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INTENTION TO DECEIVE ALTERS ACCESS TO SEMANTIC MEMORY

By

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DEDICATION

To everyone who will choose to subject themselves to difficult journeys because they believe it’s worth it. I wish you all well.

ACKNOWLEDGEMENTS

"I hate quotes, tell me what you know" – Ralph Waldo Emerson

This phrase blew the back of my head off when I was 15 years old. Another 15 years later, and I've learned it takes an incredible amount of support to say something original. It's impossible to thank everyone who helped this crazy life of mine lead to a doctoral defense. So to everyone I don't name, know that if you cared for me, I got the message, and I'm grateful. If I have to name names, I'd like to thank Victoria Macht, for reminding me the importance of a happy life, all while pulling me over so many finish lines I couldn't have crossed alone. Cade Warren, for teaching me *entrenchment*, and helping me name so many other things that beforehand, only existed as glimmers in my mind. My undergraduate mentors, Kirk McDermid and Laura Lakusta, I doubt the two of you ever met, but thank you for believing in a starry-eyed kid, and teaching him what a productive thought is. Fernanda Ferreira for training me in psycholinguistic methods, which made this dissertation possible. Steven Luke for helping me grasp what a degree of freedom is, and why it matters. The Psychology Department at USC for your support and patience. My committee, Amit Almor, Robin Morris, and Brian Habing, for your compassionate, yet rigorous, standards. My mentor Jennifer Vendemia, thank you for pushing me, and showing me I am capable of more than I ever imagined. My parents for their love and faith. You kept me on track to do what I set out to do all those years ago. Finally, thank you to Bruce Springsteen for giving this gutter rat from Jersey the emotional permission he needed to pursue something so gloriously difficult.

ABSTRACT

I conceptualize a theory of deception within the perspective of discourse and pragmatics while choosing to examine the decision to engage in deception within the perspective of cognitive psychology. Currently, cognitive perspectives of deception have emphasized that inhibitory control of one's motor processes are vital because in order to respond deceptively, one must prevent honest behavior from leaking into one's actions. Although indirect evidence for inhibition is heavily linked with deception, current empirical data connecting motoric control with deceptive responses has been difficult to observe. I propose a theoretical perspective that shifts the role of inhibitory control in deception away from motoric control and into long-term memory knowledge structures. I propose that deception requires the inhibition of semantic-memory so as to enable the construction of short-term memory representations that contradict semantic-memory. In order to examine this question, I constructed sentences that either reflected or violated world-knowledge (i.e. true or false sentences) and also manipulated the predictability of these sentences. Participants read these sentences and either responded deceptively or honestly. The findings suggest that deception suppresses semantic activation that normally is triggered automatically. The final experiment validated a novel method to study deception and suggested that the specific nature of a goal underlying the deceptive behavior is related to this suppression of semantic memory. Future studies are proposed to explore if the suppression of semantic memory is generalized across all knowledge-structure or is specific to the nature of the deceptive goal.

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Chapter 1 INTRODUCTION

Krapohl & Sturm (2002) define deception as "intentionally providing misleading information." The emphasis of this definition is on the act of deploying a deceptive response. Due to the forensic/clinical nature of deception research, the lie-response portion of deception tends to be emphasized in order to focus on the signal detection aspects of deception when it does occur (Spence, et al., 2004; Langleben, 2008). However, this approach is not necessarily compatible with a theory driven approach to understanding the cognitive processes involved in deception. For this type of approach, conceptualization of deception within the broader perspectives of discourse and pragmatics provides a richer theoretical platform from which to frame a testable model. In its simplest case (Sip, Roepstorff, McGregor, & Frith, 2008) two individuals (i.e. two interlocutors) engage in the social exchange of information, but the liar chooses to not cooperate with their conversation partner (McCornack, Morrison, Paik, Wisner, & Zhu, 2014). In the following paragraphs, I describe some of the more influential theories of information exchange in conversation, and then describe a theory of deception based on the subversion of the conversation rules that are normally implicitly followed during honest behavior.

Information exchange schemas: honesty and deception

The most influential theory related to the conversational rules governing social exchange of information is the one proposed by Paul Grice (1975). He presented conversation as being a generally cooperative venture between two or more willing participants. This cooperation principle is governed by several implicit rules, known as Gricean Maxims. He denoted four distinct maxims: Quantity (i.e. only say as much as is necessary for the listener to understand your point), quality (i.e. only say what you know to be true, or at least signal when you are unsure about something), relation (i.e. only say what is relevant to the topic of the conversation), and manner (i.e. say things as clearly as possible, avoiding intentional obscurity or ambiguity). He summarized these Maxims in the principle of cooperation, which states

> "Make your conversational contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk-exchange in which you are engaged."

Gricean maxims are postulated to direct the ebb and flow of the cooperative social exchange of information, in which one person requests information and another seeks to provide it. The type of information that can be requested/provided is dependent on the specific dynamic of the conversation, varying from simple greetings, personal life stories, and long-term classroom instruction. Because conversation is dynamic, including two or more individuals each seeking their own conversational goals, interlocutors must agree to let the speaker/listener roles naturally shift so as to keep the other person invested in the conversation (Wilson & Sperber, 1981; Ramos, 1998). Speakers and listeners agree to maintain an equilibrium of informational exchange, where both interlocutors are allowed the opportunity to pursue their personal conversational goal. Speakers honestly convey information relating to their goal and listeners honestly convey information regarding their degree of receptiveness to that goal. If both interlocutors believe that the equilibrium is being maintained, then both parties will likely deem the conversation sufficiently worthwhile instead of choosing to abandon the conversation and do something else.

Although the informational exchange equilibrium is described above as being an inherent law of conversation, it is important to remember that it only exists so much as the interlocutors choose to adapt their behavior in accords to the goals of their conversation partner. The decision to behave in accords to these maxims requires an explicit decision to cooperate with a conversation partner. McCornack et al (2014) recently conceptualized deception as involving an intentional violation of these maxims. The usefulness of this theory is that it provides predictable outcomes (e.g. violating the maxim of manner would likely elicit a lie of omission whereas violating the maxim of quality would elicit a lie of fabrication). The propositions of this theory have already had tremendous impact on deception research by stimulating further refinements to deception theory (Walczyk, 2014).

In the spirit of contributing theoretical perspectives to the deception literature, I propose a theory of deception based on the decision to cooperate with a conversation partner. I agree that conversations involve the adoption of a certain set of conversational rules by an interlocutor, and the specifics of these rules direct their behavior throughout the conversation. The specific rules that govern one's manner of information exchange will be referred to as an *informational exchange schema.* Under an honest schema, the interlocutor cooperates with their conversational partner, allowing the conversation to oscillate back and forth between their goals and their partner's goals in accords to the equilibrium. However, I propose that under a deceptive schema, the liar adopts a set of rules that is so radically biased towards their personal goals, that in order to achieve them, the liar must intentionally disregard or even sabotage their conversational partner's goals. From this theory, I define *deception* as "the intentional subversion of the social equilibrium between the information a speaker can potentially share and the information that is relevant to the listener's conversational goals." Within this context, I define a *lie* as "the behavior intentionally designed by the speaker to subvert the social equilibrium." Thusly, the theory of informational exchange differentiates the decision to deceive from the actual deployment of a deceptive response.

I argue that an information exchange schema contains the following orthogonal dimensions: intention to balance shared informational exchange (honesty) vs. intention to violate shared informational exchange (deception). Within honesty, speakers behave in accordance to Gricean maxims, allowing the listener's goals to inform the content of their messages without any plan to subvert this equilibrium. However, as soon as a context involves the decision to monitor for message content which, if encountered, would trigger a deceptive schema, both dimensions of the informational exchange schema are brought online. Each new solicitation requires the liar to evaluate where the solicitation falls on these orthogonal dimensions, which determines the liar's response. This evaluative monitoring is an additive factor even for those occasions if the liar decides to be honest (Locker & Pratarelli, 1997). As conversation progresses, liars cooperate only when it is advantageous to do so (e.g. admitting truthful content the listener already knows, admitting minor transgressions so as to induce trust, and other behaviors that cohere with the deceptive-schema's goals, even if they are not necessarily lies). Therefore, in such a conversation, the liar is honest only because the solicitation did not match the deception-signal, not because they chose to abandon the deceptive-schema.

The primary contributions of this theory of deception are twofold: 1) The intention to deceive is a stage that precedes the decision to elicit an honest/deceptive response and 2) the process of monitoring for the absence/presence of the deceptive-signal (i.e. the reason for the deception) within the environment directs the decision to elicit an honest/deceptive response. The purpose of this dissertation is to examine the processes involved in monitoring for a linguistic deceptive-signal and how such a goal influences the processes of language comprehension as well as the deployment of schema-appropriate behavior in response to the comprehended language.

Conscious intentionality predominates deception research

A long held assumption in the field of deception is that conscious intentions are a necessary part of the deceptive act (Trovillo, 1939; Masip, Garrido, & Herrero, 2004; Phillips, Meek, & Vendemia, 2011). Under this assumption, honesty is conceived as cognitive baseline and deception introduces additional cognitive processes onto this baseline. This conception proposes that honesty is the process of generating and deploying a prepotent response whereas deception is the decision to inhibit and replace this prepotent response. One conclusion used to support the additive demands of intentionality is that deception is more effortful than honesty, as reported by early deception researchers examining physiological and cognitive measures (Münsterberg, 1908; Marston, 1920; Burtt, 1921; Goldstein, 1923; Larson, 1923) and modern deception researchers using cognitive, physiological, and neuroscientific measures (for reviews, see (Johnson Jr, 2014; Vendemia & Nye, in press).

Initially, deception researchers emphasized the emotional consequences that followed from the conscious decision to deceive (Jung, 1910), which came to be referred to as the *deceptive attitude* (Marston, 1917). Goldstein (1923) described the deceptive attitude as: “The consciousness of deception appeared as strain, self-consciousness, hesitation, conflict of impulses, emotional disturbances”. In self-reports, the subjective struggle associated with the intentional act of deception was linked to moral discomfort (DePaulo, Kashy, Kirkendol, Wyer, & Epstein, 1996) or fear of consequences (DePaulo, et al., 2003). Although emotional sequelae are relevant to deception, I argue that cognitive processes are more intimately involved, which is why I have chosen to integrate deception and honesty under the information schema that emphasizes cognitive mechanisms instead of emotional reactions.

Deception requires the conscious self-monitoring of one’s behavior, which is cognitively taxing and time consuming (Lane & Wegner, 1995) relative to more rapid and automatic ways to access knowledge, such as the implicit spreading of activation across associated concepts in semantic memory (Collins & Quillian, 1969; Collins & Loftus, 1975; Neely, 1977). Current theories of deception posit that liars explicitly construct a representation of the deceptive-signal (i.e. information that if encountered, would elicit a deceptive response), and implicitly activated semantic information is judged in accordance to its relation to that signal (Sporer, 2016; Walczyk, Harris, Duck, & Mulay, 2014; Phillips, Meek, & Vendemia, 2011). Given the explicit self-monitoring and inhibitory control involved in deception (Sip, Roepstorff, McGregor, & Frith, 2008), and that implicit semantic activation is assumed to be an automatic process (Neely, 1977), deception research has focused on the intentional mental operations conducted on activated content, not the processes involved in the initial semantic activation in and of itself (Walczyk, Roper, Seemann, & Humphrey, 2003; Masip, Blandón-Gitlin, de la Riva, & Herrero, 2016; Seymour, Seifert, Shafto, & Mosmann, 2000).

The informational exchange theory of deception agrees with prior theories of deception that deceptive-schemas require an extensive amount of explicit decisions: constructing the deceptive-signal, goal-monitoring to detect the deceptive-signal if encountered, the decision to generate a deceptive-response following signal-detection, and finally, the decision to deploy the deceptive response. However, unlike prior theories, the deceptive-schema is argued to alter the process of evaluating conversational content, which means that honest-schemas and deceptive-schemas may involve radically different means of processing stimuli and retrieving memorial content.

In order to examine how memory activation differs across deception and honesty, this dissertation will examine how honesty and deception evaluate sentences and generate responses to these sentences, while varying the semantic-relation of the information within those sentences I will review the deception literature, presenting evidence that while honest response time (RT) predictably varies in response to experimental manipulations, deceptive RT is more resilient to such effects. I will present a model that encapsulates assumptions that are shared across virtually all deception models, referred to as the Prepotent-Inhibition Model, and review deception research that conflict with these assumptions. I will then propose an alternative model that could account for these conflicting findings, referred to as the Binding-Suppression Model. Finally, I will present original research that supports the predictions of this model.

Resilience and stability of deceptive responses

Resistance to experimental manipulations

The difficulty involved in deceptive responding is evidenced by longer and more variable response times for deception than for honesty (Johnson, Barnhardt, & Zhu, 2004;

Vendemia, Buzan, & Simon-Dack, 2005). Although these delayed and variable response times suggest that deception is more cognitively demanding, paradoxically, deception research has also reliably shown that honest responses are more responsive to experimental manipulations than deceptive responses. For example, deceptive responses are more resilient than honest responses to long-term practice and familiarity with the task (Vendemia, Buzan, & Green, 2005), suggesting that the difficulty of deception is not related to inexperience with deceptive responding in an experimental paradigm. Some evidence suggests that greater experience with deception only reduces the capacity to respond honestly without influencing deception (Verschuere, Spruyt, Meijer, & Otgaar, 2011). Deception is also less facilitated than honesty by the amount of amount of preparatory time before a response is required (Ito, et al., 2012), an effect that holds even when the preparatory cues signal the exact motoric response that should be elicited when the response-cue is encountered (Vendemia, Buzan, & Simon-Dack, 2005; Vendemia, Buzan, Green, & Schillaci, 2006). If deception elicited an additive factor on cognitive processing, the fundamental rules of limited-capacity resources would suggest that cognitive resources should be more easily overwhelmed under a deceptive schema than an honest schema (Broadbent, 1977; Posner, 1980; Pashler, 1994).

On the other side of the spectrum of preparation, deception is less influenced than honesty when participants must decide for themselves whether to be deceptive or honest, as reported by greater increases in honest RT than deceptive RT, as well as a nullification of differences between honesty and deception when participants must intentionally decide (Johnson, Barnhardt, & Zhu, 2003; Williams, Bott, Patrick, & Lewis, 2013). In a prisoner's dilemma-like paradigm in which participants were instructed to be honest/deceptive to a confederate or allowed to decide for themselves to be deceptive/honest, response time was similar across deception and honesty when participants decided which schema to adopt (Carrión, Keenan, & Sebanz, 2010). Carrión et al (2010) also recorded ERPs as participants performed this task, and reported that instructed-deception, chosen-deception, and chosen-honesty all elicited a larger medial-frontal negativity component (i.e. N450) than instructed-honesty which is a component considered to index strategic monitoring of cognitive-conflict (West, Bailey, Tiernan, Boonsuk, & Gilbert, 2012). The primary explanation for this finding is that when participants are required to decide, the introduction of strategic meta-cognitive decision-making can artificially increase the difficulty of honesty without extensively altering the difficulty of deception because deception inherently requires strategic monitoring (Vendemia, Buzan, & Simon-Dack, 2005; Williams, Bott, Patrick, & Lewis, 2013).

The malleability of honest responses and resilience of deceptive responses to experimental manipulations is particularly evident in tasks involving rapid stimulus-response bindings. For example, emotional saliency of stimuli has long been known to elicit rapid attentional orientation and alter behavioral response time (Mackay, et al., 2004). However, emotional saliency of stimuli influences honest response times, but not deceptive response times (Ito, et al., 2011). Similarly, experimental manipulations designed to interfere with prepared responses tend to increase latency of honest responses without increasing deceptive responses, as when interference stems from dual-task paradigms (Hu, Evans, Wu, Lee, & Fu, 2013), distractor stimuli (Duran, Dale, & McNamara, 2010), or one's personal beliefs (Johnson, Henkell, Simon, & Zhu, 2008). In summary, experimental manipulations reliably influence the speed in which honest-schemas select and deploy responses, but these effects are either greatly reduced or even nullified under a deceptive-schema.

Resilience of deceptive responses to individual differences

The resiliency of deceptive response times to variations via experimental manipulation also appears to extend to research examining individual differences in cognitive measures. For example, individual differences in executive function reliably explain variance in honest responses but explain minimal variance in deceptive responses, as observed with executive-function battery tests which measured inhibition, shifting, and spatial memory, (Visu-Petra, Miclea, Buş, & Visu-Petra, 2014), and with verbal short-term memory (STM) capacity (Farrow, Hopwood, Parks, Hunter, & Spence, 2010). Although some variance in deceptive performance has been attributed to variability in cognitive function (Morgan, LeSage, & Kosslyn, 2009), many studies only examine difference scores between honest and deceptive responses. Without information on how honest responses were affected by experimental manipulations, it is difficult to draw any conclusions about the relationship between cognitive functions and deception.

Resilience of deceptive responses to induced cognitive load

Applied research in the law enforcement field supports the malleability of honest responses and resiliency of deceptive responses (Vendemia, Schillaci, Buzan, Green, & Meek, 2006). Inducing cognitive load consistently improves differentiation of liars from truth-tellers (Vrij, Fisher, & Blank, 2017; Wainer, Gruvaeus, Blair, & Zill, 1974), but this must be done carefully so as to only induce cognitive load on liars and not on truth-tellers (Verschuere, Meijer, & Vrij, 2016). For example, one reported method to induce cognitive load on liars was to require suspects to convey their alibi in reverse-order, because it was assumed innocent suspects could easily reverse their episodic memories, but guilty suspects would need to recreate the alibi from scratch (Vrij, et al., 2008). Although the concept initially created much excitement, later research has revealed that requiring suspects to report an episodic memory in reverse order mostly causes innocent suspects to appear more deceptive (Fenn, McGuire, Langben, & Blandón-Gitlin, 2015).

Contrarily, deception appears most easily detectable when both the innocent and the guilty are motivated to feel relaxed and free to state a large amount of information (Vrij, Hope, & Fisher, 2014), especially if the questions are difficult to expect (Vrij & Granhag, 2012). However, when the questions are difficult to understand, such as when law enforcement investigators include complex exclusionary clauses to simple questions, the increase in comprehension difficulty reduces detectability of deception (Podlesny & Raskin, 1978). I posit that increasing the cognitive complexity of a task, whether it be the comprehensibility of a question or introducing additive factors that obstruct responding (e.g. requiring that an alibi be reported in reverse order), the difficulty associated with an honest schema is increased to a far greater extent than the difficulty associated with a deceptive schema. The reason for this is that deception is already difficult to perform and virtually impossible to prepare for unless the liar can practice an explicit stimulus-response script (Vrij & Granhag, 2012). The actual content of the question or the response-modality parameters is not going to differentiate the cognitive-load of a liar drastically. Contrarily the effort involved in honest behavior is heavily contingent on the parameters of stimulus-response binding (Donders, 1868). Therefore, by increasing the difficulty of honesty to a greater extent than the difficulty of deception, the difference in cognitive effort between honesty and deception is ameliorated.

In summary, honest schemas are governed by the rules of informational exchange, meaning that honest responses will vary in accords with the context, such that contexts that reduce the complexity involved in stimulus-processing → response-selection will facilitate responding whereas more cognitive complex contexts will delay honest responding due to the extra cognitive processing required (Sternberg, 1969). Contrarily, deception operates on a series of rules that are entirely separate from the standard rules of conversation, therefore, the effort required to elicit a deceptive response does not vary in a similar manner as an honest response. The informational exchange theory of deception argues that honesty and deception are subject to entirely different rules of cognitive complexity, which means it should be possible to increase difficulty of honesty without altering the difficulty of deception. Both schemas are subject to unique rules that govern cognitive processes. Methods to detect deception should consider rules of both schemas.

Deception and the inhibition of prepotent responses

One of the primary reasons postulated for the difficulty associated with deception involves the *inhibition of prepotent responses* (Spence, et al., 2001; Vendemia, Buzan, & Simon-Dack, 2005; Johnson, Barnhardt, & Zhu, 2003). Inhibition is the active prevention of one process as a function of another process (MacLeod, 2007). Prepotent responses are holistic sequences of events which result from ballistic processes (Osman, Kornblum, & Meyer, 1986) that can be automatically deployed without conscious intention or planning (Shiffrin & Schneider, 1977; Friedman & Miyake, 2004), such as the rapid ocular orientation to a light (Kane, Bleckley, Conway, & Engle, 2001) or the recognition of common words by skilled reader (Stroop, 1935; MacLeod, 1991). Such automatic responses do not benefit from practice nor are they impaired by cognitive-load or autonomic arousal (Hasher & Zacks, 1979).

Taken together, the inhibition of a prepotent response can be defined as the active prevention of a ballistic process which normally reaches its point of no return without conscious thought or interference from other processes. Inhibitory control of motor activity is reported to be vital component of deception (Hadar, Makris, & Yarrow, 2012; Duran, Dale, & McNamara, 2010; Debey, De Houwer, & Verschuere, 2014; Duran, Dale, Kello, Street, & Richardson, 2012) and it has a place in virtually every major model of deception (Vendemia, Schillaci, Buzan, Green, & Meek, 2006; Walczyk, Harris, Duck, & Mulay, 2014; Sporer, 2016). As depicted in Figure 1.1, these models propose that liars inhibit the honest response in order to generate and deploy a deceptive response. This application of inhibitory control is related to the difficulty associated with deception.

