 10 [−70.0 ms] respectively). Similarly two participants (speakers 4 and 7) showed only modest differences across conditions (183.7 ms and 163.3 ms respectively). We will return to a consideration of these findings shortly (see section 4.2).

3.4. *Analysis 4: Testing the contradictory gesture hypothesis*

The following procedure was used in order to determine whether any "contradictory iconic gestures" had occurred: Each of the 65 gestures that encoded properties of one of the three critical changes in the comic were individually transcribed, and any apparent semantic mismatches between the morphological structure of the imagistic movement and the speakers corresponding verbal output were noted and analyzed by one of the experimenters (D.C.). Additionally, a naive judge was asked to review all 65 gestures for any signs of a semantic mismatch between the form of the imagistic movement and the accompanying speech. The judge was allowed to watch each gesture as many times as she wished, but only had access to the immediate gesture-speech compound, not the whole narrative. The judge had not seen the original comic and so could not be influenced by its semantic content.

Both the experimenter and the judge independently identified the same three gestures, all of which were executed in the deceptive condition. Each of these gestures were produced by a different individual, and in their form, appeared to contradict the semantic information encoded in the speaker's vocal output. Critically, these gestures appeared to communicate aspects of the original (i.e., true) version of the comic. No evidence of gesture-speech mismatches in the remaining hand movements of the truthful condition was observed. These "contradictory" gestures are best dealt with in the "Discussion and further analysis" section (see section 4.1), as they are intricately linked to a number of important theoretical and practical considerations.

4. Discussion and further analysis

The present experiment was designed to examine the frequency of speakers' iconic hand movements in both truthful and deceptive discourse and has, with the exception of the first analysis, yielded results that are consistent with the experimental predictions. In the initial analysis, however, when the frequency of all iconic hand gestures recorded in the study were compared across the truthful and deceptive conditions, no significant differences were obtained, despite previous research suggesting that gesture frequency decreases during deception (e.g., DePaulo et al. 2003; Ekman et al. 1991). That the differences between the conditions did not reach significance is perhaps not that surprising given that only a relatively small proportion of the deceptive narratives were centered around non-truths (only three of the eleven frames). Given then that approximately 75% of participants' utterances in the deceptive condition were actually truthful, it seems likely that speakers were recounting an insufficient number of non-truths to alter their *overall* gesture production rate across conditions.

Collectively, the second and third analyses focused exclusively on those gestures that appertained to the three modified details and consequently represented total deviations from the truth. In line with the experimental hypotheses it was found that speakers not only executed significantly fewer iconic gestures when lying[8] (Analysis 2), but that when participants did generate hand movements during deception they were significantly more likely to have shorter stroke phases and less likely to include post-stroke holds, than those produced during truth-telling (Analysis 3).

4.1. *In search of contradictory iconic gestures*

Before considering the implications of these findings, we first turn our attention to an examination of the final hypothesis (i.e., in search of "contradictory iconic gestures"). Recall that in total, three participants' gestures were identified (by both the experimenter and a naive judge) in the deceptive condition that, in their form, appeared to transmit semantic information that was incompatible with the information encoded in the linguistic channel. These participants' iconic gestures seemed to disclose properties of the truthful version of the comic, while their speech conveyed the non-truths that they had been instructed to communicate to the stooge. Critically, no mismatches between speech and gesture were obtained in the truthful condition. Presented below are the three speech extracts along with their accompanying contradictory iconic gestures. Consider the following example in which the participant must claim that Ivy locks the DJ into the back of the car using the side door.

Example (7)
"She like pushes the DJ into the side door of the car and like [slams it shut]"

Figure 6. *Iconic: Left hand is at about shoulder level, with the palm facing outward, away from speaker, fingers outstretched. Suddenly, hand descends rapidly so that the palm faces towards ground.*

What is interesting about this example is that while the speaker claims that the DJ was pushed into the car using the side-door, her iconic gesture reveals that she has accurately retained a truthful mental representation of the event depicted in the comic, in which Ivy pushed the DJ into the *boot* of the car (*hand descends rapidly*). Additional evidential support that suggests that here the speaker's iconic gesture refers to the shutting of the door, rather than the boot can be obtained by comparing this hand movement to the *same* speakers "equivalent" gesture in the truthful condition (i.e., when describing the slamming shut of the boot; see example 8).

