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Kinesic Patterning in Deceptive and Truthful Interactions

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Abstract

A persistent question in the deception literature has been the extent to which nonverbal behaviors can reliably distinguish between truth and deception. It has been argued that deception instigates cognitive load and arousal that are betrayed through visible nonverbal indicators. Yet, empirical evidence has often failed to find statistically significant or strong relationships. Given that interpersonal message production is characterized by a high degree of simultaneous and serial patterning among multiple behaviors, it may be that patterns of behaviors are more diagnostic of veracity. Or it may be that the theorized linkage between internal states of arousal, cognitive taxation, and efforts to control behavior and nonverbal behaviors are wrong. The current investigation addressed these possibilities by applying a software program called THEME to analyze the patterns of kinesic movements (adaptor gestures, illustrator gestures, and speaker and listener head movements) rated by trained coders for participants in a mock crime experiment. Our multifaceted analysis revealed that the quantity and quality of patterns distinguish truths from untruths. Quantitative and qualitative analyses conducted by case and condition revealed high variability in the types and complexities of patterns that were produced and differences between truthful and deceptive respondents questioned about a theft. Patterns incorporating adaptors and illustrator gestures were correlated in counterintuitive ways with arousal, cognitive load, and behavioral control, and qualitative analyses produced unique insights into truthful and untruthful communication.

Keywords

Patterns, Deception, THEME, Kinesics, Interpersonal communication

Introduction

Interpersonal deception is a complex interaction between two or more individuals, in which one individual attempts to lead the other(s) to a false conclusion, often for personal gain. Although several summaries and meta-analyses have confirmed that truth tellers and deceivers differ in the nonverbal behaviors they exhibit during interpersonal interaction (e.g., DePaulo et al. 2003; Hartwig and Bond 2011; ten Brinke and Porter 2013; Vrij 2000), authors of meta-analyses have concluded that individual nonverbal indicators are often too few and faint to accurately distinguish truth tellers from deceivers (DePaulo et al.2003; Hartwig and Bond 2011). Additionally, evidence that nonverbal indicators of deceit are inconsistent across investigations and variable across time (Buller et al. 1989; Burgoon et al. 1999; Hamel et al. 2007; Stiff et al. 1994; White and Burgoon 2001) supports the conclusion that such indicators lack diagnostic utility. Although we agree that nonverbal cues are often subtle, we also believe that they can reliably discriminate between truth and deception if analyzed as constellations of behaviors that form patterns. This article offers empirical support that even a small set of kinesic behaviors can set truth tellers apart from deceivers when examined as part of recurrent patterns. In support of this claim, we conduct a multifaceted analysis that includes quantitative and qualitative analyses of individual behaviors, patterns of behaviors, and correlations with factors theorized to account for deception displays.

Individual Predictors Versus Patterns as Predictors

One explanation for the weak performance of nonverbal indicators in past analyses is that they have been studied singly. Single behaviors are less reliable than combinations of behaviors, as demonstrated in a few investigations where multiple behavioral predictors produced stronger effects than analyses of individual behaviors (Castellano et al. 2008; Ekman et al. 1991, 1976; Vrij et al. 2004). The approach we report here goes a step further by considering not just a collection of multiple kinesic predictors but rather the recurring structural relationship among simultaneous and sequential behaviors that can effectively discriminate between truthful and deceptive interactions.

Undergirding this conjecture are some fundamental properties of interpersonal communication. First, it is axiomatic that communication is itself a patterned rather than haphazard activity. Communication follows rules for lexical choice, syntax, discourse scripts, turn-taking routines, relational communication sequences, and the like. Second, these regularities in communication not only make understanding possible but also reveal much about relationships, situations, and pathways to interaction outcomes (e.g., Bavelas1950; Dawson 1987; Leavitt 1951; Perlow et al. 2004). Humans are thus well conditioned to expect and respond to patterned behavior in predictable ways. Third, kinesic behaviors may form nonobvious, hierarchically organized patterns. For example, Grammer et al. (1998) found that courting pairs exhibited complex, hierarchically structured, and synchronized patterns of nonverbal behavior that were predictive of the female's interest in the male. It follows that other types of episodes, deceptive encounters among them, may be similarly marked by patterns signaling an interlocutor's veracity. Such patterning may be quite imperceptible in light of deceivers' deliberate attempts to control their behavior so as to appear credible and truthful (Buller and Burgoon 1994; Zuckerman et al. 1981). The subtlety and complexity of these patterns may elude the conscious awareness of observers and interlocutors alike but still be accessible through instrumentation and computerized analysis, as will be demonstrated here.

In the remainder of this article, we first articulate the rationale for three hypotheses derived from persistent claims in the deception literature that deceit elicits more negative affect and levies more cognitive taxation than truth telling, prompting deceivers to also exercise more control over their behavior, leading to observable differences in behavior. Next, we describe an experiment that was conducted in which some participants committed a theft then lied about it to an interviewer, while other participants were innocent and told the truth. We describe the behavioral observation coding that measured the individual behaviors to be analyzed and the pattern analysis tool THEME that was used to search for patterns. We then present results of the hypothesis tests using both traditional statistical tests and THEME pattern analysis to compare deceptive and truthful communication and we examine how the patterns relate to the theorized factors of negative arousal, cognitive load, and behavioral control. Next, we consider what the patterns reveal about truthful and untruthful communication. We conclude with implications not only for the ability of nonverbal behavior to reveal communicator veracity but also the potential of pattern analysis to pick up on subtleties in interpersonal communication more generally.

Deception and Indicators of Cognitive Difficulty

That deception is more cognitively demanding than truth telling has been a persistent conclusion in the deception literature and one demonstrated in a host of experiments (e.g., Bagley and Manelis 1979; Doherty-Sneddon et al. 2002; Goldman-Eisler 1968; Mann and Vrij 2006; Mann et al. 2002; Vrij et al. 1996, 2008). The additional cognitive burdens associated with deceit are many. Prevaricators must mentally retrieve the truth, decide whether to speak the truth or substitute in an alternative version of reality, manufacture or recall the falsified story to be told to the target, and formulate message content, language, and accompanying nonverbal behaviors in a manner resembling a truthful response. Furthermore, they must also monitor their own words and actions and the target's feedback to them to discern if the deception is successful, all the while fulfilling normal turn-taking responsibilities (Burgoon and Buller 1994). These greater cognitive demands can interfere with nonverbal performance such that deceivers change their rate of illustrator gestures; reduce hand, finger and limb movements; avert their gaze; reduce blinks; show changes in upper or lower facial expressions; hesitate and pause more; introduce more disfluencies in their speech; and give the appearance of "thinking harder." Many of these behaviors clearly reveal interference with communicative performance. Some of the nonverbal changes, such as gaze aversion and suppression of gesturing, may help to manage the cognitive load by closing off the communication channel temporarily and limiting the tasks of integrating verbal and nonverbal channels into a coherent whole but nonetheless can still result in awkward, stilted presentations.

Some of the changes also reflect greater demands on working memory. As explained by Sporer and Schwandt (2006), in the case of complex lies at least, deception entails assembly and construction of new renditions of events and details that must be cross-checked against truthful versions so as to avoid contradictions and implausible accounts. Deceptive responding likewise activates brain regions that monitor activity and handle conflicting response tendencies (Johnson et al. 2004). This can produce incongruous messages. Franklin (2007), for instance, showed that narrators giving deceptive accounts of a video they had viewed used hand gestures that told one story (the true account) while their words were telling a different one (the false account). Non-fluent or incongruent kinesic activities thus may signal deceit. Truth-telling, on the other hand, involves the far less mentally taxing tasks of recalling the truth and telling it.