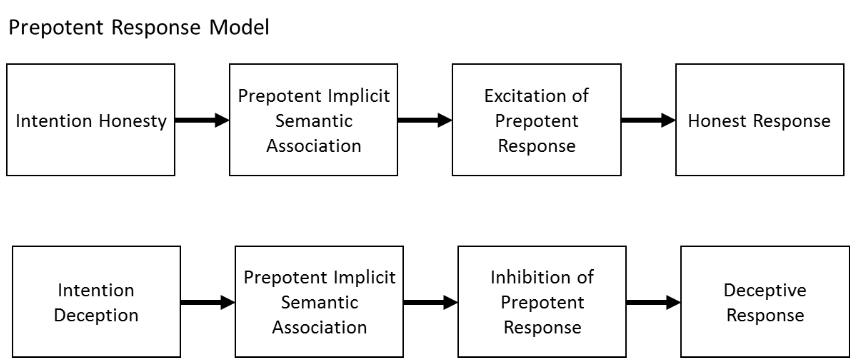

Figure 1.1: Prepotent Inhibition Model. In this model, the critical element is the excitation or inhibition of the prepotent response following sentence evaluation.

Inhibitory control is a complex construct to measure because it is inherently defined by the context of the ballistic process that is currently being inhibited. Examples of inhibitory control include: Inhibition of stimulus-response congruity, in which a stimulus which would normally activate a response must be inhibited in order to deploy another response (Stroop, 1935; MacLeod, 1991). Inhibition of distracting/irrelevant information, in which participants construct a top-down goal and suppress all stimuli that are irrelevant to the goal (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Inhibition of prepared responses, in which someone initiates a response, but subsequently decides that response is inappropriate and must cancel the response before it is deployed (Osman, Kornblum, & Meyer, 1986). Although it seems obvious that deception should involve some form of inhibitory control, research endeavors have generally failed to identify any link between deception and any specific type of inhibitory control (Caudek, Lorenzino, & Liperoti, 2017). In tasks comparing honesty and deception, performance on these inhibitory control tasks explain variance that is either solely associated with honesty or variance that is shared across both honesty and deception (Debey, Verschuere, & Crombez, 2012; Debey, De Schryver, Logan, Suchotzki, & Verschuere, 2015). Even when inhibitory control of planned responses was measured via individual differences, with stop-signal reaction time, while also experimentally manipulated, with sober vs. intoxicated participants, neither stop-signal reaction time nor sobriety explained variance unique to deception, (Suchotzki, Crombez, Debey, Van Oorsouw, & Verschuere, 2015).

If deceptive-schemas inhibit prepotent responses, then deception research should explore the effects of such inhibition on the responsiveness of prepotent responses. Different prepotent responses (e.g. pupillary dilation, galvanic skin response, heart rate, etc.) differ in their response to deceptive schemas (Verschuere, Kindt, Meijer, & Ben-Shakhar, 2016). For example, physiological evidence suggests that deceptive schemas suppress all prepotent motor responses, not just those associated with honesty

(Pennebaker & Chew, 1986). When a mechanism is inhibited, it becomes less responsive to stimuli which would normally activate it (Kane, Bleckley, Conway, & Engle, 2001). If deception inhibits mechanisms that are normally involved in behavioral responding, then perhaps their suppression is related to the cognitive demands of deception. Imagine hanging a picture on the wall while refusing to use a hammer. It is still possible, but lacking such an appropriate tool increases the difficulty. Similarly, if deceptive-schemas suppress a wide range of cognitive mechanisms that are available under an honest-schema, then those mechanisms will be less responsive to stimuli under deceptive-schemas. Deception's reliance on slower cognitive operations relative to honesty results in the paradoxical finding that deceptive responses are: 1) Longer and more variable than honest responses and b) more stable across experimental contexts than honest responses.

Deception and the inhibition of semantic memory

Liars actively inhibit implicit semantic associations from directing response generation in order to construct responses that may not cohere with semantic and episodic memory (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Meek, Phillips, Boswell, & Vendemia, 2013). By suppressing the role of semantic activation on response-generation, liars must rely on conscious evaluative processes to generate responses that contradict semantic memory and sufficiently accomplish their conversational goals (Frith & Frith, 2008). From this perspective, honesty and deception might differ in processing time because honesty involves cognitive resources that operate on a faster timescale than the cognitive resources involved during deception, such as the decision to allow exogenous cues to direct attentional search as opposed to constantly requiring goal-based vetting of generated-responses (Hutchinson & Turk-Browne, 2012).

The conscious decision to deploy a response that directly contradicts semantic memory may underlie the subjective conflict as well as the processing costs associated with deception. Constant self-regulation rapidly depletes cognitive resources (Vohs & Heatherton, 2000) and can be detrimental to one's emotional and physical health (Lane & Wegner, 1995). Such subjective conflict will not be resolved via verbal working memory capacity or inhibitory control. Perhaps the resiliency of deception to experimental manipulation is due to the proactive inhibition of implicit processes. If implicit processes are no longer allowed to direct responding under a deceptive schema, then not only will deceptive responses become inherently delayed, but also, any effects that would elicit differential degrees of implicit responding will become nullified due to the utter lack of involvement from implicit processes.

The concept that deception inhibits semantic memory from informing motor responses is not unfounded in the literature (Gardner, 1937; Runkel, 1936; Morgan & Ojemann, 1942; Münsterberg, 1908). Luria (1932) likened deception to the destruction of organized behavior, whereby the liar prevents automatic associations from informing motor output and then selectively replaces undesirable honest responses with deceptive ones. The conscious awareness and suppression of unexpressed responses has been argued to delay behavioral responding relative to when stimulus-response programs are informed by rapid semantic associations (Morgan & Ojemann, 1942; Vrij, 1997). When Farrow et al. (2010) observed that verbal working memory only benefited honest responses, they argued that honest responses benefited from rapid memory retrieval because each memory-trace did not require conscious evaluation if semantic associations were sufficiently strong but every deceptive response required conscious evaluation regardless of memory-trace strength. In fact, this effect was so profound that high verbal working memory increased the detectability of deception because as verbal working memory increased, honest responses became faster and deceptive responses remained the same, resulting in larger differences between honest and deceptive responses. The inaccessibility of implicit associations to inform deception delayed responses until such time as conscious evaluative processes can determine the appropriateness of a response. Therefore, deception detection was facilitated by speeding honest responses instead of influencing deceptive responses.

The field of psychophysiological detection of deception also supports the reduced accessibility to memory-traces when under a deceptive schema. For example, the P3b ERP waveform, itself a neural signature of memory updating (Polich, 2007), is suppressed in deception relative to honesty (Vendemia, Buzan, Green, & Schillaci, 2006; Vendemia, Schillaci, Buzan, Green, & Meek, 2009; Stelmack, Houlihan, & Doucent, 1994; Johnson, Barnhardt, & Zhu, 2003; 2004; Johnson, Henkell, Simon, & Zhu, 2008). Most intriguingly, when a memory-trace contains misinformation, and thus is relatively less cogent, honest-schemas elicit a suppressed P3b whereas deceptive-schemas consistently suppress P3b regardless of memory cogency (Meek, Phillips, Boswell, & Vendemia, 2013). Further evidence that deception alters memory activation is that under honest-schemas, stimuli that are similar to remembered items, but do not match (e.g. when two playing cards share a number, but differ in suit) elicit larger P3b amplitudes than stimuli that are very different from remembered items (e.g. when one playing card is a number and the other is a face card), whereas under deceptive-schemas, all mismatch stimuli elicit similar P3b components regardless of similarity to the remembered item

(Marchand, Inglis-Assaff, & Lefebvre, 2013). It appears that the potential for activation gradients within semantic memory, which have long been reported to be an automatic component of semantic memory (Neely, 1977; Heyman, Hutchison, & Storms, 2016), may be proactively suppressed following the activation of a deceptive-schema.

Further ERP deception research has examined the N400, a component associated with automatic memory retrieval processes (Kutas & Hillyard, 1984; Kutas & Federmeier, 2011). The examination of this component in deception has revealed that the N400 is enhanced (i.e. more negative going) in deception relative to honesty, suggesting that deception restricts access to memory (Meek, Phillips, Boswell, & Vendemia, 2013; Vendemia, Schillaci, Buzan, Green, & Meek, 2009; Stelmack, Houlihan, & Doucent, 1994; Tu, et al., 2009; Proverbio, Vanutelli, & Adorni, 2013). Although the N400-effect has been reported when comparing deceptive responses to semantically-relevant vs. semantically-irrelevant information (Ganis & Schendan, 2013), few studies have counterbalanced semantic-relation and information schema. The majority of N400 studies on information schema have examined the relationship between schema and either sentence truth-value or stimulus-response congruity following a response-cue (Meek, Phillips, Boswell, & Vendemia, 2013). There has been minimal work comparing deception and honesty during the process of sentence evaluation and then examining the N400 on words varying in semantic-relation to the constructed context. One goal of the present research is to provide the deception literature with the materials to examine sentence evaluation during honesty and deception in such a way that sentence-evaluation is orthogonal to sentence truth-value and stimulus-response conflict.

Deception: inhibition of motor responses or semantic memory?

Individuals who are prepared to deceive activate a response inhibition process prior to the evaluation of incoming information, even if they eventually opt to be honest. In order to respond honestly, this inhibitory process must be decoupled, which incurs a cognitive-cost for the otherwise honest response. Figure 1.2 shows that responding honestly with a different response than the prepared one required similar time as either deceptive response, but deceptive responses were relatively similar regardless of response interference (Vendemia, Buzan, & Simon-Dack, 2005).

By choosing to monitor for a deceptive-signal which, liars may activate inhibition in a proactive manner, in order ensure all incoming information is evaluated. Even if someone chooses to respond honestly, the time it takes to decouple the inhibitory process may nullify any memorial benefits of implicit semantic activation (see Figure 1.2)

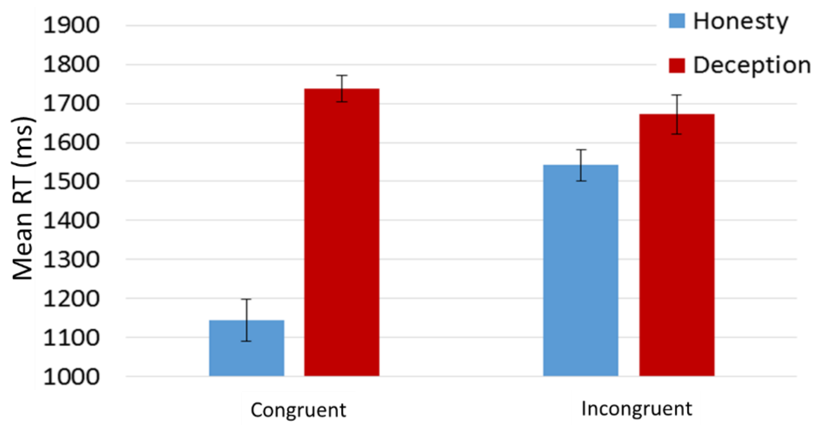

Figure 1.2: Congruent and Incongruent RTs when participants were not cued until Stimulus 2. Adapted with permission from (Vendemia, Buzan, & Simon-Dack, 2005)

Prior research has proposed that the role of response inhibition is additive to the honest prepotent response. In such a model, referred to as the Prepotent Inhibition Model (see

Figure 1.1), semantic associations are similarly accessible under honesty and deception, but deception engages inhibitory control predominantly on motoric processes. Semantic associations transcend spatial and temporal boundaries, allowing for distinct memory episodes to be consolidated together if their features are sufficiently similar (Tse, et al., 2007; Ghosh & Gilboa, 2014; Tulving, 1972). This consolidation enables past experiences to implicitly inform current behavior without explicit memory retrieval of individual episodic events. Although survival is often facilitated by generalizing prior experiences to the current environment (Seligman, 1970), deception usually requires a response that will not generalize outside the immediate context because it contains information that is simply not true.

I propose that inhibitory control operates within semantic associations, such that the automatic spreading of activation between associated concepts in semantic memory is suppressed, hereafter referred to as the Binding-Suppression Model (see Figure 1.3). The Binding-Suppression Model proposes that in order to engage in a deceptive act, one must choose to suppress semantically-associated concepts as those associations are based in one's understanding of world-knowledge, and deception requires the liar to generate information that overtly contradicts that knowledge. Under a deceptive schema, the truth interferes with implicit spreading of activation across semantic memory is suppressed, which enables the liar to consciously integrate information that would otherwise elicit interference from semantic-memory.

If deception inhibits semantic memory, much about the literature becomes clear. Deceptive responses are less subject to experimental manipulations or individual differences than honesty because those experimental variables are more relevant to automatic semantic associations than conscious evaluations. If deception inhibits those associations, then variation in semantic associations will predict variation in honest

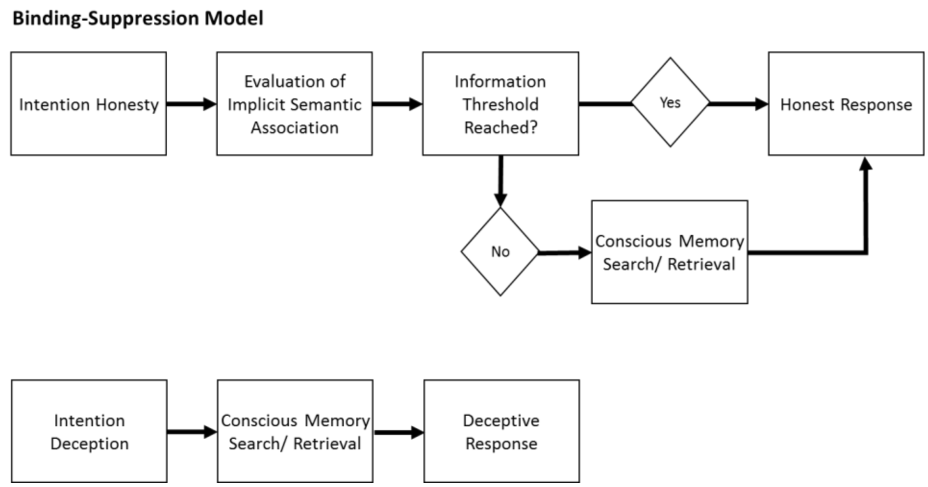

Figure 1.3: Binding-Suppression Model. In this model, the critical element is the involvement or suppression of implicit semantic associations. If these are suppressed by deception or impoverished stimuli, then conscious memory search and retrieval is required in

responses, but not in deceptive responses. This also explains why deceptive responses have a much higher “floor” of response latency than honesty. Honest responses can be rapidly deployed if sufficient information is rapidly attained, but this does not apply for deceptive responses. Without the involvement of rapid semantic associations, deceptive responses must be generated via slower systems accessible to conscious evaluation.

When deception is viewed from the cognitive perspective provided by the Binding-Suppression Model, the historical research emphasizing the emotional consequences of the deceptive attitude deserve to be reinterpreted. In his initial work on reaction time of deceptive responses, Marston (1920) describes a state of deception-specific response delays as follows:

The witness, unable to concentrate because of the inevitable physiological expressions of his fear, becomes more and more introspectively aware of the fear content itself, and proceeds to exert great effort to suppress this fear….such increased effort only tends to bring intellectual and motor processes into consciousness in addition to the fear content already present. – pg 79

Marston's argument is that a liar's awareness of potential consequences elicits emotional reactions which prevent the generation of thoughts unrelated to the emotion, which then only increase the emotional consequences which only further prevents the generation of other thoughts. When the cognitive framework underlying binding-suppression is considered, Marston's observation can be reinterpreted without changing his observation.

My interpretation is that the decision to activate a deceptive schema triggers binding-suppression, which suspends the implicit generation of novel thoughts. Although an emotional experience can be elicited via awareness of potential consequences, the emotional experience itself does not impair one's ability to generate novel thoughts. Instead, I propose that binding-suppression is always active when one decides to lie, regardless of the emotional consequences. I do agree that under situations that elicit potential consequences, the introspective awareness of binding-suppression, as described by Marston (1920), can propel the intensity of these emotional experiences. But these two concepts, binding-suppression and the deceptive attitude, are distinct components underlying the deceptive-schema.

Deception and the complexity of response-selection

As the literature currently exists, the only consistent experimental manipulation that alters latencies of deceptive responses is the complexity involved in selecting and deploying an appropriate response. Psychological research has long observed that as number of viable responses increases, time required to select and deploy a particular response also increases (Donders, 1868), and this finding appears to extend to the complexity involved in determining a deceptive response. For example, lying about a fact is easier than lying about a held belief, as measured by response latency (Ofen, Whitfield-Gabrieli, Chai, Schwarzlose, & Gabrieli, 2017) and speech-errors (Vru & Heaven, 1999). Similarly, open-ended questions (e.g. describe what happened) induce deception specific difficulty relative to simple yes/no questions (Walczyk, Roper, Seemann, & Humphrey, 2003) and are effective in differentiating deceptive responses from honest responses (Oxburgh, Myklebust, & Grant, 2010), presumably because open-ended questions provide liars less explicit direction in generating responses.

The hypothesis that deception becomes more difficult as number of available responses are increased has been quantitatively examined in Williams, Bott, Patrick, & Lewis (2013). These researchers presented participants with either two-choice alternatives or three-choice alternatives meaning that, liars presented with two-choice alternatives merely had to select the single incorrect response whereas liars presented with three-choice alternatives had to determine which of the two incorrect responses should be selected. Contrarily, honest responding only changed in the degree of visual search needed to locate the honest response choice, so the difference in difficulty across honesty and deception was unique to deception. This increase in response alternatives increased latency of deceptive responses without influencing honest responses. These researchers also found that preemptively invalidating one of the response alternatives in three-choice alternatives reduced the deception specific difficulty. On the other side of this spectrum, the sole exception to the finding of delayed responding in deception is that deceptive responses can be speeded if an explicit stimulus-response script can be learned and practiced (Vrij & Granhag, 2012), providing further proof that response-complexity is a primary source of deception-related response variability. These findings bolster the argument that the process of constructing and selecting the lie response is an additive factor unique to the deception. The process of examining deception and honesty should consider the fact that there is greater response-ambiguity in deception relative to honesty.

Summary of literature review of deception research

I hypothesized that deception involves an inhibitory mechanism which is active at the semantic level, such that semantic associations which implicitly generalize across concepts are suppressed, requiring the liar to rely on slower conscious evaluations that do not vary as a result of stimulus-based features (e.g. semantic-relatedness). I conducted three experiments to test the Binding-Suppression Model by manipulating the accessibility of semantic memory traces during response generation. If deception inhibits prepotent responses by suppressing bindings between easily accessible memory traces and stimulus-response bindings, then the degree of truth prepotency should not influence deceptive RT, but truth prepotency should influence honest RT.

Psycholinguistic manipulations and the accessibility of semantic memory

Although honest responses are assumed to be prepotent, that doesn't necessarily mean that honest responses are simple to generate and deploy. In order to respond honestly, participants understand task-rules, process environmental stimuli, determine the appropriate response, and then deploy the response. Effects in each of these processing stages will sum into response, which can easily lead to erroneous conclusions about a mental process (Sternberg, 1969). For example, the Wason Selection Task, in which participants must comprehend rules and then generate potential hypotheses to test them, has long been used to study executive-function and higher order reasoning (Wason, 1968;

Sperber, Cara, & Girotto, 1995). However, modern evidence suggests that many of these reported effects reflect simpler issues related to text processing instead of higher order reasoning (Almor & Sloman, 2000). Psychological research requires extensive experimental control in order to isolate an intended psychological construct (Osgood, 1953), so the notion that honesty is a simple process should not be taken for granted

One factor that is necessary for honesty and deception is sentence-evaluation because comprehending someone's intended message is vital for conversation. In this dissertation, sentence-evaluation involves comparing the meaning of a sentence against world knowledge (i.e. is it true or false). Psycholinguistic evidence reveals that determining truth-value is complex (Clark & Chase, 1972; Carpenter & Just, 1975; Wason, 1959; Singer, 2013) but there are certain patterns in terms of how the relationships between words influence the complexity of sentence-evaluation (Collins & Quillian, 1969; Rips, Shoben, & Smith, 1973; MacDonald, Pearlmutter, & Seidenberg, 1994). Below, I define and describe some of the relations relevant for this dissertation.

Lexical information, word-based linguistic information, constrains the relationships between words within a sentence (MacDonald, Pearlmutter, & Seidenberg, 1994). Lexical relationships are generally divided into two forms of information: *semantic* and *syntactic*. Semantic relationships are defined as those that exist between the meanings of words within the sentence whereas syntactic relationships are defined as the functional relationships between words within the sentence. Semantic relationships are generally accessed automatically, even under states of high cognitive load whereas syntactic relationships require more effortful processing and are less accessible under states of high cognitive load (Friederici, Rueschemeyer, Hahne, & Fiebach, 2003).

During sentence-evaluation, semantic-memory activates knowledge structures, and sentence-evaluation enables people to determine the degree to which that sentence is true by comparing it to what is known about the world. Overall, world-knowledge refers to information that is heavily *entrenched*, which means that certain beliefs are contingent on world-knowledge being accurate (Shipley, 1993). The more entrenched a concept is within knowledge structure, the more easily it is comprehended and the more resistant it is to change or even damage (Langacker, 1987). Therefore, sentences that are *true* are evaluated as such because they cohere with deeply entrenched concepts within LTM to a greater degree than false sentences. Therefore, over the course of their lifetime, participants have had a greater frequency of exposure to true concepts than false concepts. Through the process of sentence-evaluation, people compare the sentence to world, and mismatches elicit a false evaluation (Hagoort, Hald, Bastiaansen, & Petersson, 2004).

