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# The inhibitory spillover effect: Controlling the bladder makes better liars *

**Elise Fenn**[a,b], **Iris Blandón-Gitlin**[b,*], **Jennifer Coons**[b], **Catherine Pineda**[b], and **Reinalyn Echon**[b]

[a]Claremont Graduate University, United States

[b]California State University, Fullerton, United States

## Abstract

The *Inhibitory-Spillover-Effect* (*ISE*) on a deception task was investigated. The ISE occurs when performance in one self-control task facilitates performance in another (simultaneously conducted) self-control task. Deceiving requires increased access to inhibitory control. We hypothesized that inducing liars to control urination urgency (physical inhibition) would facilitate control during deceptive interviews (cognitive inhibition). Participants drank small (low-control) or large (high-control) amounts of water. Next, they lied or told the truth to an interviewer. Third-party observers assessed the presence of behavioral cues and made true/lie judgments. In the high-control, but not the low-control condition, liars displayed significantly fewer behavioral cues to deception, more behavioral cues signaling truth, and provided longer and more complex accounts than truth-tellers. Accuracy detecting liars in the high-control condition was significantly impaired; observers revealed bias toward perceiving liars as truth-tellers. The *ISE* can operate in complex behaviors. Acts of deception can be facilitated by covert manipulations of self-control.

### Keywords

Inhibition; Deception; Cognitive load; Inhibitory spillover effect

## 1. Introduction

Inhibitory control, or inhibition, is involved in a wide range of situations and can emerge in different forms, from avoiding a desirable piece of chocolate cake (impulse control), to focusing on a task at hand (motor inhibition), to disregarding obtrusive thoughts (memory suppression). These seemingly different types of self-control acts are believed to share a common origin that influences inhibitory abilities in unrelated domains (Tuk, Zhang, & Sweldens, 2013, 2015). Tuk, Trampe, and Warlop (2011) showed that a physiological state of control (inhibiting the urgency to urinate) significantly enhanced performance on behavioral tasks requiring cognitive impulse control (e.g., Stroop task). Findings on this

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*Corresponding author at: Department of Psychology, P.O. Box 6846, Fullerton, CA 92834-6846, United States. iblandon-gitlin@fullerton.edu (I. Blandón-Gitlin).

effect – named the *Inhibitory Spillover Effect* (ISE) – hold possible implications to various applied domains as well as theory development. To understand the operation of this phenomenon in a complex real-world task, we investigated the ISE on a deception task performed during a dynamic interview. Behavioral and neuroimaging research suggests that compared to truth telling, the act of deception requires greater access to executive control processes, in particular inhibitory control (Gombos, 2006; Walczyk, Igou, Dixon, & Tcholakian, 2013). If the ISE extends to complex behaviors, then inducing people into a state of physiological inhibitory control will in fact facilitate performance on a deception task requiring cognitive and behavioral control.

### 1.1. Cognitive mechanisms underlying deception

Research suggests that a central cognitive mechanism involved in deceptive behavior is inhibition (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009; Gombos, 2006). A number of deception models and theories also implicate inhibitory control as a key difference between deceptive and truthful responding (see Walczyk et al., 2013 for a review of the literature). A central idea in most of these cognitive models is that the truth is the default mode, and more than truth tellers, liars must inhibit the truth response to activate a false response. Liars must do this while monitoring other aspects of their deception such as keeping track of what they say, creating a plausible story, and monitoring their own and others' behaviors. This often makes lying more demanding than truth telling. In several studies Walczyk and colleagues reported that lying took longer than truth telling during both reaction time tasks and person-to-person interactions, and liars' self-report accounts indicated they had to "consciously inhibit the truth" (Walczyk, Roper, Seemann, & Humphrey, 2003; Walczyk et al., 2005). The interpretation of these results was that lying involves more effort (e.g., inhibiting a true response) than telling the truth. Results of several recent behavioral studies provide additional support for the notion that lying requires more inhibitory control than truth telling (e.g., Debey, Verschuere, & Crombez, 2012; Hu, Evans, Wu, Lee, & Fu, 2013; Visu-Petra, Varga, Miclea, & Visu-Petra, 2013).

Furthermore, a number of imaging studies have demonstrated the critical role inhibition plays in deception. Although brain images typically show a number of areas involved in particular cognitive tasks, there is a general consensus that areas in the prefrontal cortex (PFC) and the anterior cingulate cortex (ACC) are more active during deception than during truth-telling (Abe, 2009; Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Lee et al., 2002). These structures are believed to be part of executive processes and have unique functions (Christ et al., 2009; Dreher & Grafman, 2003). In particular the left dorsolateral PFC is responsible for manipulating contents of working memory, selecting from a range of responses, suppressing inappropriate responses, and task switching. The ACC is involved in monitoring situations of response conflict and error detection (Botvnick, Cohen, & Carter, 2004). Using special meta-analytic procedures to summarize the results of neuroimaging studies, Christ et al. (2009) noted that deception is associated with increased brain activity in areas particularly involved in inhibitory control, working memory and task-switching. In addition, Gamer, Bauermann, Stoeter, and Vosse (2008) found that the frontal and cingulate regions in the brain were active more during deceptive than truthful responding, and this activity was correlated to slower reaction times and increased skin conductance.

Abe et al. (2006) provided evidence for an interference effect arising from activated true information during deceptive responses. In their study participants told the truth about an experienced event, denied experiencing the event, or falsely admitted experiencing the event. Compared to all brain regions examined, participants' ACC was activated significantly more in the deny condition than the false-admit condition. Because the ACC is associated with signaling response conflict between competing stimuli one interpretation of these results is that lying about an experienced episodic event activated true information, creating a response conflict that likely required greater inhibitory control than any other condition (Abe et al., 2006). In sum, the results of behavioral and neuroimaging studies show that more than truth telling, deception tends to require greater need for inhibitory control.

