Physically Scarce (vs. Enriched) Environments Decrease the Ability to Tell Lies Successfully

Leanne ten Brinke[1]

Poruz Khambatta[2]

Dana R. Carney[1]

[1]University of California—Berkeley,

2220 Piedmont Ave, Berkeley, CA 94720

[2]Stanford University,

655 Knight Way, Stanford, CA 94305

Corresponding author: Leanne ten Brinke, 635 Bakar Faculty Building, 2220 Piedmont Avenue, Berkeley, CA 94720; email: leannetenbrinke@berkeley.edu

Abstract

The successful detection of deception is of critical importance to adaptive social relationships and organizations, and perhaps even national security. However, research in forensic, legal, and social psychology demonstrates that people are generally very successful deceivers. The goal of the current research was to test an intervention with the potential to decrease the likelihood of successful deception. We applied findings in the architectural, engineering and environmental sciences that has demonstrated that enriched environments (vs. scarce ones) promote the experience of comfort, positive emotion, feelings of power and control and increase productivity. We hypothesized that sparse, impoverished, scarcely endowed environments (vs. enriched ones) would decrease the ability to lie successfully by making liars feel uncomfortable and powerless. Study 1 examined archival footage of an international sample of criminal suspects (N = 59), including innocent relatives (n = 33) and convicted murderers (n = 26) emotionally pleading to the public for the return of a missing person. Liars in scarce environments (vs. enriched) were significantly more likely to reveal their lies through behavioral cues to deception. Experiment 2 (N = 79) demonstrated that the discomfort and subsequent powerlessness caused by scarce (vs. enriched) environments lead people to reveal behavioral cues to deception. Liars in scarce environments also experienced greater neuroendocrine stress reactivity and were more accurately detected by a sample of 66 naïve observers (Study 3). Taken together, data suggest that scarce environments increase difficulty, and decrease success of deception. Further, we make available videotaped stimuli of Experiment 2 liars and truth-tellers.

Keywords: deceptive behavior; deception detection; environments

Physically Scarce (vs. Enriched) Environments

Decrease the Ability to Tell Lies Successfully

Diverse forms of living organisms deceive—ranging from bacteria (e.g., Göpel & Görke, 2014), to plants (e.g., Jersakova, Johnson, & Kindlmann, 2006), to human and non-human primates (e.g., Bryne & Corp, 2004; DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996). Even tiny wheeled robots with simple neural networks, programmed only to signal the presence of food and poison, quickly evolve deceptive communication strategies in order to survive (Floreano, Mitri, Magnenat, & Keller, 2005). Deception is theorized to have evolved in order to maximize survival (Hamilton, 1964), and poor lie-telling is considered a handicap (Zahavi & Zahavi, 1997). While telling lies offers a survival advantage, so does the accurate detection of lies. However, as ubiquitous as lies are, humans are not very good at detecting them—performing just above chance (54%; Bond & DePaulo, 2006; Tierney, 2014). In recent years, the fields of forensic and social psychology have turned their attention away from the bleakly robust finding that humans are terrible lie-detections, and toward understanding the conditions under which humans *can* detect deception. Specifically, recent research efforts seek to identify how situational constraints can be leveraged to (a) decrease a person's ability to tell a lie successfully in order to (b) increase a perceiver's ability to accurately detect lies (Vrij, Granhag, Mann, & Leal, 2011).

To date, this research has generally shown that increasing the pressure on the person telling the lie (vs. truth) will significantly hinder their lie-telling success by increasing stress reactivity and depleting cognitive resources. For example, cognitively taxing the lie-teller will significantly reduce effectiveness (Vrij, Granhag, Mann, & Leal, 2011). Making the lie-teller feel powerless has similar effects (Carney, Yap, Lucas, Mehta, McGee, & Wilmuth, 2015), as does increasing the intensity of to-be-concealed emotions (Porter, ten Brinke, & Wallace, 2012). Increasing the perceived importance of stressful lying may also reduce deception effectiveness (i.e., motivational impairment effect; DePaulo, Kirdendol, Tang, & O'Brien, 1988; but see Hartwig & Bond, 2014). In the current research, our hypothesis was inspired by research in fields such as architecture, design, engineering and environmental science by looking at the intervention power of *physical environments*.

The Psychological Impact of Physical Environments

Environments affect human emotion, cognition, and behavior. Relative to bland concrete cityscapes, exposure to nature can increase attentional resources and reduce stress (e.g., Taylor, Kuo, & Sullivan, 2001; Ulrich et al., 1991); a view of nature from one's home can buffer low-income children from stress and improve feelings of self-worth (e.g., Wells & Evans, 2003), and having a hospital room with a view of a natural landscape can even improve physical healing following a major surgery (Ulrich, 1984).

The way in which we construct interior spaces too can affect human experience and behavior. The effect of environmental design on human experience is leveraged in retail settings, for example (Bitner, 1992). A store with harsh lighting, linoleum floors and narrow aisles has a sparse "discount" image, while luxury stores are opulent and outfitted with soft lighting, carpet, and wide aisles (Gardner & Siomkos, 1986). Customers feel more comfortable in the richly-decorated settings, items in these environments are perceived to be more valuable, and greater intentions to purchase are reported, relative to sparsely-decorated stores (Baker, Parasuraman, Grewal, & Voss, 2002). In effect, richly-decorated environments can prompt us to feel and behave as if we have means, while sparsely-decorated environments prompt us to feel and behave as if we are without.

Indeed, environments are carefully considered in order to cohere with organizational goals, and workplaces are increasingly being engineered to improve employee experience and productivity (Gruber, de Leon, George, & Thompson, 2014). Although it was widely assumed that sparsely-decorated office environments would limit distractions and improve employee productivity (i.e., Taylorist; Taylor, 1911), research actually suggests that participants in such a scarce environment report feeling less autonomy, more anxiety and make more mistakes on an attention task, relative to those in an office enriched with aesthetic cues such as brightly colored posters and plants (Davis, 1984; Knight & Haslam, 2010). Environmentally scarce offices make work less enjoyable for employees, decrease self-reported concentration, and lead to perceived and actual reductions in productivity relative to offices enriched with green plants (Nieuwenhuis, Knight, Postmes, & Haslam, 2014). The addition of plants to indoor spaces, in particular, has been found to decrease physiological stress responses, improve mood, feelings of comfort, attention, and productivity (Kim & Mattson, 2002; Larsen, Adams, Deal, Kweon, & Tyler, 1998; Lohr, Pearson-Mims, & Goodwin, 1996; Shibata & Suzuki, 2002). The psychological state caused by a physically scarce environment, on the other hand, includes feelings of anxiety, powerlessness, and mental taxation—effects that are strikingly similar to those experienced under conditions of resource scarcity (Mullainathan & Shafir, 2013). These basic cognitive and emotional effects lead to a myriad of (often, negative) outcomes, including poor decision-making, diminished learning, and a decreased sense of control (e.g., Kraus, Piff, & Keltner, 2009; Mani, Mullainathan, Shafir, & Zhao, 2013; Shah, Mullainathan, & Shafir, 2012; Sweller, 1988).

The Current Research

Taking together (a) the need for more realistic interventions to enhance lie-detection efforts, (b) research on the significant impact of environments on human psychology, and armed with (c) a handful of clues about which social psychological conditions might better impede lie-detection success, we tested the hypothesis that scarce (vs. enriched) environments would lead to ineffective deception. Specifically—based on the literature (Knight & Haslam, 2010; Ulrich et al., 1991)—we expected that this pattern would occur because feelings of comfort, experienced in enriched settings, would improve lie-telling ability such that liars in this context would not differ from truth-tellers. In contrast, we expected that the discomfort of a scarce environment would increase behavioral cues to deception among liars—making the scarce liars condition the only one in which deceptive behavior is hypothesized to be observed. Liars in scarce environments were expected to exhibit greater signs of deceptive behavior (signals of anxiety and cognitive load; Hypothesis 1) and be more accurately detected by naïve observers relative to lies told in an enriched environment and truths in either setting. In Study 1, we examined the effect of a scarce environment on behavior during extremely high-stakes, emotional pleas to the public for the return of a missing loved one; pleaders were later determined to be either deceptive murderers, eventually convicted of killing the person they pleaded to find, or genuinely distraught relatives. In Study 2, we manipulated an environment (scarce vs. enriched) and veracity (genuine vs. deceptive) in an experiment in which participants plead their innocence in the theft of $100. Subjects completed measures of their subjective experience (i.e., level of comfort in the room; feelings of power) and provided saliva samples to be analyzed for neuroendocrine stress response. Interrogation videos were coded for cues of deceptive behaviors, and level of (dis)comfort in the room, leading to feelings of power(lessness), was examined as a potential path to behavioral leakage (Hypothesis 3). Videos were also shown to a separate sample of naïve observers to examine whether liars in scarce environments were easier to detect than liars in enriched environments and truth-tellers in either environmental condition (Hypothesis 3; Study 3). In the studies reported below, we report how we determined our sample size, all data exclusions (if any), and all conditions in the study (Simmons, Nelson, & Simonsohn, 2011).