The process of integrating words into a holistic unit is incremental, whereby each word adjusts the meaning that the sentence could convey (Morris, 1994; Altmann & Kamide, 1999; Matsuki, et al., 2011; Isberner & Richter, 2013). By incrementally integrating linguistic input into a holistic unit, information that is incongruent with the context is rapidly suppressed, enabling one to integrate only relevant information into the preceding context (Fischler & Bloom, 1979; Stanovich & West, 1979; Swinney, 1979; Neely, 1977). This suppression process is informed by how constraining the context is with respect to what is congruent. As the probability of an individual word in a context (i.e. cloze-probability) becomes increasingly high, the effort required to comprehend and integrate that word into the sentence is reduced (Payne & Federmeier, 2017).

Relevance of psycholinguistic research to deception research

Liars must comprehend the meaning of stimuli which prompt deceptive responses (e.g. questions) and subsequently generate a lie that is uniquely appropriate for that particular stimulus. Because language comprehension is often a necessary preceding component of deception generation, I posit that deception research can be conducted with greater precision if linguistic features of stimuli are experimentally manipulated. Deception and honesty may elicit distinct processing patterns during evaluation of sentence truth-value, and if so, uncontrolled variation in sentence complexity may obscure, or even alter, effects related to deception or honesty. Manipulating the lexical relationships relevant to sentence evaluation will enable me to observe deception and honesty across different linguistic environments. If certain lexical manipulations influence honesty, but not deception (or vice-versa), the distinct cognitive processes that underlie deception and honesty will be better understood. I argue that the findings from psycholinguistic literature can inform the use of linguistic stimuli in experimental designs for deception research by manipulating the degree of involvement required by automatic and controlled processes.

The goal of this series of studies is to examine the role of lexical information in the process of deploying deceptive vs. honest responses. In the present studies, I manipulated the semantic and syntactic relationships within sentences and examined how deception/honesty differed in truth-value evaluation as well as subsequent responses to prompts. By altering statement comprehensibility, I examined the relationship between the operations which underlie deception and those which underlie semantic memory. Upon examining the role of lexical relationships in deception and honesty, I examined how sentence content and intent-to-deceive interacted when participants needed to simultaneously determine truth-value and whether or not it was appropriate to be deceptive or honest.

Chapter 2 DESIGNING TEST ITEMS

Plausibility Item Development

I conducted a series of item-development studies to construct items that balanced sentence truth-value with the content of the sentence itself.

Methods

Participants

Participants were 16 undergraduate students at the University of South Carolina, who participants in exchange for extra credit in a psychology course

Materials

Items that varied in plausibility were developed to develop a set of items that would allow me to test if the lexical relationships within a sentence are relevant to the process of sentence evaluation across different information schemas. These items consisted of three sentences each, with one true sentence that would contain semantically related words (true sentences), and two false sentences. One false sentence would contain semantically related words (implausible sentence), and the other would contain semantically unrelated words (violation sentences). All sentences were designed to be grammatically correct and interpretable. These items would allow me to test if information schema altered the process of evaluating truth-value, as would be observed by deceptive and honest schemas eliciting different patterns of responding to the false sentences. The Prepotent Inhibition Model predicted that the implausible sentences will benefit from semantic relationships whereas the Binding-Suppression Model predicts that such semantic facilitation would be suppressed under a deceptive schema.

I adapted sentences from prior research on truth evaluation (Nieuwland, 2015) in order to create three types of sentences: true, implausible, and violation as shown in Table 2.1. True sentences (1) referred to semantically-related information in a manner consistent with world knowledge. Implausible sentences (2) referred to semantically-related information in a manner inconsistent with world knowledge. Violation sentences (3) referred to semantically-unrelated information.

Table 2.1: Stimuli developed based on plausibility. The pre and post-critical region are constant, but the object-noun in the critical region was manipulated

Pre-critical region		Object			Post-critical region
Subject	Verb	True	Implausible	Violation	
Teachers	punish	students	principals	nurses	that are disrupting the class
Cowboys	ride	horses	buffalo	camels	when they go to the ranch
Lifeguards	protect	swimmers	sharks	birds	at the beach
Hunters	shoot	deer	cattle	insects	during the hunting season
Gardeners	plant	flowers	weeds	sand	to make their garden prettier
Weathermen	report	storms	asteroids	murders	that are expected in the next few days
Barbers	cut	hair	wigs	steak	while carrying on a conversation
Plumbers	remove	clogs	weeds	lamps	using special equipment
Architects	design	buildings	tunnels[1]	sandcastles	with a lot of windows
Cleaners	wash	clothes	paper	trees[1]	using detergent
Supervisors	scold	workers	senators	pets[1]	who show up late
Authors	write	books	laws	schedules[1]	to make a living
Witnesses	describe	suspects	bystanders[1]	buildings[1]	as causing the crime
Attorneys	meet	clients	prisoners[2]	hermits	at their law firm
Journalists	report	news	nothing[1]	recipes	to inform the public about important issues

1 Sentences in evaluation of the Post-Critical-Region was required to assess truth-value.

2 Post-experiment analysis suggested the sentence's truth-value was ambiguous

As depicted in Table 2.1, the sentences contained a pre-critical region containing a plausible noun-verb combination, the critical region containing the truthful, contradictory or implausible information, followed by a post-critical region which contained contextual information consistent with both pre-critical and critical region information. A total of 15 items were created, totaling 45 sentences, as can be seen in Figure 2.1. Participants were divided into two groups. All participants encountered the true sentences, but half of the participants encountered the contradictory sentences and

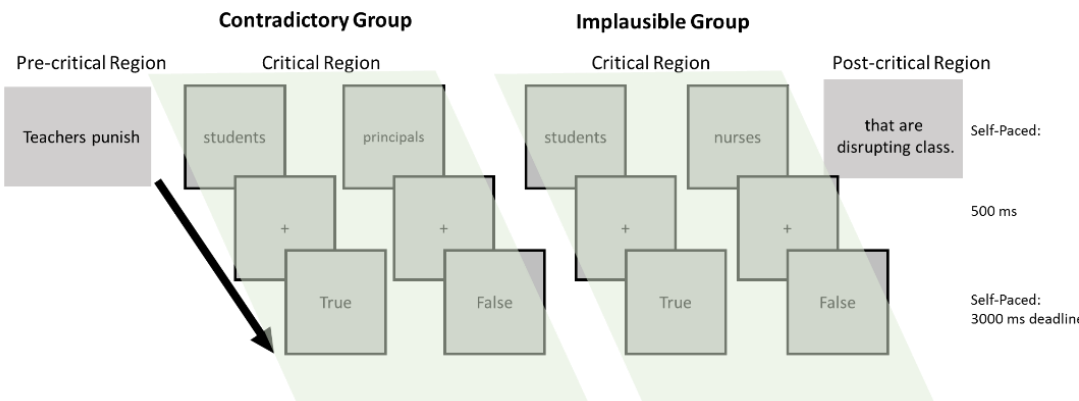

Figure 2.1: Experimental Design to develop plausibility items. Honesty and deception are cued by font-color, with the second prompt containing either the word True or False. Each sentence was repeated 6 times throughout the experiment, cued for honesty and deception 3 times each.

the other half encountered the implausible sentences. Each sentence was repeated 6 times throughout the experiment, resulting in a total of 240 trials.

Procedure

The procedure will be addressed in more detail in the current research section, but see Figure 2.2 for a visual depiction. Participants arrived in the lab and practiced a pen-and-paper version of the task before practicing the task on the computer. In order to proceed to the experiment, each participant had to achieve at least 67% accuracy. For each trial, participants were presented with a sentence that they evaluated as true or false. When they were ready to continue, they pressed the spacebar and viewed a fixation point for 500 ms (plausibility item development) or 750-1250 ms (all other studies). They were then presented with a second-prompt, the word *True* or *False*. The information schema for the trial was cued by font color (all studies except Embedded-Cue) or sentence-

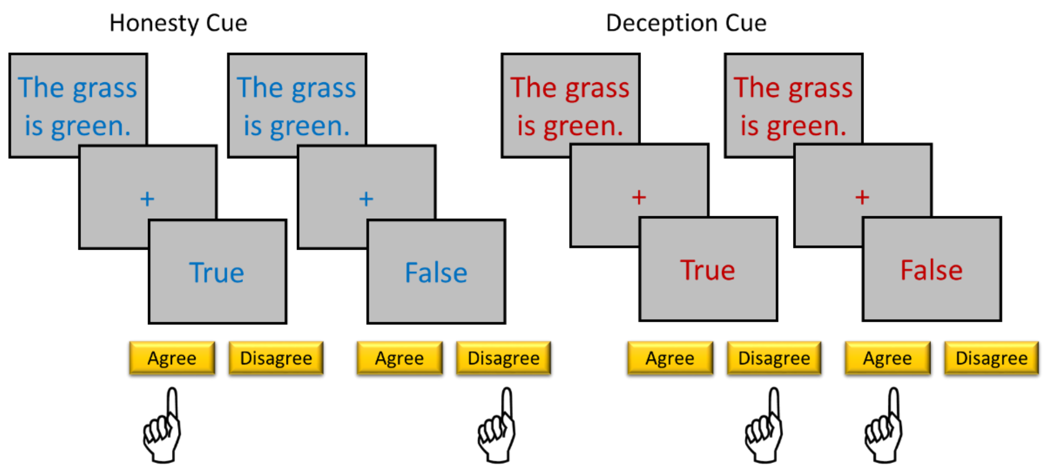

Figure 2.2: Directed Deception Task using a Standard Sentence Verification Task. A sentence is presented on a screen for 2500-3000ms, followed by a fixation prompt, and then the word "True" or "False". Participants are cued by font-color to respond honestly or deceptively, and they do so by indicating their agreement or disagreement with the second prompt.

content (Embedded-Cue), and participants were instructed to respond in accordance to the information schema by pressing a key to indicate agreement or disagreement with the prompt-word.

H1: I expected to replicate previous research showing that honest responses are faster and more accurate than deceptive responses.

H2: I expected to replicate previous research showing that honest responses are faster and more accurate when responding to true sentences than to false sentences.

H3: I predicted that deceptive responses would be faster and more accurate when responding to anomalous sentences than to implausible and violation sentences.

Results

One participant was removed from the study after data collection, when the post session interview revealed that English was the participant's second language, leaving 16 participants for data analysis. I conducted two paired t-tests on RT and error data, comparing honest and deceptive responses. Participants responded significantly faster [$t(15) = 3.20$, $p < 0.01$] when responding honestly (M = 722 ms, SD = 141 ms) than when responding deceptively (M= 827 ms, SD = 246 ms), and elicited a significantly greater proportion of accurate responses [$t(15) = 3.68$, $p < 0.005$] when responding honestly (M = 0.95, SD = 0.03) than when responding deceptively (M = 0.90, SD = 0.07).

In order to test the effect of lexical relationships on deceptive and honest responding, I conducted unpaired t-tests comparing RT data and error data of the plausibility group (n=9) to the violation group (n=7). I found no significant differences between conditions for either errors or RTs for either honest or deceptive responses.

Post-hoc analysis

Post-hoc evaluations revealed two confounds in stimuli: 1) Sentence length and 2) location of truth-value disambiguation within sentence. In order to identify patterns within the sentences that might lead to better item construction, I performed a principal components analysis on the RT of every sentence presentation. The analysis explained 72.42% of the variance in RT within the sentences using 15 components. Overall, the sentences clustered into components according to truth-value, with certain notable exceptions. Implausible sentences consistently clustered together, but certain true and violation sentences were either inappropriately grouped or distributed across multiple factors. An examination of these sentences suggested that unusually strong syntactic relationships between words influenced RT more strongly than semantic relationships, suggesting that certain syntactic effects may have confounded the results.

Conclusions

After evaluating the potential confounds, I realized that plausibility was not the critical factor underlying the manipulations. The semantic relationships within the words of the sentences was more important. I opted to redirect my research to differentiate the role of semantic and syntactic relationships in evaluating truth-value. I also determined that controlling the sentence region in which truth-value was disambiguated was critical to developing a psycholinguistically controlled set of items. I decided to design items in which the region of disambiguation was matched across sentences.

Lexical Violation Item Development

Following the initial assessment of plausibility, I determined that further refinements were necessary with respect to sentence length, truth-value disambiguation location, and lexical relationships. Additionally, I wanted to create a list of items that would mimic deception paradigms, with the exception that the schema-cue would be embedded into the sentence content itself instead of the color. I determined that one method would be to develop a set of items that varied in accordance with a simple categorical judgement, such that the entire item list could be easily separated based on this categorical judgement. However, this manipulation should not interfere with sentence-evaluation, and potentially not even be noticed unless the categorical judgement itself was a top-down goal during sentence-evaluation. The reason for this parameter is that I wanted the schema-cue to be based entirely within the mind of the participant, such that participants given schema-based instructions and participants who are naïve to the schema-manipulation could read the exact same items, but only the schema-instructed participants would notice the categorical distribution of the items. Such an outcome is not possible with the artificial nature of the color schema-cue.

Methods

Participants

Participants were 16 undergraduate students at the University of South Carolina, who participants in exchange for extra credit in a psychology course

Materials

Based on plausibility item development, I made critical changes to reduce the confounds of sentence-length and truth-value disambiguation. The items were redesigned to consist of only three words in the grammatical structure of Subject-Verb-Object. The subject-noun was isolated for the categorical manipulation, such that two lists of items were created based on the following categories of subject-nouns: Humans and non-human animals (e.g. Architects, Beavers). During this process, I generated as many potential subject-nouns as possible in order to create potential candidates that varied in their phonological features (e.g. initial phoneme, word length) and semantic features (e.g. taxonomy: occupations/phylogeny). When one feature was determined to be the highest ranking feature present in the candidate list, I intentionally attempted to generate candidates that violated that feature in a way that introduced variety to the candidate list. The verb was selected such that, when integrated with the subject-noun, the subject-verb context would be semantically cohesive and elicit specific predictions for subsequent content (e.g. Architects design, Beavers gnaw).

The object-noun was manipulated so as to trigger truth-value disambiguation across four different sentence types (one true and three false). The false sentences were designed such that the falsity is detected at distinct processing stages (see 1-4).

(1) True sentences: ***Barbers cut hair***
(2) Implausible sentences: ***Barbers cut wigs***
(3) Violation sentences: ***Barbers cut steak***
(4) Anomalous sentences: ***Barbers cut waves***

The final list was controlled to also include an equal number of humans and non-human animals for the subject-noun. By matching all sentences in accordance to the preceding context, and only manipulating the object-noun, I could examine the role of distinct lexical-relationships across information schemas in a more controlled manner. At this point, the parameters regarding sentence constraint and lexical relationships are purely subjective and based on the principles within the psycholinguistic literature. The conclusions obtained from lexical-violation item development informed the type of objective validations necessary for the current research. The items are available in **Error! Reference source not found.**.

Implausible sentences contained words that were easily mapped onto pre-existing knowledge structures whereas the object-nouns in the violations sentences are not stored in the same knowledge structure as the preceding context. It is known that the experimental context could alter participants' internal parameters which define sentence evaluation (Arkes, Boehm, & Xu, 1991; Dechêne, Stahl, Hansen, & Wänke, 2010). I opted to present the implausible and violation sentences to two separate groups of participants, but both groups were presented with true and anomalous sentences. The group that received the implausible sentences are referred to as the plausibility group and the group that received violation sentences are referred to as the violation group; see Figure 2.3. Therefore, the plausibility group would read sentences containing information that were already associated within long term memory while the violation group would process information not associated within long term memory. I predicted that stronger memory traces of the sentences would be encoded in the plausibility group than the violation group. These memory traces would reduce time required to compare the probe and sentence and will result in shorter RTs for the plausibility group than the violation group.

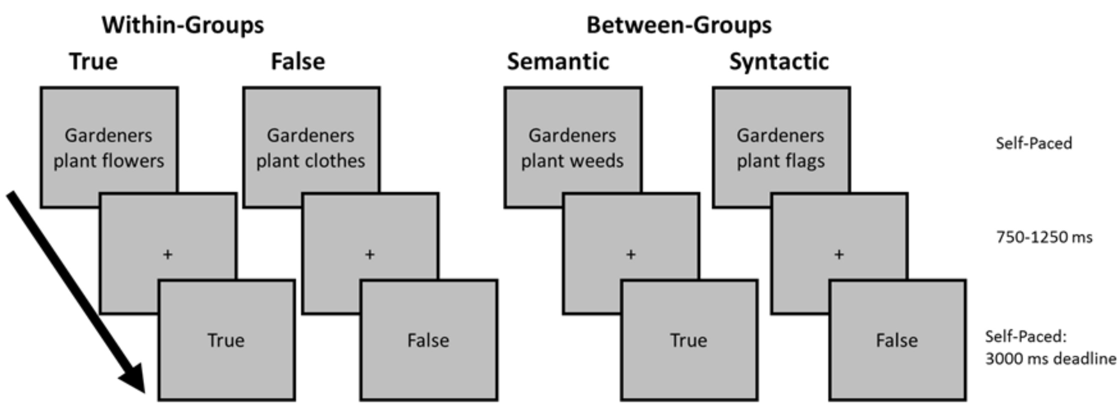

Figure 2.3: Experimental Design for deployment of lexical-violation items. All participants encountered true sentences containing semantically related words and false sentence containing semantically unrelated words. One group also received false sentences containing semantically related words and another group received sentences whose syntactic constraints did not match the prior context

Procedure

The procedure was identical to the plausibility item development procedure.

H1: I expected to replicate previous research revealing that honest responses are faster and more accurate than deceptive responses.

H2: The plausibility-group would elicit faster reading and response times than the violation-group across all sentences.

H3: Honest responses to true sentences would be faster than all other sentence types, and honest responses to implausible sentences would be faster than violation and anomalous sentences, which would not differ from one another.

H4: I hypothesize that, deceptive response times will be faster for violation and anomalous sentences than for true sentences and implausible sentences.

Results

Data Screening

Two participants were removed from the study after data collection because their accuracy failed to exceed 80%, leaving 16 participants for data analysis, with eight participants in each group. Fifteen items were removed because at least one truth-value condition had less than 67% accuracy, leaving 49 items for data analysis. The first five trials were removed to correct for familiarity with the paradigm. Data screening totaled 26% of the data. For the RT analysis, I removed all trials with RTs of less than 300 ms, incorrect response on the current trial, or an incorrect response on the immediately preceding trial. The removal of these responses totaled 14% of the data.

Analyses

When analyzing RT, there was no effect of Group so it was dropped from the analysis, and the semantic-false and syntactic-false sentences were collapsed into a single factor referred to as partial-false sentences. I conducted an ANOVA on schema and truth-value. There was a significant effect of schema [$F(1, 15) = 6.98$, $p < 0.05$] which was subsumed under an interaction with truth-value [$F(2, 30) = 4.39$, $p < 0.05$]. Significantly faster response time to true sentences [$t(15) = 7.32$, $p < 0.0001$] was observed for honest responses ($M = 684$ ms, $SE = 39$ ms) than for deceptive responses ($M = 862$ ms, $SE = 56$ ms). A similar pattern was observed for partial sentences [$t(15) = 1.87$, $p < 0.05$], with honest responses ($M = 774$ ms, $SE = 44$ ms) requiring less time than deceptive responses ($M = 865.86$, $SE = 85.35$). No significant differences were observed between honest and deceptive responses. The tests partially confirmed my hypotheses, such that detectability of deception decreased as sentences became less comprehensible.

In order to determine why these differences of detectability were observed, I separated the honesty and deception conditions and conducted pairwise comparisons of each sentence type within the schema conditions. As seen in Figure 2.4, honest responses to true sentences ($M = 680$ ms, SE = 89 ms) were faster (all p-values < 0.005) than both honest responses to partial sentences ($M = 771$ ms, $SE = 80$ ms) and honest responses to false sentences ($M = 752$ ms, $SE = 84$ ms), while honest responses to partial sentences and false sentences did not differ from each-other. Contrarily, deceptive responses did not differ across all truth-value conditions (all p-values > 0.10).

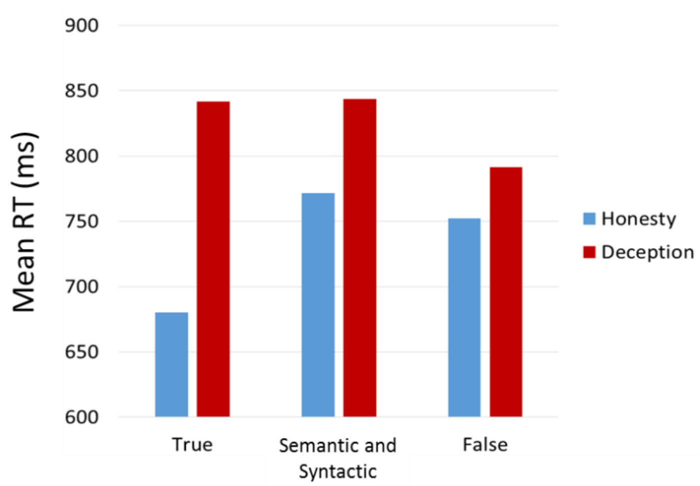

Figure 2.4: RT as a function of schema and truth-value

Although there was no significant effect of group in the omnibus ANOVA, I tested my hypothesis regarding the effect of group with a one-tailed independent samples t-test, comparing RT of the implausible group across all sentence-types to the violation group. The effect was only a nonsignificant trend ($t(14) = 1.34$, p = 0.10). Given that statistical learning operates on syntactic parsing processes (Fine, Jaeger, Farmer, & Qian, 2013), I performed a follow-up analysis to test if the groups adapted to the experiment differently. I conducted a generalized linear model examining the effect of trial and Group on the RT associated with each sentence type, which is depicted in Figure 2.5. Trial was nested within truth-value, with group as a between-subjects variable. The omnibus test was significant [$\chi^2(7) = 113.43$, $p < 0.001$, and there was a significant main effect of Group [$\chi^2(1) = 35.36$, $p < 0.001$] and a significant effect of trial × Group × truth-value [$\chi^2(6) = 60.69$, $p < 0.001$]. The regression model predicted that the semantic-group responded more quickly than the syntactic-group [β=-230 ms, SE = 9 ms, $\chi^2(1) = 35.36$, $p < 0.001$]. With regards to the effect of trial on the semantic-group, the regression model predicted that trial reduced RT for the true sentences [β = -24 ms, SE = 1 ms, $\chi^2(1) = 5.46$, $p < 0.02$].and false sentences [β= -32 ms, SE = 2 ms, $\chi^2(1) = 7.68$, $p < 0.01$], with no significant effect of trial on partial sentences (P > 0.05). For the syntactic-group, the regression model predicted that trial reduced RT for the true sentences [β = -75 ms, SE = 1 ms, $\chi^2(1) = 50.34$, $p < 0.001$], false sentences [β = -68 ms, SE = 2 ms, $\chi^2(1) = 30$ ms, $p < 0.001$, and partial sentences [β = -57 ms, SE = 2 ms, $\chi^2(1) = 22.71$, $p < 0.001$].