### 1.2. Inhibitory spillover effect and self-control

In theory, if inhibition is a key component of deception, then facilitating liars' access to inhibitory control resources should make deceptive acts less difficult. Recent research on the ISE phenomenon suggests that performing two tasks simultaneously, each requiring different forms of inhibitory control facilitates access to control mechanisms, enhancing performance on the central task. In a series of studies, Tuk, Trampe, and Warlop (2011) tested this effect by manipulating bladder pressure (or urination urgency). Urination urgency was chosen because it recruits brain areas (such as the ACC, and right inferior frontal gyrus, rIFG) that tend to be active during inhibitory control tasks. Participants in a high bladder, or high control condition (drank 700 ml of water) outperformed people in a low bladder, or low control condition (drank 50 ml of water) on several temporal decision-making tasks. For example, participants were asked to choose between a smaller reward of €16 received the next day, and a larger reward of €35 received in 35 days. Participants in the high bladder condition chose the larger, more delayed reward significantly more often than participants in the low bladder condition. The authors interpreted these results as suggesting that inhibiting the urge to void while simultaneously invoking inhibitory cognitive control on a different task (intertemporal decision-making task) facilitated overall performance. Further supporting this interpretation, results of Verbruggen, Adams, and Chambers (2012) suggest that performing a motor control task while completing a gambling task (dual-task, stop-signal condition) reduces likelihood of risky betting when compared to completing a gambling task alone (single-task condition).

One interpretation of the ISE is that because a variety of inhibitory tasks rely on a common or "overlapping" network in brain areas, facilitating access to one inhibitory domain facilitates access to other (unrelated) domains. Berkman, Burklund, and Lieberman (2009), and Anderson and Levy (2009) argued that although different types of inhibition, such as cognitive, emotional, and motor suppression appear to be subjectively different, they tend to share a common neurological system. The authors reviewed neuroscience research independently investigating each type of inhibition and showed that tasks in each domain led to activation in the same brain regions (specifically areas in pre-frontal cortex and the ACC). Additionally, Berkman et al. demonstrated that increased activation in one of these target areas is associated with inhibitory activities in related structures. Participants completing a motor inhibition task (go/no-go task) showed increased activation of the rIFC while

exhibiting suppression activity in the amygdala during negative charged trials. Effectively, the intentional motor inhibition task led to (unintentional) emotion inhibition.

The ISE results are not contradictory to established findings on depletion and self-control effects (e.g., Baumeister, Bratslavsky, Muraven, & Tice, 1998; Hagger, Wood, Stiff, & Chatzisarantis, 2010). Self-control depletion occurs when inhibition in one task (e.g., suppressing emotional reactions during a sad film) reduces subsequent ability to inhibit self-control on another task (e.g., eating tempting foods like ice cream). The results of Tuk, Zhang, and Sweldens (2013) suggest that this latter type of depletion effect occurs when tasks are performed *sequentially* whereas the ISE occurs when tasks are performed simultaneously. For example, participants instructed to inhibit their emotions during a film showed enhanced self-control over their eating behavior (i.e., ate fewer potato chips) than participants who did not inhibit their emotions during the film. However, the effect was reversed when tasks were performed sequentially; participants who inhibited their emotions during the film, compared to participants instructed not to inhibit showed less self-control over their eating behaviors during a subsequent test. Taken together, the results of the behavioral and neuroimaging studies support the notion that inhibitory tasks rely on a common or associated network and that under some conditions there is a beneficial effect in the activation of such system.

### 1.3. Current study

This study extends the ISE by examining the effect on participants completing a complex real-world deception task. Based on the results of Tuk et al. (2011) and Berkman et al. (2009), we predict that a physiological state invoking inhibitory control may facilitate liars' ability to exert control over behavioral cues during interviews. Further, when liars are able to exert better control, third-party observers should be less accurate detecting their deception. This study tests these hypotheses across two experiments.

## 2. Experiment 1

Using a similar procedure to Tuk et al. (2011) participants were assigned to a high or low physical inhibitory control condition by manipulating amount of water consumption. Subsequently, participants lied or told the truth about their personal opinions on "hot-button" social issues during a video-recorded interview. For this study we chose an opinion-telling paradigm because opinions tend to involve "well-learned" facts or truths (e.g., Johnson, Henkell, Simon, & Zhu, 2008), and thus suppression of this information should be increasingly difficult during deceptive interviews. A great need for cognitive inhibitory control during deception would be expected (see also Leal, Vrij, Mann, & Fisher, 2010). After the interviews, third-party observers of the videotaped interviews assessed the extent to which behavioral cues associated with truth (e.g., spontaneity) and deception (e.g., cognitive demand) were displayed by interviewees. The principal hypothesis of Experiment 1 was that liars in the high inhibitory control condition would show better control over their behaviors compared to other conditions.

## 2.1. Method

**2.1.1. Participants and design—**The Institutional Review Board at the authors' universities approved the study and all human subject ethical guidelines were followed. For the *stimulus collection phase*, twenty-two university students participated as both liars and truth tellers (all female; *M* age = 18.64 years; *SD* = 1.00). Participant-interviewees received course credit. They were also offered a $10 compensation if they successfully convinced the interviewer of their views. Because of ethical reasons participants were compensated regardless of what the interviewer reported. This phase has a 2(inhibitory control: high vs. low) × 2(veracity: lie vs. truth) mixed design, with Veracity as the within-subjects variable.

During the *observation phase*, seventy-five students (63% female; *M* age = 20.79, *SD* = 5.25) from a large university in a metropolitan city participated to assess behavioral cues displayed by interviewees. These observers received course credit. This phase used a 2(inhibitory control: high vs. low) × 2(veracity: lie vs. truth) within-subjects design. Various dependent measures were collected in this phase.