Study 1

To conduct an ecologically-valid test of Hypothesis 1, we examined archival data of suspected murderers to test whether deceptive behavior was related to the scarcity of the environment in which genuinely distraught relatives and deceptive murderers appealed for missing persons.

Methods

Persons of Interest: Deceptive Murderers and Genuinely-Distraught Relatives

The entire sample of $N = 78$ criminal suspects emotionally pleading for the return of a missing relative, collected by ten Brinke and Porter (2012), was considered for inclusion in this study. Since our hypotheses concerned the scarcity/enriched nature of indoor environments, those individuals pleading in an outdoor environment ($n = 19$) were excluded. Of the remaining (N = 59) suspects, 26 (20 male) were deceptive murderers who were guilty of killing the person they pleaded to find. The remaining 33 suspects (17 male) were not involved in their relative's disappearance and were genuinely pleading for their safe return. Deceptive murderers were labeled as such if they had been convicted of the missing person's murder based on strong physical evidence (e.g., possession of the murder weapon or the victim's remains, DNA, etc.). Genuinely distressed individuals were labeled as such if they were innocent of murdering the missing loved one they pleaded for on television. These missing persons were either determined to have gone missing in the absence of foul play (e.g., ran away; suicide) or were murdered by another, unrelated individual who was eventually convicted based on similarly strong physical evidence as described above (see ten Brinke & Porter, 2012 for additional details on establishing ground truth in these cases). All videos were shown on public television in the United States, Canada, the United Kingdom, or Australia between the years of 1985 and 2009.

Coding Environments and Deceptive Behavior

Coding the Physical Environment of the Pleaders. Three ratings of environmental richness were made for the setting in which each individual provided their public appeal. Ratings of richness of color, objects, and texture were made on 7-point Likert scales. Ratings were reverse-scored and combined into a mean environmental scarcity score to describe each pleader's environment. Inter-rater reliability was established on the full set of videos by a second blind-to-veracity coder ($r = .817$, $p < .001$).

Coding Deceptive Behavior. Behavioral cues to deception were selected based on what had previously been found to reliably dissociate truth-tellers from liars in this high-stakes, emotional context (ten Brinke & Porter, 2012). Trained coders, blind to veracity, coded the presence/absence of seven universal emotional facial expressions (happiness, sadness, fear, disgust, surprise, anger, contempt) in the upper and lower face separately using a frame-by-frame coding procedure (Porter & ten Brinke, 2008) based on the Facial Action Coding System (FACS; Ekman, Friesen, & Hagar, 2002). A second trained coder also examined each pleader's emotional facial expressions to assess inter-rater reliability. The dichotomously coded presence (or absence) of emotions in the upper and lower face was highly reliable ($\alpha = .67$, $p = .001$, 87.8% agreement; Krippendorf, 1980). Additional information on coding procedures is detailed in ten Brinke and Porter (2012). Verbal cues (i.e., word count, tentative word use) were calculated using LIWC (Pennebaker et al., 2007), which reliably counts words in psychologically relevant categories.

A composite deceptive behavior score was created for each pleader by calculating their mean rating on each of the following *z*-scored variables, tapping cognitive load and emotional arousal: decreased word count, tentative word use, increased duration of smiles (up-turned lips; *zygomaticus major* activation; this behavior is considered inappropriate in a genuine appeal and may signal duping delight; Ekman, Friesen, & O'Sullivan, 1988), and decreased duration of sadness (particularly among muscles in the forehead: *frontalis* and *corrugator*; this behavior is consistent with a genuine appeal but is difficult to falsify in the absence of genuine sadness; ten Brinke, Porter, & Baker, 2012).

Results

Supporting Hypothesis 1, scarce environments increased deceptive behavior of lying murderers, $r(26) = .446$, $p = .025$, but not genuinely distressed individuals, $r(33) = .070$, $p = .699$ (see Figure 1)[1,2]. That is, scarce environments were associated with ineffective deception even among a highly-motivated, forensic sample of murderers (see Table 1 for correlations between each individual rating and behavior). However these data were correlational and a number of other factors could account for the observed relation. The goal of Experiment 2 was to test the causal role of environmental scarcity on deceptive ineffectiveness.

Experiment 2

Following evidence for the association between scarce environments and deceptive behavior in a sample of murderers, we conducted an experiment to (a) establish that scarce environments *cause* ineffective deception and (b) investigate the behavioral and physiological outcomes of deception in a scarce (vs. enriched) environment. Participants genuinely or falsely pleaded their innocence in the theft of a $100 bill, in a scarcely or richly decorated office. Testing Hypothesis 1, we compared behavior exhibited by liars in the scarce environment to the behavior of liars in the enriched environment and truth-tellers in both environmental conditions. We also examined level of discomfort in the room, leading to decreased feelings of power, as a potential meditational path for this effect (Hypothesis 2).

Method

Participants

[1] These relationships appear to be robust; in partial correlations controlling for pleader gender and relationship to the victim, scarce environments continue to increase deceptive behavior of lying murderers, $r(26) = .475$, $p = .022$, but not affect genuinely distressed individuals, $r(33) = .052$, $p = .781$.

[2] A z-test, comparing the Pearson correlations coefficients for genuine and deceptive appeals, revealed that the effect of environment was marginally greater for deceptive individuals, $z = 1.48$, $p_{one\text{-}tailed} = .07$.

Eighty-one participants (M_{age} = 20.86, *SD* = 2.39; 41 females) participated in exchange for either $16 or course credit. Participants were randomly assigned to plead, genuinely (*n* = 44) or falsely (*n* = 37), that they did not steal a $100 bill from a scarce (*n* = 43) or enriched (*n* = 38) physical space. An additional four subjects completed the experiment but were excluded from subsequent analyses for not following instructions; they confessed to stealing the money. Data was collected with the goal of having approximately 20 participants in each of the four (veracity X environment) cells; this number was guided by previous research and represents approximately double the number of participants per cell collected by Frank and Ekman (1997) and Carney et al. (2015).

Materials & Procedure

The experiment used a 2 (scarce vs. enriched environment) x 2 (genuine vs. deceptive denial) between-subjects design. Subjects were randomly assigned to complete the experiment in either an undecorated (scarce) or richly decorated (endowed) office. After reading and signing a consent form, participants completed a questionnaire to ensure that they had followed instructions for providing an uncontaminated saliva sample, were given instructions, and then provided a baseline saliva sample—approximately 10 minutes after arriving for the experiment. The experimenter left the room and participants were instructed to engage in a high-stakes mock crime paradigm (described in detail, below). In short, participants were randomly assigned and instructed by computer to either steal or not steal a $100 bill hidden in a wallet in the room. All participants were instructed to deny stealing the money and financially incentivized to do so successfully. Following the theft, the experimenter, who was blind to veracity condition and hypotheses, entered the room and interrogated the subject. After the interrogation, the subject completed ratings of their subjective experience (comfort of the room, powerful feelings) and filler questionnaires on the computer for an average of 22 minutes (*SD* = 4.15) to allow salivary cortisol reactivity to approach its peak level. Following this, the participant provided a post-interrogation saliva sample, was debriefed, paid and excused.

Manipulating Environments

A standard office space was manipulated to be either scarce or enriched. In the scarce condition, the office contained only an empty desk, simple chair, small computer screen and plain overhead cabinet—minimal objects necessary for completion of the experiment. In the enriched condition, extending a manipulation used by Knight and Haslam (2010), many colorful, textured, varied, and complex items were added to the environment—all were items possibly found in an office setting (e.g., pens, highlighters, post-it notes, framed pictures, posters, candles, an alarm clock, a lamp, a figurine and a potted plant) were added. These were intended to enrich the space by increasing the presence and variation of colors, objects and textures in the room (see Figure 2).