The implausible group activated entrenched representation during their evaluations whereas the violation group activated novel representations during their evaluations. Several dozen instances will not provide enough experience to alter entrenched representations but minimal experience with novel representations can elicit implicit learning of statistical regularities across these instances, thus facilitating processing of subsequent instances (Fine, Jaeger, Farmer, & Qian, 2013).

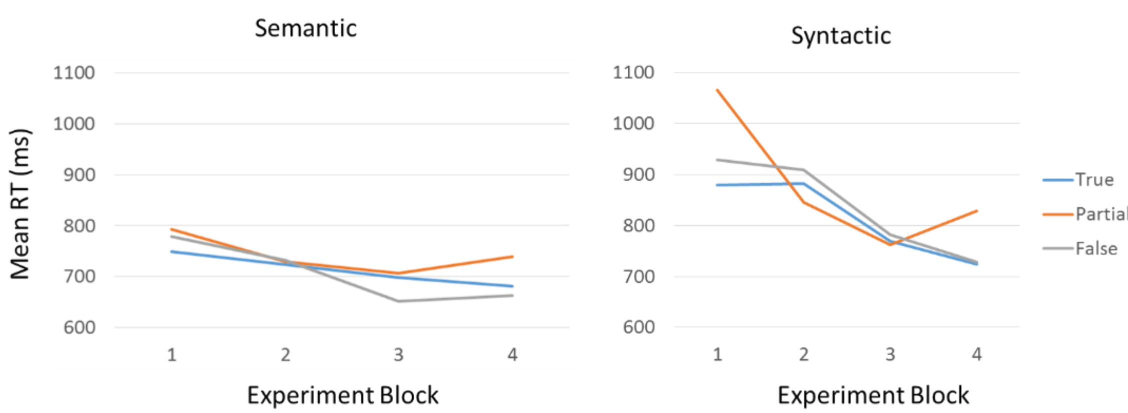

Figure 2.5: RT across trials for participants in semantic and syntactic groups as function of truth-value

I hypothesized that truth-value would influence honest responses, but not deceptive responses. To test this, I conducted a one-tailed unpaired t-test to test if the groups differed in their honest and deceptive responses to partial sentences. There was a trend in the expected direction, suggesting that the semantic group responded more quickly [$t(15) = 1.61$, $p = 0.064$] when making honest responses to partial sentences (M = 710 ms, SE = 93 ms) than the syntactic-group (M = 833 ms, SE = 151 ms). Also as expected, deceptive responses to partial sentences did not differ between groups ($p > 0.05$). A follow-up analysis was conducted on the other truth-value conditions. Because I lacked apriori hypotheses for group differences across these truth-value conditions, I used two-tailed t-tests. When responding to true sentences, both groups were similar in their honest and deceptive responses (p > 0.05). A trend was discovered for honest responses to responses to anomalous sentences, such that participants in the implausible group responded more quickly [$t(15) = 1.94$, $p = 0.07$] when making honest responses ($M = 687$ ms, $SE = 93$ ms) than those in the violation group ($M = 822$ ms, $SE = 130$ ms). Deceptive responses to anomalous sentences did not significantly differ between groups (p > 0.05).

I hypothesized that honest responses would be more affected by lexical relationships than deceptive responses. This hypothesis was supported, as honest responses differed as a function of sentence content and experimental context, whereas deceptive responses were not affected by these variables.

Post-hoc analyses

I refrained from hypothesizing effects of schema on reading time due to the absence of available research. I examined reading time in a mixed ANOVA: 2 (Group: implausibility vs. violation) × 2 (Schema: honesty vs. deception) × 3 (truth-value: true vs. partial vs. anomalous). There were no significant effects of group in main effects or interaction, but there were main effects of schema [$F(1, 14) = 12.18$, $p < 0.01$] and an interaction between schema and truth-value [$F(2, 28) = 4.07$, $p < 0.05$]. The main effect of schema showed that honest schemas ($M = 2700$ ms, $SE = 136$ ms) elicited significantly faster reading times [$t(1, 14) = 3.01$, $p < 0.01$] than deceptive schemas ($M = 3325$ ms, $SE = 226$ ms). Two-tailed t-tests were conducted to examine truth-value across schemas. For honest schemas, true sentences were read ($M = 2293$ ms, $SE = 114$ ms) significantly faster [$t(15) = 2.10$, $p < 0.05$] than anomalous sentences ($M = 2973$ ms, $SE = 285$ ms) and partial sentences ($M = 2835$ ms, $SE = 250$ ms) at a trending significant level [$t(1, 15) =$

1.67, *p*=0.12]. For deceptive schemas, there was no effect of truth-value (all p-values > 0.5). The impact of deceptive schemas can be seen on mean reading time in Figure 2.6

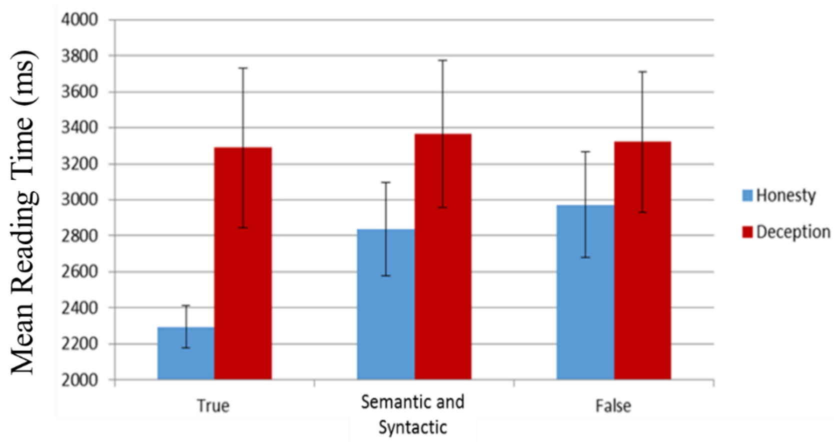

Figure 2.6 Effect of truth-value and cue on reading time. Reading time is longer when participants are cued to respond deceptively

Conclusions

As can be seen in Figure 2.6, truth-value only influenced reading times under honest schemas, with true sentences requiring less time than anomalous sentences whereas truth-value did not influence reading time deceptive schemas. This finding replicates the research showing that false sentences require more time than true sentences (Clark & Chase, 1972), but this finding does not generalize to deceptive schemas. Taken with plausibility item development, these findings support the Binding-Suppression Model that sentence content does not alter sentence evaluation time under a deceptive schema, but sentence content does alter evaluation time under an honest schema. Deception researchers have reported null-effects when examining difference-scores between deception and honesty, arguing that certain experimental manipulations can reduce the difficulty involved in making deceptive responses (Verschuere, Spruyt, Meijer, & Otgaar, 2011). However, the results of item development suggested that certain experimental manipulations may not alter difficulty of deceptive responses and instead, are only altering the difficulty of honest responses. Finally, the need to screen more than 10% of the data suggests that these items need to undergo further revision.

Revising Lexical Violation Items

Methods

Participants

Participants were 17 undergraduate students at the University of South Carolina, who participants in exchange for extra credit in a psychology course

Materials

I revised the items from lexical violation item development that failed the accuracy check, resulting in 64 items, with similar conditions as before. The revised list is reported in Appendix B.

Procedure

The procedure was identical to plausibility item development.

Hypotheses

I expect to replicate the effect of schema on sentence-evaluation: 1) honest-schemas would elicit faster response times to true sentences than false sentences, and 2) deceptive-schemas would nullify the effect of truth-value.

Results

I analyzed the effect of truth-value and schema on log-transformed RT with a linear mixed effects regression (LMER), as is recommended to maintain assumptions of normality (Baayen, Davidson, & Bates, 2008). Subjects and items were coded as random effects and the accuracy on preceding trial nested within subject. Truth-value and schema were coded as fixed effects. The random effect of item did not explain a significant amount of variance to the model, so it was removed, demonstrating the high consistency across items. The results of the LMER is reported in Table 2.2 and the raw data is presented in Figure 2.7. Honest responses to true sentences were faster than honest

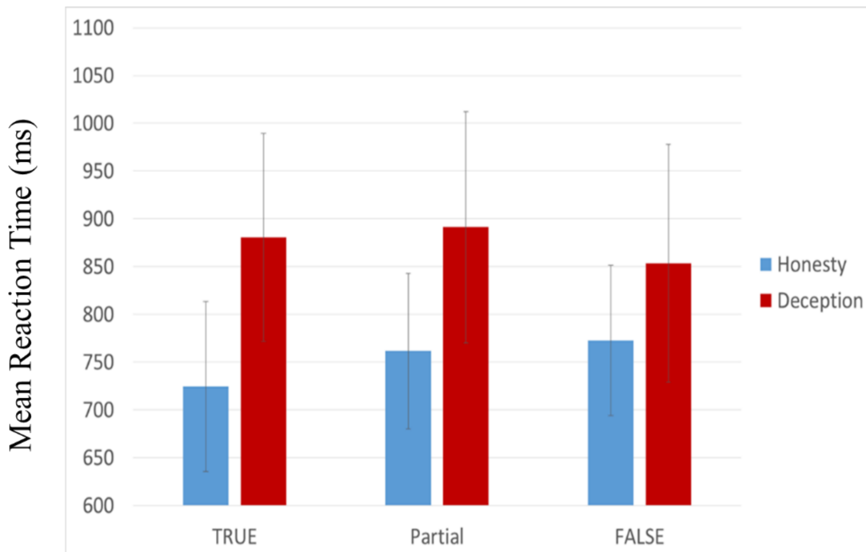

Figure 2.7: The effect of truth-value and schema on mean response time. Results suggest different effects of truth-value across honest and deceptive schemas.

responses to partial and false sentences, which did not differ from one another. However, deceptive responses to false sentences were faster than deceptive responses to true and partial sentences, which did not differ from one another.

My hypothesis was partially supported, such that honest responses to true sentences were faster than sentences that were evaluated as being false (partial and anomalous) whereas deceptive responses did not differ between true and partial sentences even though the type of evaluation differed. The Binding-Suppression model predicts that sentences which can be rapidly evaluated can subsequently be rapidly responded to (e.g.

true sentences relative to partial and anomalous sentences) when one is responding honestly, but not when one is responding deceptively.

Table 2.2: LMER results for effect of truth-value and instruction on RT to probe

All evaluations

	B	CI	t	p
(Intercept)	6.58	6.49 – 6.67	129.48	**<.001**
Instruction (Honesty vs Deception)	0.12	0.09 – 0.14	9.001	**<.001**
Honesty: Truth-value (True vs. Partial & False)	0.11	0.06 – 0.15	4.613	**<.001**
Honesty: Truth-value (Partial vs False)	0.02	-0.02 – 0.07	1.015	0.31
Deception: Truth-value (True vs. Partial & False)	-0.15	-0.21 – -0.08	-4.352	**<.001**
Deception: Truth-value (Partial vs False)	-0.07	-0.14 – -0.00	2.01	**0.045**

Discussion

Deception was most easily detected for true sentences, and the reason for this detectability is the ease of honest responses to true sentences relative to false sentences. Within information schemas, different effects of truth-value were observed. Deceptive schemas elicited similar responses across true and implausible sentences, which were more delayed than anomalous sentences (true = implausible > anomalous). Contrarily, honest responses were faster to true sentences than to both types of false sentences, implausible and anomalous, which did not differ from one another (true < partial = false). It appears that information schema alters the influence of truth-value on subsequent responding, as honesty elicits faster responses to true sentences, but deception elicits slower responses to true sentences. Additionally, deceptive schemas are differently influenced by lexical relationships than honest schemas: Implausible and anomalous clustered under honest schemas whereas implausible and true clustered under deceptive schemas. The current research project explores the relationship between information schema, lexical relationships, and truth-value. To improve precision and interpretability of this research, I decided to drop the violation condition from further experiments.

Validation of conceptual entrenchment and linguistic expectancy

The item development process revealed it was possible to differentiate the relationship of schema and semantic-relation within a truth-value. However, there were two potential confounds in lexical violation items. First, the item design only allowed for differences in semantic-relation across false sentences, with no manipulated differences across true sentences. The second confound was that although the sentences were intended to vary in truth-value within a constrained subject-verb context, this was not empirically validated.

It is difficult to solve the non-orthogonality of semantic-relation and truth-value because semantic-relation and truth-value are not necessarily orthogonal features. The sheer presence of information that is semantically unrelated to a concept heavily reduces truth-value (McCloskey & Glucksberg, 1979). Only recently have psycholinguists begun identifying specific contextual properties that can preclude such false evaluations, such as including extensive linguistic qualifiers (Nieuwland & Martin, 2012) or presenting the otherwise unrelated information in a context that is uniquely appropriate (Filik, 2008). Given that these solutions involve the use of linguistically complex contexts to overrule semantic-relation effects, I did not consider them appropriate to examine the role of implicit semantic activation across information schemas. However, the role of context in influencing the integration difficulty of subsequent content was appropriate within the paradigm. Although it may be impossible to vary the degree to which a word is semantically related to a concept without altering truth-value, it is not impossible to vary the degree to which the preceding context generates expectations of upcoming words without altering truth-value.

Linguistic expectancy refers to the coherence between the current meaning activated by a sentence context and the adjustments that will be necessary in order to accommodate upcoming lexical content (Kutas & Hillyard, 1984). As new words are encountered, readers integrate them into the preceding context, which is recurrently revised based on the coherence between context and word (Hale, 2003), and the degree of required revisions is a major source of cognitive processing (Frank, 2013). If a context elicits a high expectancy for a particular word, but instead that context is completed with a highly unexpected word, readers will generally need to revise their expectancies in order to fit the new word into the context. Comparatively, the highly expected word would demand minimal revisions, and therefore would be more easily integrated into the context than the unexpected word (Frank, Otten, Galli, & Vigliocco, 2015; Smith & Levy, 2013). Items were developed for the Lexical-Expectancy study and Embedded-Cue study in order to examine the role of linguistic expectancy in sentence evaluation by manipulating the expectancy of the object-noun within the sentences in a manner that is orthogonal to the truth-value of that sentence.

Expectancy can be quantified via the cloze-probability test (Bloom & Fischler, 1980). Participants receive a sentence fragment and then provide the word that is most likely to complete the sentence. The cloze-probability of a word refers to the probability of that word being selected to complete the sentence. Therefore, the cloze-probability of an individual word can be conceptualized as the expectancy of that word from the perspective of that specific sentence context. The process of empirically validating cloze-probability and truth-value was conducted using Mechanical Turk (www.MTurk.com), and validation proceeded in a three-stage sequence: cloze-probability validation of subject-verb contexts, and truth-value validation of sentences.

Cloze-probability validation

Subject-nouns developed in prior iterations of item development were selected and novel subject-nouns were generated as needed based on similar parameters (e.g. Archers, Chickens). I selected an object noun that I wanted the subject-verb context to elicit (e.g. arrows, eggs). Based on the subject-object relationship, I generated verbs that I believed would create a subject-verb context that was likely to elicit the object-noun, but would vary in the number of other object-nouns that could be elicited as well (e.g. Archers shoot/notch/fire/hold/prepare, Chickens lay/hatch/guard/protect/watch). All subject-verb contexts were presented to a minimum of 20 raters on Mechanical Turk with approval ratings that are greater than 95% and resided within the continental United States. Subject-verb contexts were presented in a random order with the instructions "fill in the blank with the word you think would best complete the sentence."

Cleaning of the cloze-probability data proceeded as follows: Misspellings were corrected (e.g. arrows → arrows), plural and singular nouns were counted as one (e.g. arrow = arrows), punctuation was removed (e.g. arrows. → arrows), and quantified phrases were cleaned if they consisted of less than 33% of total responses from that rater (e.g. lots of arrows → arrows). Semantic and/or taxonomically similar responses were not cleaned, and instead were counted as two distinct entries (e.g. arrowheads =/= arrows). Mturk users were removed and replaced if their data was deemed to be corrupted (e.g. quit rating process before completing), unrelated to task (e.g. 33% of data contained words that no other user entered), violated task parameters (33% of data included multi-word phrases instead of a single word) or included otherwise inappropriate language (e.g. profanity). Compensation was given to removed Mturk raters on a case-by-case basis, depending on how intentional the user appeared to be in providing unusable data.

The goal was to develop contexts that varied in the mathematical mean of cloze-probability, but not in the mathematical mode of cloze-probability. Therefore, cleaned data was organized based on the subject-noun, and within that category, the verbs were organized based on the object-noun with the highest cloze-probability value generated from that context. If a verb elicited an object-noun with greater than 50% cloze-probability, that context was marked as a potential candidate for a high-cloze condition. Contexts which elicited that object-noun with a lower cloze-probability were marked as candidates for the low-cloze condition, so long as the highest cloze-probability response was shared in both contexts. For example, *Archers shoot* elicited *arrows* at 90% cloze-probability and although *Archers hold* elicited *arrows* at 15% cloze-probability, it also elicited *bows* at 65% cloze-probability. Even though these contexts differed in their elicitation of *arrows*, it is not appropriate to argue that *Archers hold* is a low-cloze context. If the highest cloze-probability ranking was a tie between multiple words, those verbs were counted as viable candidates for the low-cloze condition of those object-nouns.

Truth-value validation

The cloze-probability validation was intended to create two different cloze-probability contexts for a single object-noun. The subject-verb context was combined with the highest cloze-probability object-noun obtained from Mturk raters in order to create the true condition of the truth-value manipulation. In order to create the false condition, I selected object-nouns that were thematically similar to the true object-noun (e.g. arrows → bullets), but were designed to create a sentence that would be evaluated with a false truth-value.

Sentences were presented to 10 Mechanical Turk Master Raters who specialize in categorization tasks, with the instructions "Rate each sentence on a scale of 1-2-3-4-5 in terms of how true you believe the sentence to be, with 1 being completely false, and 5 being completely true". In order to qualify for truth-value validation, true sentences required an average truth-value rating between 4-5, and false sentences required an average truth-value rating between 1-2. Similar rules of data screening governed the removal of Mturk users as during the cloze-probability validation. If a true sentence failed the truth-value requirements, the context was sent back to the cloze-probability validation stage. If a false sentence failed the truth-value requirements, then a different object-noun was selected and another set of ratings was collected, or the entire context was sent back to the cloze-probability validation stage in order to create a more effective context. This cycle continued until I created 40 items with four sentences that passed these validation requirements.

After creating this list of 40 items that were validated on truth-value and cloze-probability, I validated the verbs and the objects on several basic psycholinguistic metrics. More specifically, word frequency, age-of-acquisition, syllable length, and letter length of the verbs and the objects were obtained (Brysbaert & New, 2009; Kuperman, Stadthagen-Gonzalez, & Brysbaert, 2012) and the manipulations of cloze-probability and truth-value were tested for differences in these variables using a paired t-test. If a condition elicited significant different results, I selected the item with the most extreme differences, and began the process of revising it and/or creating new items. This process continued until 40 items were validated in accordance to the cloze-probability and truth-value parameters as well as the psycholinguistic controls. The average cloze-probability obtained for these 40 items was as follows: Low-cloze (*M*=45.62%, *SD*=14.64%), high-cloze (*M*=83.87%, *SD*=13.95%). The truth-values for the four sentences was as follows: low-cloze true (*M*=4.49, *SD*=0.31), high-cloze true (*M*=4.66, *SD*=0.24), low-cloze false (*M*=1.77, *SD*=0.24), high-cloze false (*M*=1.65, *SD*=0.35). Cloze-probability did not have a significant effect on truth-value ($p > 0.10$, suggesting that cloze-probability related to the verb did not influence the truth-value related to the object-noun.

Chapter 3 RESEARCH

I conducted three studies to test the predictions of the Binding-Suppression Model. The first examined the role of semantic relationships on sentence-evaluation across honest and deceptive schemas. The second study examined the role of linguistic expectancy on sentence evaluation across honest and deceptive schemas. Finally, the third study tested if these findings generalized to an ecologically valid paradigm, where information schema cues were embedded in a sentence context instead of sentence color.