## 2.2. Materials and procedure

### 2.2.1. Stimulus collection phase

**2.2.1.1. Inhibitory Task:** Inhibitory control was manipulated by inducing urination urgency. Upon arrival to the lab, participant-interviewees completed the inform consent and an opinion questionnaire for the deception task (see below). They were then told a cover story. They were told that as an extra procedure – not associated with the interview – they would have to take part in a water-drinking task to assess the taste of water. They were asked to use the restroom before the water-drinking task because there would be no other opportunity to do so until the end of the study. They were then randomly assigned to the high (drank five glasses of water out of five different glasses, 700 ml. total) or low (took a sip of water from five different glasses, 50 ml. total) inhibitory control condition. Next, interviewees waited for 45 min before the interview, a timeframe that ensured a full bladder in the high control condition (see Tuk et al., 2011). During this time participants completed surveys for a study not related to the current one. The manipulation had the intended effect; on a scale of 1 (not at all urgent) to 7 (very urgent) participants in the high bladder control condition reported a stronger urge to urinate ($M = 4.38$, $SD = 2.67$) than those in the low bladder control condition ($M = 2.21$, $SD = 1.97$), $t(20) = 2.18$, $p = .042$, Cohen's $d = .97$.

**2.2.1.2. Deception task:** Interviewees completed a questionnaire probing their opinions on controversial social and moral issues (e.g., death penalty, gun control, or gay rights).[1] A research assistant selected two opinions that the interviewee had indicated they felt very strongly either for or against the issue (highest or lowest number on the rating scale). Thus, lying involved providing an argument in opposition to their personal beliefs. After the waiting period following the water-taste task, participants were instructed to lie or tell the truth about the targeted opinions. The order of truths and lies was counterbalanced across

[1]Based on a recent Gallup poll (Saad, 2010), we created a social and moral issues questionnaire to fit our college sample. The questionnaire consisted of 22 divisive topics which participants rated, using a Likert-type scale (1 = strongly agree, 7 = strongly disagree). Participants also rated how strongly they personally felt about the issues, using a Likert-type scale (1 = very strongly, 7 = no feelings). All participants screened were included because all provided extreme views on

participants. For deception, the research assistant instructed participants, “We are asking you to lie to the interviewer about your opinion on _____. Please do not inform the interviewer that you are lying about your opinion. If you successfully fool the interviewer you will earn a gift card. The interviewer will come in shortly after I leave and will ask you about your opinion and how you came to it.” For truth telling, participants were told to tell the truth about the target opinion and to be as convincing as possible.

The interview began with a statement of the interviewee’s opinion and stance (“I hear that you strongly agree/disagree with _____”). The interviewer (experiment-blind) then asked how the interviewee developed their opinion. In the event that the interviewee ceased speaking before the target time, the interviewer asked follow-up questions (“What aspects of the issue were critical in forming this opinion?”/“How did you develop this opinion?”), and if necessary, continued by open-ended prompts for more information (“Tell me more.”/ “Please continue.”). At the end of the first interview, the interviewer left the room to allow the experimenter to give the interviewee instructions about the next prompt before returning to conduct the second part of the interview. All interviews were video recorded focusing on the interviewee.[2]

**2.2.1.3. Videos:** Videos were created for each account given (true or false). Each video clip included the 60-s timeframe it took to provide the target account. This resulted in 44 independent video clips representing the 22 participants in each of four experimental conditions: 11 high inhibitory control liars, 11 low inhibitory control liars, 11 high inhibitory control truth-tellers, and 11 low inhibitory control truth-tellers. Four sets of videos that included clips from each of the experimental conditions were created for observers to evaluate. This ensured cognitively manageable stimulus materials to evaluate on all behavioral cues. Each of the video set did not repeat interviewees; only one account (true or false) from a given interviewee was included.

### 2.2.2. Observation phase

**2.2.2.1. Behavior ratings:** Participant-observers rated the interviewees on 10 behavioral cues to truth and deception (see Table 1). This list of cues to truth and deception were chosen based on results of prior studies suggesting that cognitive load (e.g., “how hard does the interviewee appear to be thinking?”) and anxiousness (e.g., “how anxious does the interviewee appear?”) are cues to deceit, and confident and convincing appearance (e.g., “how confident does the interviewee appear?”) are cues to truth (DePaulo et al., 2003; Hartwig & Bond, 2011; Sporer & Masip, 2011). For example, Hartwig and Bond (2011) meta-analyzed the relationship between the appearance of lie and truth behavioral cues and

[2]At the end of the interview participants completed the Attentional Network Task (ANT) as an extra manipulation check of inhibitory control. The ANT trials described in Apfelbaum and Sommers (2009) is similar to the Stroop task in that it creates interference effects from its stimuli (in incongruent trials) and is known to recruit inhibitory processes (Fan, McCandliss, Sommer, Raz, & Posner, 2002). In previous studies the ISE was revealed with similar cognitive inhibitory tasks (e.g., Tuk et al., 2011). For error rate and reaction time (RT), separate 2(inhibitory control: high vs. low) × 2(ANT trial: congruent vs. incongruent) mixed design ANOVAs were conducted. Only *RT* resulted in a significant effect; participants were slower on incongruent than congruent trials, $F(1,20) = 7.59$, $p = .012$, $d = .62$. Other effects were not significant ($Fs < 3.36$). The expected effect of inhibitory control manipulation on the ANT was not revealed, likely because the task was given at the end of the interview, a time frame that is much longer than previous ISE studies. This extra delay may have reduced ANT differences between conditions, causing participants to reach more extreme levels of urination urgency. Results of some studies suggest that at more extreme levels of urination urgency, performance on cognitive tasks is reduced (Jousse et al., 2013; Lewis et al., 2011). The boundary conditions of the ISE must be assessed in future research.

actual veracity across 134 cues. Results suggested that liars appeared to be thinking harder, more indifferent and less spontaneous than truth tellers. Truth tellers appeared to be more cooperative and relaxed, and produced stories that were more realistic than liars. Participants in the present study rated on Likert-type scales the presence or absence on a 1(not at all present) to 7(very present) scale for each of six cues to deceit (three cues related to overall anxious appearance, three cues related to overall cognitive load) and four cues to truth (relating to confident and convincing appearance).