The complexities of generating deceptive utterances can disrupt the ability to integrate verbal and nonverbal behaviors, to create novel utterances, and to produce coherent discourse. Research on the verbal behaviors associated with deception bolster this account of the disruptive and cognitively taxing effects of deception (DePaulo et al. 2003; Vrij et al.2000). For example, deceivers tend to use shorter utterances; fewer words and sentences (particularly when they lack opportunities to plan, rehearse, or edit their ongoing discourse); more repetition of words and phrases; less diverse vocabulary; less complex syntax and vocabulary; less detail; and more disfluencies than do truth tellers (Burgoon and Qin 2006; Newman et al. 2003; Toma and Hancock 2010; Zhou et al. 2004).

McNeill et al. (McNeill 1985, 1992; McNeill et al. 1994) have demonstrated persuasively that the production of the verbal component of messages originates from the same mental impulse that produces accompanying gestures and other nonverbal expressions. The coherent production of meaning occurs through the integration of interdependent verbal and nonverbal elements into a single message. Disruption of any part of this assemblage of components may therefore impair overall message production.

If (or when) deceit short-circuits message production by virtue of imposing greater cognitive demands on the communicator, then the resultant verbal and nonverbal messages may reveal evidence of that impairment in both the quantity and quality of the output. One design feature of language is its productivity, or its ability to generate an infinite number of novel sentences. As part of a unified message production process, nonverbal behaviors should share this same combinatorial potential of being put together and ordered in a variety of patterns. Just as deception-induced depletion of cognitive resources may disrupt the ability to produce a variety of novel sentences, so may it also result in speakers defaulting to shorter, simpler, repetitive, and inelegant forms of verbal and nonverbal expression, much as occurs when speakers experience stage fright or communication apprehension. After all, it is easier to devolve to simpler language and to repeat oneself than to search for new vocabulary and construct new and more complicated constructions.

Arousal is a sense of excitement (positive or negative), and is generated when people are faced with an unusual or threatening experience, such as a situation in which the person needs to lie (Caso et al. 2005; Sporer and Schwandt 2007; Wright et al. 2012). Futhermore, people who believe they will get away with lying have an even greater increase in arousal (Gonza et al. 2001). Arousal leads to an increase in stress (Ekman 1992; Gonza et al. 2001; Vrij et al. 2000), and further taxes the individual cognitively.

While it is difficult to measure arousal objectively, some symptoms can be measured indirectly through behavioral indicators. Arousal is associated with suppressed extremity movement (Reinhard et al. 2011; Sporer and Schwandt 2007; Vrij 2008), increased blood pressure and heart rate, sweaty palms (Derksen 2012), and an increase in vocal disfluencies (such as 'um') (Villar et al. 2000, 2011). Arousal can also be measured using perceptual, self-reported measures (Bohlin and Kjellberg 1973; Kjellberg and Bohlin1974), though there is debate as to whether such measures correlate well with physiological arousal (Blascovich et al. 1992).

An alternative perspective originating from interpersonal deception theory (IDT; Buller and Burgoon 1996) is that deceivers engage in strategic behavior designed to mask their deceptive intent and to advance a favorable self-presentation. Thus, although deceivers may experience some discomfort, negative affect, and cognitive challenges, they will also work to manage their demeanor so that they are believed, suppressing any indications of discomfort, negative affect, and excessive cognitive demands (Gunnery et al. 2013; Hurley and Frank 2011; Porter and ten Brinke 2008).

Pattern Analysis

The current investigation tested these possibilities through application of an innovative pattern analysis tool called THEME (Magnusson 2005, 2006). THEME is a commercially available software program that analyzes patterns of discrete events in time-oriented data. The data are divided according to distinct event types, with a beginning and ending time associated with each occurrence. If multiple actions begin at the same time, they are coded as separate events but with the same time code. In this way, each event can be treated individually. THEME systematically searches for patterns of events that occur frequently throughout the dataset. The frequency required for THEME to label a pattern is adjusted by interview length, meaning that longer interviews will require more occurrences of a pattern. A *t-pattern* (short for THEME-pattern) is defined as a set of events that occurs either concurrently or sequentially more often than would be expected by chance if all events were independently distributed (Magnusson 2006). THEME identifies these patterns, along with various characteristics of the patterns (e.g., number of events in the pattern, pattern complexity, number of occurrences of the pattern within the dataset), and allows the researcher to examine and compare them. Unlike analyses that only examine sequences of adjacent behaviors, THEME identifies behaviors that occur within a critical time interval, then develops those patterns by adding further behaviors to the pattern when they also occur within the critical interval. Patterns can also be added together, creating large patterns that are hierarchically composed of smaller patterns.

THEME has been employed successfully in such research as gender roles in teams (Koch et al. 2005), family conflict (Hardway and Duncan 2005), and the functioning of autistic children (Plumet and Tardif 2005) among others. In the current investigation, we employed the latest beta version of THEME (6.0) to find patterns of kinesic behaviors among innocent and guilty individuals being interviewed about a mock theft.

The limitations of human observers and the laborious nature of nonverbal observational coding have often led to pattern research being limited to molar constructs such as sociometric networks of relationships among communicators and organizational leadership structure. The THEME software package allows the discovery of more complex patterns formed from the events recorded by human observers. Moreover, because the patterns recognized by THEME can occur concurrently, the software can extract a large sample of patterns within interactions.

Hypotheses

We have argued that when deception is more cognitively taxing than truth telling, as is often the case, telling untruths may be disruptive to deceivers' message production and interpersonal interactions, causing such interactions to show less patterning than that of truth tellers. The demands on working memory that yield longer response latencies, slower speech, and more abbreviated answers together may also dampen involvement—something that is a lubricant for smooth interaction—and disturb the coordination of interaction. The current investigation thus considered whether the composition and complexity of patterns in deceptive interactions differ from those in truthful interactions.

Operationally, four characteristics of interaction speak to pattern composition and complexity: the diversity of elements within patterns, pattern length, hierarchical levels of patterns, and repetitiveness of patterns. THEME labels each time-bound behavior as an event and each category of behavior as an event type. *Diversity* refers to how many different event types are exhibited. *Length* refers to how many events are chained together in a pattern. *Level* refers to how hierarchically subordinated subsets of patterns are.

As already noted, when people tell lies, their speech is more hesitant and abbreviated, less lexically and syntactically complex and diverse than that of truth tellers (Zhou et al. 2004). Our first hypothesis tested whether analogous effects would emerge in the patterns of nonverbal behavior. Stated formally,

H1

Truthful individuals exhibit nonverbal behavior patterns that (a) include greater diversity of event types, (b) are longer (include more events), and (c) are more hierarchically complex (have more levels) than deceivers.

The alternative theoretical perspective consistent with IDT is that, contrary to H1, deceivers' patterns may show more rather than less variability. Henningsen et al. (2000) showed mock witness testimony to students who were then asked to rate the deceptiveness of participants. Testimonies that showed irregular patterns of deceptive behavior were judged as more deceptive than were testimonies with consistently high or low levels of deceptive cues. From this one might surmise that deceivers' increased cognitive burden would produce more erratic behavior and thus result in more, and more varied, patterns. Alternatively, and the position we favored as more likely, is that deceivers operating under increased cognitive load would lapse into repeating the same communication patterns so as to reduce their effort level. Millar and Rogers (1987) identified repetitive patterns as dysfunctional in the context of relational message exchange, arguing that greater adaptability and flexibility are needed to maintain healthy interpersonal communication. In the same vein, deceivers might be less adaptable and likely to default to repetition of the same behavioral sequences. We also reasoned that because deceivers attempt to control their nonverbal behavior, overzealous suppression of activity could produce a wooden, rigidified pattern (DePaulo et al. 2003) that would also reduce the variability and novelty of behavior.