Pilot Testing Environment. A pilot test examined the psychological mindset caused by these two conditions (scare vs. enriched). Participants (N = 77; 41 female; M_{age} = 21.55, SD = 2.50) rated their experience while sitting in the rooms in a between-subjects design. A manipulation check question which read “This room is decorated” was answered on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale and confirmed that participants found the scarce environment (M = 1.64, SD = .96) to be less decorated than the enriched environment (M = 5.71, SD = 1.06), $t(75) = -17.64$, $p < .001$. Further, and as expected, participants in the lean environment had more scarcity-related semantic concepts available and accessible to them relative to those in the enriched environment. Specifically, using a lexical decision task, participants in the scarce environment were significantly faster at identifying scarcity-related words (e.g., lack, bare, less, scant, scarce, shortage) than matched control words ($M_{difference\ (scarcity\ –\ matched\ control)}$ = -4.06, SD = 66.86), as compared to those in the enriched environment ($M_{difference}$ =

30.61, *SD* = 80.56), *t*(74) = -2.04, *p* = .045. Those assigned to the scarce environment also rated the room as less psychologically comfortable (*M* = 4.00, *SD* = 1.04) than those in the enriched environment (*M* = 4.78, *SD* = .94) using a 4-item measure adapted from Knight and Haslam (2010), *t*(75) = 3.43, *p* = .001. Specifically, participants rated the extent to which the room was a pleasant place to work, had a good atmosphere, felt soulless (reverse-scored) and how uncomfortable they felt in the room (reverse-scored), on 7-point scales (α = .64). Finally, and consistent with Knight and Haslam (2010), participants in the scarce environment felt marginally less powerful (*M* = 4.33, *SD* = .87) than those in the enriched environment (*M* = 4.74, *SD* = 1.06), *t*(75) = 1.88, *p* = .064. Items measured the extent to which participants felt high status, dominant, in charge, powerful, and submissive (reverse-scored) (α = .81). Together, these findings provide evidence that the scarce environment affected human experience as expected; it was perceived as less decorated than the enriched environment, made participants feel less comfortable, powerful, and primed a scarcity mindset.

Salivary Collection Procedures

Standard salivary-hormone collection procedures were used to measure cortisol (Dickerson & Kemeny, 2004; Stanton & Schultheiss, 2009). Participants were asked not to eat, drink, or brush their teeth for at least 2 hours prior to providing saliva and completed a questionnaire so that refrainment from these activities could be verified. Additional questions asked participants about menstrual cycle and exercise—no data exclusions based on their questionnaire responses were necessary. Experimental testing was conducted between 10:30 am and 5 pm to reduce any effects of daily circadian rhythms on cortisol levels. Further, there were no differences in age or gender of participants assigned to each condition that might confound group differences in cortisol reactivity. Before providing both saliva samples, participants rinsed their mouths with water to remove debris and then provided approximately 1.5 ml of saliva through a straw into a sterile polypropylene microtubule using a passive drool method. Samples were immediately frozen to avoid hormone degradation and to precipitate mucins. Analysis was conducted by Salimetrics. A subset of all samples (10%) were assayed in duplicate for salivary cortisol using a highly sensitive enzyme immunoassay; duplicate assays were highly reliable. The intra-assay coefficient of variation (CV) for duplicate assays was 3.36%. One individual's baseline cortisol level was far outside of the normal range at 1.960 μg/dl (> 16 standard deviations above the mean), likely indicating contamination of the sample; this individual was excluded from analysis. Three additional participants' data were not analyzed as they were unable to provide the requested volume of saliva necessary for reliable measurement. Cortisol levels of the remaining 77 participants were in the normal range at both baseline (M = .175 μg/dl, SD = .106) and follow-up (M = .197 μg/dl, SD = .16). A cortisol reactivity score was calculated for each participant by subtracting their baseline cortisol level from their post-interrogation measurement; scores were standardized (z scored) prior to analyses.

High-Stakes Mock Crime

A "high-stakes mock-crime paradigm" was borrowed from the criminal justice literature (for a review, see Kircher, Horowitz, & Raskin, 1988). This paradigm has also been widely used in the social psychological deception literature (e.g., Carney, Yap, Lucas, Mehta, McGee, & Wilmuth, 2015; Frank & Ekman, 1997).

Once alone in the room, subjects were randomly instructed by the computer to steal or not steal a $100 bill from a wallet in the room. Subjects in both conditions were told that if they could successfully convince the experimenter that they had not taken the $100 bill, they would be allowed to keep the money. Thus, all participants were incentivized to be convincing during the subsequent interrogation. See Figure 3 for the verbatim instructions subjects were given.

After subjects indicated that they were ready for further directions, the experimenter entered the room and interrogated the subject by asking a series of questions. Experimenters received extensive training prior to conducing the experiment. They were trained (a) to ask the questions in a neutral affective tone, (b) not to deviate from their interview script, and (c) not to provide verbal or nonverbal feedback to participants' responses. Experimenters engaged in multiple practice sessions prior to running participants to ensure that they behaved as trained.[3] First, "baseline questions" (i.e., neutral questions not pertaining to the mock theft but which are verifiable) were asked, followed by "critical questions". A baseline question, for example, was: "Please describe for me, what you are wearing today, in as much detail as possible." Examples of critical questions include: "Please describe to me, in as much detail as possible, everything that happened since you arrived to participate in this experiment," "Did you steal the money from this office?" and "Why should I believe you?" Following the interrogation, the experimenter completed a checklist of seven deceptive behaviors; if the subject engaged in *none* of the behaviors, the participant was permitted to keep the $100.

Sixty-three participants provided consent for the use of their videos in future research; these videos (36 truthful, 27 deceptive) are freely available for research use from the authors.

[3] To ensure that the experimenters behaved as trained, we created audio files of each of the 63 interviews for which we had participants' permission to use for future research purposes, and recruited $N = 549$ individuals on Amazon's Mechanical Turk to rate the experimenter's vocal tone. Each of these individuals listened to a single audio file and provided 1(not at all) to 7 (extremely) ratings of the assertiveness and friendliness of the experimenter's vocal tone. This resulted in a mean of 8.17 ratings per interview. Using the assertiveness and friendliness (reverse-scored) ratings, mean scores of the interviewer's "toughness" were created for each interview. Toughness ratings were first subjected to a one-way ANOVA on condition (scarce liars, scarce truth-tellers, enriched liars, and enriched truth-teller) to contrast the behavior of liars in the scarce condition to all others (3, -1, -1, -1), as per our a priori statistical approach. The effect of condition was not significant, $F(3, 59) = .35$, $p = .79$, nor was the contrast of interest, $t(59) = .49$, $p = .63$. Further, we subjected vocal toughness ratings to a 2 (veracity) X 2 (environment) ANOVA. There was no significant main effect of veracity, environment, nor a significant interaction, all ps > .35.

Subjective Experience Ratings

Following the interrogation, participants completed the same measures of level of comfort in the room (α = .63) and feelings of power (α = .85) as pilot study participants. During this time, participants also answered several personality questionnaires that acted as filler tasks prior to the follow-up saliva sample; these questionnaires were not scored or analyzed.

Coding Deceptive Behavior

Interrogations were recorded with a video camera and later coded for behavioral cues associated with deception. In particular, the following behaviors, indicating elevated cognitive load and anxiety, were coded: decreased word count, slowed speech rate, increased speech hesitations, greater appearance of "thinking hard", a general impression of being uncooperative, increased expression of false smiles, and fewer pronouns. These cues have all been examined extensively in prior research (e.g., DePaulo et al., 2003; Ekman, Friesen, & O'Sullivan, 1988; Newman, Pennebaker, Berry, & Richard, 2003; Vrij, et al., 2008). These behaviors tap the same fundamental psychological constructs as those in Study 1, but were chosen for maximum likelihood of discriminating genuine versus deceptive denials of transgressions, specifically. This is appropriate since behavioral signals of deception are known to differ as a function of lie type (DePaulo et al., 2003).