Example (8)

"So Ivy like [slams him into the boot of his car]"

Figure 7. *Iconic: Left hand is slightly below shoulder level, palm faces away from speaker, fingers outstretched. Hand descends rapidly, until the palm faces towards ground. Right hand is static, and appears to be in a post-hold lock.*

In both its *form* and *manner of execution* the gesture that the participant produced when truthfully describing the shutting of the DJ into the boot (example 8) was almost identical to the gesture she exhibited when deceptively describing the locking of the DJ into the side of the car (example 7). This provides compelling support not only for the idea that the *same* truthful idea was dominant in the speaker's mind during the production of both utterances, but critically that the underlying truthful properties of the event unwittingly found expression through "gestural leakage," as Beattie (2003) would predict. Furthermore, the gesture made by this participant when describing the opening of the side-door (example 7) is *markedly different* from those hand movements executed by the majority of the other participants who gestured on this changed detail. Presented below is a participant's gesture that typifies the "standard imagistic representation" made by the majority of participants when describing the opening of the side-door.

Example (9)

"shoves him through the [side door and like slams it shut]"

Figure 8. *Iconic: Right hand appears to grip a handle (e.g., of a door). Entire arm rapidly swings sideways (from left to right). Action appears consistent with opening a car-door.*

No contradictory gestures occurred that were associated with the second modified detail of the comic (the spillage of bubble liquid). Nevertheless, two participants demonstrated similar contradictory gestures in relation to the final changed detail, in which they had to falsely claim that bubbles were coming out of Ivy's ears, as opposed to her mouth. Given their similarity, both gestures (examples 10 and 11) shall be presented together.

Example (10)

"so then [bubbles start coming out of her ears]"

Figure 9. *Iconic: Both hands briefly hover less than an inch from the speaker's mouth. Fingers point inwards towards mouth. Hands then start to move away from each other in parallel, and seem to encode the motion-path of the bubbles (i.e., by capturing the idea of dispersion through space). Crucially, the gesture does not occur at level with the ears.*

Example (11)

"so in the end all the bubbles [were coming out of her ears]"

Figure 10. *Iconic: Right hand rises to immediately below mouth, fingers curled slightly. Fingers begin to uncurl and straighten before entire hand flicks forward into the gesture space. Again, the gesture occurs close to the speaker's mouth but away from the ears and appears to encode the idea of diffusion through space.*

Once again it is clear that there is a discrepancy between the participants' speech ("*coming out of her ears*") and the semantic information communicated by the accompanying iconic gestures (*hands briefly hover less than an inch from the speaker's mouth; Right hand rises to immediately below mouth*). Although subtle differences in gesture morphology were observed for the above speakers across conditions when describing the final frame of the comic, both the truthful and deceptive gestures *consistently* occurred near to the speakers' mouths. Conversely, an inter-gestural review of the remaining participants who gestured on this event revealed marked variations in where they *located* the gesture by condition. More specifically, when describing the final frame of the comic, the remaining narrators tended to execute their gestures next to the mouth in the truthful condition, or next to the ears in the deceptive (see appendices 2 to 4 for more information).

4.2. *Resolving individual differences*

By examining several features of iconic hand gestures (namely their frequency, form and duration) during deception, the present study represents the first *systematic* attempt to operationalize and empirically test Beattie's (2003) contradictory gesture hypothesis. The finding that gesture stroke duration was significantly shorter in the deceptive condition, and less likely to include post-stroke holds, provides experimental support for Beattie's central proposition that liars decrease their gesture frequency because they "do not want to risk giving the game away through revealing hand movements" (2003: 168). In suppressing that equally important other side of communication (i.e., gesture), speakers subconsciously select a strategy which will reduce the probability that the form of the gesture will signal possible deceit. As Ekman (2001 [1985]) points out, liars in general pay less attention to their body during deception than to their voice because "they know that they will be held more accountable for their words than for the sound of their voice, facial expressions or most body movements" (2001 [1985]: 81). Of course, the hands occupy an unusual status in relation to the human body. After all, because hand gestures are often perceptible in a speaker's visual field, it seems likely that people are at least *partially* aware that these movements perform some function, even though they are almost certainly unaware of precisely what the function is. In turn, this lack of insight into what the hands are doing, together with a peripheral consciousness that they do *something*, might well be the underlying mechanism that makes people anxious that the form of the gesture could potentially reveal information that they are actively attempting to conceal, leading to gesture reduction during deception.