As for the amount of patterning, two contrasting predictions are possible. THEME generates a count of the total number of patterns produced, regardless of their length. On the one hand, H1 postulates that truth tellers will be more productive than deceivers in producing novel utterances. By extension, that same productivity could lead to a greater total number of patterns, both new and old. In general, the expectation that truth tellers will have more coherent discourse implies that they will also engage in more patterned communication overall, especially when questioning turns to the theft and imposes greater cognitive taxation on deceivers. On the other hand, the H1 prediction that deceivers' discourse will consist of more redundant patterns opens the door for deceivers' patterns differing from those of truth tellers only in composition and not in quantity. H2 therefore posited a nondirectional hypothesis regarding quantity. H3 further tested whether the shift from the baseline phase of questioning, during which all interviewees should have been truthful, to the phase of questioning about the transgression (i.e., the theft) would alter the variability in patterns by deceivers and truth tellers.

H2

Deceptive individuals differ from truthful individuals on the quantity of different patterns exhibited.

H3

Deceptive individuals differ from truthful ones in changeability in patterns from baseline questions to transgression-related questions.

Of course, the advantage of a pattern analysis approach is its ability to generate insights beyond the observation of the individual behaviors. As a basis for comparison, we therefore also conducted analyses of the individual behaviors, examining both the between-subjects differences of truthful and deceptive participants and the within-subjects, over-time changes across phases of the interview.

Method

Overview

The hypotheses were tested by re-examining a subset of interviews from a mock theft experiment in which student participants either "stole" a wallet from a classroom or were present during the theft. Both innocent and guilty parties were interviewed immediately after the theft by trained interviewers who questioned them about other innocuous topics before questioning them about the theft. All participants were instructed to convince the interviewer of their credibility and innocence, resulting in innocent participants being truthful and guilty participants being deceptive. Interviews took place in one of three modalities: text, audio, and face-to-face. As THEME requires discrete events for its analysis and only the face-to-face modality provided discrete kinesic behaviors, analysis was confined to this condition.

Whereas most studies of deception are based on very brief excerpts of interaction, often averaging 30 seconds or less (see, e.g., DePaulo et al. 2003), the full power of THEME is best employed with much longer interactions where there are opportunities for a variety of patterns to emerge. The current corpus offered just such an opportunity because interviews ranged from 10 to 15 minutes in length and covered multiple topics. The inclusion of a truthful baseline period also permitted both between-subjects analyses (between truth tellers and deceivers) and within-subjects analyses (from baseline to theft questioning). The use of baseline questioning is not only standard practice in conducting clinical and educational research entailing interventions but also is common practice among practitioners attempting to ascertain deceit during interviews. Unlike highly controlled experiments that investigate single utterances or that impose artificial constraints on turns at talk, this investigation permitted participants to engage in more naturalistic discourse amenable to interlocutors adapting to one another's communication and establishing unique dyadic interaction patterns. As a consequence, this investigation stands as an exception to the usual deception experiment by affording enough time and interactivity to uncover temporal dynamics and particularized patterns.

Sample

Data for the current experiment were derived from a larger experiment (N = 186) investigating interview credibility and deception (see Burgoon et al. 2006). The current analysis was based on the 4,200 behavioral observations of innocent and guilty participants who met the following criteria: (a) participated in the face-to-face (full audiovisual) interview condition, (b) followed all experimental instructions, (c) did not confess to the mock theft, and (d) had recordings that were of high enough quality to conduct precise behavioral observation and coding. The resultant sample (n = 26), although small, yielded an exceptionally large number of observations to analyze due to the repeated observations of 10 behaviors across 20 questions (26 × 10 × 20 = 4,200).

The full experiment recruited subjects from an introductory communication course to participate in a study of interviewing credibility and deception. Participants received extra credit for their participation and were incentivized with a monetary bonus of $10 plus a chance to earn an additional $50 if they successfully convinced the interviewer of their credibility and innocence. The most successful participants in the innocent and guilty conditions were each awarded $50. Demographically, the face-to-face condition was 70 % female, 75 % Caucasian, 15 % African-American, and 10 % Hispanic/Latino, Pacific Islander, or another ethnicity; mean age was 19.4.

Interviewers were 3 male students ranging in age from 22 to 29. One was an experienced interviewer who conducted interviewing and interrogation training for John E. Reid and Associates. He trained and observed the other two interviewers and all three practiced following the scripted interview during a pilot test of procedures conducted with 30 participants.

Experimental Design and Procedures

For this experiment, participants were randomly assigned to one of two roles: truthful (n = 8) or deceptive (n = 18). In the deceptive condition, participants were instructed to steal a wallet from a classroom, to conceal it on their person and then subsequently lie about the theft when interviewed about it. Participants who had confessed to the theft or failed to lie on all theft-related questions (n = 5) were removed from the data set so as not to contaminate deceptive responding with some truthful responding. In the truthful condition, participants were innocent bystanders to the theft but were alerted to the possibility of a theft taking place in their classroom so that all participants would be vigilant in class on the day they were scheduled for their interview.

All participants were interviewed about the theft immediately after the class by one of the interviewers and told to convince the interviewer of their innocence. The interview was scripted so as to reduce variations between participants. Participants also completed a written statement and questionnaire. Guilty participants were expected to lie during the interview in order to appear innocent. Innocent participants were urged (and assumed) to be completely truthful during the interview, since they had not committed the mock theft.

All experimental procedures were approved by the University Institutional Review Board. All experimental participants gave their informed consent prior to their inclusion in the study.

Dependent Measures

THEME requires coding of specific discrete events. Thus, we focused on kinesic nonverbal behaviors that were amenable to locating identifiable starting and stopping points or could be coded as simple frequencies (e.g., a nod). The first class of behaviors to be coded was*illustrator gestures*, which are the gestures that accompany and clarify speech and thus aid in listener understanding (Holler and Beattie 2003). An example of an illustrator would be raising a hand above one's head when describing a tall person. The second class of behaviors was *adaptors*, which are a broad category of kinesic behaviors used to satisfy physical or psychological needs (Ekman and Friesen 1969). Examples of adaptors are scratching the nose, picking at clothes, cracking joints, or yawning. In our case, we identified whether the illustrators and adaptors were performed by the right and or the left hand and in an upper or lower, left or right quadrant of space relative to the trunk. Classifying by location gave a further level of granularity to aid in uncovering distinct patterns. An additional category was created for adaptors involving the face or neck, such as rubbing the neck, head, or eyes. The final adaptor included in our analysis was lip adaptors, which included pursing, licking, or biting lips, tongue-showing, and other related mouth movements often indicative of concentration, consternation, confusion, or nervous activity. The last category of kinesic indicators included *head movements* such as nods, shakes, and punctuated movements. The nods used in our classification were divided between those committed while the actor was speaking and those displayed while the actor was listening. Speaking head movements are used to illustrate and complement what is being said or to punctuate speech, signify tense, and the like (Birdwhistell 1970; Chovil 2004). Nods and shakes while listening (also called backchannel cues) provide visual feedback to the speaker that they are being heard and understood (Duncan 1974).

The video-recorded interviews were subjected to behavioral observation by teams of trained coders (three coders per behavior and region being coded) using CMI's Behavioral Annotation System (C-BAS) Version 2.0, a software tool developed for time-stamped behavioral observation (Meservy 2010).[1] The behaviors selected for analysis, with summary statistics for guilty participants, innocent participants, and overall, appear in Table 1. Using C-BAS, coders watch an audiovisual recording of an interaction and either press a key each time they observe a frequency-based behavior or hold down the key for the duration of any time-based behavior, releasing the key when the behavior ends. C-BAS time-stamps each coded behavior at the individual frame level, providing extremely fine-grained recordings of serial behavior and interleaving subsequent codings within the same file for precise synchronization of behavior.