Nonverbal behaviors ("thinking hard", cooperativeness, and frequency of false smiles) were coded by individuals who were blind to condition and hypotheses. 22.22% (n = 18) of participants were double-coded to assess inter-rater reliability, which was found to be acceptable for all variables (rs = .806, .623, and .788, ps < .001, respectively). Verbal responses were transcribed and subjected to linguistic analysis using the LIWC program (Pennebaker, Booth, & Francis, 2007) to analyze word count, speech rate (word count/duration of response), proportional frequency of speech hesitations and pronoun use. In line with the baseline theory of deceptive behavior, the difference between each behavior from baseline to relevant questions was calculated (but see: Ewens, Vrij, Jang, & Jo, 2014). Standardized *z*-scores of each behavioral difference were averaged to create a composite deceptive behavior score.

Results

We predicted that liars in the scarce condition would engage in the most deceptive behavior compared to all other conditions. As such, an *a priori* contrast weight sequence 3, -1, -1, -1, was used to test this hypothesis, across scarce-environment liars, scarce-environment truth-tellers, enriched-environment liars, and enriched-environment truth-teller conditions. Supplemental 2 (veracity) X 2 (environment) ANOVAs were also conducted.

Scarce Environments Increases Liars' Deceptive Behavior

A one-way ANOVA on condition (scarce liars, scarce truth-tellers, enriched liars, and enriched truth-teller) was conducted with a contrast to compare the behavior of liars in the scarce condition to all others. As expected, the effect of condition was significant, $F(3, 77) = 6.20$, $p = .001$, $r = .442$, and liars in a scarce environment leaked more deceptive behavior than individuals in any other condition, $t(77) = 3.40$, $p = .001$, $r = .342$ (see Figure 4). A 2 (veracity) X 2 (environment) ANOVA revealed main effects for both veracity, $F(1, 77) = 7.49$, $p = .008$, $r = .298$, and environment, $F(1, 77) = 11.52$, $p = .001$, $r = .361$, but no significant interaction, $F(1, 77) = .02$, $p = .888$. Liars showed significantly more deceptive behavior than truth-tellers, and a scarce environment was associated with more deceptive behavior than an enriched one. Importantly, one-sample *t*-tests revealed that liars in scarce environments showed a significant increase in deceptive behavior from baseline to critical questions, $t(18) = 3.86$, $p = .001$, while liars in the enriched condition showed no change, $t(17) = -.19$, $p = .850$. In contrast, truth-tellers in a scarce environment showed no change, $t(23) = .43$, $p = .672$, while those in the enriched condition experienced a decrease in behaviors related to deception, $t(19) = -3.31$, $p = .004$.

In addition to deceptive behavior scores, increases of the stress hormone, cortisol, were examined. Cortisol levels are regulated by the hypothalamic–pituitary–adrenocortical (HPA) axis and can have negative implications for mental and physical health. For example, low socioeconomic status is associated with both higher basal cortisol levels and negative health outcomes including greater chance of illness and reduced longevity (McEwen & Gianaros, 2010). Prior research has found that the mock interrogation described here, among other tasks that feature motivated performance and social-evaluative threat, cause a significant increase in cortisol levels (Carney et al., 2015; Dickerson & Kemeney, 2004). Using the same statistical approach as above, a one-way ANOVA revealed as significant effect of condition, $F(3, 73) = 2.97$, $p = .037$, $r = .330$. Critically, liars in a scarce environment evidenced greater cortisol reactivity than all other groups combined, $t(73) = 2.82$, $p = .006$, $r = .315$ (see Figure 5). Results of a 2 X 2 ANOVA revealed a significant main effect of veracity, $F(1, 73) = 4.24$, $p = .043$, $r = .235$, and a marginally significant interaction, $F(1, 73) = 3.66$, $p = .060$, $r = .219$, but no main effect of environment, $F(1, 73) = .87$, $p = .354$. Liars ($M = .24$, $SD = 1.26$) showed significantly greater cortisol reactivity than truth-tellers ($M = -.22$, $SD = .61$). Follow-up analyses to the interaction revealed that while liars in a scarce environment experienced greater cortisol reactivity than truth-tellers, $F(1, 38) = 5.84$, $p = .021$, liars and truth-tellers in an enriched environment did not differ, $F(1, 35) = .018$, $p = .893$.

Discomfort in Scarce Environments Mediates Liars' Deceptive Behavior

Using the PROCESS macro for SPSS created by Hayes (2013), we tested a meditational path model whereby lying in a scarce environment would decrease level of comfort in the room, leading to decreased feelings of power and an increase in deceptive behavior (Hypothesis 2; see Figure 6). The independent variable was a dummy code that contrasted scarce environment liars with all other participants.[4] The composite measure of deceptive behavior was used as the dependent variable, and mean scores on level of comfort in the room and powerful feelings items were entered as potential mediators. Mean ratings of comfort in the room, led to decreased feelings of power, and mediated the relationship between lying in a scarce environment and the magnitude of deceptive behavior (indirect effect = .031; 95% CI: .005, .086; based on 1,000 bootstrapped samples).[5] This finding suggests that using scarce environments as an intervention shifts a consciously accessible sense of comfort and power that then mitigates the ability to deceive successfully.

Study 3

Studies 1 and 2 demonstrated that deception under conditions of environmental scarcity is accompanied by greater behavioral signals of deception. But, can observers pick up on these differences? Study 3 tests Hypothesis 3, which posits that liars in a scarce environment will be more easily detected by naïve observers. While research suggests that humans are poor lie detectors, performing at or only slightly above chance (54%; Bond & DePaulo, 2006), even untrained observers appear to use accurate behavioral signals to make veracity decisions (Hartwig & Bond, 2011). Low accuracy rates then, may be attributable to the subtlety of deceptive behaviors rather than observer ineptitude. Consistent with this reasoning, Vrij et al. (2011) found that lies accompanied by increased behavioral “tells” are more readily detected than those with relatively subtle “tells”. As such, we expect that liars in a scarce environment—who

---

[4] A similar meditational model was conducted, including only those assigned to the lie condition and comparing the effects of lean versus enriched environments on feelings of comfort and power, leading to deceptive behavior. Consistent with the model described in text, the indirect effect was significant indicating that liars in the lean environment felt less comfortable and less powerful, leading to increased behavioral leakage.

[5] Mean ratings of comfort and feelings of power were also examined independently in separate meditational models, using Preacher and Hayes (2004) SOBEL macro. On their own, neither mediator produced a significant indirect effect, *p*s > .15.

reveal greater behavioral cues to deception—may be more accurately detected than liars in an enriched environment and truth-tellers.

Method

Participants

Sixty-six participants who did not participate in Experiment 2 (M_{age} = 20.14; 31 females) were recruited to watch a subset of the videotaped interrogations from Experiment 2 and rate whether each person was lying or telling the truth. Participants were paid $16 and no data exclusions were made. We sought to exceed the typical sample size in a lie detection study, and did so by approximately 1.5 times. Based on a review of over 200 such studies, Bond and DePaulo (2006) reported that the average study included 41 receivers, who each judged the veracity of 16 messages (e.g., Frank & Ekman, 1997; Vrij & Mann, 2001; Reinhard, Greifeneder, & Scharmach, 2013). The study was conducted in two experimental sessions with space for 36 participants each at private computer workstations (minus no-shows).

Materials and Procedure

Naïve participants with no training in deception detection, exposure to the videos or experience with the paradigm were recruited to watch 24 videos of individuals who plead their innocence in the theft interrogations described in Experiment 2, including 6 liars and 6 truth-tellers from the scarce office and 6 liars and 6 truth-tellers from the enriched office. Participants were not provided with any information regarding the base rate of truths and lies in the videos that they were about to watch. Videos were randomly selected and edited to a) crop out any visual signals of the environmental condition and b) include only two critical interrogation questions (specifically, “Did you steal the money from this office?” and “Ok – then please describe to me, in as much detail as possible, everything that happened since you arrived to participate in this experiment.”). On average, clips were 72 seconds (*SD* = 30.63) in duration.

After watching each video, participants completed a binary forced choice measure asking whether they thought targets were lying or telling the truth.