Hypotheses

In the Semantic-Relatedness, I examined the effect of information schema on sentence evaluation while varying semantic relationships within sentence contexts. In Linguistic-Expectancy, I dropped the anomalous condition from the Semantic-Relatedness, so there were only two conditions of truth-value, and introduced a verb manipulation designed to alter the expectancy of object-noun in the true-condition. If honest and deceptive schemas are similarly informed by implicit processes, then linguistic expectancy should be similarly informative to sentence evaluation and response processes across both honest and deceptive schemas. However, if deceptive schemas do inhibit all implicit processes, then linguistic expectancy should only influence honest schemas, with no effect on deceptive schemas. In the Semantic-Relatedness and the linguistic expectancy as well as virtually all other deception studies involving linguistic materials, the truth-value and schema-cue associated with a trial are placed into different facets of the sentence (i.e. linguistic and perceptual features respectively). In order to test if the processes involved in determining truth-value share a limited-capacity with the processes involved in determining schema, Embedded-Cue was conducted, in which truth-value and schema-cue were simultaneously embedded into the sentence. It is predicted that the process of sentence evaluation and subsequent responding would deviate from those observed in previous studies because of the limited-capacity of sentence-evaluation and the additional requirements involved to maintain the schema-cue in working-memory instead of it being presented externally in the sentence and the probe.

Data analysis approach

This research implemented concepts and methods from several disciplines, all of which possess unique approaches to data analysis and presentation of results. I chose to analyze and present the data in a manner that would be meaningful to readers across the varying domains while still providing the most accurate presentation of the results.

To analyze the relationship between the dependent and independent variables in the following studies, I conducted a within-subjects analysis of variance (Winer, Brown, & Michels, 1971) Follow-up analyses were conducted as needed to evaluate significant interaction effects. Across all studies, the primary dependent variables included reading time and response time, and a primary independent variable shared across studies is the schema (honesty vs. deception). Specifically, for Semantic-Relatedness, another independent variable was truth-value (true vs. implausible vs. anomalous). Specifically, for Linguistic-Expectancy and Embedded-Cue, independent variables also included truth-value (true vs. false), and cloze-probability (low vs. high).

Effects sizes for ANOVA factors are η_p^2, which is defined as the amount of variation in the data explained by the factor divided by the sum variation explained by the factor and the variation associated with individual variation within the observations (i.e. Sums of $Squares_{BetweenGroups}$ / Sums of $Squares_{BetweenGroups}$+ Sums of $Squares_{WithinGroups}$). This test reveals how much of the variation in the dependent variable are based in the experimental manipulation relative to the individual variability of the participants who elicited the dependent variable. Effect sizes for contrasts and t-tests are Cohen's *d*, which is defined as the difference between two means divided by their pooled standard deviation ($Mean_{difference}$ / SD_{pooled}). Based on literature recommendations, the pooled standard deviation was adjusted based on correlations between conditions in order to better determine the within-subjects detectability of effects (Lakens, 2013). Estimates of effect size for small, medium, and large effects are 0.01, 0.06, and 0.14 respectively for η^2 and 0.2, 0.5, and 0.8 respectively for cohen's *d* (Cohen, 1988), although recent developments in statistics have added estimates of very large and huge effects, which respectively refer to effect sizes of 1.2 and 2 (Sawilowsky, 2009).

In order to explore questions relating to the individual variability of subjects' reading and response time with respect to schema and truth-value, a series of linear mixed-effects regressions were conducted on the raw data, using the lme4 package in R (Bates, Maechler, Bolker, & Walker, 2014). Reading and response time was log-transformed, as is recommended to maintain assumptions of normality (Baayen, Davidson, & Bates, 2008). The primary individual difference variable was CFQ score. Cloze-probability was not included in these models for several reasons. First, each experiment contained 36 participants and between 32-56 items, so in order to construct a model that was both appropriately powered and meaningfully interpretable, I chose to limit potential interactions to a three-way interaction instead of a four-way interaction.

Second, CFQ is related to inhibitory control of distracting/irrelevant information, specifically with respect to inhibiting such information from activating an inappropriate prepotent response (Friedman & Miyake, 2004). Because truth-value must be explicitly considered in order to identify the appropriate response and cloze was only involved during the determination of truth-value, I determined that truth-value was more relevant to the relationship between cognitive-failures and schema than cloze-probability. Therefore, the individual difference analyses in Linguistic-Expectancy and Embedded-Cue did not include cloze-probability as an independent variable. Subjects and items were included as a random effect. Upon fitting the maximal model for random slopes, slopes/intercepts were removed if they did not contribute significant variance to the model, using the lmerTest package in R (Kuznetsova, Brockhoff, & Christensen, 2015). In order to remove variance accounted for by general practice effects or cognitive fatigue, the linear effect of trial was included as a non-interacting fixed effect and the effect of trial was included as a non-interacting random slope for subjects, thus removing variance related to transient state-based practice/fatigue (Baayen, Vasishth, Kliegl, & Bates, 2017), allowing for the more precise examination of trait-based cognitive failures.

Procedure

Participants arrived at the lab and the experimenter familiarized them with the task requirements. If they agree to give verbal informed consent, they completed a pen-and-paper version of the task. The experimenter gave instructions and feedback during this time. Following the pen-and-paper version, the participants completed a practice session on the computer. The practice session was identical to the actual experiment, except feedback was provided after every response in order to train the participant on the task instructions; practice stimuli were similar but not identical. Participants must perform at 67% accuracy on at least 12 trials; participants who were unable to reach 67% by 30 trials did not perform the experiment due to inability to perform the task, but they did receive participation credit. Before the trial, the computer screen presented the response box instructions as a reminder. When participants were ready to begin, they initiated the trial with a button press

The two-stimulus directed-deception test (DRT) was adapted for this experiment (Vendemia, Buzan, & Simon-Dack, 2005). Participants evaluated the truth-value of a sentence, hereafter referred to as stimulus 1 or S1, compare the evaluation with stimulus 2 (S2: “true” or “false”), and respond honestly/deceptively regarding whether or not S2 accurately reflects their S1 evaluation. Schema is cued by font color of S1 and S2 (red-lie, blue-truth). These were not counterbalanced as prior research has shown that honest and deceptive responses are not different across the color-cues (Vendemia & Buzan, 2003). The correct response was balanced, so that participants respond “agree” and “disagree” at an equal rate to all schemas and truth-values. Deceptive and honest trials were randomly presented so no between-trial pattern was presented, but color cues for S1 always matched color cues of S2. The primary difference between the DRT used in prior studies and the DRT employed in the current study is that prior studies have generally Given that preparedness to deceive can influence processing time effects (Vendemia, Buzan, & Simon-Dack, 2005), I measured evaluation time and response time separately to differentiate processing associated with response generation from truth-value and preparedness to deceive.

Study 1: Semantic-Relatedness

Methods

Participants

36 undergraduate students from the University of South Carolina participated in this study for extra credit in a psychology course

Materials

A subset of true, implausible, and anomalous items were selected from those that passed the accuracy check in the Lexical Violation Item Development studies. Additional items were constructed as needed in order to create a total of 64 items. I designed the schema-cue to be orthogonal to truth-value by presenting each item's true condition in both information schemas (honesty and deception) while false conditions were counterbalanced across information schemas. I counterbalanced the relation between truth-value and schema-cue across participants as well as the exact probe word associated with each of these conditions, so that each combination of truth-value, schema-cue, and probe-word within each item was presented at an equal frequency across the entire study. The entire set of 64 items are available in Appendix B, but only True, Implausible, and Anomalous sentences were presented Semantic-Relatedness.

Procedure

Procedure was identical to item development procedures with one exception. Following completion of the DRT, participants completed the cognitive-failures questionnaire (Broadbent, Cooper, FitzGerald, & Parkes, 1982).

Results

Data screening

Items that elicited accuracy rates of less than 67% in any of the six possible conditions were removed from all analyses, which eliminated 7.81% of the data. All inaccurate responses were removed, which eliminated 5.74% of the data. I calculated means and standard deviation for each participant based on the screened data. Response times and reading times that were less than 300 ms or 2.5 SDs away from the participant's grand mean were replaced with that participant's grand mean, a method designed to use an individual participant's data to impute data of their individual outliers (Stevens, 2012). In total, 2.76% of the reading data was replaced and 2.59% of the response data was replaced.

Sentence reading time

I conducted a 2 X 3 repeated-measures ANOVA, examining the effect of schema (honesty vs. deception) and truth-value (true vs. implausible vs anomalous) on reading time. There were significant main effects of schema $F(1,35)=20.38$, $p<0.0001$, $\eta_p^2=0.368$ and truth-value, $F(2,70)=17.51$, $p<0.0001$, $\eta_p^2=0.21$, but these effects were subject to an interaction $F(2,70)=6.96$, $p=0.0017$, $\eta_p^2=0.09$. The main effects elicited large effect sizes and the interaction elicited a medium effect size. Follow-up t-tests revealed that when participants intended to be honest, reading time of sentences was faster than they intended to be deceptive, with significant differences at the level of true-sentences (*M*=2979 ms, *SD*=1154 ms vs. *M*=3687 ms, *SD*=1515 ms), $t(35)=5.54$, $p<0.0001$, $d=1.14$, implausible sentences (*M*=3559 ms, *SD*=1392 ms vs. *M*=3961 ms, *SD*=1656 ms), $t(35)=-3.26$, $p=0.0012$, $d=-0.58$, and anomalous sentences (*M*=3389 ms, *SD*=1376 ms vs. *M*=3719 ms, *SD*=1617 ms), $t(35)=-2.59$, $p=0.0068$, $d=-0.45$. As is evident from the effect sizes, true sentences elicited more detectable differences between honesty and deception than implausible and anomalous sentences. Results can be seen in Figure 3.1.

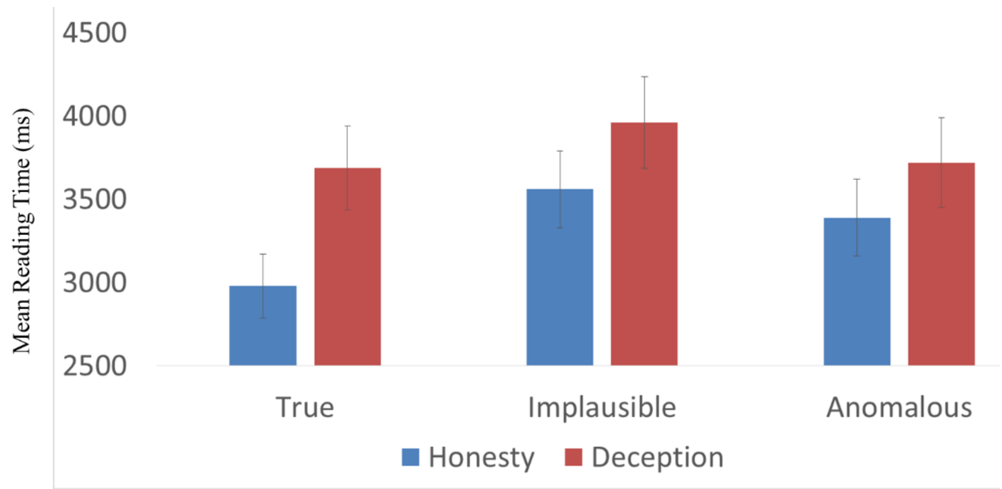

Figure 3.1: Semantic-Relatedness reading time results. Honest-schemas vary in accords to truth-value whereas deceptive-schemas vary in accords to explicit ambiguity resolution. Honest-schemas always faster than deceptive=schemas

At the level of honest intentions, true sentences were read faster than implausible sentences (*M*=2979 ms, *SD*=1154 ms vs. *M*=3559 ms, *SD*=1392 ms), $t(35)=5.54$, $p<0.0001$, $d = 1.04$ as well as anomalous sentences (*M*=2979 ms, *SD*=1154 ms vs. *M*=3389 ms, *SD*=1376 ms), $t(35)=3.62$, p=0.0004, $d = 0.68$, and anomalous sentences were read faster than implausible sentences at a trending significant level (*M*=3389 ms, *SD*=1376 ms vs. *M*=3559 ms, *SD*=1392 ms), $t(35)=3.62$, p=0.0004, $d = 0.29$. At the level of deceptive-intentions, true sentences were read more quickly than implausible sentences (*M*=3687 ms, *SD*=1515 ms vs. *M*=3941 ms, *SD*=1656 ms), $t(35)=-3.51$, p=0.0006, $d=-0.66$, and anomalous sentences were also read more quickly than implausible sentences (*M*=3719 ms, *SD*=1617 ms vs. *M*=3941 ms, *SD*=1656 ms),

$t(35)=-2.71$, $p=0.0051$, $d=0.50$, but true sentences and anomalous sentences were read for a similar amount of time.

Post-hoc analysis

A qualitative assessment of the reading time results suggested that the implausible sentences were subject to a similar processing cost relative to the anomalous sentences (approximately 200-250 ms). If the reading time cost was similar across schemas, then that would suggest there was an additive factor that contributed specifically to reading time of implausible sentences. If so, then after accounting for this factor, processing requirements of false sentences appear similar under an honest schema, and processing times of all sentences appear similar across a deceptive schema. I conducted a post-hoc two-way analysis of variance, only testing the effect of schema (honesty vs. deception) and truth-value within the false-sentences (implausible vs. anomalous). There were significant main effects of schema $F(1,35)=10.26$, $p=0.0029$, $\eta_p^2=0.23$ and truth-value, $F(2,70)=8.09$, $p=0.0075$, $\eta_p^2=0.19$, with no significant interaction observed between these effects $F<1$. The results of the post-hoc analysis reveal similar effects of schema across truth-value as well as similar effects of truth-value across schema, suggesting that the implausible sentences were subject to an additive factor that was observed similarly across schemas.

Individual differences

The lmer analysis revealed that individual differences in CFQ did not explain unique variance in reading time at any level of analysis. Due to its redundancy, the results are not reported.

Probe response time

I conducted a 2 X 3 repeated-measures ANOVA, examining the effect of schema (honesty × deception) and truth-value (true × implausible × anomalous) on response time. There were significant main effects of schema $F(1,35)=12.11$, $p=0.0013$, $\eta_p^2=0.257$ and truth-value, $F(2,70)=4.28$, $p=0.017$, $\eta_p^2=0.057$, but these main effects were subject to a significant interaction, $F(2,70)=21.18$, $p<0.0001$, $\eta_p^2=0.23$. The effect of schema was large and the effect of truth-value was medium, but that the interaction effect size was large suggests that these effects differed heavily across conditions. Results can be seen in Figure 3.2.

Figure 3.2: Semantic-Relatedness response time results. Honest-schemas vary in accords to truth-value whereas deceptive-schemas vary in accords to relatedness to entrenched concepts. Honest-schemas faster than deceptive=schemas for all sentence-types except Anomalous

Follow-up t-tests revealed that the effect of schema varied as a function of truth-value. Honest responses were faster than deceptive responses at the level of true sentences (M=658 ms, SD=151 ms vs. M=786 ms, SD=236 ms), $t(35)=-5.84$, $p<0.0001$, $d=-1.24$, as well as for implausible sentences (M=718 ms, SD=163 ms vs. M=779 ms, SD=256 ms), $t(35)=-2.92$, $p=0.0031$, $d=-0.69$, but there was no significant difference between honest and deceptive responses to anomalous sentences $t<1$. The effect of truth-value on response time differed across schema. When participants responded honestly, true sentences elicited faster responses than both implausible sentences (M=658 ms, SD=151 ms vs. M=718 ms, SD=163 ms), $t(35)=5.91$, $p<0.0001$, $d=-1.01$ and anomalous sentences (M=658 ms, SD=151 ms vs. M=727 ms, SD=172 ms), $t(35)=-5.38$, $p<0.0001$, $d=-0.93$, but honest responses were similar across implausible and anomalous false sentences. $t<1$. When participants responded deceptively, anomalous sentences elicited faster responses than both true sentences (M=738 ms, SD=247 ms vs. M=786 ms, SD=236 ms), $t(35)=2.96$, $p=0.006$, $d=0.49$ and implausible sentences (M=738 ms, SD=247 ms vs. M=779 ms, SD=256 ms), $t(35)=3.27$, $p=0.002$, $d=0.55$, but deceptive responses were similar across true and implausible sentences $t<1$.

Individual differences

The lmer analysis revealed that individual differences in CFQ did not explain unique variance in response time at any level of analysis. Due to its redundancy, the results are not reported.

Discussion

Honest schemas elicited faster reading times than deceptive schemas, and the effects of truth-value interacted with schema. Honest schemas elicited faster reading time to true sentences than both implausible and anomalous sentences, which were read faster than implausible sentences. Contrarily, deceptive-schemas, elicited similar reading times for true and implausible sentences, both of which were read faster than implausible sentences. Post-hoc analyses revealed that reading time of implausible sentences was subject to an additive factor relative to anomalous sentences which affected honest and deceptive schemas. These analyses suggest that, after accounting for implausibility cost, deceptive-schemas elicited similar reading times across sentences. True sentences elicited larger differences between honesty and deception than both implausible and anomalous sentences, which elicited similar differences between honesty and deception.

Response time patterns differed from reading time patterns. Overall, honest responses were faster than deceptive responses, but unlike reading times, this was not stable across sentences. True sentences elicited the largest differences between honesty and deception, followed by implausible sentences, whereas anomalous sentences elicited similar response times between honesty and deception. Follow-up analyses revealed that honest-schemas elicited faster responses to true sentences than to both implausible and anomalous sentences, which did not differ from one another. Deceptive-schemas elicited similar response times to true and implausible sentences, both of which were slower than response times to anomalous sentences. CFQ had no effect, suggesting that cognitive failures are irrelevant to these phenomena.

Honest schemas activate explicit processes to supplement implicit processes

As the Binding Suppression Model predicts, the largest factor of reading time was whether the presence/absence of semantic activation (schema: honesty vs. deception) would enable/suppress access to entrenched concepts in LTM (truth-value: true vs. implausible vs. anomalous). As predicted, honest schemas elicited the fastest reading and response times when semantic activation was extensively triggered (true sentences) relative to when evaluative processes required conscious search/retrieval (implausible / anomalous sentences). Following sentence-evaluation, honest-schemas encoded truth-value effectively, as evidenced by honest response times varying in accordance to truth-value, with no differences across false sentences (true < implausible = anomalous). However, deceptive-schemas elicited a more complex response time pattern. Sentences that were the least related to entrenched concepts (anomalous sentences) required the least amount of cognitive effort (Anomalous < Implausible = True). This effect is intriguing, as it is a complete reversal of what is normally observed when examining comprehension and responding to true and false sentences.

Deceptive schemas inhibit the role of implicit memory processes

The Binding-Suppression Model predicted that deceptive schemas would proactively inhibit semantic activation, relegating all memory processes to proceed via conscious search/retrieval. Therefore, stimuli capable of triggering semantic activation would elicit distinct memory processes under honest and deceptive schemas, but stimuli incapable of triggering implicit semantic activation would elicit similar memory processes under honest and deceptive schemas. Therefore, the Binding-Suppression Model predicts that differences between honesty and deception should be directly related to a stimulus' latent capacity to trigger implicit semantic activation, because honest schemas activate semantic-memory and deception will suppress it.

My data supported this prediction in both reading and response times. True sentences elicited the largest behavioral differences between honesty and deception relative to implausible and anomalous sentences. The different effects of schema on anomalous sentences across reading and response time strongly suggest that binding-suppression is initiated during sentence-evaluation, as evidenced by the stable effects of deception across reading time. However, binding-suppression may not be stably involved during response-generation. If deceptive-schemas elicited a broad binding-suppression effect during response-generation, there should have been effects of deception across all sentences, instead of only true and implausible sentences. Therefore, detecting deception during response-generation may require careful control of the previously evaluated content in order to maximize the detectability of deception instead of ameliorate it.

It is possible that binding-suppression is differently involved across sentence-evaluation and response-generation, but the unbalanced design is potential confound. Although prior research suggests that false evaluations are qualitatively different than true evaluations (McCloskey & Bigler, 1980; Glucksberg & McCloskey, 1981), research also suggests that contextual effects related to stimuli alters strategic processing (Lorch, 1981; Reder, 1987). Furthermore such context effects can strongly alter how concepts are activated and responded to (Mayo, Schul, & Rosenthal, 2014; Saunders & MacLeod, 2006). Based on these findings, it is possible that the multiple false conditions increased ambiguity of false evaluations relative to true evaluations. I examined if semantic-relation effects generalize across truth-values by conducting Linguistic-Expectancy.

If I observed unique effects of schema, then this pattern should be stable in Linguistic-Expectancy, such that if I presented only true and implausible sentences, deceptive-schemas should elicit response times to implausible sentences that replicate the current experiment. Contrarily, if task-parameters drove the effect, that suggests that deceptive-schemas are influenced by content of neighboring deceptive-schemas, even if they are irrelevant to the current task. Therefore, if I presented only true and implausible sentences, deceptive-schemas should elicit response times to implausible sentences that replicate the anomalous sentences reported in the current experiment.

Regardless of the source of the response time effects, the reading time effects suggest that deceptive-schemas and honest-schemas conduct sentence-evaluation very differently. If these effects are replicated, that would suggest that deceptive-schemas initiate binding-suppression during sentence-evaluation. Such a replication would be strong evidence that the cognitive demands of deception are behaviorally observable long before motoric generation of a lie response. Further deception research examining the unique signatures of deception during sentence-evaluation as they are distinct from response-generation would greatly expand the precision with which deception can be detected. Linguistic-Expectancy examined the generalizability of these effects by manipulating two factors within sentence-evaluation: sentence-integration (constructing the propositional message of the sentence) and truth-value disambiguation (evaluating whether the sentence's propositional message accurately reflects world knowledge)

Study 2: Linguistic expectancy

The first study suggested that honest and deceptive schemas were similarly influenced by explicit processes related to truth-value ambiguity, as evidenced by the longer reading time of implausible sentences relative to the anomalous sentences. The response time results suggest that deceptive schemas were more influenced by Semantic-Relatedness than truth-value, as evidenced by longer deceptive responses to true and implausible than anomalous sentences. However, the unbalanced item design precluded strong conclusions. In order to examine truth-value as separate from semantic-relation of sentence-content, I manipulated expectancy of the object-noun and the truth-value of the sentence. These were orthogonally manipulated via altering the verb to elicit differential degrees of expectancy (i.e. cloze-probability) and by altering the object-noun to elicit differential evaluations of sentence truth-value.