But why did three speakers produce mismatching gesture-speech compounds, while the remaining participants did not? Of course, it is always difficult to resolve individual differences across speakers, especially in the domain of gesture. As Kendon points out "[q]uestions about how gesture usage might vary systematically by age, sex, setting, discourse circumstance and the like, although of great interest and importance, have not been explored" (2004: 110). Nevertheless, we now attempt to consider why three of the participants went on to produce a contradictory gesture each in the deceptive condition, while the majority did not show evidence of gesture-speech mismatches. A detailed reexamination of the data focusing in particular on potential inconsistencies in the performance of the three participants who produced gesture-speech mismatches, with the pattern produced by the remaining participants lead to a number of surprising results. While the mean gesture production rate in the deceptive condition was 1.4, the three participants who produced contradictory iconic gestures had the *highest* gesture rate during deception (with an overall mean gesture rate of 3.7). In other words, when lying these three participants had a combined gesture rate that is more than two and a half times higher than the mean gesture rate during deception. Of these three speakers who made contradictory gestures, two made the same number of gestures in both conditions (four gestures in each), while the remaining participant showed only a modest reduction in their gesture frequency when lying (producing four gestures in the truthful and three in the deceptive condition). Conversely, the vast majority of the remaining participants (76.5%) reduced their gesture frequency by *at least half* in the deceptive, than the truthful condition. Put simply, the three speakers who produced contradictory iconic gestures, did not reduce their gesture frequency during deception at the same rate as the remaining participants.

Additionally, it was discovered that both of the participants who made gestures with *longer* stroke phases in the deceptive condition, and one of the participant who showed little differences across conditions (see Table 6, participant seven) were in fact the *same* speakers who produced the gesture-speech mismatches. It seems therefore that these participants in particular may have only a very limited insight into their gestural behavior. Whereas most participants reduced the frequency and duration of their gestures accordingly, these three speakers did not modify their behavior. By failing to adopt a strategy of suppression, these participants appear to have placed themselves "at risk" of being caught, and indeed went on to generate gesture-speech mismatches. Perhaps these speakers apparent inability to regulate and constrain their gestural behavior during deception is the principal factor mediating whether or not they manifest mismatches between speech and gesture.

Overall then, this study not only corroborates previous research findings regarding the frequency of gestures during deception, but also demonstrates that occasionally gestural morphology may preserve the underlying truthful properties of an event, even when the speaker's verbal output is able to effectively deliver a lie. The current findings call for greater dialogue between those researchers investigating nonverbal cues to deceit, with those interested in the semiotic value of gesture in communication taxonomies. Studies investigating bodily action during deception should therefore begin to work towards a fuller recognition of, and capitalize on the unique placement of imagistic hand movements as an integral component of the linguistic system *per se* (see McNeill 1992, 2005).

Of course, this experiment only represents a preliminary application of gesture with the deception literature. Additional research is needed to assess the robustness of the phenomenon, especially across a diverse range of discourse settings (e.g., during interrogation, rather than passive monologue; when lying about actual experienced events, rather than imagined scenarios). Additionally, it remains unclear whether trained interrogators would in fact notice these mismatching gesture-speech ensembles in real-time interaction, and whether speakers who produce a mismatch under one set of circumstances would make one on another occasion. While we support Ekman's view that there is no universal behavioral indicator that can reliably distinguish reality from fiction, every lie has its own unique semantic structure, and it may only be through a detailed exploration of individual gesture-speech ensembles, the potential inconsistencies between them and their temporal structure that deception can be detected.