Results

Scarce Environments Make Liars Easier to Detect

Following the statistical approach set out in Experiment 2, we found that an *a priori* contrast supported Hypothesis 3, which postulated that liars in scarce environments (M = 56.06, SD = 20.18) would be detected more accurately than all others, $F(1, 65) = 4.67$, $p = .034$, $r = .259$. A 2 (veracity) X 2 (environment) repeated measures ANOVA revealed a main effect of environment, $F(1, 65) = 11.73$, $p = .001$, $r = .391$; observers were more accurate at detecting the veracity of statements produced in scarce, relative to enriched, environments. While there was no significant main effect of veracity, $F(1, 65) = 1.31$, $p = .257$, $r = .141$, veracity interacted with environment, $F(1, 65) = 4.99$, $p = .029$, $r = .266$ (see Figure 7). Further, only scarce-environment liars were detected at a rate significantly greater than chance, $t(65) = 2.44$, $p = .017$. In contrast, the detection of liars in an enriched environment (M = 44.44, SD = 17.86) was significantly *below* chance, $t(66) = -2.53$, $p = .014$. The detection of truth-tellers in either environment (scarce: M = 54.29, SD = 18.79; enriched: M = 52.78, SD = 20.38) did not differ from chance, ps > .05.

Complimenting the analyses above, signal detection analyses were also conducted. Signal detection theory (SDT) yields estimates of participants' ability to discriminate between liars and truth-tellers with a statistic named *d'* (i.e., sensitivity), and allows for the calculation of a criterion (*c*), or threshold, at which the participant decides to label a deceptive. Once converted to standardized *z* scores, the overall hit rate (correct detection of deceptive pleaders) and false alarm rate (genuine pleaders labeled as deceptive) were used to create *d'* (sensitivity) and *c* (criterion) scores (Stanislaw & Todorov, 1991). Sensitivity and criterion scores were calculated for each observer's responses to videos recorded in scarce and enriched environments separately. A series of *t*-tests were conducted to examine whether *d'* or *c* differed across environment. As expected, observers were more sensitive to liars in the scarce (*d'*: *M* = .28, *SD* = .75) than the enriched (*d'*: *M* = -.08, *SD* = .62) environment, *t*(65) = 3.38, *p* = .001. While discrimination did not differ from 0 (i.e., no discrimination, or at-chance responding) for the enriched environment videos, *t*(65) = -1.07, *p* = .29, discrimination was significantly greater than 0 in the scarce condition, *t*(65) = 3.05, *p* = .003. Further, observers utilized a less biased criterion for assessing scarce environment liars and truth-tellers (*c*: *M* = -.02, *SD* = .39), relative to those in an enriched environment (*c*: *M* = .12, *SD* = .44), *t*(65) = -2.22, *p* = .030. While a truth-bias was present for enriched environment videos, *t*(65) = 2.15, *p* = .035, the criterion for scarce environment videos did not differ from 0 (i.e., no bias), *t*(65) = -.48, *p* = .63. These findings allow us to conclude that the observer's percentage accuracy in detecting scarce environment liars is the result of an ability to discriminate liars from truth-tellers, and not simply a reflection of a lie bias.

Discussion

Together, results presented here suggest that interventions involving changes to one's physical environment may provide a practical and low-cost route to mitigating deception effectiveness. Specifically, telling lies in environments that are physically scarce—that is, devoid of color, objects, and textures—is associated with feeling uncomfortable and powerless, and reduces the leakage of behavioral "tells" by liars. Environmental scarcity increased neuroendocrine reactivity and the leakage of verbal and nonverbal signals of deception both in an experimental setting and in uncontrolled televised appeals, with a student sample and a community (criminal) sample, respectively. Further, naïve observers were able to discriminate lies told in a scarce environment more accurately than those told in a lean environment, and above the level of chance.

Individuals in enriched environments, by contrast, lied with relative ease. In the lab, liars in enriched environments were detected at a rate *lower* than would be expected by chance. These findings build on work by Carney et al. (2015), who found that feeling powerful too (defined as having access and control over resources) can improve the ability to lie. The powerful leaked fewer deceptive behaviors and were more difficult to detect, relative to the powerless (Dubois et al., 2015). Consistent with these findings, it seems that those in enriched physical spaces too are buffered from the stress of telling lies.

Practical Implications & Future Directions

Results provide a unique illustration of the effect of environments on human behavior and provide a practical lesson for lie detectors: be aware of your surroundings. Findings suggest that cues to deception can be increased and more accurately identified with a simple environmental manipulation. We add to an emerging literature that shows how simple changes to interviewing strategies can help identify the deceptive, without adversely affecting the innocent (Vrij, Granhag, Mann, & Leal, 2011). Further research testing the mechanism by which scarce environments affect deceptive behavior will be important in understanding how this simple shift in context affects human functioning and how it may serve as a novel and cheap way to enhance lie detection. We found that the discomfort associated with lie-telling in a scarce environment led to feeling powerless and ultimately to the increased leakage of deceptive behavior. Other mechanisms, however, deserve attention. For example, environmental effects on attention and available cognitive resources may also mediate the success of telling lies.

Additional study of how environmental scarcity is experienced may highlight important mediators and moderators of this effect. For example, if participants attributed the enriched nature of the room to the resources of the experimenters, enriched liars may have experienced less guilt for stealing from an institution signaling wealth—accounting for their feelings of relative comfort. Further, incidental effects of the greater (building) environment may affect how the scarcity or richness of the interrogation room is perceived. For example, while walking through an enriched environment to a scarcely decorated interrogation room may make suspects uncomfortable, walking through a scarce environment—as one might encounter in a poorly funded police department—to a scarce interrogation room may empower a suspect, alerting them to the lack of resources available to prosecute them.

Our findings are consistent with the stereotypical notion of a criminal interrogation room—a stark, sterile room that increases the difficulty of lying successfully. However, real interrogation rooms rarely take this stereotypical form (D. Baxter, personal communication, March 21, 2014). Additional work is necessary to understand the complex effects of environmental manipulations and how they impact deceptive behavior, potentially allowing us to design environments that are maximally effective for detecting lies. More generally, environments may be chosen such that they align with the goal of the interaction. For example, in an information-gathering interview, law enforcement officials might be wise to avoid the scarce environment—better suited to reveal deceptive behavior—and seek an enriched space in which a witness of suspect might feel comfortable to disclose additional information.

Conclusion

We find that the cognitive and emotional effects of being in a scarce environment decrease the ability to lie convincingly, leading to more behavioral “tells” in acts of deception. Additionally, despite decades of research suggesting that human lie detection is surprisingly poor, our results suggest that lies told under conditions of environmental scarcity can be more accurately detected by naïve observers than lies told in environments of relative abundance. Coupling this environmental pressure with interviewing techniques that challenge the liar are likely to produce greater increases in accuracy. With additional research, results may provide lie detectors with a simple, cheap, and easy-to-institute intervention for the improved detection of deception in organizational, legal, and security settings.

Acknowledgement

We would like to thank S. Porter for his involvement in the collection of Study 1 videos, and the Social and Nonverbal Behavior Lab at University of California, Berkeley for their helpful comments and support. We would also like to acknowledge the Haas School of Business, who provided financial support for this research, and SSHRC who supported this research through a Postdoctoral Fellowship awarded to LtB. Finally, we would like to thank anonymous reviewers who provided helpful comments, and contributed to an improved manuscript.

References

Baker, J., Parasuraman, A., Grewal, D., & Voss, G. B. (2002). The influence of multiple store environment cues on perceived merchandise value and patronage intentions. *Journal of Marketing*, *66*, 120-141.

Bitner, M. J. (1992). Servicescapes: the impact of physical surroundings on customers and employees. *The Journal of Marketing, 56,* 57-71.

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

Byrne, R. W., & Corp, N. (2004). Neocortex size predicts deception rate in primates. *Proceedings of the Royal Society B: Biological Sciences, 271*, 1693-1699.

DuBois, D., Nichiporuk, N., tenBrinke, L., Rucker, D., Galinsky, A. D., & Carney, D. R. (2015). *Equilibrium in power and deception: The powerful are better liars but the powerless are better lie-detectors*. Manuscript under review.

Carney, D. R., Yap, A. J., Lucas, B., Mehta, P., Ferrero, J. N., McGee, J. A., & Wilmuth, C. A. (2015). *Power buffers stress.* Manuscript under revision.

Davis, T. R. (1984). The influence of the physical environment in offices. *Academy of Management Review*, *9*, 271-283.