According to the Prepotent Inhibition Model, deceptive-schemas do not inhibit semantic memory, but rather motor-responses are delayed until conscious awareness can evaluate response-generation. If so, the facilitative effect of entrenched concepts could be nullified in response time. But, entrenchment should still influence sentence-evaluation for two reasons: 1) Sentence-evaluation requires a single button-press, so there is no response-ambiguity to consider and 2) entrenched concepts should be more easily evaluated than novel concepts. Therefore, the Prepotent-Inhibition Model predicts similar deceptive response times across true and false sentences, but faster reading time for true relative to false sentences. The model's prediction for expectancy is uncertain

According to the Binding-Suppression Model, deception alters the manner in which memory is accessed during sentence-evaluation. Deceptive-schemas suppress implicit semantic activation, and instead, LTM is consciously and exhaustively searched. This hypothesis argues that deception devalues good-enough heuristics and explicitly evaluates relevant information (Mayo, 2015; Mayo, Alfasi, & Schwarz, 2014; Posten & Mussweiler, 2013; Friesen & Sinclair, 2011; Kleiman, Sher, Elster, & Mayo, 2015)

I predict that under an honest-schema, Linguistic-Expectancy will influence sentence-evaluation, such that higher cloze-probability will reduce reading time, but following sentence-evaluation, there will be no effect of cloze-probability on response-generation. With respect to deceptive-schemas, I hypothesize that neither linguistic expectancy nor truth-value will inform sentence-evaluation, and expectancy will not influence response-generation. However, based on Semantic-Relatedness, I hypothesize that false sentences will elicit faster responses than true sentences. Therefore, if either expectancy or truth-value inform reading and response times in a similar manner as honest-schemas, my hypothesis is not supported. But if such effects are nullified or even reversed, the results will support and further inform the Binding-Suppression Model.

Methods

Participants

36 undergraduate students from the University of South Carolina participated in this study for extra credit in a psychology course

Materials

Forty sentences were constructed that varied in truth-value (true vs. false) and cloze-probability (low vs. high). I adapted materials from Semantic-Relatedness in accords with prior materials and validations of cloze-probability (Bloom & Fischler, 1980; Block & Baldwin, 2010; Hahn, 2012) to suit the demands of my parameters (e.g.

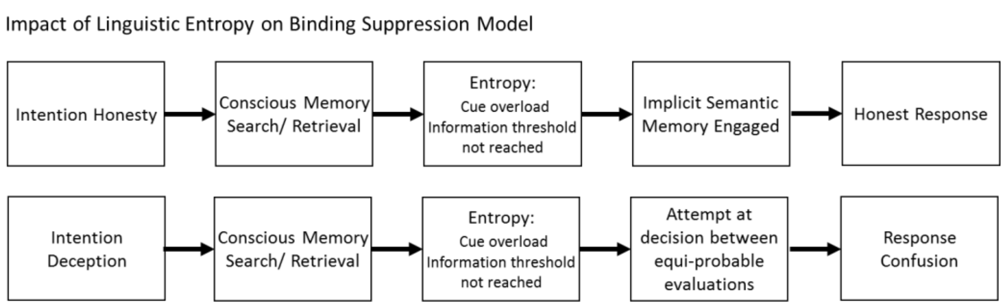

Figure 3.3: Effect of Entropy on Deceptive and Honest Responding as Predicted by the Binding Suppression Model

truth-value, cloze-probability, subject-categories, psycholinguistic controls, etc.).

Stimuli consisted of 40 subject-nouns (20 animals and 20 humans) which began a three-word sentence with a syntactic structure of Subject-Verb-Object. For each sentence, the subject-noun was constant (e.g. Archers, Chickens), but the verb and the object were manipulated, creating a total of four distinct three-word sentences for each subject-noun. The verb was manipulated so as to construct a context where the object-noun was highly predictable (e.g. Archers shoot, Chickens lay) or where the object-noun was less expected, but both verb-contexts agreed on the most likely completion (e.g. Archers prepare, Chickens guard). The object was manipulated so as to construct a sentence that was either true (Archers shoot arrows, Chickens lay eggs) or false (Archers shoot bullets, Chickens lay rocks). The entire set of 40 items are presented in Appendix C.

Procedure

Procedure was identical to Semantic-Relatedness

Results

Data screening

For reading time and response time analyses, I removed all items which elicited accuracy rates of less than 67% in any of the six possible conditions. This resulted in an elimination of 2.5% of the data. I then eliminated all inaccurate responses, which resulted in an elimination of 5.36% of the data. I calculated means and standard deviation for each participant based on the accurate items and accurate trials. Response times and reading times that were less than 300 ms or 2.5 SDs away from the participant's mean were replaced with their overall mean for that dependent variable. For reading times, 2.96% of the data was replaced and for response times, 2.54% of the data was replaced.

Sentence reading time

I conducted a 2 X 2 X 2 repeated-measures ANOVA, examining the effect of schema (honesty vs. deception), truth-value (true vs false), and cloze (low vs. high) on reading time. There were significant main effects of schema, $F(1,35)=10.59$, $p=0.0025$, $\eta^2=0.23$, truth-value, $F(1,35)=12.14$, $p=0.0013$, $\eta^2=0.26$, and cloze $F(1,35)=9.72$, $p=0.0036$, $\eta^2=0.22$. These main effects were subject to a trending interaction between schema and truth-value $F(1,35)=3.51$, $p=0.069$, $\eta^2=0.09$ and a significant interaction between schema and cloze $F(1,35)=5.99$, $p=0.019$, $\eta^2=0.13$. No other interactions were significant, Fs<1. The effect sizes related to schema and truth-value were large, while the effect sizes of cloze and all interactions were medium.

The main effect of schema revealed that honest schemas elicited faster reading time than deceptive schemas ($M=3361$ ms, $SD=1177$ ms vs. $M=4388$ ms, $SD=2277$ ms). The main effect of truth-value revealed that true sentences were read faster than false sentences ($M=3699$ ms, $SD=1426$ ms vs. $M=4045$ ms, $SD=1704$ ms). The main effect of cloze revealed that high-cloze sentences were read faster than low-cloze sentences ($M=3767$ ms, $SD=1564$ ms vs. $M=3974$ ms, $SD=1534$ ms). However, the two-way interaction between schema and cloze as well as the trending two-way interaction

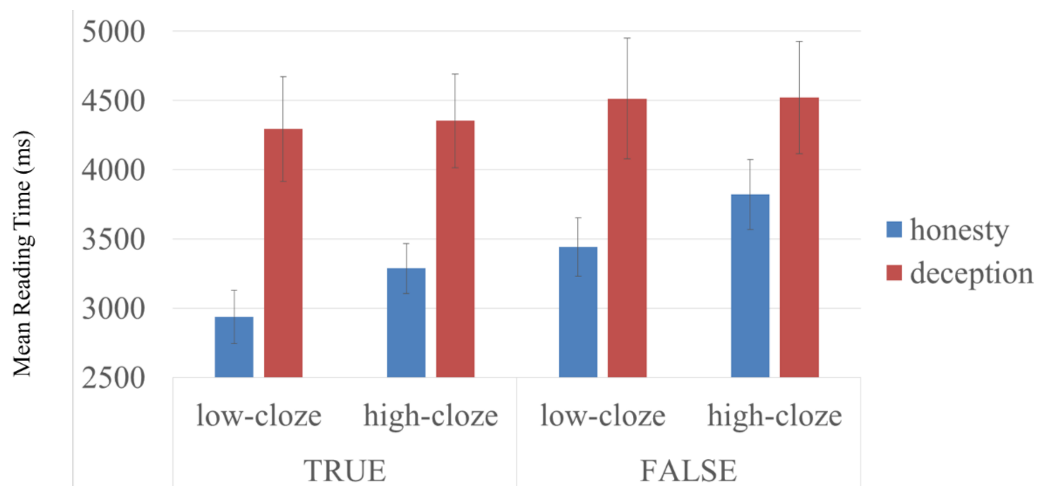

Figure 3.4: Linguistic-Expectancy reading time results. Honest-schemas vary in accords to cloze-probability and truth-value whereas deceptive-schemas require similar reading time across all sentence-types. Honest-schemas always faster than deceptive-schemas

between schema and truth-value suggested that the effects of cloze and truth-value differed as a function of whether participants intended to be honest or deceptive. Although honest-schemas elicited reading times that varied in accordance with sentence-content, deceptive-schemas suppress this variability (Figure 3.4).

Simple main effects contrasts were conducted to follow up these interactions. Under an honest schema, reading times were significantly influenced by cloze significantly influenced reading times $F(1,35)=21.28$, $p<0.0001$, $\eta^2=0.38$ and truth-value $F(1,35)=18.63$, $p=0.0001$, $\eta^2=0.35$, but there was no interaction between these effects. The simple main effects revealed that high-cloze sentences were read faster than low-cloze sentences (*M*=3187 ms, *SD*=1153 ms vs. *M*=3542 ms, *SD*=1244 ms) and true sentences were read faster than false sentences (*M*=3118 ms, *SD*=1071 ms vs. *M*=3611 ms, *SD*=1347 ms). Contrarily, under a deceptive schema, reading time was not significantly influenced by cloze or truth-value, and there was no interaction between these effects, all *F*s<1.6.

In order to evaluate the influence of these effects on the detectability of deception, I conducted one-tailed t-tests to examine the difference between honesty and deception across all sentence types. Honest schemas elicited faster reading times than deceptive schemas at the level of low-cloze true sentences (*M*=3287 ms, *SD*=1080 ms vs. *M*=4349 ms, *SD*=2040 ms), $t(35)= -3.75$, $p=0.0003$, $d= -0.72$, high-cloze true sentences (*M*=2950, *SD*=1160 ms vs. *M*=4255 ms, *SD*=2275 ms), $t(35)= -3.97$, $p=0.0001$, $d= -0.76$, low-cloze false sentences (*M*=3797 ms, *SD*=1511 ms vs. *M*=4461 ms, *SD*=2434 ms), $t(35)= -1.85$, $p=0.036$, $d=0.33$, and high-cloze false sentences (*M*=3425 ms, *SD*=1267 ms vs. *M*=4501 ms, *SD*=2609 ms), $t(35)= -2.87$, $p=0.0034$, $d=0.56$.

Individual differences

The lmer analysis revealed that individual differences in CFQ did not explain unique variance at any level of analysis. Due to its redundancy, results are not reported.

Probe response time

I conducted a 2 X 2 X 2 repeated-measures ANOVA, examining the effect of schema (honesty vs. deception), truth-value (true vs false), and cloze (low vs. high) on response time. There were significant main effects of schema, $F(1,35)=16.17$, $p=0.0003$, $\eta^2=0.32$ and truth-value, $F(1,35)=4.522$, $p=0.041$, $\eta^2=0.11$. These main effects were subject to a significant interaction between schema and truth-value $F(1,35)=19.25$, $p<0.0001$, $\eta^2=0.35$. The effect sizes for schema was large while the effect size for truth-value was medium, but the interaction effect size was large, suggesting that the effect of schema and truth-value on response time varied heavily as a function of this interaction. Results are seen in Figure 3.5.

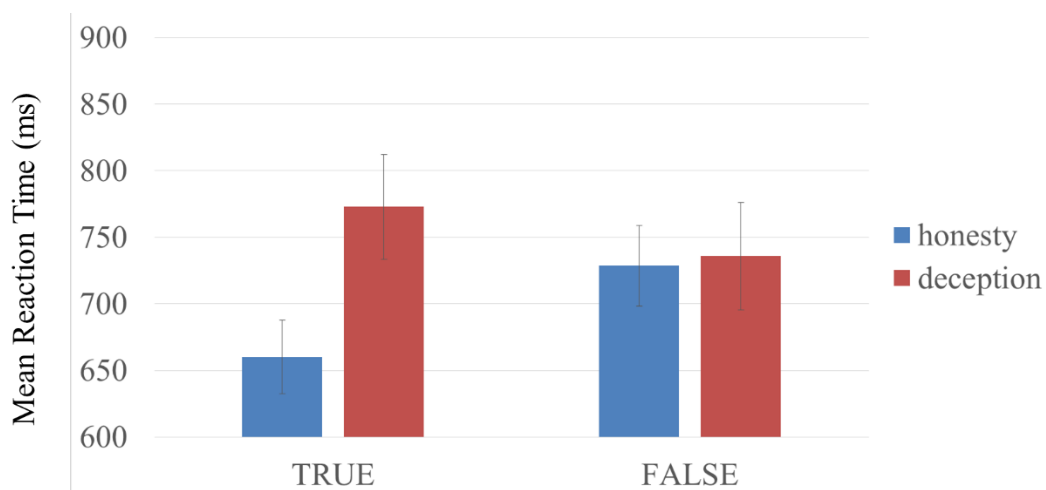

Figure 3.5: Linguistic-Expectancy response time results. Honest-responses are faster than deceptive responses only at the level of true sentences.

Simple main effects contrasts were conducted to examine the influence of truth-value across schemas. These tests revealed that under an honest schema, truth-value significantly influenced response times $F(1,35)=40.75$, $p<0.0001$, $\eta^2 = 0.538$, such that true sentences elicited faster responses than false sentences (*M*=661 ms, *SD*=166 ms vs. *M*=730 ms, *SD*=181 ms). However, under a deceptive schema, truth-value only elicited a trending significant effect on response times $F(1,35)=3.09$, $p=0.087$, $\eta^2 = 0.081$, which suggested that false sentences elicited faster response times than true sentences (*M*=776 ms, *SD*=242 ms vs. *M*=745 ms, *SD*=236 ms).

To further understand the interaction, simple main effect contrasts were conducted to examine schema across truth-values. These tests revealed that when participants responded to a true sentence, schema significantly influenced response times $F(1,35)=34.90$, $p<0.0001$, $\eta^2 = 0.50$, such that honest schemas elicited faster response times than deceptive schemas (*M*=661 ms, *SD*=166 ms vs. *M*=776 ms, *SD*=236 ms). However, when participants encountered a false sentence, there was no effect of schema on reading times, $F<2$. Taken together, these findings suggest that false sentences elicited no differences between honesty and deception, and that relative to their respective responses to false sentences, honest responses were facilitated by true sentences while deceptive responses appeared to encounter interference from true sentences.

Individual differences

The lmer analysis revealed that individual differences in CFQ did not explain unique variance at any level of analysis. Due to its redundancy, results are not reported.

Discussion

The patterns associated with reading times were overall similar to patterns observed in Semantic-Relatedness. Honest schemas elicited faster reading time than deceptive schemas across all sentence types, but the effect of schema interacted separately with both truth-value and cloze-probability. Under honest-schema, both truth-value and cloze-probability elicited the expected main effects (truth-value: true < false; cloze-probability: high-cloze < low-cloze). Neither of these effects were observed under deceptive schemas; similar reading times across all sentence types.

Following sentence evaluation, there was an interaction between truth-value and schema on response times, with no effect of cloze-probability. Following a true sentence, honest responses were faster than deceptive responses, but there was no difference between honest and deceptive response times following a false sentence. The reason for this nonsignificant difference on false sentences is that honest responses were faster following true sentences than false sentences, whereas there was a trend for deceptive responses to true sentences to be slower than deceptive responses to false sentences. CFQ had no effect, suggesting that cognitive failures are irrelevant to these phenomena.

As in Experiment 1, the Binding-Suppression Model predicts that the largest difference between honesty and deception should be associated with stimuli that are most capable of triggering implicit semantic activation. Under an honest schema, implicit semantic activation facilitates both initial construction of STM representations as well as subsequent operations on those representations, but under a deceptive schema, implicit processes are nullified, requiring similar amount of explicit search/retrieval regardless of implicit semantic relationships between stimuli. My data supported this prediction.

Sentence evaluation reflects long term memory retrieval

The Binding-Suppression Model predicts that honest schemas evaluate sentences based on an interdependency of implicit and explicit memory processes. Implicit semantic activation operates first, rapidly retrieving semantically-related information and explicit memory search/retrieval bolsters this representation if the semantic-activation is not sufficient to trigger decision thresholds. As the deficit between semantic-activation and decision-threshold grows, a greater amount of explicit search/retrieval is needed to supplement the impoverished mental representation. Similarly, as the coherence between semantic activation and a relevant entrenched concept become increasingly aligned, the amount of required search/retrieval decreases to a comparable degree. Both truth-value and cloze-probability contributed distinct sources of variance in sentence-evaluation, and this orthogonal contribution is reflected in the reading times of honest-schemas

Contrary to honest schemas, where sentence-evaluation is predictably informed by a multitude of sources, linguistic-experience and world-knowledge are irrelevant to deceptive-schemas. It appears that following the activation of binding-suppression, decision-thresholds are no longer directed in accordance to one's lifelong experience with that language can mean, whether it be statistical distributions of lexical items or the LTM structures that organize and store world-knowledge. Although the Informational Exchange Schema Theory predicts that deceptive-schemas sufficiently emphasize the liar's personal goals such that the liar's world knowledge is deemed irrelevant, it is remarkable how apt a description that is with respect to the current results.

After identifying that deceptive-schemas were observed to nullify the role of LTM structures in sentence-evaluation, I examined if this nullification was inherent to the concept of a deceptive-schema or if this nullification was driven by the specific parameters of the deceptive-schema adopted for these particular studies. So far, the deceptive-schemas in this dissertation have constructed a deceptive-signal that consists of a perceptual color-cue. If the deceptive-signal alters LTM accessibility in accordance to the features of the deceptive-signal itself, then all previous deceptive-signals would not activate semantic-content within LTM. Colors have no relation to sentence-content, so even if certain LTM structures were accessible (e.g. color-hues, color-terms), the experiments were not designed to observe activation. The final study of this dissertation was designed to test if the relationship between the deceptive-signal and LTM access.

The final study of this dissertation, known as Embedded-Cue, the deceptive-signal consisted of a categorical judgement, which required participants to identify the topic of the sentence, and if the topic matched the deceptive-signal, then it required a deceptive response. If binding-suppression nullifies LTM retrieval entirely, then the relation of the deceptive-signal to the embedded-cue should elicit similar null effects in sentence-evaluation as the color-cue did in Linguistic Expectancy. But if the deceptive-signal restructures LTM access in some capacity, then the relation of the embedded-cue to the deceptive-signal should influence sentence-evaluation.

Study 3: Embedded-Cue

Experiments 1 and 2 examined how deception and honesty differ between responding to different levels of truth-value prepotency. However, both experiments involved participants knowing immediately whether they were going to be deceptive or honest, regardless of the meaning of the sentence. But that is not an accurate representation of how deception is carried out in the real-world, so the generalizability of these findings to real-world deception is suspect. Language-comprehension processes differ based on the task-demands of the experimental context, as is evident in other, non-deceptive experiments (Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Kintsch & Mangalath, 2011; Barsalou & Medin, 1986).

In order to better understand how one decides to be either deceptive or honest, I examined how linguistic information can be used to direct that decision. Participants responded to sentences similar to those in previous studies, but instead of being cued by font-color, participants were deceived based on whether the sentence contains a human or a non-human animal (or vice-versa). Therefore, participants needed to determine truth-value while they simultaneously determine whether or not to deceive. By requiring participants to monitor the actual sentence content for schema-disambiguation, I can examine the degree to which the decision-to-deceive interacts with language-comprehension processes in order to generate a deceptive-response.

Methods

Participants

36 undergraduate students from the University of South Carolina participated in this study for extra credit in a psychology course

Materials

The items from Linguistic-Expectancy were reviewed and judged for inclusion in Embedded-Cue. In order to prevent ambiguity in the semantic categorization task, items that contained both humans and animals in any of their conditions were removed (e.g. cowboys ride horses, shepherds herd sheep). Of the items that remained, items were judged with respect to the accuracy criterion in Linguistic-Expectancy, so as to ensure only those items that elicited sufficiently accurate responses were selected for inclusion in Embedded-Cue, resulting in 32 items (16 animal-subjects and 16 human-subjects). To ensure that the list of 32 items were similarly valid as the list of 40 items, I evaluated the new list of items on psycholinguistic control variables, cloze-probability, and truth-value. No differences were observed across truth-value and cloze-probability in psycholinguistic control variables. The average cloze-probability obtained for these 32 items was as follows: Low-cloze (*M*=46.09%, *SD*=15.04%), high-cloze (*M*=82.34%, *SD*=15.21%). The truth-values for the four sentences was as follows: low-cloze true (*M*=4.52, *SD*=0.27), high-cloze true (*M*=4.67, *SD*=0.23), low-cloze false (*M*=1.73, *SD*=0.30), high-cloze false (*M*=1.65, *SD*=0.35). Cloze-probability did not have a significant effect on truth-value, suggesting that the cloze-probability manipulation of the verb did not influence the truth-value manipulation of the object-noun. All four conditions of the 32 items were presented to participants, resulting in a total of 128 sentences. These items are available in Appendix D:

Procedure

Procedure was identical to Linguistic-Expectancy with the exception of how the participants were cued to deceive. Instead of being cued to deceive based on the color of the sentence, participants were instructed to determine whether the sentence conveyed information about a human (e.g. archers, mechanics, janitors) or a non-human animal (e.g. chickens, eagles, beavers), and to adopt an honest or deceptive schema based on this decision. The schema-category relationship was counterbalanced across participants to ensure honesty and deception were connected to humans and animals at an equal frequency. Due to the schema-cue no longer being orthogonal to the sentence content, it was impossible to counterbalance the truth-value of an item with the schema-cue. Therefore, whereas in Semantic-Relatedness and Linguistic-Expectancy, I presented half of the sentences within an item as an honest schema and the other half as a deceptive schema, in Embedded-Cue, each individual participant responded 100% honestly or 100% deceptively to a particular item. Counterbalancing across participants ensured that each sentence was associated to honesty and deception with equal frequency, but this equality occurred across participants instead of within.