**2.2.2.2. Content analyses:** The interviewees' accounts were transcribed verbatim and prepared for content analyses using the Linguistic Inquiry Word Count (LIWC) computer software (Pennebaker, Booth, & Francis, 2007). The LIWC analyzes accounts on a word by word basis, where each word is compared against a file of 2000 pre-selected dictionary words that are allocated to 72 linguistic categories. The LIWC counts words in psychology-relevant dimensions across numerous domains including the detection of deception (see Tausczik & Pennebaker, 2010, for a review). Newman, Pennebaker, Berry, and Richards (2003) reported that specific linguistic cues discriminated between true versus deceptive statements. For example, exclusive words (e.g., *but*, *except*, or *without*) are less likely to be included in deceptive accounts because those accounts tend to be simpler than true accounts. Simpler accounts may be given due to cognitive load experienced by the speaker as well as a strategy to reveal very little when deceiving others (Hauch, Blandón-Gitlin, Masip, & Sporer, 2014). Based on Hauch et al. meta-analytic findings, we selected 11 linguistic markers that may indicate cognitive load or story complexity.

## 3. Results and discussion

### 3.1. Differences among groups on cues to truth and deception

The principal hypothesis of Experiment 1 is that liars in the high inhibitory control condition would show better control over their behaviors compared to other conditions. To test this hypothesis we conducted the following analyses. First, conceptually related behavioral cues were clustered and averaged to create truthfulness and deception cue categories (Table 1 reports descriptives on individual cues and clusters). Second, 2 × 2 within-subjects ANOVAs on behavior clusters and 2 × 2 mixed ANOVAs on LIWC categories were conducted. Third, pairwise comparisons between truth tellers and liars in each inhibitory control condition were made first (typical of deception research), followed by target comparisons between high control liars and the low control conditions. Finally, comparisons were made between truth tellers in the low and high control conditions. We predict small differences between these truth teller groups given that truth telling may not rely on inhibition to the same degree as lying does. That is, truth tellers are not expected to experience as large of an ISE as liars in the high control condition. As suggested in the literature reviewed, the ISE should impact tasks that rely heavily on the inhibitory network (e.g., lying).

**3.1.1. Interviewee behaviors—**For simplicity, nine of the ten associated behavioral cues ratings from third-party observers were averaged to create three variables: cognitive load, anxiety, and confident and convincing appearance.[3] Table 1 presents average ratings for

each item per condition. All ratings were on a 1–7 scale. A 2(control) × 2(veracity) within-subjects ANOVA was run for each clustered variable.

For *cognitive load*, there was a significant main effect of veracity condition and the interaction. Observers rated liars ($M$ = 3.64, $SD$ = .71) as thinking less hard than truth tellers ($M$ = 3.81, $SD$ = .65), $F(1,74) = 4.96$, $p = .029$, $d = .15$. Importantly, the interaction was significant, $F(1,74) = 6.52$, $p = .013$. In the high control condition liars ($M$ = 3.46, $SD$ = .86) were rated as thinking significantly less hard than truth tellers ($M$ = 3.92, $SD$ = .94), $t(74) = 3.26$, $p = .002$, $d = .51$; whereas in the low control condition, liars ($M$ = 3.82, $SD$ = .94) and truth tellers ($M$ = 3.71, $SD$ = .81) appeared to be thinking at similar levels, $t(74) = .82$, $p = .416$, $d = .13$. Furthermore, analyses revealed that liars in the high control condition appeared to have experienced less cognitive load than liars ($t(74) = 2.43$, $p = .018$, $d = .40$) and truth tellers ($t(74) = 2.81$, $p = .016$, $d = .30$) in the low control condition. Also, truth tellers in both conditions did not significantly differ on perceived cognitive load, $t(74) = 1.51$, $p = .135$, $d = .24$.

For *anxiety*, there was a main effect of control condition and an interaction. Observers rated high control participants ($M$ = 3.76, $SD$ = .98) as more anxious than low control participants ($M$ = 3.39, $SD$ = .77), $F(1,74) = 1.74$, $p < .001$, $d = .15$. Importantly, the interaction was significant, $F(1,74) = 10.39$, $p = .002$. In the high control condition, liars ($M$ = 3.50, $SD$ = 1.23) were perceived as less anxious than truth tellers ($M$ = 4.01, $SD$ = 1.21), $t(74) = 3.05$, $p = .003$, $d = .42$; whereas in the low control condition, liars ($M$ = 3.54, SD = 1.02) appeared more anxious than truth tellers ($M$ = 3.24, $SD$ = .89), $t(74) = 2.33$, $p = .023$, $d = .31$. Furthermore, liars in the high control condition did not appear significantly more anxious than truth tellers in the low control condition $t(74) = 1.95$, $p = .055$, $d = .24$. Also, truth tellers appeared more anxious in the high control than low control condition $t(74) = 5.59$, $p < .001$, $d = .72$. No other effect was significantly different on anxiousness ($t < 1$).

For *confident and convincing* appearance, all effects were statistically significant. Observers rated liars ($M$ = 3.63, $SD$ = .66) as more confident and convincing than truth tellers ($M$ = 3.39, $SD$ = .80), $F(1,71) = 9.39$, $p = .003$, $d = .33$. Those in the high control condition ($M$ = 3.65, $SD$ = .79) were rated as more confident and convincing than those in the low control condition ($M$ = 3.37, $SD$ = .80), $F(1,71) = 6.72$, $p = .012$, $d = .35$. The significant interaction, $F(1,71) = 15.40$, $p < .001$, qualifies these main effects. In the high control condition, liars ($M$ = 4.01, $SD$ = 1.05) were rated as *more* confident and convincing than truth tellers ($M$ = 3.28, $SD$ = 1.06), $t(71) = 4.36$, $p < .001$, $d = .69$; whereas in the low control condition, liars ($M$ = 3.25, $SD$ = .95) were rated similarly confident and convincing as truth tellers ($M$ = 3.49, $SD$ = .95), $t(71) = 1.94$, $p = .057$, $d = .25$. Furthermore, analyses revealed liars in the high control condition appeared more confident and convincing than truth tellers ($t(71) = 3.73$, $p < .001$, $d = .52$) and liars in the low control condition ($t(71) = 4.24$, $p < .001$, $d = .76$. Also,

[3]The cluster variables were created based on the face validity of the nine items. Factor analyses were not appropriate given the number of variables and sample size (Tabachnick & Fidell, 2001). The Cronbach's alpha values for the three clusters were >.80. The one question on controlled appearance was analyzed separately, as it was not strongly associated with the items in the other variables. Degrees of freedom for some results differ because of missing responses. Note on Table 1 that the means on each question show similar patterns as those of the clustered variables.

truth tellers in both conditions did not significantly differ on perceived confident and convincing appearance, $t(71) = 1.40$, $p = .166$, $d = .212$.