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

DePaulo, B. M., Kirkendol, S. E., Tang, J., & O'Brien, T. P. (1988). The motivational impairment effect in the communication of deception: Replications and extensions. *Journal of Nonverbal Behavior, 12*, 177-202.

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

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*, 355-391.

Ekman, P., Friesen, W. V., & O'Sullivan, M. (1988). Smiles when lying. *Journal of Personality and Social Psychology, 54*, 414-420.

Ekman, P., Friesen, W. V., & Hager, J. C. (2002). *FACS investigator's guide*. Salt Lake City, UT: A Human Face.

Ewens, S., Vrij, A., Jang, M., & Jo, E. (2014). Drop the small talk when establishing baseline behaviour in interviews. *Journal of Investigative Psychology and Offender Profiling*. *Online First Publication.*

Floreano, D., Mitri, S., Magnenat, S., & Keller, L. (2005). Evolutionary conditions for the emergence of communication in robots. *Current Biology*, *17*, 1–6.

Frank, M. G., & Ekman, P. (1997). The ability to detect deceit generalizes across different types of high-stake lies. *Journal of Personality and Social Psychology*, *72,* 1429-1439.

Gardner, M. P., & Siomkos, G. J. (1986). Toward a methodology for assessing effects of in-store atmospherics. *Advances in Consumer Research*, *13*, 27-31.

Göpel , Y., & Görke, B. (2014). Lies and deception in bacterial gene regulation: the roles of nucleic acid decoys. *Molecular Microbiology*, *92*, 641–647.

Gruber, M., de Leon, N., George, G., & Thompson, P. (2015). Managing by design. *Academy of Management Journal*, *58*, 1-7.

Hamilton, W.D. (1964). The genetical evolution of social behaviour, part I. *Journal of Theoretical Biology*, *7*, 1–16.

Hartwig, M., & Bond Jr, C. F. (2011). Why do lie-catchers fail? A lens model meta-analysis of human lie judgments. *Psychological Bulletin*, *137*, 643-659.

Hartwig, M., & Bond, C. F. (2014). Lie Detection from Multiple Cues: A Meta-analysis. *Applied Cognitive Psychology*, *28*(5), 661-676.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Jersáková, J., Johnson, S. D., & Kindlmann, P. (2006). Mechanisms and evolution of deceptive pollination in orchids. *Biological Reviews, 81*, 219-235.

Kim, E., & Mattson, R. H. (2002). Stress recovery effects of viewing red-flowering geraniums. *Journal of Therapeutic Horticulture, 13,* 4 –12.

Krippendorf, K. (1980). *Content Analysis: An Introduction to Its Methodology*. Beverly Hills, CA: Sage.

Kircher, J. C., Horowitz, S. W., & Raskin, D. C. (1988). Meta-analysis of mock crime studies of the control question polygraph technique. *Law and Human Behavior*, *12*, 79-90.

Knight, C., & Haslam, S. A. (2010). The relative merits of lean, enriched, and empowered offices: an experimental examination of the impact of workspace management strategies on well-being and productivity. *Journal of Experimental Psychology: Applied*, *16*, 158-172.

Kraus, M. W., Piff, P. K., & Keltner, D. (2009). Social class, sense of control, and social explanation. *Journal of Personality and Social Psychology, 97,* 992-1004.

Krebs, J. R., and Dawkins, R. (1984). Animal signals: Mind reading and manipulation. In J. R. Krebs and N. B. Davies (Eds.), *Behavioural Ecology: An Evolutionary Approach*. Oxford: Blackwell.

Larsen, L., Adams, J., Deal, B., Kweon, B. S., & Tyler, E. (1998). Plants in the workplace: The effects of plant density on productivity, attitudes, and perceptions. *Environment and Behavior, 30,* 261–281.

Lehmann, L., & Keller, L. (2006). The evolution of cooperation and altruism – a general framework and a classification of models. *Journal of Evolutionary Biology*, *19*, 1365–1376.

Lohr, V. I., Pearson-Mims, C. H., & Goodwin, G. K. (1996). Interior plants may improve worker productivity and reduce stress in a windowless environment. *Journal of Environmental Horticulture, 14,* 97–100.

Mani, A., Mullainathan, S., Shafir, E., & Zhao, J. (2013). Poverty impedes cognitive function. *Science*, *341*, 976-980.

Mann, S., Vrij, A., & Bull, R. (2002). Suspects, lies, and videotape: An analysis of authentic high-stake liars. *Law and Human Behavior, 26*, 365-376.

McEwen, B. S., & Gianaros, P. J. (2010). Central role of the brain in stress and adaptation: links to socioeconomic status, health, and disease. *Annals of the New York Academy of Sciences, 1186*, 190-222.

Mullainathan S., Shafir E. (2013). *Scarcity: Why having too little means so much*. New York, NY: Henry Holt.

Newman, M. L., Pennebaker, J. W., Berry, D. S., & Richards, J. M. (2003). Lying words: Predicting deception from linguistic styles. *Personality and Social Psychology Bulletin*, *29*, 665-675.

Nieuwenhuis, M., Knight, C., Postmes, T., & Haslam, S. A. (2014). The relative benefits of green versus lean office space: Three field experiments. *Journal of Experimental Psychology: Applied, 20*, 199-214.

Pennebaker, J. W., Booth, R. J., & Francis, M. E. (2007). Linguistic inquiry and word count: LIWC [Computer software]. Austin, TX: liwc.net.

Porter, S., & ten Brinke, L. (2008). Reading between the lies identifying concealed and falsified emotions in universal facial expressions. *Psychological Science, 19*(5), 508-514.

Porter, S., ten Brinke, L., & Wallace, B. (2012). Secrets and lies: Involuntary leakage in deceptive facial expressions as a function of emotional intensity. *Journal of Nonverbal Behavior, 36*(1), 23-37.

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers, 36*, 717-731.

Reinhard, M. A., Greifeneder, R., & Scharmach, M. (2013). Unconscious processes improve lie detection. *Journal of Personality and Social Psychology*, *105*, 721-739.

Shah, A. K., Mullainathan, S., & Shafir, E. (2012). Some consequences of having too little. *Science*, *338*, 682-685.

Shibata, S., & Suzuki, N. (2002). Effects of the foliage plant on task performance and mood. *Journal of Environmental Psychology*, *22*, 265– 272.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, *22*, 1359-1366.

Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers*, *31*, 137-149.

Stanton, S. J., & Schultheiss, O. C. (2009). The hormonal correlates of implicit power motivation. *Journal of Research in Personality*, *43*, 942-949.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and instruction*, *4*, 295-312.

Taylor, F. W. (1911). *The principles of scientific management*. New York, NY: Harper & Brothers.

Taylor, A. F., Kuo, F. E., & Sullivan, W. C. (2001). Coping with ADD: The surprising connection to green play settings. *Environment and Behavior, 33,* 54-77.

ten Brinke, L., & Porter, S. (2012). Cry me a river: Identifying the behavioral consequences of extremely high-stakes interpersonal deception. *Law and Human Behavior, 36,* 469.

ten Brinke, L., Porter, S., & Baker, A. (2012). Darwin the detective: Observable facial muscles reveal emotional high-stakes lies. *Evolution and Human Behavior, 33,* 411-416.

Tierney, J. (March 23, 2014). At Airports, a Misplaced Faith in Body Language. *The New York Times.* Retrieved from: http://www.nytimes.com/2014/03/25/science/in-airport-screening-body-language-is-faulted-as-behavior-sleuth.html?_r=0

Ulrich, R. (1984). View through a window may influence recovery. *Science, 224* (4647), 224-225.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology*, *11*, 201-230.

Von Hippel, W., & Trivers, R. (2011). The evolution and psychology of self-deception. *Behavioral and Brain Sciences*, *34*, 1-16.

Vrij, A. (2008). *Detecting lies and deceit: Pitfalls and opportunities*. John Wiley & Sons.

Vrij, A., Granhag, P. A., Mann, S., & Leal, S. (2011). Outsmarting the liars: Toward a cognitive lie detection approach. *Current Directions in Psychological Science*, *20*, 28-32.

Vrij, A., & Mann, S. (2001). Who killed my relative? Police officers' ability to detect real-life high-stake lies. *Psychology, Crime and Law*, *7*, 119-132.