Data analyses

Data analyses were similar to Semantic-Relatedness.

Results

Data screening

For reading time and response time analyses, I eliminated all inaccurate responses, which resulted in an elimination of 5.29% of the data. I calculated means and standard deviation for each participant based on the accurate trials. Response times and reading times that were less than 300 ms or 2.5 SDs away from the participant's mean were replaced with their grand mean for that dependent variable. For response times, 2.84% of the data were replaced and for reading times, 2.71% of the data were replaced.

Sentence reading time

I conducted a 2 X 2 X 2 repeated-measures ANOVA, examining the effect of schema (honesty vs. deception), truth-value (true vs false), and cloze (low vs. high) on reading time. There were significant main effects of schema, $F(1,35)=19.06$, $p<0.0001$, $\eta^2=0.35$ truth-value, $F(1,35)=13.85$, $p=0.001$, $\eta^2=0.28$, and cloze $F(1,35)=7.07$, $p=0.011$, $\eta^2=0.17$. There was an interaction between schema and truth-value $F(1,35)=7.82$,

p=0.0083, η^2=0.18. All other effects and interactions were insignificant, Fs<1. The effect sizes of schema, truth-value, cloze, and the interaction between schema and truth-value were all large. Reading times for sentences containing embedded schema cues varied according to cloze probability for both schemas, but truth-value only exerted an effect on honest-schemas (Figure 3.6).

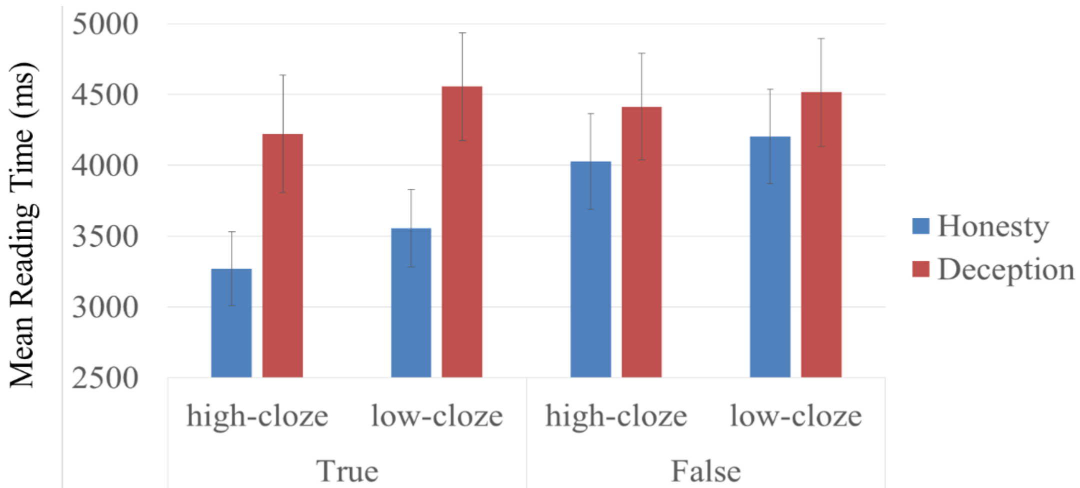

Figure 3.6: Embedded-Cue reading time results. Honest-schemas were influenced by cloze-probability and truth-value but deceptive-schemas were only influenced by cloze-probability. Honest-schemas were consistently faster than deceptive schemas.

The main effect of schema revealed that honest schemas elicited faster reading time than deceptive schemas (M=3836 ms, SD=1721 ms vs. M=4508 ms, SD=2299 ms). The main effect of truth-value revealed that true sentences were read more quickly than false sentences (M=3984 ms, SD=1870 ms vs. M=4360 ms, SD=2124 ms). The main effect of cloze revealed that high-cloze sentences were read more quickly than low-cloze sentences (M=4274 ms, SD=1972 ms vs. M=4070 ms, SD=2010 ms).

Simple main effects contrasts were conducted in order to examine the effect of truth-value across schemas. These tests revealed that under an honest schema, truth-value significantly influenced reading times $F(1,35)$=18.57, p=0.0001, η^2 = 0.35, such that true sentences were read more quickly than false sentences (*M*=3467 ms, *SD*=1518 ms vs. *M*=4206 ms, *SD*=2037 ms). Contrarily, under a deceptive schema, there was no effect of truth-value on reading times, $F<1$.

To further understand the interaction, simple main effects were conducted to examine the effect of schema across truth-values. When participants read true sentences, schema significantly influenced response times $F(1,35)=17.09$, $p<0.0001$, $\eta^2 = 0.328$, such that honesty elicited faster reading times than deception (*M*=3467 ms, *SD*=1518 ms vs. *M*=4502 ms, *SD*=2411 ms). When participants read false sentences, schema significantly influenced reading times $F(1,35)=5.16$, $p=0.029$, $\eta^2 = 0.13$, such that honesty elicited faster reading times than deception (*M*=4206 ms, *SD*=2037 ms vs. *M*=4514 ms, *SD*=2282 ms). Therefore, the source of the interaction between schema and truth-value is that truth-value influenced reading times when participants intended to be honest, but not when they intended to be deceptive, which means that honesty and deception are most easily distinguished under true sentences because false sentences shrink the difference between honesty and deception by increasing the reading time of honesty without influencing reading time of deception.

To identify how these effects influenced the detectability of deception, one-paired t-tests were conducted to examine the difference between honest and deceptive schemas across all sentence types. These tests revealed that honest schemas elicited significantly faster reading times than deceptive schemas at the level of low-cloze true sentences (*M*=3619 ms, *SD*=1560 ms vs. *M*=4665 ms, *SD*=2551 ms), $t(35)= -3.14$, $p=0.001$, $d= -0.62$, high-cloze true sentences (*M*=3314 ms, *SD*=1647 ms vs. *M*=4446 ms, *SD*=2483 ms), $t(35)= -4.51$, $p<0.0001$, $d= -0.91$, low-cloze false sentences (*M*=4294 ms, *SD*=2122 ms vs. *M*=4630 ms, *SD*=2375 ms), *t*(35)= -2.02, *p*=0.025, *d*=0.40, and at a trending significant level for high-cloze false sentences (*M*=4118 ms, *SD*=2067 ms vs. *M*=4492 ms, *SD*=2353 ms), *t*(35)= -1.62, *p*=0.057, *d*=0.31.

Individual differences

The lmer analysis replicated the overall findings from the ANOVA analysis, such that true sentences were read more quickly than false sentences (β=0.18, *t*=7.36, *p*<0.001), honest responses were faster than deceptive responses (β=0.21, *t*=7.49, *p*<0.001), and as the interaction coefficient for truth-value:Schema is negative (β=-0.15, *t*=6.02, *p*<0.001) and the main effect coefficients are positive, the difference between true and false sentences is much smaller when participants intended to respond deceptively than when they intended to respond honestly. As expected, numeric value of trial reduced response times, such that as participants became more experienced with the paradigm, they made faster responses (β=-0.10, *t*=-5.60, *p*<0.001).

Table 3.1: LMER analysis of reading time in Embedded-Cue, as predicted by truth-value, schema, and individual differences in CFQ

	B	CI	*t*	*p*
(Intercept)	7.95	7.82 – 8.08	123.6	<.001
Trial	-0.27	-0.33 – -0.20	-7.86	**<.001**
Truth-Value (true vs. false)	0.18	0.13 – 0.23	7.36	**<.001**
Schema (honest vs. deception)	0.21	0.16 – 0.27	7.49	**<.001**
CFQ	0.04	-0.07 – 0.15	0.66	0.517
Truth-Value x Intention	-0.15	-0.20 – -0.10	-6.02	**<.001**
Truth-Value x CFQ	0.02	-0.02 – 0.05	0.84	0.392
Schema x CFQ	-0.01	-0.06 – 0.05	-0.21	0.853
Truth-Value x Schema x CFQ	-0.07	-0.12 – -0.02	-2.67	**0.006**

There was no main effect of CFQ nor was there an interaction between CFQ and schema or between CFQ and truth-value, but there was a significant three-way interaction

(β=-0.07, t=-2.67, p=0.006). The lack of a main effect of CFQ or an interaction with other main effects reveals that CFQ did not overtly influence reading time specifically of any specific condition. Instead, it influenced the relationship between other conditions. As seen in Figure 3.7, when those with lower rate of cognitive-failures adopted a deceptive schema, they were more likely to read true sentences faster than false sentences whereas those who reported higher rates of cognitive failures were more likely to read false sentences faster than true sentences.

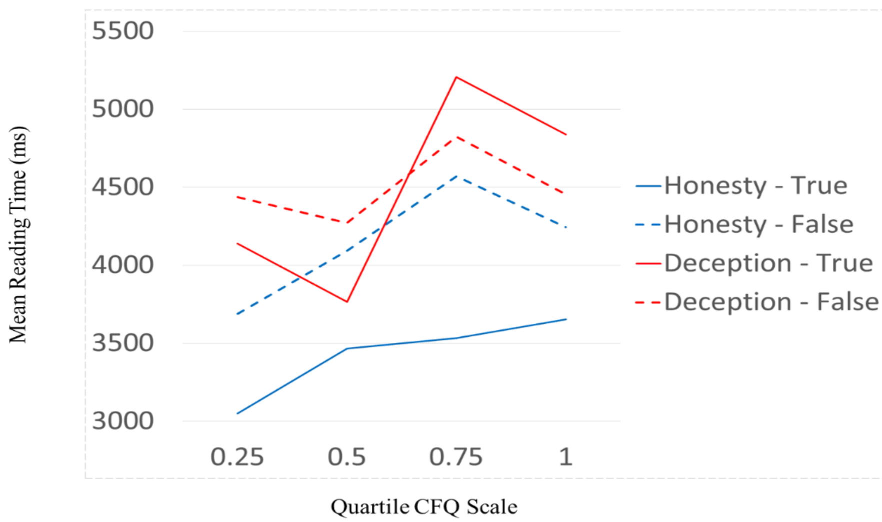

Figure 3.7: LMER analysis of reading time in Embedded-Cue predicted by truth-value, schema, and individual differences in CFQ.

Probe response time

I conducted a 2 X 2 X 2 repeated-measures ANOVA, examining the effect of schema (honesty vs. deception), truth-value (true vs false), and cloze (low vs. high) on response time. There were main effects of schema $F(1,35)=15.86$, $p<0.0001$, $\eta^2=0.31$ and truth-value $F(1,35)=8.12$, $p=0.0073$, $\eta^2=0.188$. These effects were subject to an interaction between schema and truth-value $F(1,35)=23.32$, $p<0.0001$, $\eta^2=0.40$. All other effects and interactions were insignificant, *F*s<1.5. The effect sizes of schema, truth-value, and the interaction between schema and truth-value were all large.

Simple main effects contrasts were conducted in order to identify the source of the interaction between schema and truth-value. These tests revealed that under an honest schema, truth-value significantly influenced response times $F(1,35)=34.08$, $p<0.0001$, $\eta^2=0.493$, such that true sentences elicited faster responses than false sentences (M=706 ms, SD=181 ms vs. M=807 ms, SD=181 ms). Under a deceptive schema, the effect of truth-value influenced response times at a trending significant level $F(1,35)=3.69$, $p=0.063$, $\eta^2 = 0.10$, such that false sentences elicited faster responses than true sentences (M=789 ms, SD=244 ms vs. M=821 ms, SD=206 ms). Given that Linguistic-Expectancy suggested true sentences delayed deceptive responses, I conducted a one-tailed t-test to evaluate significance level in a more hypothesis-driven manner, and the test revealed that true sentences elicited significantly slower deceptive response times than false sentences $t(35)=-1.81$, $p=0.039$, $d=0.47$.

To further understand the interaction, simple main effect contrasts were conducted to examine the effect of schema across the truth-values. These tests revealed that when participants responded to a true sentence, schema significantly influenced response times $F(1,35)=57.05$, $p<0.0001$, $\eta^2 = 0.62$, such that honest responses were faster than deceptive responses (M=691 ms, SD=174 ms vs. M=821 ms, SD=206 ms). However, when responding to a false sentence, the effect of schema was not significant, $F<1$. Only true sentences were capable of eliciting significant differences between honest and deceptive responses, as seen in Figure 3.8

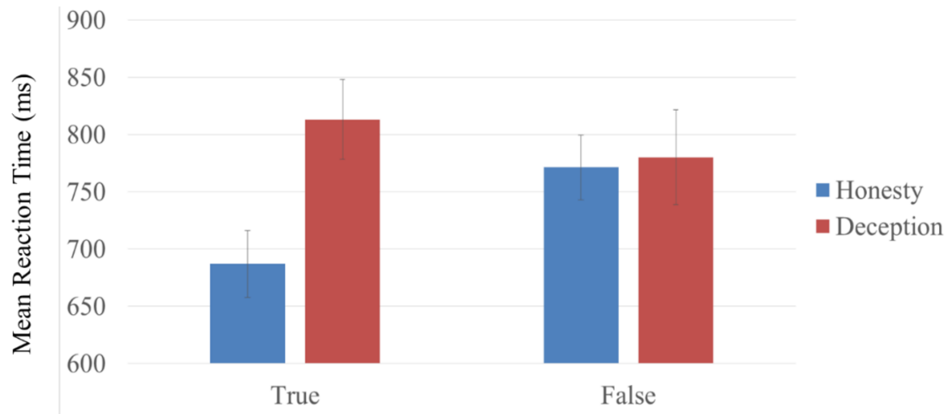

Figure 3.8: Embedded-Cue response time results. Honest-responses are faster than deceptive responses only at the level of true sentences.

Overall, these effects replicated prior effects, revealing that true sentences elicited the largest differences between honesty and deception while false sentences did not elicit significant differences. Furthermore, this study replicated the effect of truth-value on schema in response times, such that relative to false sentences, true sentences facilitated honest responses while they interfered with deceptive responses.

Individual difference analysis

The lmer analysis replicated the overall findings from the ANOVA analysis, such that true sentences elicited faster responses than false sentences (β=0.14, t=10.27, p<0.001), honest responses were faster than deceptive responses (β=0.18, t=8.69, p<0.001), and as the interaction coefficient for truth-value:Schema (β=-0.20, t=10.38, p<0.001) is both negative and larger than either of the positive main effect coefficients, deceptive responses to false sentences are faster than deceptive responses to true sentences. As expected, numeric value of trial reduced response times, such that as participants became more experienced with the paradigm, they made faster responses (β=-0.10, t=-5.60, p<0.001).

Table 3.4: LMER analysis of response time in Embedded-Cue, as predicted by truth-value, schema, and individual differences in CFQ

	log(Response Time)			
	β	CI	*t*	*p*
(Intercept)	6.45	6.39 – 6.51	203.43	<.001
Trial	-0.10	-0.13 – -0.06	-5.60	<.001
Truth-Value (true vs. false)	0.14	0.11 – 0.16	10.27	<.001
Schema (honest vs. deception)	0.18	0.14 – 0.22	8.69	<.001
CFQ	0.14	0.08 – 0.20	4.64	<.001
Truth-Value x Intention	-0.20	-0.24 – -0.16	-10.38	<.001
Truth-Value x CFQ	-0.02	-0.05 – 0.00	-1.74	0.081
Schema x CFQ	0.02	-0.02 – 0.05	0.79	0.446
Truth-Value x Schema x CFQ	0.05	0.02 – 0.09	2.83	0.005

Individual differences in CFQ had a positive effect on response time, such that those who reported lower levels of cognitive failures elicited faster responses than those who reported higher levels of cognitive failures (β=-0.14, t=4.64, p<0.001). There was a trending interaction between truth-value and CFQ, such that there was a greater difference between true and false sentences at lower levels of CFQ relative to higher levels of CFQ (β=-0.02, t=1.74, p=0.081). However, the three-way interaction revealed that the effect of CFQ on truth-value differed across honest and deceptive responses (β=0.05, t=2.83, p=0.005).

As depicted in Figure 3.9, honest responses to true sentences were faster than to false sentences, but a trending significant two-way interaction suggests that this difference was larger at lower rates of cognitive failures. The three-way interaction reveals that CFQ did not alter the difference between honest and deceptive responses at the level of true sentences (solid lines in Figure 3.9), but CFQ did alter the difference between honest and deceptive responses at the level of false sentences (dashed lines in

Figure 3.9). At lower levels of CFQ, honest and deceptive responses to false sentences were relatively similar whereas at higher levels of CFQ, there was a marked difference. The cause of this difference is that CFQ delayed deceptive responses to false sentences to a greater extent than it did honest responses to false sentences, which had the dual effect of making deceptive responses to false sentences slower than honest responses to false sentences as well as removing the significant differences between deceptive responses to true and false sentences that was evident at lower levels of CFQ. In sum, CFQ moderated the effect of truth-value on response times, with the effect of truth-value on honest responses being more resilient than the effect of truth-value on deceptive responses.

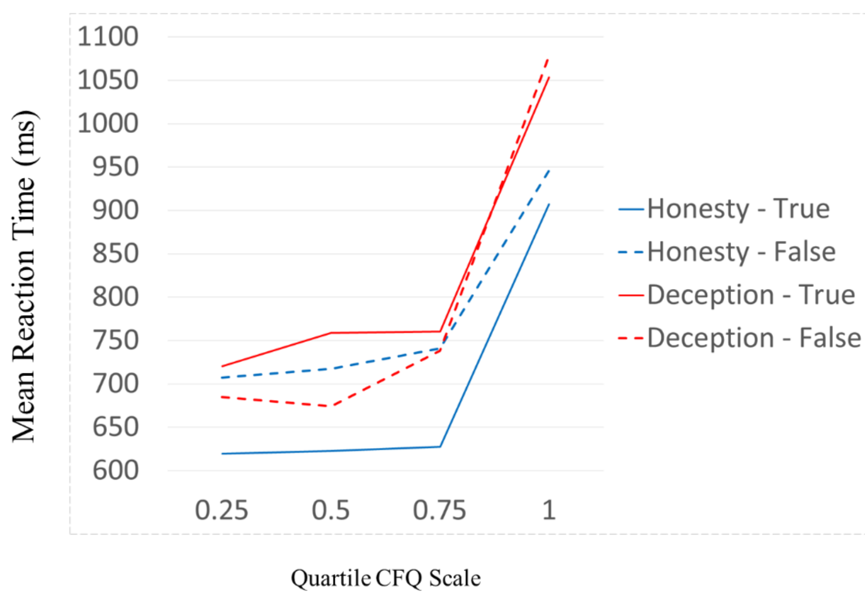

Figure 3.9: LMER analysis of response time in Embedded-Cue predicted by truth-value, schema, and individual differences in CFQ predicting reading time

Discussion

Review of reading and response time results

Honest-schemas within Embedded-Cue replicated the reading time effects observed in Linguistic-Expectancy: true sentences were read faster than false sentences, high-cloze sentences were read faster than low-cloze sentences, true sentences elicited faster responses than false sentences, and cloze-probability did not influence response time. These findings suggest that monitoring for an embedded-cue did not introduce an additive factor onto sentence-evaluation relative to monitoring for a perceptual-cue. Contrarily, deceptive-schemas in Embedded-Cue elicited different reading time patterns as those observed in Linguistic-Expectancy. Although the null effect of truth-value on reading time of deceptive-schemas was replicated across both experiments, the effect of cloze-probability differed across experiments. Whereas Linguistic-Expectancy only elicited an effect of cloze-probability for reading time under honest-schemas, the Embedded-Cue revealed a main effect of cloze-probability on reading time for both honest and deceptive-schemas In summary, when participants monitored for a color-cue, there was no effect of sentence-content, either through cloze-probability or truth-value whereas when participants monitored for an embedded-cue, cloze-probability facilitated reading time while truth-value replicated color-cues and elicited null effects.

Following sentence-evaluation, response time patterns for honest and deceptive schemas followed a similar pattern as previously observed: Honest responses to true sentences were faster than honest responses to false sentences whereas deceptive responses showed the opposite pattern, such that deceptive responses to false sentences were faster than deceptive responses to true sentences. Response times were similar for honesty and deception when responding to a false sentence, but honest-responses were significantly faster than deceptive-responses when responding to a true sentence. This response pattern is similar to that observed in Linguistic-Expectancy, such that the largest difference between honest and deceptive responses is observed in true sentences.

Effect of cognitive-failures on reading time

The ID analysis of response times revealed that CFQ did not drastically alter the results of the ANOVA conducted on reading times, but it did explain how cognitive failures influenced the interactive relationship between truth-value and schema. The individual differences analysis revealed that CFQ did not overtly predict reading time of any individual condition, but it did predict the relationship between reading time of true and false sentences when participants held a deceptive schema. As depicted in Figure 3.7, CFQ did not predict reading time for honest-schemas. However, under a deceptive schema, lower rates of cognitive failures predicted shorter reading times for true sentences than false sentences, but this pattern reversed as rate of cognitive-failures increased, such that higher rates of cognitive failures predicted shorter reading times for false sentences relative to true sentences.