For the ratings on the perception of *controlled* appearance, a 2(control) × 2(veracity) within-subjects ANOVA showed a main effect of condition only; those in the low inhibitory control condition ($M = 4.18$, $SD = .87$) appeared more controlled than those in the high control condition ($M = 3.57$, $SD = .89$), $F(1,72) = 27.31$, $p < .001$, $d = .69$. It is unclear how to interpret this latter result but it is interesting given that deception researchers have noted that an overly controlled appearance is a sign to deception because liars sometimes try too hard to make a good impression (Hartwig, Granhag, Strömwall, & Doering, 2010).

**3.1.2. Linguistic cues in interviewees' accounts[4]—**Comparisons using mixed ANOVAs, with bladder condition as the between-subject factor, were conducted on the a priori selected LIWC linguistic cues. Significant effects resulted in three of these cues, *word count, exclusive words, and insight words*. A 2(control) × 2(veracity) mixed ANOVA, on *word count* revealed a significant interaction, whereas in the high control condition, liars ($M = 174.38$, $SD = 31.89$) used significantly more words than truth tellers ($M = 149.13$, $SD = 34.66$), $t(7) = 5.49$, $p = .001$, $d = .76$, in the low control condition, the accounts of truth tellers ($M = 160.15$, $SD = 39.95$) and liars ($M = 156.85$, $SD = 36.81$) did not significantly differ, $t(12) = .35$, $p = .733$, $d = .09$, $F(1,19) = 5.06$, $p = .037$. For *exclusive words*, the 2 × 2 revealed a marginally significant interaction, $F(1,19) = 4.3$, $p = .053$. In the high control condition, liars ($M = 4.72$, $SD = 1.77$) used more exclusive words than truth tellers ($M = 3.14$, $SD = 1.24$), $t(7) = 2.56$, $p = .038$, $d = 1.03$, whereas in the low control condition truth tellers ($M = 5.14$, $SD = 1.63$) used the same number of exclusive words as liars ($M = 4.44$, $SD = 1.93$), $t(12) = .90$ $p = .384$, $d = .39$. For *insight words*, the 2 × 2 revealed a significant effect of inhibitory control condition only, high control interviewees ($M = 4.91$, $SD = 1.88$) used more insight words than low control interviewees ($M = 2.90$, $SD = 1.65$), $F(1,19) = 11.48$, $p = .003$, $d = 1.16$.

### 3.2. Interviewees' self-reported experience

Analyses of ratings on self-reported experiences of nervousness, ease of strategy use, and cognitive load resulted in no statistically significant effects among conditions ($Fs < 3.41$).

### 3.3. Summary

The pattern of results show that increased urination urgency led to fewer behavioral cues to deception and more cues to truthfulness in lying versus truth-telling conditions. This provides support for the principal hypothesis in Experiment 1. Third-party observers' data shows that these high inhibitory control interviewees were in more cognitive control and their behaviors appeared more confident and convincing when lying than when telling the truth. They also provided longer accounts with more signs of story complexity when lying than when telling the truth.

[4]For content analysis of accounts, the unit of analysis is *interviewee*. Each interviewee provided a true and a false account. An error in one video clip did not allow content analysis of that interviewee's truth and lie video pair. Thus, only 21 interviewees' accounts could be analyzed.

An important question is whether truth tellers were detrimentally affected by the bladder manipulation. The additional analyses on the rated behavioral cues suggest that truth tellers were not detrimentally affected by the urgency manipulation. While truth tellers did differed on the anxiousness measures (high control appeared more anxious), they did not differ on measures of cognitive load or confident and convicting appearance. Importantly, results also show that liars in the high control condition appeared significantly better at controlling their behaviors than truth tellers and liars in the low control condition.

In essence these results show that liars looked more truthful overall when in a high state of inhibitory control. This suggest that the ISE was operating; on the cognitively complex task of deceiving, interviewees showed a significant ability to control their behaviors when induced to be in an increased versus regular inhibitory state. This interpretation is bolstered by the fact that the same interviewee provided both a true and a false account within inhibitory control condition. However, these results do not reveal the extent to which these behavioral differences affect deception detection in a more direct way. Experiment 2 was conducted to determine the extent to which a high state of inhibitory control influences observers' accuracy at detecting deception.

## 4. Experiment 2

In Experiment 2, a second set of third-party observers viewed the videos from Experiment 1 and assessed whether interviewees were lying or telling the truth. The principal hypothesis is that discriminating between truths and lies will be less accurate when viewing interviewees in the high versus low control conditions.

### 4.1. Methods

**4.1.1. Participants—**Students ($N$ = 118) from a large university in a metropolitan city participated for course credit as third-party observers (78% were male; $M$ age = 19.84 years, $SD$ = 2.72).

**4.1.2. Design and procedure—**Participants viewed 60 s videos of the interviews from Experiment 1 and made true/lie judgments on each. As in Experiment 1, observers watched 1 of four sets of videos. Experiment 2 involved a 2(inhibitory control: high vs. low) × 2(veracity: lie vs. truth) within-subjects design. There are three dependent variables. One dependent variable is the proportion of correct identification of truths and lies. This allows statistical comparison of accuracy in identifying truths and lies in each of the experimental conditions. The other two dependent variables are discrimination accuracy as assessed by $A'$ and bias in discrimination as assessed by $B''$. These latter two values derive from Signal Detection Theory (SDT) analyses that allow for a more sensitive assessment of discrimination accuracy and the criteria (liberal or conservative) used to make judgments. The current SDT analyses focuses on lie detection which involves assessing the detection of the lie signal against the "noise" signal (truths). Thus, the current discrimination measure of $A'$ is based on hits (correctly identifying lies) and false alarms (misidentifying truths as lies). Higher $A'$ values indicate greater accuracy and higher $B''$ values indicate greater bias to responding "true" (see Donaldson, 1992 for a description of nonparametric measures in SDT and Stanislaw & Todorov, 1999 for a description of SDT).