Table 1 Summary statistics for nonverbal behavioral observations, by conditions and overall

Behavior	N	Min	Max	M	SD	Median
Guilty ($n = 18$)						
Face/neck adaptor	250	2	45	15.63	16.52	6
Lip pursing	132	1	30	8.80	7.88	8
Left adaptor, upper trunk	2	1	1	1.00	0.00	1
Left adaptor, lower trunk	566	3	134	35.38	39.31	17
Right adaptor, upper trunk	3	1	2	1.50	0.71	1.5
Right adaptor, lower trunk	515	1	103	32.19	33.77	19
Left illustrator	408	1	69	25.50	24.97	16.5
Right illustrator	788	2	132	43.78	40.76	26
Speaker nod	464	4	85	25.78	22.05	19
Listener nod	175	3	18	9.72	4.00	9
Innocent ($n = 8$)						
Face/neck adaptor	154	10	44	22.00	13.61	14
Lip pursing	51	1	19	7.19	6.10	7
Left adaptor, upper trunk	26	2	15	6.50	5.80	4.5
Left adaptor, lower trunk	376	17	115	53.71	40.99	33
Right adaptor, upper trunk	25	2	20	8.33	10.12	3
Right adaptor, lower trunk	383	17	116	54.71	40.93	30
Left illustrator	109	3	39	15.57	14.29	12
Right illustrator	243	3	83	34.71	30.99	29
Speaker nod	213	1	65	30.43	25.97	24
Listener nod	63	4	18	9.00	4.93	7
Overall ($n = 26$)						
Face/neck adaptor	404	2	45	17.57	15.67	10
Lip pursing	183	1	30	8.32	7.25	7.5
Left adaptor, upper trunk	28	1	15	4.67	5.32	3
Left adaptor, lower trunk	942	3	134	40.96	39.83	22
Right adaptor, upper trunk	28	1	20	5.60	8.08	2
Right adaptor, lower trunk	898	1	116	39.04	36.70	27
Left illustrator	517	1	69	22.48	22.42	12
Right illustrator	1,031	2	132	41.24	37.87	28
Speaker nod	677	1	85	27.08	22.75	19
Listener nod	238	3	18	9.52	4.18	9

Coders received over 20 h of training and practice on each behavior to be measured and made separate passes through the videos for separate regions of the body and type of kinesic movements (e.g., head, face, gestures in upper and lower trunk regions). Reliabilities for coding were calculated for the frequency of coded adaptors (Cronbach'sα = 0.91), illustrators (α = 0.91), and head nods (α = 0.80). Most of these behaviors occur many times in every interview, and identifying the patterns of behavior is too complex for the unaided human eye.

After these videos were coded and reliability determined, the data from the two coders were merged into one file and converted into a THEME-compatible format with beginning and end times assigned to each event. Duplicate events were removed. Overlapping events were assigned the earliest and latest time-stamps to encompass the entire possible range of a given event.

To provide insight into whether behaviors were a function of the theorized factors of negative arousal, perceived cognitive difficulty, and attempted behavioral control, participants completed three self-report measures. Six 7-interval unipolar rating scales measured negative arousal (e.g., "not at all" to "very flustered" during the interview) and achieved a reliability of 0.85. Four 7-interval unipolar scales measured cognitive difficulty (e.g., "not at all" to "very challenging mentally" to answer the questions) and achieved a reliability of 0.89. Due to low reliability a single unipolar scale measured behavioral control ("How much did you try to control your nonverbal behavior?" "not at all" to "very much").

Results

Individual Behavior Analysis

Before conducting THEME analysis, we conducted two analyses of the individual coded behaviors. Independent sample *t*-tests compared the mean individual behaviors exhibited by deceptive versus truthful participants. None of the *t*-tests was statistically significant, as shown in Table 2. Even when tested with more powerful veracity by interview phase repeated measures ANOVAs, the individual nonverbal behavior analyses produced only one significant effect that was due to differences during the baseline rather than theft phase of questioning.[2] Had the individual behavior analyses been the only ones conducted, the conclusion drawn might have been that nonverbal behaviors are unreliable in discriminating truth from deception. However, these findings also open the door for demonstrating the power of THEME to provide unique insight into how deception is enacted.

Table 2 Mean frequency, (SD) and *t* test comparisons of nonverbal behaviors

	Condition		*t*	*df*	*p*
	Guilty	Innocent			
Face/neck adaptor	15.63 (16.52)	22.00 (13.61)	0.966	21	0.345
Lip pursing	8.80 (7.88)	7.19 (6.10)	0.524	20	0.606
Left adaptor, upper trunk	1.00 (0.00)	6.50 (5.80)	1.897	4	0.131
Left adaptor, lower trunk	35.38 (39.31)	53.71 (40.99)	0.999	21	0.329
Right adaptor, upper trunk	1.50 (0.71)	8.33 (10.12)	1.165	3	0.328
Right adaptor, lower trunk	31.19 (33.77)	54.71 (40.93)	1.278	21	0.215
Left illustrators	25.50 (24.97)	15.57 (14.29)	1.203	21	0.242
Right illustrators	43.78 (40.76)	34.71 (30.99)	0.599	23	0.555
Speaker nods	25.78 (22.05)	30.43 (25.97)	0.419	23	0.679
Listener nods	9.72 (4.00)	9.00 (4.93)	0.345	23	0.733

The second set of analyses consisted of examining bivariate correlations among the counts of individual behaviors and the self-report measures of negative arousal, cognitive difficulty, and behavioral control. Since interaction length differed among the participants, and to make the correlation results comparable with correlation results discussed in the next section, counts were converted to a percentage of that participant's total behavior. When correlated with measures of negative arousal, cognitive difficulty, and behavioral control, at least two possible outcomes could be expected. The first, fitting with the notion that deception is associated with rigidity as deceivers concentrate under the additional cognitive burden required to deceive and attempt to suppress telltale signs, would be negative relationships between movement behaviors such as illustrators and adaptors on the one hand and negative arousal, cognitive difficulty, and behavioral control on the other hand. Alternatively, higher degrees of negative arousal and cognitive load might be positively associated with increased adaptors in the form of nervous fidgeting when confronted about the deception and perhaps an increase in illustrating hand movements while speaking (illustrators) to present one's deceptive responses more persuasively. This finding presaged the possibility that deception would be more associated with an assertive than a retiring and nervous communication pattern.

Significant results were obtained among the self-report measures—negative arousal was significantly and positively correlated with cognitive difficulty, $r(24) = 0.68$, $p < 0.01$, and behavioral control, $r(24) = 0.42$, $p < 0.05$—but only one behavioral measure produced a significant correlation—negative arousal was positively correlated with illustrators (as a percentage of total behaviors), $r(24) = 0.60$, $p < 0.01$. This relationship was even more pronounced among deceivers $r(16) = 0.68$, $p < 0.01$. This finding suggests that deception is associated with assertive, illustrative speaking gestures. Due to the underpowered analysis, although other relationships attained large to medium-large effect sizes, they did not achieve statistical significance. They are available upon request.

THEME Parameters

The first step in conducting THEME analysis was to set parameters for the pattern searches. Because THEME searches for "frequent" patterns, a first parameter to set is how many times a pattern must occur to qualify it as a pattern. For our analyses, we configured THEME to discard patterns that occurred fewer than five times during the course of an interaction. We chose this fairly stringent criterion to limit attention to patterns that truly are recurrent and because a more liberal criterion can render far too many patterns to interpret.

A second criterion is the critical interval within which two events must occur to regard them as related. A statistical test determines the size of this interval. We set the *p*-value for this test at 0.005.