Appendix 1: Ivy the Terrible (full version)

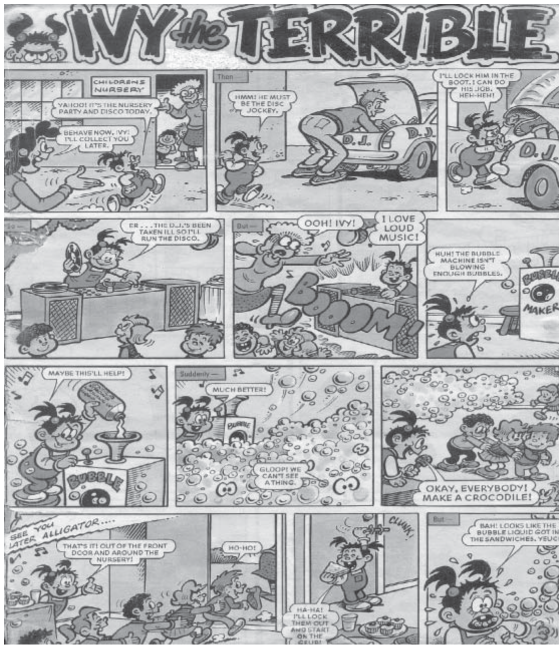

Figure 11. *Ivy the Terrible (full version)*

Appendix 2: Equivalent truthful gestures for the speakers identified as making "contradictory gestures" when describing final frame of the comic

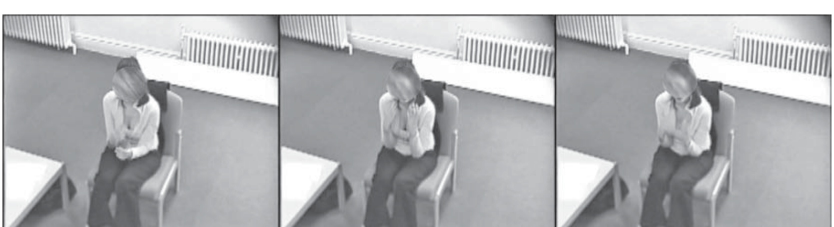

Figure 12. *"and so bubbles start coming [out of her mouth]." Iconic: Both hands ascend together, until they are immediately below the speaker's mouth. Fingers point upwards towards mouth. Hands then move apart, and descend in union.*

Figure 13. *"and in the end bubbles [start coming out of her mouth]." Iconic: Right hand hovers below mouth, left hand a little lower. Palms face towards mouth. Fingers are outstretched. Both hands hover briefly below mouth, before descending together. Hands appear to encode the volume of bubbles coming from the character's mouth.*

Appendix 3: Proto-typical "deceptive" gesture created when deceptively describing the final frame of the comic

Figure 14. *"and come [out of her ears]." Iconic: Palms of hands cover both ears. Both hands then move away from the ears. Gesture appears to index the idea that bubbles stream out of the character's ears.*

Appendix 4: Proto-typical gesture created when truthfully describing the final frame of the comic

Figure 15. *"and so [bubbles come out of her mouth]." Iconic: Both hands rise towards speaker's mouth. Fingers uncurl and outstretch, before hands swing wide apart at elbows. Gesture captures the expanse of bubbles leaving the character's mouth.*

Notes

* The authors would like to dedicate this paper to the memory of Susan Fielder, who was a student of gesture and a true friend to all who know her. She will be greatly missed.

1. Nevertheless, in the interest of clarity we have chosen to stick closely to McNeill's original typology and focus predominantly on iconic hand movements.
2. In accordance with standard conventions, the meaningful part of the gesture, the so-called "stroke" phase, is represented by enclosing the concurrent part of the speech in square parenthesis.
3. I.e., to the right of Kendon's (1988) continuum
4. The word "trunk" is used in North American English.
5. An insufficient number of pre-stroke holds were observed to conduct inferential statistics on their frequency across conditions, without violating the statistic's underlying assumptions. Nevertheless, Table 4 suggests that there is very little variation in their frequency by condition (less than 0.6%).
6. Here the small number of n's is not the result of ties. Only eight participants produced gestures that contained a retraction phase in both the deceptive and the truthful condition.
7. An insufficient number of pre-stroke holds were observed to conduct inferential statistics on phase duration, without violating the statistic's underlying assumptions. Similarly, as participants only produced four post-hold strokes in the deceptive condition, it was not possible to conduct an inferential statistic to determine significance.

8. At least when *only* those gestures which encoded aspects of the three modified details were considered.

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