### 4.2. Results and discussion

**4.2.1. Proportion of correct identifications—**The proportion of correctly identifying truths and lies was analyzed. A 2(inhibitory control) × 2(veracity) within-subjects ANOVA on accuracy scores revealed all significant effects: a significant main effect of veracity $F(1,117) = 149.84$, $p < .001$, $d = 1.13$, a significant main effect of inhibitory control, $F(1,117) = 4.25$, $p = .042$, $d = .19$ and a significant interaction, $F(1,117) = 52.21$, $p < .001$ (see Fig. 1). Of critical importance were the results of the interaction; the magnitude of the difference in detection accuracy between truths ($M = .62$, $SD = .18$) and lies ($M = .47$, $SD = .21$), $d = .77$ in the low inhibitory control condition was small relative to the magnitude of the difference between truths ($M = .70$, $SD = .29$) and lies ($M = .28$, $SD = .25$), $d = 1.55$ in the high control condition. In line with our hypothesis the interaction shows that observers correctly identified fewer lies in the high control condition ($M = .28$, $SD = .25$) than lies in the low control condition ($M = .47$, $SD = .21$), $t(117) = 6.29$, $p<.001$, $d = .82$ . Of note is the finding that the proportion of accurately identified truths in both conditions was relatively high suggesting that identifying truth tellers was not significantly impaired by the urgency manipulation.

**4.2.2. Discrimination accuracy (A′) and bias (B″)—**Pairwise comparisons on each dependent variable revealed two effects. A marginally significant trend for observers to be less accurate when discriminating truths and lies in the high ($M = .49$, $SD = .28$) than low ($M = .56$, $SD = .21$) control condition, $t(117) = 1.89$, $p = .06$, $d = .28$. Importantly, observers showed significantly more bias toward choosing “truth” when judging interviewees in the high ($M = .65$, $SD = .51$) than low ($M = .25$, $SD = .47$) control condition, $t(117) = 6.55$, $p < .001$, $d = .82$.

**4.2.3. Summary—**The results of Experiment 2 support and extend those of Experiment 1. This new set of third-party observers was less accurate detecting deception in interviewees in the high than low control condition. In fact on the measure of bias, these observers selected “truth” more often when making judgments in the high than low control condition. Together these results suggest that because behavioral cues to deception were less obvious in interviewees in the high control condition, detecting their deception was more difficult, leading to a tendency for observers to assume truth.

Of note, our data patterns shows that liars were not generally detected significantly higher than chance levels in the low control condition. This pattern is consistent with findings in the deception literature (Bond & DePaulo, 2006, 2008). In general, cues to deception are difficult to decipher under most conditions (Hartwig & Bond, 2011, 2014), only when actively manipulating incriminating evidence and question types during interviews does the accuracy level in detecting deception can result in higher detection levels (Vrij & Granhag, 2012). Future studies could focus on the ISE effect under those conditions.

## 5. General discussion

There were three primary findings. First, in Experiment 1, deceptive interviewees in a state of high urination urgency (high control) showed more inhibitory control by displaying fewer behavioral cues to deception, more behavioral cues to truthfulness and provided longer and

relatively more complex accounts than interviewees with low urination urgency (low control). Second, in Experiment 2, third-party observers were less accurate detecting deception when viewing interviewees in the high than low control states. Finally, the data pattern shows that truth tellers were not detrimentally affected by the manipulation of inhibitory control, as their behaviors (except for anxiousness) were similar across conditions and truths were detected at high rates in both control conditions (low: $M = .62$ and high: $M = .70$). Additionally, liars in the high control condition revealed better behaviors than interviewees in other conditions. Thus, it is not the case that the results are due to a negative effect on truth tellers in the high inhibitory control condition.[5] These results indicate that the ISE can occur within a cognitively complex and dynamic situation (deception) that goes beyond tasks used in previous studies including computer responses and decisions on hypothetical scenarios (e.g., Tuk et al., 2011), and this effect tends to be strongest when both tasks require increased need for inhibition (i.e., lying in the high urgency condition).

What mechanisms could account for the effects in this study? Given that in general, deceptive individuals require increased access to executive control processes to carry out their deception convincingly, it is possible that procedures facilitating access to those executive processes may aid in the execution of the deception. As reviewed, imaging studies show that tasks requiring different aspects of self-control activate similar or overlapping areas (e.g., the ACC, rIFC) and are associated with effective inhibitory control in other domains (Berkman et al., 2009). It is likely that in our study the induction of inhibitory physical control activated inhibitory networks in our participants, which facilitated access to inhibitory processes in the deceptive condition. This is evidenced in the behavioral data in both experiments in this study. Liars did “better” overall when in a high state of physical inhibitory control.

What does it mean for a liar to perform “better”? In this study we measured liars’ ability to control nonverbal and verbal behaviors. While in most studies the difference in behaviors between liars and truth tellers is minimal, results of a recent meta-analysis suggest that there are diagnostic cues to deceit and truth (Hartwig & Bond, 2011), and analyzing the existence of multiple behavioral cues can improve deception detection accuracy (Hartwig & Bond, 2014). For example, when observers rate interviewee appearance on Likert-type scales (e.g., “how hard is the person thinking” or “how confident does the person appear”) liars tend to be judged as thinking harder than truth tellers whereas truth tellers tend to appear more confident and convincing. In this study, when inhibitory control was enhanced liars controlled such behavioral cues as cognitive load, anxiousness, and confident and convincing appearance to a greater extent and were detected with less accuracy as a consequence. Liars in the high control condition were better at evading detection.