Vrij, A., Mann, S. A., Fisher, R. P., Leal, S., Milne, R., & Bull, R. (2008). Increasing cognitive load to facilitate lie detection: the benefit of recalling an event in reverse order. *Law and Human Behavior, 32*, 253-265.

Wells, N. M., & Evans, G. W. (2003). Nearby nature a buffer of life stress among rural children. *Environment and Behavior, 35*, 311-330.

Zahavi, A., & Zahavi, A. (1997). *The handicap principle. A missing piece of Darwin's puzzle*. New York: Oxford University Press.

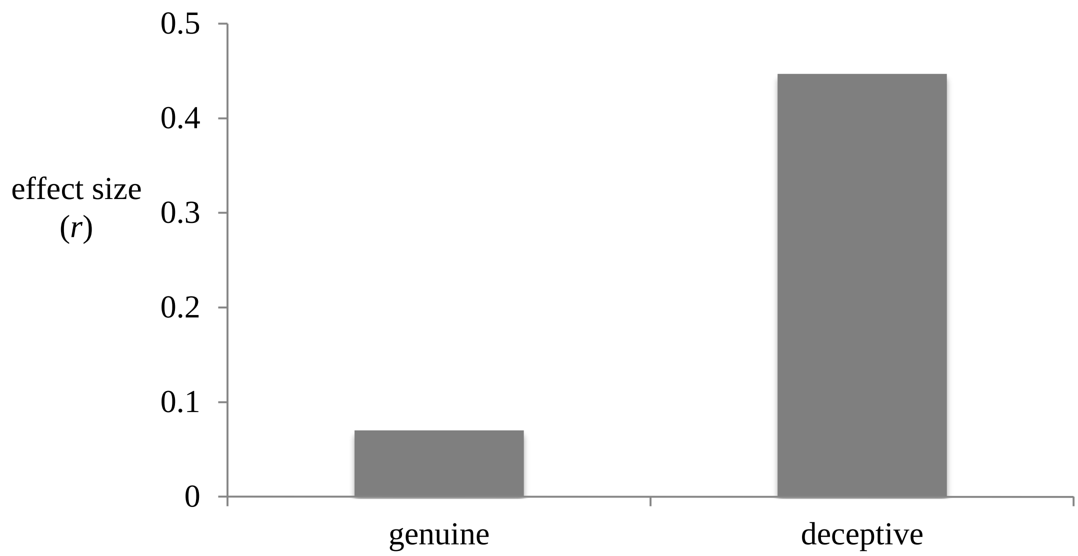

Figure 1. Effect sizes (*r*) of the relationships between environmental scarcity ratings and deceptive behaviors during genuine and deceptive public appeals.

Figure 2. Top panel depicts all of the objects that were placed in the enriched room. The scarce environment condition included no decorative objects and only a dark brown chair on which the participant sat (bottom panel).

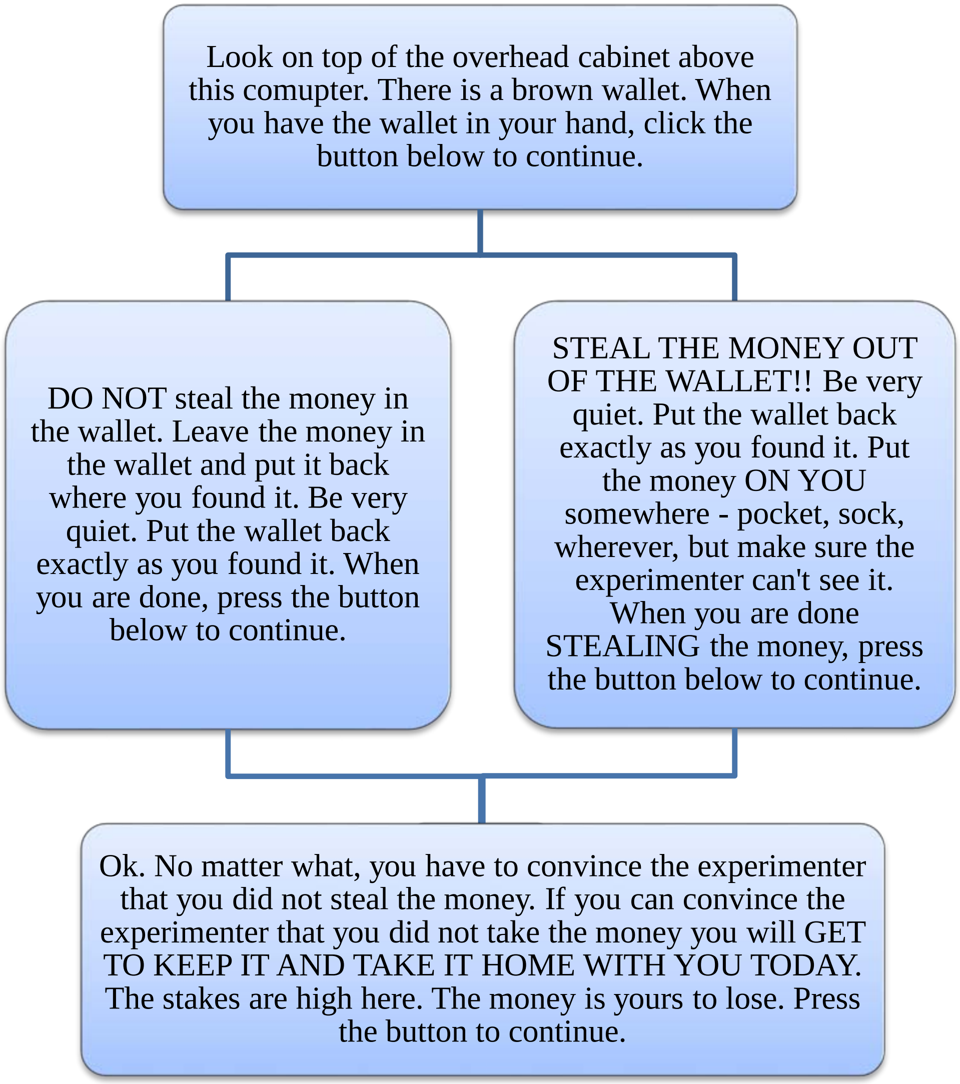

Figure 3. Verbatim computerized instructions for participants in the truth (left) and lie (right) conditions.

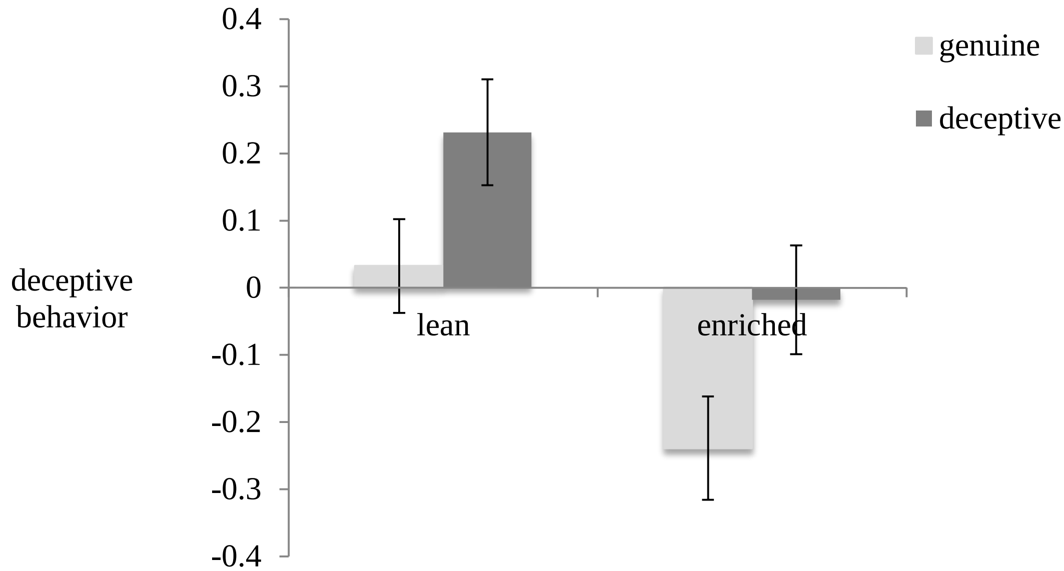

Figure 4. Standardized deceptive behavior scores (behavioral change from baseline to relevant questions) for genuine and deceptive mock-crime pleaders in environmentally scarce and enriched offices. Higher positive numbers indicate greater leakage of deceptive behavior.