A third criterion is how many levels to seek. Setting the levels too low may overlook interesting and complex patterns. Setting search levels too high will quickly overload most modern desktop computers as THEME attempts to combine increasingly complex patterns. Our maximum search level of four was determined by the operational constraints of our analysis equipment. Finally, to ensure that patterns detected are not simply random, the analysis is conducted multiple times on independent, random or shuffled reorderings of the data (see Appendix). We set this parameter to 10. Figure 1 shows the result of this comparison, with many more patterns of longer lengths found in the real data than in the randomly reordered and shuffled data.

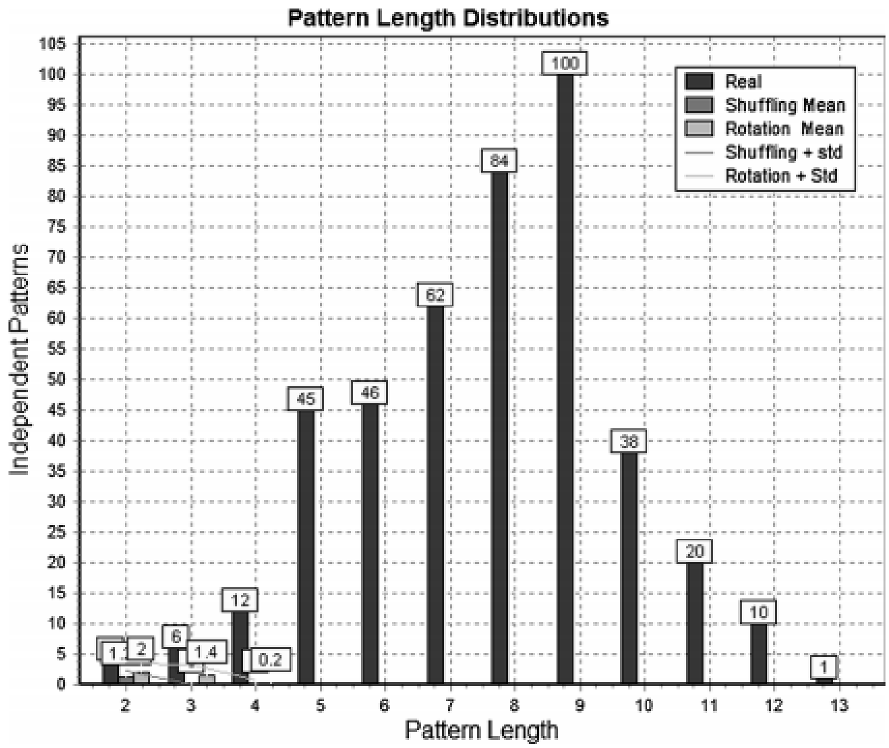

Fig. 1 Pattern length distributions for patterns derived from the actual data and from random re-orderings. The *black bars* indicate the number of patterns found of various lengths in the real data, *while dark* and *light grey bars* indicate the number of patterns found in the randomly reordered data

A sample pattern from our dataset is shown in Fig. 2. It includes the following behaviors, each with a beginning and an end: two face/neck adaptors, a left hand adaptor, a speaker nod, lip pursing, and a listener nod. As shown in the illustration, the participant's behavioral pattern begins with face/neck adaptors and a left hand adaptor beginning simultaneously (T0). The left hand adaptor ends (T1), followed by the simultaneous end of the face/neck adaptor with the beginning of a speaking nod (T2). At the end of the speaking nod, another face/neck adaptor, a left hand adaptor, and lip pursing begin (T3). This is followed by the start of a listening nod (T4), after which the lip pursing and the left hand adaptor conclude (at T5 and T6, respectively). Finally, the face/neck adaptor and the listening nod end simultaneously (T7).

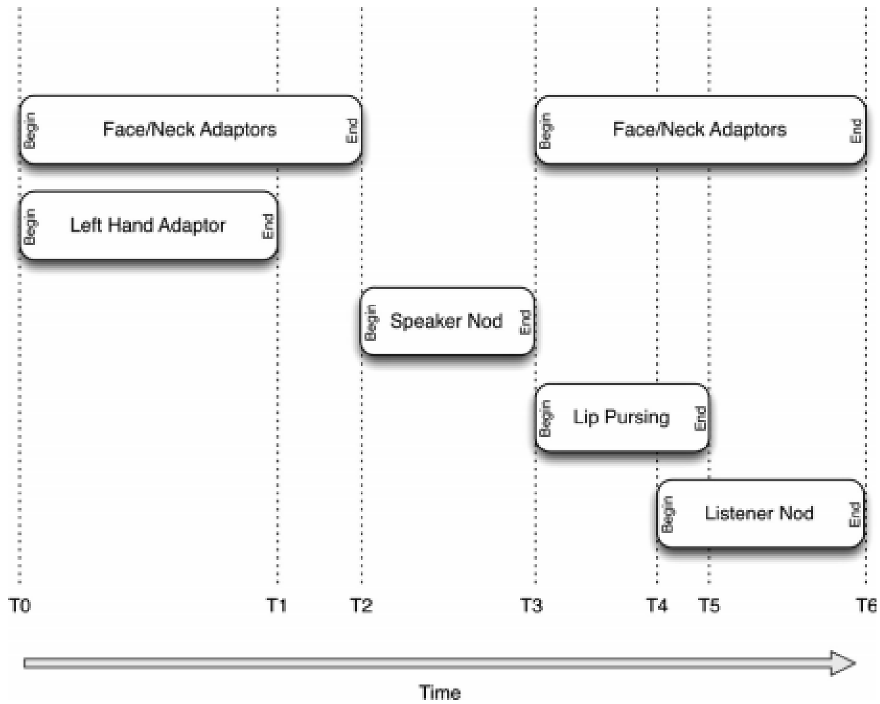

Fig. 2 Illustration of a sample pattern discovered by THEME

There are a few things to note regarding this sample pattern. First, THEME has considered the beginning and the end of a particular behavior as separate, discrete events. This permits coding both frequency behaviors (very brief occurrences) and durations. Second, the sub-pattern highlighted in Fig. 2 occurs twice during this pattern. THEME has identified the smaller pattern (consisting of the simultaneous beginning of a face/neck adaptor and a left hand adaptor, followed by the end of the left hand adaptor, followed by the end of the face/neck adaptor), and that pattern is then allowed to act as a discrete event in larger, more complex patterns. In the pattern shown in Fig. 2, the full pattern has a "level" of two, indicating that there are two tiers to this pattern, one or more sub-patterns being subsumed by the higher level pattern. A pattern level of three would indicate that the full pattern contained at least one sub-pattern which itself contained a smaller sub-pattern.

THEME's capabilities go far beyond the small sampling provided in this section. The Appendix provides an explanation of the method THEME uses to ensure that discovered patterns are due to legitimate patterns within the dataset and not due to chance discoveries. Further and more detailed discussion of THEME software can be found in (Magnusson 2005, 2006). For brevity, we highlight here the pattern-related parameters we used in our analyses in the next section (summarized with descriptive statistics in Table 3). For each participant, THEME provided the average number of unique event types per pattern, the average length of patterns, the average complexity of patterns, and the total number of unique patterns.