A question arising from these data is why would liars in the high inhibitory control condition provide longer and more complex stories than truth tellers (as defined by LIWC)? In interview contexts when a story must be told, the construction of that account may demand a

[5]It is important to note that the manipulation may affect participants in ways beyond the intended ISE when urination urgency is at an unmanageable level. The data suggest that this was not the case in this study. The majority of behavioral cue analyses show that the manipulation affected liars to a greater extent. Truth-tellers were similar in the high and low control conditions across all cues except for the anxiousness cluster.

great deal of mental resources, especially for the liars. Unlike the truth teller, the liar may have to create a story based on general scripts or basic semantic knowledge (Hauch et al., 2014). He or she may have to suppress thoughts of the truth, and monitor his/her own and others' behaviors (Gombos, 2006). Due to less cognitive recourses available to the liar, the richness of details and complexities that characterize true accounts may not be revealed in false accounts. Hauch et al. found support for this hypothesis, in their extensive meta-analysis of cues to deception assessed by computer programs, it was shown that among other cues, liars tend to provide less detailed and complex stories than truth tellers (average $d = .24$). It can be predicted that with more cognitive control and increased motivation, high control liars in our study could have been better positioned to provide more elaborated and convincing stories. This is not only supported by the LIWC analysis but also by observers' ratings on how convicting and detailed the person appeared to be.

In recent years deception research has focused on examining the cognition of lying (Gombos, 2006; Walczyk et al., 2013) with the goal of developing cognitive approaches to improve the detection of deception (Vrij & Granhag, 2012; Vrij, Granhag, Mann, & Leal, 2011). Some of this research has begun to examine the cognitive mechanisms involved in deception and the conditions under which lying is more or less difficult, although few techniques were actually constructed with consideration of underlying cognitive processes or models (Blandón-Gitlin, Fenn, Masip, & Yoo, 2014). That research suggests that as a result of an increased need for executive control during deception, there is a cognitive cost to lying. People tend to be slower responding, make more errors, and provide less detailed and convincing accounts when lying than when telling the truth. However, some studies have shown that the cognitive difficulty associated with lying is malleable. For example, practicing lies (e.g., Van Bockstaele et al., 2012) and training liars to control behavioral cues to deception (e.g., Hu, Chen, & Fu, 2012) reduce observers' ability to discriminate between truths and lies. As mentioned before, our study suggest that facilitating inhibitory activation via the ISE reduces the overall cognitive cost associated with lying; deceptive interviewees with enhanced inhibitory control provided relatively complex accounts, and appeared with less cognitive demand, were less anxious, and seemed confident and convincing. The detecting of deception was less accurate as a result. The implication of these findings for current deception research is that a covert and relatively easy-to-implement strategy that enhances inhibitory control may enable liars to evade detection.

The results of this study contribute to the clarification of the ISE in relation to depletion effects in the self-control literature (e.g., Baumeister et al., 1998; Hagger et al., 2010). Tuk et al. (2013) and Tuk, Zhang, and Sweldens (2015) attempted to reconcile the ISE findings with those from the ego-depletion literature and argued that the ISE results are not contradictory to depletion effects. Ego depletion occurs when a task requiring self-control impairs the performance on a subsequent task also requiring self-control (Baumeister et al., 1998). The ISE occurs when performing two simultaneous self-control tasks facilitate rather than impairs performance on those tasks. To explain these discrepancies Tuk et al. (2013) presented evidence showing that a suppression task (emotion inhibition during a sad film) performed before a target task (avoid junk food) had an impairment effect (increased junk food consumption), but the same tasks performed simultaneously had a facilitation effect

(less junk food consumption). In the current study, tasks involving simultaneous self-control (suppressing urgency and deceiving) had a facilitation effect on liars' performance. On the other hand, Apfelbaum and Sommers (2009) showed that a cognitive inhibition task completed *prior* to an interview had a depletion effect by impairing participants' self-presentation strategies. Together, these results suggest that performance on a cognitively demanding interview can be facilitated or impaired depending on when the additional inhibitory control task is performed (before or simultaneously). Thus, there is important new support for Tuk et al.'s proposal that the ISE occurs because of the simultaneous nature of the two self-control tasks and are in line with the notion that various types of self-control acts (e.g., cognitive, motor, or emotional) involve a common origin (Chambers, Garavan, & Bellgrove, 2009) but have different implications depending on the context in which they occur.

In conclusion, the results of this study highlight the importance of inhibitory control when deceiving and provide support for the inhibitory spillover phenomenon. The evidence suggests that the ISE operates during a complex and dynamic task (lying in a face-to-face interview); liars who simultaneously resisted a physiological urge to void demonstrated enhanced control over their behaviors, and consequently successfully evaded detection. Future research in other domains may benefit from investigating the role of an ISE in complex behaviors requiring enhanced inhibitory control such as unhealthy behaviors, or the rejection of depressive thinking. The potential of such research is promising.