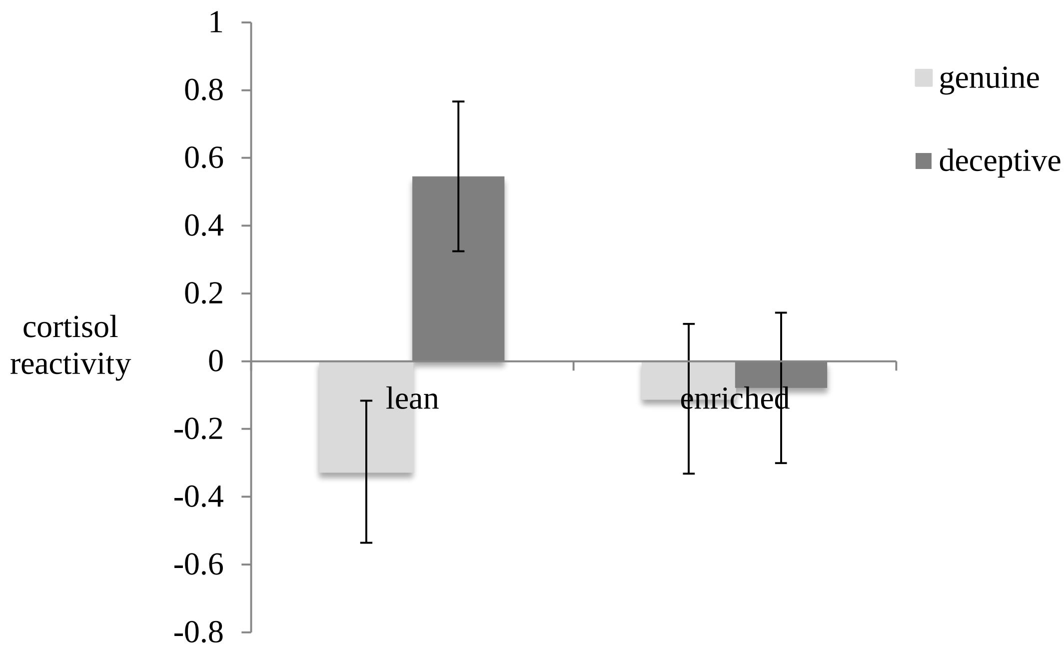

Figure 5. Standardized difference scores indicating cortisol reactivity, from baseline to post-interrogation, for genuine and deceptive mock-crime pleaders in environmentally scarce and enriched offices. Higher scores indicate greater reactivity.

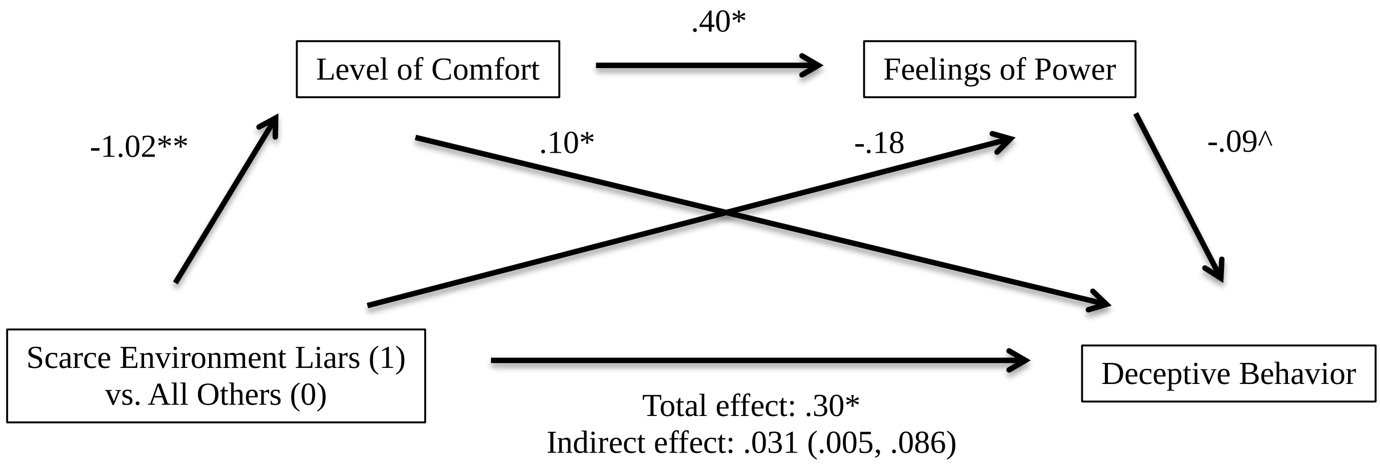

Figure 6. Discomfort, leading to feelings of powerlessness, mediates the effect of lying in a scarce environment on leakage of deceptive behavior. Coefficients produced by Preacher (2013) PROCESS macro (Model 6) appear above. Indirect effect estimated by bootstrapping 1000 resamples; 95% confidence interval appears in brackets (**p* < .05; ^*p* =.06).

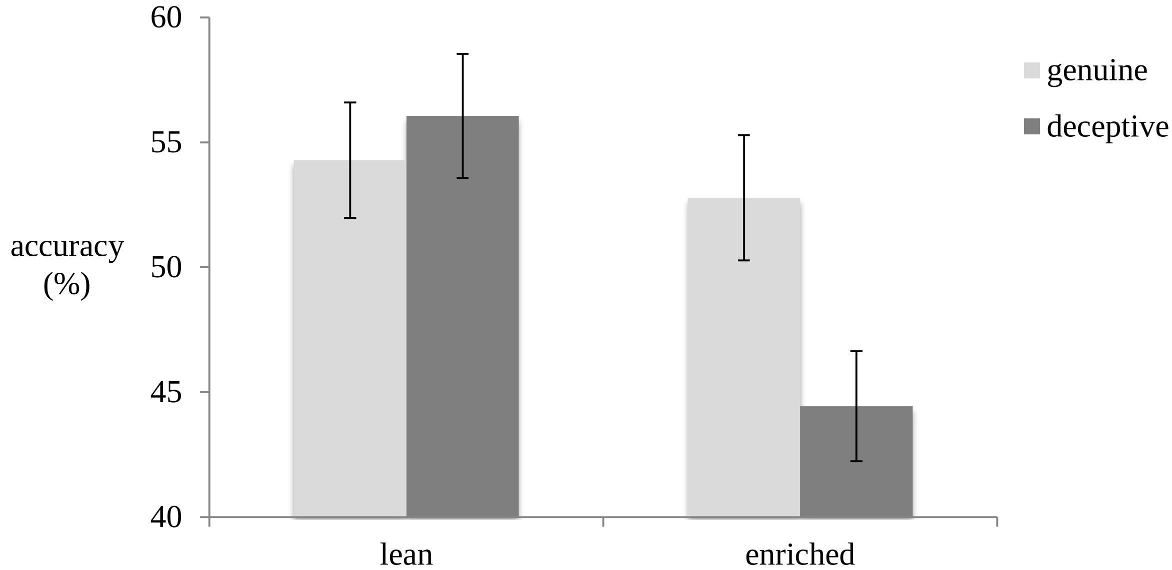

Figure 7. Percent accuracy in detecting genuine and deceptive pleas in environmentally scarce and enriched offices, by naïve observers.

Table 1. Correlations between ratings of environmental scarcity components (color, objects, texture) and deceptive behaviors of interest (word count, tentative word use, proportion of upper sadness and lower happiness expressions), for genuine and deceptive pleaders.

	Genuine			Deceptive		
	Color	Objects	Texture	Color	Objects	Texture
Word Count (*f*)	.206	-.198	.113	-.146	-.361^	-.228
Tentative Word Use (%)	-.035	.130	.089	.335	.430*	.356^
Lower Face Happiness (%)	.100	.070	.144	.236	-.020	.050
Upper Face Sadness (%)	-.006	.054	-.145	-.012	-.025	-.194
Deceptive Behavior Composite	-.125	.202	.073	.404*	.405*	.385^

*$p < .05$; **$p < .01$; ^$p < .09$