Table 3 Pattern descriptions, means, and SD of pattern metrics by condition

Metric	Brief description	Deceptive ($n = 18$)		Truthful ($n = 7$)	
		M	*SD*	*M*	*SD*
Average number of event types	Average number of different coded behaviors in an individual's patterns	12.89	2.93	15.71	2.69
Number of unique patterns	Frequency of unique patterns produced by an individual	618.56	1,416.08	1,801.00	2,414.94
Average pattern complexity	Average number of hierarchical levels in an individual's patterns	2.89	0.85	3.43	0.62
Average pattern variability	Average variability (i.e., standard deviation) of unique patterns produced by an individual	8.36	4.79	5.72	1.26

Hypothesis Tests: Comparison of Truthful and Deceptive Patterns with THEME

The next step of the analysis was to compare the truthful (innocent) respondents to the deceptive (guilty) ones on the patterning of their behavior. This was accomplished in two successive tests similar to those performed using the raw behavior data. The first was a series of *t* tests (summarized in Table 3 and discussed next), and the second was a correlation analysis incorporating the self-report measures. Consistent with H1a, there was a significant difference, $t(24) = 2.17$, $p = .02$, Cohen's $d = 1.00$, in the number of different events in patterns between deceptive ($M = 12.89$, $SD = 2.93$) and truthful ($M = 15.71$, $SD = 2.69$) participants. Truthful interviewees used more different behaviors than deceptive interviewees in their nonverbal patterns. Truthful participants also tended to average longer patterns ($M = 6.55$, $SD = 1.95$) than did deceptive participants ($M = 5.17$,$SD = 2.16$), as posited in H1b, but the difference fell short of conventional significance levels, $t(24) = 1.49$, $p = .07$, one-tailed.

Consistent with H1c, truthful interviewees had patterns that were more complex ($M = 3.43$, $SD = 0.62$) than those of deceptive interviewees ($M = 2.89$, $SD = 0.85$),$t(24) = 1.71$, $p = .05$, $d = 0.73$, one-tailed. Their patterns showed more levels, indicating more hierarchically ordered sets of nonverbal behaviors. In attempting to monitor and control their behavior, deceptive individuals appear to have also inadvertently limited the length and complexity of their patterned behaviors.

To test H2 regarding number of different patterns exhibited, it should be recalled that our parameters were set to include only patterns that occurred more than five times; thus, five is the lower limit for the number of occurrences to be included in this analysis. The data did not provide support for H2. There was no significant difference in the average number of different patterns between groups (truthful $M = 1{,}801$, $SD = 2{,}414$; deceptive $M = 618$,$SD = 1{,}416$), $t(24) = 1.15$, $p = .13$. The degree of patterning was extremely variable: truthful participants' number of patterns ranged from 96 to 4,383, whereas deceptive participants' patterns ranged from 7 up to 4,444.

This wide variation in the number of patterns has implications for this type of research. The number of patterns found in some interviews was limited by the sparsity of cues. Some individuals were simply less expressive with their hands and heads during the interview. The addition of more behaviors to the analysis would help mitigate this sparsity and enable a more meaningful comparison on the number of patterns found.

H3 posed the possibility of change in patterns over the course of the interview. Because the interview began with questions unrelated to the theft, deceptive participants were expected to exhibit a change in behavior as the interview shifted from the truthful baseline period into questions related to the theft, during which they were responding deceptively. THEME provides a filter allowing discovery of patterns that occur significantly ($p < .01$) more often before or after a given juncture. Results showed suggestive differences between the two different questioning periods. During the baseline questions, truthful participants ($M = 247$, $SD = 336$) had more patterns than deceptive participants did ($M = 98$, $SD = 395$). After the theft questioning began, truthful participants introduced an average of 23.6 new patterns ($SD = 32.2$), while deceptive participants introduced only 3.6 ($SD = 9.95$). Although the difference failed to reach conventional statistical significance levels, $t(24) = 1.47$, $p = .08$, the marked mean difference nonetheless implies that truthful participants varied their behavioral sequences more when questioning about the theft began, whereas deceivers opted for redundancy.

The second analysis was a correlation analysis similar to that performed with the percentage-based raw behavior counts in the previous section. To complete this analysis, patterns discovered by THEME were counted according to whether they included a specific behavior (e.g., patterns that included adaptor behaviors). Again because of the wide variation in number of patterns per individual, pattern counts were converted to a percentage of total patterns for that individual. These percentages were then correlated with the self-reported measures of negative arousal, cognitive difficulty, and behavioral control.

The correlation analysis involving pattern statistics produced considerably more indications of deception than did the correlation analysis with raw counts of behaviors. Percent of patterns containing adaptor behaviors was significantly and negatively correlated with all three self-reported measures: negative arousal, $r(24) = -.42$, $p < .05$, cognitive difficulty, $r(24) = -.50$, $p < .01$, and behavioral control, $r(24) = -.44$, $p < .05$. These three correlations fit with the characterization of deceivers minimizing adaptor behavior, the more they experience negative arousal and cognitive difficulty, and exert behavioral control. That is, internal states and intentions produced behaviors opposite of what is intuitive and stereotypic. Instead of negative affect and discomfort leading to leakage of telltale signs, it led to an actual suppression of those signs, a finding that has significant implications for theories that posit a one-to-one positive correspondence between internal states and external displays. In like manner, similar to the correlations with the raw behavior counts, cognitive difficulty and percent of patterns containing illustrators were highly correlated, $r(24) = .56$, $p < .01$. This supports the notion that the more deceivers experience cognitive demands in producing their deceits, the more expressive they become in their communication, illustrating with hand movements and attempting to be convincing. These zero-order correlations serve as illustration of the unique perspective afforded by the pattern discovery process THEME provides. The raw behavior counts produced fewer findings in comparison, and it was only after examining the correlations of patterns with self-reported measures that we were able to uncover the relationships among adaptors, illustrators and negative arousal, cognitive difficulty, and behavioral control.

Pattern Exploration

In addition to the differences in the number of patterns, THEME produces detailed information identifying the patterns of interest. Here we provide examples of the two longest patterns identified by THEME in each group of participants. THEME can identify patterns that are statistically more likely to appear in one set of data files than the rest. In addition to individual-level patterns, THEME can search for patterns that are common to all, or at least many, participants, while the standard THEME search occurs on a sample-by-sample basis. Segregating the data in this way allows us to identify patterns that are common in innocent participants but not in the guilty, and vice versa.

Interestingly, THEME identified far more patterns that were exclusive (or nearly so) to the innocent group than to the guilty group. When conducting the analysis, we specified that patterns must appear in at least 15 % of the samples, with a minimum of 40 occurrences. Of the 270 patterns identified by THEME using these parameters, 125 were statistically ($p < .05$) more likely to occur among innocent participants than guilty ones. Only 7 patterns were identified as statistically correlated with deception. Thus, the guilty group was characterized more by the lack of distinctive patterns than by their presence. The string identifying the longest distinctively innocent pattern was:

(b,leftadaptors,lowertrunk ((b,faceneckadaptors b,rightadaptors,lowertrunk) (e,leftadaptors,lowertrunk e,rightadaptors,lowertrunk)))[3]

After displaying a left-handed adaptor in the lap or lower limb region (such as rubbing a thigh), one hand began touching the face or neck, followed by initiation of a right-handed adaptor in the lap region, the end of the left-hand adaptor and then the end of the right hand adaptor. This pattern shows that innocent respondents were much more likely to engage in extended use of both hands to engage in adaptors, as compared to use of both hands by guilty interviewees to engage in illustrators. This pattern was much longer than the longest guilty pattern. It occurred 193 times in total, covering 3 % of the total interview duration for all participants. As mentioned above, far more patterns were unique to innocent interviews than were unique to the guilty. In contrast to the stereotype of guilty respondents exhibiting nervousness, it was the innocent respondents who were uninhibited in displaying adaptors, especially longer chains of such behaviors.