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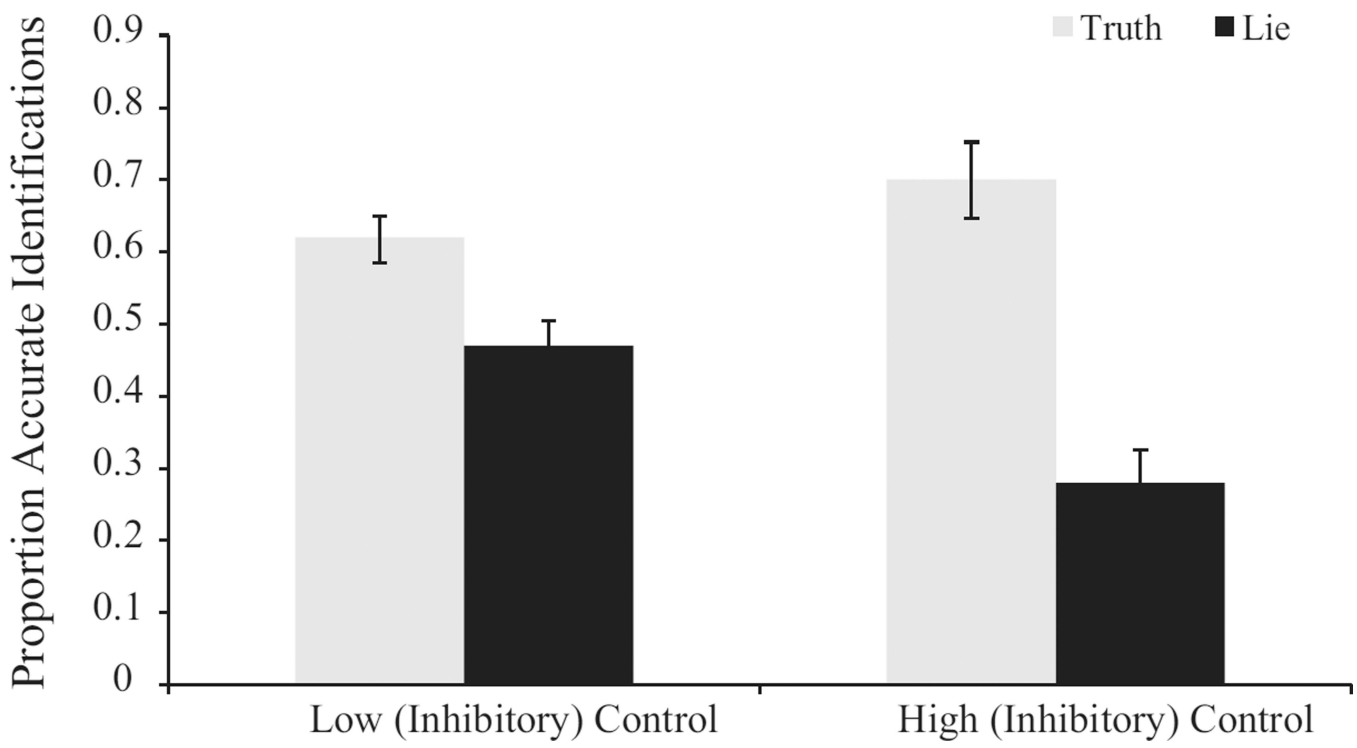


**Fig. 1.**
Experiment 2: Accuracy scores as a function of inhibitory control condition. Error bars represent standard error of the mean.

**Table 1**

Experiment 1: Third-party observers' ratings on behavioral cues, as a function of cluster, inhibitory control and veracity condition.

| Behavioral cues | Low control | | | | | | High control | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Truth | | Lie | | | | Truth | | Lie | | | |
| | *M* | *SD* | *M* | *SD* | *t* | *d* | *M* | *SD* | *M* | *SD* | *t* | *d* |
| **Cognitive demand** | **3.71** | **0.81** | **3.82** | **0.94** | **0.82** | **0.13** | **3.92** | **0.94** | **3.46** | **0.86** | **3.26**** | **0.51** |
| How hard does the interviewee appear to be thinking? | 4.16 | 1.03 | 4.27 | 1.13 | 0.71 | 0.10 | 4.27 | 1.28 | 3.87 | 1.24 | 1.90 | 0.32 |
| How much difficulty does the interviewee appear to be having in answering the questions? | 3.89 | 1.14 | 4.11 | 1.23 | 1.30 | 0.19 | 4.04 | 1.40 | 3.30 | 1.31 | 3.24** | 0.55 |
| How distracted does the interviewee appear? | 3.08 | 0.98 | 3.06 | 1.13 | 0.09 | 0.02 | 3.45 | 1.30 | 2.81 | 1.28 | 3.21 | 0.5 |
| **Anxiousness** | **3.24** | **0.89** | **3.54** | **1.02** | **2.33*** | **0.31** | **4.01** | **1.21** | **3.50** | **1.23** | **3.05**** | **0.42** |
| How anxious does the interviewee appear? | 3.34 | 1.05 | 3.71 | 1.27 | 2.28* | 0.32 | 3.85 | 1.29 | 3.39 | 1.35 | 2.63* | 0.35 |
| How much does the interviewee appear to fidget? | 3.14 | 1.06 | 3.37 | 1.05 | 1.63 | 0.22 | 4.17 | 1.34 | 3.61 | 1.38 | 2.84** | 0.41 |
| **Confident and convincing appearance** | **3.49** | **0.95** | **3.25** | **0.95** | **1.94** | **0.25** | **3.29** | **1.06** | **4.01** | **1.05** | **4.36***** | **0.69** |
| How detailed are the interviewee's responses? | 3.75 | 1.17 | 3.45 | 1.19 | 1.97 | 0.25 | 3.56 | 1.30 | 4.18 | 1.15 | 3.22** | 0.51 |
| How spontaneous is the interviewee? | 2.88 | 1.06 | 2.79 | 1.14 | 0.74 | 0.08 | 2.97 | 1.38 | 3.03 | 1.13 | 0.35 | 0.05 |
| How confident does the interviewee appear? | 3.79 | 1.08 | 3.56 | 1.16 | 1.42 | 0.21 | 3.43 | 1.19 | 4.15 | 1.22 | 3.66*** | 0.6 |
| How convincing is the interviewee? | 3.48 | 1.23 | 3.13 | 1.20 | 2.27* | 0.29 | 3.12 | 1.37 | 3.86 | 1.17 | 3.69*** | 0.58 |
| **Controlling** | | | | | | | | | | | | |
| How controlled is the interviewee's posture? | 4.23 | 0.99 | 4.12 | 1.06 | 0.90 | 0.10 | 3.59 | 1.07 | 3.56 | 1.09 | 0.24 | 0.03 |

Note. All ratings were on a 1 (not at all) – 7 (extremely) scale. Cognitive demand and anxiousness involve cues to deception. Confidence and convincing appearance indicates cues to truthfulness. Controlling indicates cues to deception. Bolded rows represent the mean of each cluster (e.g., Cognitive Demand).

* $p < .05$.

** $p < .01$.

*** $p < .001$.