The longest identified deceptive pattern was only three events long. The string was as follows:

((e,rightillustrators (b,leftillustrators b,rightillustrators))

This pattern, which shows a tight connection between right and left illustrators, occurred 308 times throughout the sample, but statistically more frequently in the guilty interviews. This pattern occurred during 4 % of the total time of all interactions, so it filled a significant amount of the total interview time. What is curious about this pattern is that the deceiver would stop using the right hand for an illustrator gesture, then begin illustrating with the left hand—not a usual pattern—and resume right-hand illustrating. What followed after this sequence did not occur with enough regularity to form a consistent pattern but the fact that these three event types were linked and recurrent begs for additional close observation of when and how people use one-handed versus two-handed gesturing. The visual image this provokes is one of a lack of self-synchrony or a forced attempt to use speech-related gestures, inasmuch as most people are right-handed and will initiate illustrative gesturing with their dominant, not their nondominant, hand.

These two contrasting patterns between truth tellers and deceivers also may begin to illuminate the feeble showing for individual nonverbal behaviors as telltale signals of deception. If truth tellers are freer with their use of adaptor gestures, which have been stereotypically linked with lying, and deceivers manage to engage in some illustrative gesturing, something assumed to be more common among truth tellers, then the role of kinesic gestures in deception needs to be rethought.

Discussion

This reexamination of face-to-face interviews from a larger deception experiment was undertaken to assess the power of patterns of behavior as a way of differentiating truthful from deceptive communication. Its original contributions lie in its demonstration that sequences of interrelated behavior mark the veracity of discourse by communicators with conflicting motives, the ways in which those patterns diverge are predictable but their relationship to theorized etiologies of nonverbal deceptive displays run counter to long-held views of how psychological states manifest themselves behaviorally. Although individual indicators of deception may often be subtle, with small effect sizes (DePaulo et al. 2003), sequences of interrelated behaviors may reveal a communicator's veracity, especially as regards the complexity, frequency of occurrence of the patterns. A recap of the results from the hypothesis tests and correlational analyses shows the multifaceted ways in which patterns are associated with veracity.

Hypothesis 1

Truthful individuals exhibit nonverbal behavior patterns that (a) include greater diversity of event types, (b) are longer (include more events), and (c) are more hierarchically complex (have more levels), than deceivers.

Our results provided support for H1a and H1c, with suggestive positive results for H1b. The indication that truthful individuals' patterned behavior is both more diverse and more complex than deceivers—or put differently, that deceivers' patterns are comprised of fewer unique event types and are simpler—may be an extension of the principle of overcontrol. The four-factor theory (Zuckerman et al. 1981), self-presentation theory (DePaulo 1992), and interpersonal deception theory (Buller and Burgoon 1996) all contend that deceivers attempt to control telltale signs of deceit to enhance their self-presentation and appear credible. Such control, however, may become excessive and result in less spontaneity, causing deceivers to lapse into what Millar and Rogers (1987) identified as dysfunctional interaction sequences.

The reduced complexity also may be an unintentional consequence of increased cognitive load. Because deception has been found to create additional cognitive demands on deceivers that are manifested through changes in their behavior (Sporer and Schwandt 2007), we hypothesized that differences would emerge between our truth-telling interviewees, who were innocent of the theft, and out duplicitous respondents who were guilty of stealing a wallet. Elsewhere, Berger et al. (1989) established that plan complexity had a negative effect on verbal fluency. Producing deceptive responses may have had an analogous effect. When the interview turned to the matter of the ostensible transgression and to questions of what should happen to the guilty party, our guilty participants had to concoct and maintain a story line regarding the theft and the events surrounding it, and to answer questions on the fly about whether perpetrators of the theft should be given a second chance. They had to simultaneously monitor their own communication for consistency, plausibility, and normalcy while also watching their interviewer for any signs of suspicion and disbelief. These extra cognitive burdens were not shouldered by their innocent (truthful) counterparts.

Hypothesis 2

Deceptive individuals differ from truthful individuals in the quantity of different patterns exhibited.

Hypothesis 2 was not supported largely because of the huge variability in the number of patterns. Such variability is persuasive evidence of the heterogeneity among individuals when it comes to the patterns in nonverbal behavior. The differences between individuals within conditions were much greater than the differences between the two conditions. As we begin to study this type of nonverbal behavior pattern, the large variability between individuals provides an interesting future direction. Personality factors may certainly make a difference in the degree of patterning that occurs. Other moderators worthy of investigation are the social skills of the interactants and the demeanor of the interviewer. Although our interviewers were all trained to maintain a neutral demeanor and to follow an interview script, casual observation of the videotaped interviews suggested that the most experienced interviewer was more comfortable with the interviewing role, whereas one of the other interviewers occasionally interjected leading questions that may have put the interviewee more at ease.

Hypothesis 3

Deceptive individuals differ from truthful ones in variability in patterns from a truthful baseline to deceptive responding.

Consistent with our speculation that deceptive individuals might exhibit less productivity and more redundancy than truth tellers when shifting from the baseline questions to the theft-related questions, we saw a tendency for more novel patterns among truthful participants. Although we expected differences to be most evident during the theft-related portion of their interview, we also entertained the possibility that differences would be evident from the outset, inasmuch as thieves knew they were going to be questioned about the theft and still had the wallet on their person. Professional interviewers and interrogators are trained to look for anticipatory signs of stress during questioning (Walters 2002), and research by Patton (2008) analyzing these same mock theft interviews had demonstrated some anticipatory behavior by deceivers even prior to responding to questions related to misconduct. Patton's analysis incorporated numerous automatically measured nonverbal behaviors that each yielded a small correlations with deception. Although the individual correlations were mostly nonsignificant and produced very small effect sizes, when combined into an index, they showed a consistent separation between deceivers and truth tellers during both the baseline phase and the deception phase. This consistent separation implied that deceivers, who knew they would be questioned eventually about the theft, were already displaying an anticipatory response that persisted throughout the entire interaction. Thus it is possible to have both a stable main effect for deception and deception by phase interaction that produces temporal changes during the theft questioning. One does not obviate the other.

Theoretical Implications

Behavioral patterning has received little theoretical attention, perhaps because patterns of behavior are difficult to discern and easily escape awareness of interlocutors and human observers. But the fact that these patterns are detectable means both that there are very real differences between truth and deception and that with the right tools, such patterns can be ascertained.

One reason deception displays may have lacked diagnosticity in many past investigations is that instead of being passive organisms giving off unintended and uncontrollable leakage, deceivers may manage their performances to appear non-culpable. Contrary to the longstanding view that deceivers' felt arousal, negative affect, and cognitive load generate telltale behavioral signs of discomfort, negative emotions, and overly wooden and inexpressive communication, higher degrees of arousal, negative affect, and cognitive load were associated with fewer adaptor gestures and more illustrator gestures. To the extent that they controlled their performances, it was in a manner that promoted credibility rather than undermined it. These findings challenge theoretical positions such as the leakage hypothesis (Ekman and Friesen 1969), four-factor theory (Zuckerman et al. 1981), and motivation impairment effect (DePaulo and Kirkendol 1989) by demonstrating that deceivers' nonverbal behaviors are not direct read-outs of internal states. Instead, deceivers are able to regulate their displays so that outward behaviors convey the opposite of the internal states—conveying composure rather than distress and expressivity rather than tension.

At a high level of understanding, the current results revealed the degree to which communication is indeed a structured activity. Although individual variability and creativity in message production is certainly to be expected, and indeed, is the nature of human discourse, the results of the THEME analysis also show communication to be highly patterned, both in terms of interconnectedness of individual behaviors and their recurrence over a stretch of interaction.

At a more specific level, the current corpus confirms that deception influences a communicator's nonverbal behavior. Dunbar et al. (2014) had hypothesized and confirmed that deception alters interactional synchrony. The present investigation adds to that understanding of interpersonal deception by presenting another aspect of communication patterning that can be affected by deception.

However, patterns can only be examined when interactions are of sufficient length for repeated patterns to emerge and are naturalistic enough that what is observed reflects the individual's own message production rather than being an artifact of some experimental manipulation or other contextual factor. The corpus upon which the current analysis was undertaken is one of the few available with sufficient lengthy and naturalistic message exchanges to support such an analysis. It thus offers a first glimpse into a novel approach to analyzing not only deception but also interpersonal communication in general and analyzing them in terms of structural properties rather than statistical frequencies of actions.

Future Directions

Ample opportunity remains to further explore patterned behavior in the context of deception. Discovering and analyzing patterns in deceptive communication could produce interesting insights, for example, into what types of behaviors tend to initiate patterns, or what types of behaviors tend to lead to other behaviors when deception is taking place. Even more interesting is the potential for insights to be gained from looking at the interaction between deceiver and target. We might discover, for example, how a deceptive individual responds to certain types of behaviors tend to initiate patterns, or what types of behaviors tend to lead to other behaviors when deception is taking place. Even more interesting is the potential for insights to be gained from looking at the interaction between deceiver and target. We might discover, for example, how a deceptive individual responds to certain types of behaviors performed by the listener. Such insights into the interactional tendencies of deception are particularly conducive to pattern analysis, with insights gained that would be impossible if analyzing individual behaviors or sets of behaviors in a traditional manner. Such an analysis was limited in the present case because interviewers followed an interview script rather than engaging in fully extemporaneous communication but it would be possible if interviewers were given more latitude in their interviewing style.

This paper also provides a brief introduction to the behavior pattern analysis tool THEME. This introduction is limited in part because of the nature of the data set being analyzed. THEME has been designed for use with large datasets composed of dozens of behavior types. We analyzed the mock theft data set using only 20 different behaviors. However, any data set that can be broken into discrete temporal events is fit for analysis with THEME, and the larger the sample size and set of cues to be investigated, the better for THEME.

Conclusion

We have demonstrated significant differences in the complexity, length, and distribution of nonverbal kinesic behaviors when an individual is being deceptive versus truthful. THEME provides a method for in-depth analysis of the patterning of communication between individuals that is not achievable by unaided human observers. Like the genome project made possible by the microscopic analysis of DNA, pattern analysis may produce key insights into the nature of human social interaction.

Footnotes

1 Initial coding was conducted using Noldus' *Observer*, a commercially available software tool for computer-assisted behavioral annotation. Because of various computer compatibility, timing precision, and end-user problems with the system, our University of Arizona Center for the Management of Information developed a new tool, C-BAS, that was used to code some of the same behaviors again at a finer level of granularity.

2 Some of the behaviors did, however, show main or interaction effects by question and motivation. These results will be reported elsewhere, along with self-report and linguistic measures, as they are most pertinent to motivation effects.

3 In the pattern strings displayed, “b” and “e” refer, respectively, to the beginning and end of the behavior being referenced.

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Conflict of interest

The authors declare that they have no conflict of interest.

Appendix

In order to demonstrate that the patterns identified in the data are truly the results of patterned behavior, THEME compares the results of the real data analysis to the results of two types of randomization. THEME can compare samples based on the number of patterns at various lengths, the number of patterns at various levels, and the distribution of the occurrences of patterns. Under shuffling, the data points in each interview are randomly shuffled together. Under rotation, the times between occurrences of a single event type are preserved, but the relationship between events is not. For example, each row in Fig. 2 represents the occurrences of a single event type. Imagine slicing the rows of Fig. 2 such that each strip held only a single event type. Wrapping those strips around a cylinder and randomly rotating each strip in either direction is rotation. Thus, the time relationships between occurrences of a single event type are held constant, but the time between occurrences of different event types are randomized.

The THEME pattern search is then run again on each random rearrangement, and the number of patterns at each length identified and compared. Figure 1 shows the results of this analysis from one mock theft interview. It is immediately apparent that there is a significant difference between the real data set and the randomized data. The black bars represent the number of patterns of each length for the real data. The dark and light grey bars show the average number of patterns from the 5 random runs for shuffling and rotation, respectively. Figure 3 shows the number of standard deviations between the randomized data and the real data at each pattern length. The rotation randomization found no patterns longer than length 4 in any of the runs, and the longest pattern with shuffling was only 2 events long, so there is no standard deviation for longer lengths. With THEME, then, we see that individuals' behavior was significantly patterned. The differences from randomized distributions of these same events are striking.

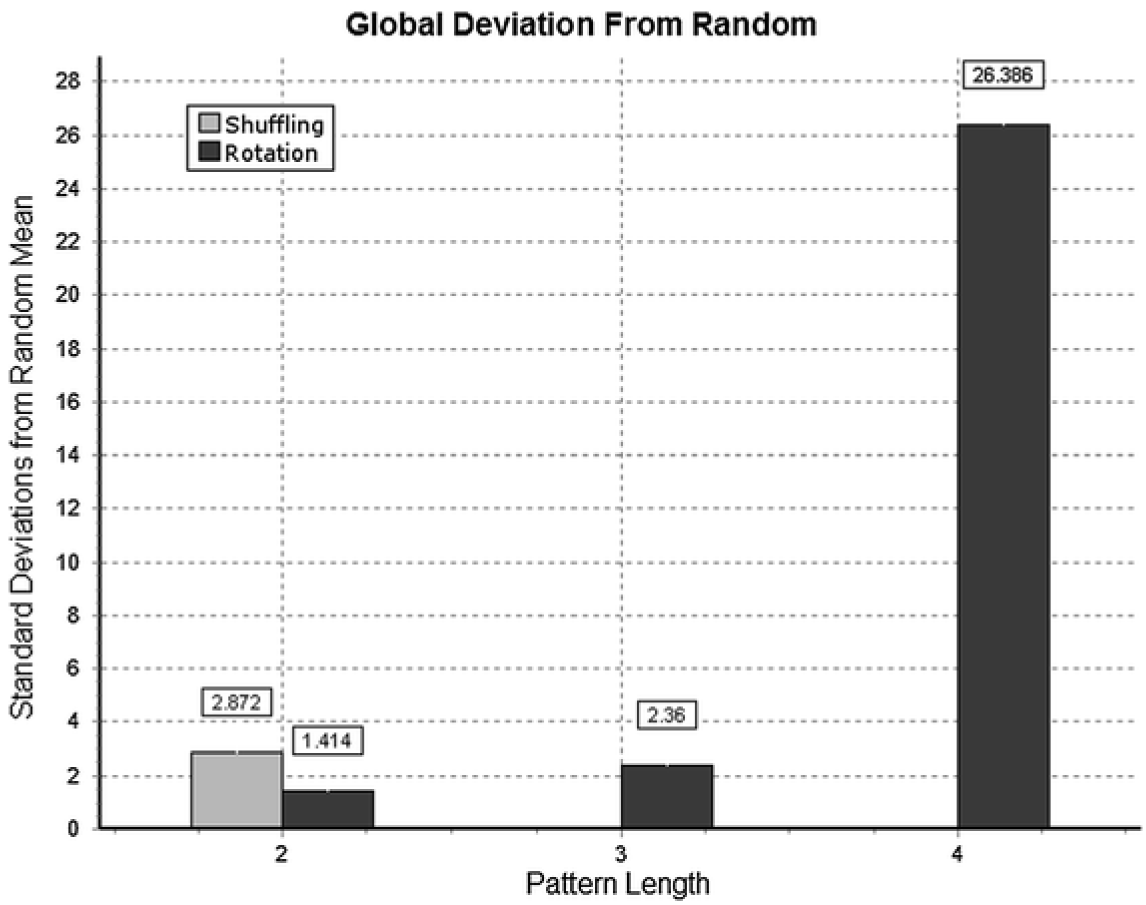

Fig. 3

Deviation from random. *Taller bars* indicate that more patterns were found in real data compared to randomly reordered data

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