Effect of cognitive-failures on response time

The main interpretations to take away from this analysis are: 1) Effects of truth-value were predominantly observable only at lower rates of cognitive failures, and 2) effects of schema were far more extensive at higher rates of cognitive failures than at lower rates of cognitive failures. More specifically, the ANOVA analysis revealed longer response times for deceptive responses to true sentences than to false sentences and it also revealed similar response-times between honest and deceptive responses to false sentences. The analysis examining rate of cognitive-failures revealed that both of these effects were only observed at lower rates of cognitive failures, whereas at higher rates of cognitive-failures, the primary effect was a larger difference between honest and deceptive responses.

Binding-suppression

The Binding-Suppression Model predicts that when one intends to deceive, all forms of implicit semantic activation are preemptively suppressed, but it appears that the accessibility of some forms of semantic information is contingent on the nature of the deceptive-schema. The null effect of truth-value corroborates the prediction that deception suppresses preferential access of entrenched concepts, suggesting that the embedded-cue altered the accessibility of more transient semantic associations that are relevant to incremental sentence evaluation processes. I argue that in Embedded-Cue, cloze-probability informed the suppression process of the embedded cue, thus influencing the time course of initiating suppression of irrelevant task-instructions.

Expectation

Truth-value likely influences the suppression process for the same reason as cloze-probability does; surprisal. But, truth-value also denotes the end of a sentence, and signals the reader to determine the truth-value and encode it into a STM buffer. During this process, any existing bindings between the STM representation and LTM are fully expunged in order to reduce interference between world-knowledge and effective deception. This expunging process may be unique to deception. If a true concept is retrieved, liars must update the true concept into a false one and if a false concept is retrieved, liars must update the false concept into a true one. In deception, no concepts are entrenched. They're all constructed in the moment for the moment.

Dual task: Goal-monitoring vs. word-recognition

Linguistic-Expectancy involves different cognitive requirements as Embedded-Cue. The former involves an omnipresent perceptual cue and the latter involves a categorical-cue that required active maintenance and effective encoding into the STM buffer. Unlike Linguistic-Expectancy and the other studies, participants needed to conduct some form of maintenance rehearsal in order to maintain the subject-cue, while simultaneously, they also needed to construct and maintain sentence truth-value in order to appropriate evaluate and then respond to the probe. Most importantly, these operations must be conducted in a contingent fashion, such that schema-disambiguation (honesty or deception) informed the response-generation computation (i.e. agree or disagree). In Embedded-Cue, the locus of goal-monitoring (i.e. deceptive-signal detection) and sentence-evaluation converged into shared stimulus-features, increasing the likelihood that the limited-capacity resources of STM would be overloaded relative to prior studies. Below, I describe how this disruption effect is captured in the cognitive-failures analysis.

Cognitive failures and deception

I argue that the null effect of cognitive-failure rate on honest-schemas replicates prior deception research that honesty does not require extensive goal-monitoring as well as prior cognitive research that cognitive-failure rate does not predict task performance when goal-monitoring is not necessary (Broadbent, Cooper, FitzGerald, & Parkes, 1982). However, under deceptive-schemas, cognitive-failure rate reversed the effect of truth-value on reading time. The Binding-Suppression Model predicts deceptive-schemas suppress implicit semantic activation. Below, I describe how rate of cognitive failures is particularly relevant to efficacy of deceptive-schemas in the Embedded-Cue.

First, without implicit semantic activation, all search/retrieval/maintenance processes require active effort and entrenchment has no facilitative effect. Second, the rate of cognitive failures was only relevant for Embedded-Cue, so the extra maintenance requirements relative to the other experiments may explain the role of cognitive-failures. In Embedded-Cue, sentence-evaluation required active maintenance of the schema-cue, meaning that participants needed to integrate S-V-O words into a holistic unit, while simultaneously maintaining the subject-noun and how it relates to the deceptive-signal. Third, lower rates of cognitive failures predict greater effectiveness in directing retrieval resources as well maintaining relevant content in the face of interference. In sum, the Embedded-Cue required participants to conduct two distinct operations in order to successfully perform this task, and rate of cognitive-failures likely predicted disruptions in effective goal-monitoring, such that the necessary information was effectively maintained and appropriately operated on.

Under a deceptive-schema, lower rates of cognitive-failures predicted an entrenchment benefit (i.e. Reading times: true < false). Unlike true sentences, false sentences do not reflect world knowledge, meaning that false sentences require less binding-suppression of LTM than true sentences. If lower rates of cognitive-failures reduce likelihood of disruptions, then perhaps as cognitive-disruptions become more likely, sentences that require the greatest amount of cognitive-focus (deceptive-schemas evaluating true sentences) are most likely to experience delays following a disruption. The additional requirements of re-engaging binding-suppression in order to properly execute a deceptive-schema will delay sentence reading time of true sentences relative to false sentences.

As rate of cognitive failures increased, the rate of disruptions for explicit memory search/retrieval likely increased, which required restarting cognitive operations. The deceptive-signal would likely need to be checked again, which will delay sentence-evaluation. Comparative, a lower rate of cognitive failures improves goal-monitoring efficacy. It's important to note that cognitive-failure rate did not predict reading time of either true sentences or false sentences, and the ANOVA analysis revealed no differences between true and false sentences. The contribution of cognitive-failure rate is that it organized the reading time of true and false sentences, with lower rates predicting that true sentences will be read more quickly than false sentences, which gradually reversed as cognitive-failure rate increased. In summary, cognitive-failure rate did not change the outcome of the ANOVA results, but it did suggest that cognitive failure rate altered sentence evaluation strategies when participants intended to respond deceptively.

Higher rates of cognitive failure predicted slower response times across all conditions, but they were especially predictive of response time differences for deceptive-responses to false sentences. I argue that lower rates of cognitive failures were associated with greater efficacy at maintaining content that was relevant for task-performance (i.e. the embedded cue and the truth-value), as evidenced by the constant positive relationship between cognitive-failure rate and response time. Lower rates of cognitive-failures predicted faster deceptive-responses to false sentences than to true sentences because false sentences required less binding-suppression than true sentences. In order to deceptively respond to a true sentence, LTM binding must be suppressed, and failure to do so necessarily increases the response-time floor carrying out a deceptive-schema.

Automaticity vs controlled processes

This finding coheres with the long-held theory that entrenchment increases the likelihood that motor plans will activate automatically following stimulus-processing with little explicit effort necessary (Ericsson & Kintsch, 1995; Norman & Shallice, 1986; Schneider & Shiffrin, 1977). In situations where these implicit plans must be inhibited, there is a limitation to the degree to which the prepotent response can be prevented from informing current responses (Kane, Bleckley, Conway, & Engle, 2001). Entrenched concepts are necessarily more resistant to change than novel concepts, therefore, when one chooses to lie regarding an entrenched concept, the liar will need to actively suppress the prepotent response to a greater extent than when one chooses to lie about a novel concept.

Chapter 4 GENERAL DISCUSSION

Binding-suppression and information schema

There are four overall patterns that are consistent across all three studies: First, honest schemas elicited similar reading and response patterns as would be expected by the psycholinguistic literature (Morris, 2006; Almor & Sloman, 2000). Second, following the adoption of a deceptive-schema, sentence-evaluation processes were not informed by LTM structures. Third, deceptive-schemas tend to encounter slightly greater interference when the lie-response refers to an entrenched concept instead of a novel concept. Fourth, honest schemas elicited consistently faster reading times than deceptive-schemas, but honest-responses were only consistently faster than deceptive-responses when referring to a true sentence. Taken together, it appears that the single greatest predictor of deception detection was the degree of cognitive-load that was induced under honest-schemas, because in comparison to honest-schemas, there was very little effect of the manipulations on deceptive behaviors.

The results of this dissertation suggest that binding-suppression involves two stages: 1) Construct a STM buffer that is quarantined from LTM concepts and 2) ensure that quarantine is maintained until such time as the buffer is no longer necessary for the task at hand. Given that binding-suppression relies on a mechanism capable of maintaining STM representations that contradict world-knowledge, it is necessary to propose the nature a storage unit. As of now, the theorized cognitive component most relevant to this component is the episodic buffer from Baddeley & Hitch's Model of

Working Memory (Baddeley, 2000). By encoding into this transient storage unit, STM can be quarantined away the LTM-concepts from which its representation came from.

Interference theory: Entrenchment facilitates honesty and impairs deception

Since its inception, the memory literature has reliably observed that introducing novel information into entrenched memory structures creates interference because that newly revised memory structure now contains incongruent associations (McGeoch & Irion, 1952; Anderson, 2003). I propose that interference theory cogently explains why entrenched-concepts facilitated honest responses but interfered with deceptive-responses.

Deeply entrenched concepts are sufficiently rooted into LTM structures that other concepts within LTM are contingent on their validity (Shipley, 1993). If the concept *Chickens lay eggs* were evaluated as false, and then encoded back into LTM, that could have far-reaching effects, undermining concepts related to chickens, birds, and eggs. Comparatively, *Chickens guard rocks* has little relation to LTM knowledge structures. Entrenched concepts require comparatively more binding-suppression, which is necessary to prevent: 1) LTM from redirecting the deceptive-schema back to the truth and 2) ensuring that LTM remains stable and coherent after deception is successfully executed. In summary, it appears that the latent capacity for a stimulus to trigger spreading-activation may be directly related to the degree of binding-suppression required to deceptively respond to it.

Binding-suppression is necessary to quarantine STM representations from the LTM structures. If binding-suppression were prematurely released, then semantic-memory could seep into the deceptive-schema, introducing interference into the STM representations and/or the organizational structure of semantic-memory. Based on the attentional literature, the longer one is required to maintain a rigid mental state, the more likely it is for attention to wax and wane, and cause the mental set to briefly fail. If binding-suppression fails, then semantic memory may interact and thusly interfere with the deceptive-schema. In the next section, I discuss how cognitive-failure rate speaks to this transient effort to maintain binding-suppression.

Individual differences

The CFQ is not linked to standard capacity measures of cognitive functioning, such as visual/verbal working memory, conceptual short term memory, delayed recall (Broadbent, Cooper, FitzGerald, & Parkes, 1982), response-conflict via Stroop, focused attention via dichotic listening, or visual search via the embedded figures task (Martin, 1983), nor has it been linked to intrusions from either misinformation (Jaschinski & Wentura, 2002) or salient distractors (Borella, Carretti, & De Beni, 2008).

The CFQ has been linked to response-distractor inhibition (Friedman & Miyake, 2004), as evidenced by correlations between the CFQ and tasks which require active suppression of distracting/irrelevant information from activating response processes (Groome & Grant, 2005; Tipper & Baylis, 1987). One reason for the null relationships between the CFQ and inhibitory tasks such as the Stroop is that the CFQ has been linked to cognitive dissociation, which reflects one's predisposition to self-disrupt ongoing cognitive processes with no external cause (Bruce, Ray, & Carlson, 2007).

Possible explanations for this self-disruption is that CFQ may reflect one's capacity to reliably monitor their behavior, ensuring their actions are directed towards accomplishing top-down goals (Garavan, Hester, Murphy, Fassbender, & Kelly, 2006), as evidenced by the positive correlation between CFQ score and involuntary intrusion of thoughts that are unrelated to the task at hand (Verwoerd & Wessel, 2007; Smallwood, et al., 2004). In order to effectively deceive, binding-suppression must be restored and the conflicting information removed.

Regardless of the cause, it is evident that the CFQ measures one's capacity to maintain a consistent link between cognitive processes and the external environment so as to elicit behaviors that successfully accomplish top-down goals (Bridger, Johnsen, & Brasher, 2013). Due to the unpredictable nature of when/why cognitive failures manifest themselves and disrupt ongoing cognitive processes, the CFQ predicts performance specifically when participants need to maintain an active control over their thoughts over a period of time (Steinborn, Langner, Flehmig, & Huestegge, 2016). Tasks such as the Stroop and the Hayling examine response-inhibition in a more immediate fashion, with minimal requirements to maintain suppression over a period of time.

Sentence-evaluation involves the incremental integration of each word into the preceding context. This incrementally constructed proposition is encoded into STM and evaluated against organized concepts within LTM. Under an honest-schema, the distance between the proposition and LTM concepts predicts the processing requirements of sentence-evaluation, as evidenced by the effect of linguistic certainty and conceptual entrenchment. Deceptive-schemas are not influenced by these factors.

Successful inhibition of semantic memory during deception likely elicits two vital effects: 1) Prevents knowledge structures from interfering with the construction and deployment of a deceptive response and 2) protects the integrity of knowledge structures by quarantining the lie from semantic memory, ensuring that it is not encoded during reconsolidation. By inhibiting semantic association, the lie can be created and quarantined to this unique context without fear of it generalizing to general knowledge. Failure to engage this inhibitory control may be relevant to the phenomenon known as malingering, which refers to the decision to engage in a long-term deception, such as a medical diagnosis, for some form of social benefit (Merckelbach & Merten, 2012).

Over time, the content of one's deceptions can infect autobiographical memory, as individuals begin to alter their memories in order to accommodate the content of the lies (Festinger, 1962). Neuroimaging evidence supports this argument as brain activity of malingering patients reflects a population distribution, which ranges from those who resemble deceptive participants to those who resemble honest participants (Langleben, Dattilio, & Guthei, 2006). Perhaps binding-suppression requires active intentionality not only to ensure effective deception, but also to protect the integrity of the liar's personal memories intact. Over, binding-suppression may erode, and the deceptive-schema may become erroneously encoded into LTM. If so, then the Binding-Suppression Model predicts that the degree to which a deceptive response can be consciously constructed on the basis of top-down goals correlates with the subsequent integrity of knowledge structures after successful deployment of the lie.

Alternative explanations

It is possible that maintaining a deceptive schema necessarily shifts attentional processes into an exhaustive search instead of a self-terminating search. It has long been suggested that lexical access is exhaustive when the stimulus corresponds to a nonexistent concept (Forster & Bednall, 1976). Given that false sentences elicited similar response times across honesty and deception, and deceptive responses were much more similar across true and false sentences than those sentences types were in honesty, it is possible that when one intends to be deceptive, they necessarily elicit exhaustive searches regardless of whether they activated a meaning at an earlier point. If so, then the fact that deceptive responses were more delayed to true sentences than honest responses could be due to a difference in search termination criteria instead of anything to do with the suppression of LTM associations.

Another possibility that deceptive schemas are particularly taxing on the phonological loop. Prior research has showed that phonological suppression impairs task-performance that require goal-monitoring, regardless of the cognitive-load induced by task-demands (Saeki & Saito, 2004). Phonological resources are necessary in order to ensure all behaviors are goal-driven instead of stimulus-driven (Miyake, Emerson, Padilla, & Ahn, 2004) especially when that goal requires preventing habitual responding from influencing response selection (Saeki, Baddeley, Hitch, & Saito, 2013). If deceptive-schemas deplete phonological resources, then these findings can be explained by limited-capacity theories of STM. With phonological resources being directed to organize all behavior in a goal-oriented fashion, the role of stimulus-based effects will be minimized, and overall effort required to read and respond will also be increased.

Study limitations

Clinical implications

The current results suggest that honesty and deception differ in terms of what constitutes "cognitive-load." Therefore, I argue that instead of trying to induce cognitive-load on liars, clinicians may be more successful in detecting deception may by minimizing cognitive-load as much as possible. Such a procedure will then allow honest-schemas to proceed unencumbered whereas deceptive-schemas will still exhibit the cognitive-load brought on by deception. Because we know that deception is already difficult, introducing any cognitive-load onto honest-schemas may be counter-productive. If the field decides examine cognitive-effort as being an indicator of deception, then the environment should be controlled as much as possible in order to minimize the possibility that honesty will exhibit signs of cognitive-load. Then, when a suspect indicated signs of cognitive-load, the protocol will have heavily reduced the possibility that an honest-schema is eliciting those signatures. Therefore, I argue that minimizing cognitive-load will enhance the differences in cognitive-effort between honesty and deception.

Future directions

Specifics of binding-suppression

I've proposed that human cognition can construct a STM-buffer capable of maintaining representations which contradict LTM concepts. The buffer is quarantined from the LTM concepts from which the representations were based. Currently, the nature of this quarantine is unspecified, as the current data provide no predictions regarding how the cognitive system restores LTM bindings upon executing a deceptive-response. I propose a follow-up study that replicates the majority of methods from Embedded-Cue, but introduces a task-switching component: schema x subject x truth-value.

Schema-Switch:	Honesty-Repeat	Honesty-Switch
	Deception-Repeat	Deception-Switch
Knowledge:switch	Subject-Repeat	Subject-Switch
	Truth-value- Repeat	Truth-value- Switch

After having suppressed bindings related to *Chickens*, how accessible are those bindings if participants had to immediately deceive about them again vs. if they had to immediately respond honestly to those same bindings. If deceptive-schemas literally do suppress specifically the LTM concepts necessary for the deceptive-response, then there should be a particularly large switch-cost when participants are required to switch from deception to honesty on the same concept. Contrarily, there will be probably be a benefit when participants switch honesty to deception with the same category, as it is already within STM, thus binding-suppression can be more rapidly initiated.

Relation of deception and working memory models

In order to determine if deception shares capacity-limited resources with phonological representations, I plan to manipulate the phonological demands of the sentences (e.g. 3 words vs. 5 words | true vs. false sentences). By separating the subject, which signals response-intention, from the object, which signals truth-value following integration with preceding context, I can examine the role of phonological demands on the act of monitoring for deception vs. the act of deception itself.

If phonological demands elicit a main effect on reading time, that suggests that goal-monitoring for deception is dependent phonological resources, regardless of whether or not one eventually decides to deceive. If phonological demands interact with intention, such that deception incurs a larger cost than honesty during high phonological demands, then that suggests the preparation to deceive requires phonological resources. Finally, if truth-value interacts with these effects, that will inform how deceptive schemas alter the process of chunking distinct phonological representations into a single meaningful chunk.

Self-paced reading task

In order to better understand the incremental process of binding-suppression, I propose that Embedded-Cue study be replicated with a self-paced reading task. If binding-suppression nullifies LTM from the outset, there should be a diminished effect of cloze-probability both at the verb and at the noun. However, if binding is only suppressed at final integration processes, then cloze-probability should influence verb reading times.

Effort required to maintain episodic buffer

In order to determine if deception requires an active suppression of LTM bindings from the STM truth-value, I plan to examine if the duration of the delay between sentence and probe will influence response time. If an active suppression is required in order to deceive, then lengthening the delay should increase the effort required to maintain binding-suppression of the STM buffer, lengthening response times and increasing errors.

Conclusion

The present studies reveal that within the confines of a deception paradigm, the manifestations of honest behavior replicate basic cognitive psychology findings relating to incremental adjustments of linguistic certainty during sentence processing (Frank, 2013) as well as the role of entrenched concepts in declarative knowledge during sentence binding and explicit truth-value evaluation (Smith, Shoben, & Rips, 1974). Linguistic certainty reduces the amount of processing time required to understand and evaluate a sentence, but following the binding of a sentence into a holistic unit of meaning, the semantic representation of a sentence is more relevant than the specific lexical forms that comprise it (Christiansen & Chater, 2016). However, the adoption of a deceptive-schema appears to alter basic cognitive processes relating to evaluating sentences and generating responses in relation to those sentences. Deception appears to suppress implicit semantic activation during these processes, but the effort of this suppression is taxing. In order to suppress semantic memory, and construct STM representation that contradict world-knowledge, the effort involved in deploying a deceptive response is related to the strength of the contradicted memory. In summary, I argue that deception is a cognitive process just like any other, and therefore, it is prone to behavioral conflict just like any other process (e.g. interference, decay), but it’s possible that the rules which govern the manifestation of behavioral conflict in honesty may not be generalizable to behavioral conflict in deception.

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APPENDIX A: LINGUISTIC-EXPECTANCY STIMULI

Subject Category: Humans						
Item	Subject	Verb	True	Semantic	Syntactic	False
1	Archers	shoot	arrows	bullets	drugs	sandals
2	Architects	design	houses	closets	weddings	suits
3	Astronomers	study	stars	law	soccer	smiles
4	Attorneys	meet	clients	prisoners	dates	poems
5	Babysitters	watch	toddlers	parents	sunsets	music
6	Barbers	cut	hair	wigs	steak	waves
7	Bartenders	mix	drinks	cakes	speeches	lakes
8	Brokers	pick	stocks	songs	apples	phantoms
9	Caterers	prepare	meals	bacteria	lessons	baths
10	Chefs	cook	pancakes	pears	wax	storms
11	Coaches	train	athletes	soldiers	computers	gates
12	Cowboys	ride	horses	camels	bicycles	peacocks
13	Dancers	perform	waltzes	concerts	karate	journals
14	Doctors	diagnose	patients	strangers	engines	meadows
15	Farmers	raise	cows	pests	taxes	roads
16	Gardeners	plant	flowers	weeds	flags	clothes
17	Hunters	track	ducks	termites	expenses	paper
18	Janitors	clean	rooms	shoes	consciences	tape
19	Knights	rescue	princesses	villains	firefighters	aluminum
20	Lifeguards	protect	kids	sharks	cattle	books
21	Mechanics	fix	cars	toys	marriages	daylight
22	Novelists	write	books	music	laws	beads
23	Parents	lecture	children	pilots	audiences	vehicles
24	Plumbers	repair	faucets	trucks	skin	spoons
25	Postmen	deliver	mail	food	babies	oil
26	Runners	carry	liquid	tea	poison	keys
27	Sailors	chart	courses	highways	sales	stoves
28	Shepherds	herd	sheep	bison	riots	motorcycles
29	Students	attend	lectures	funerals	physicians	wicker
30	Teachers	instruct	students	principals	monkeys	cameras
31	Therapists	treat	depression	measles	movies	darkness

32	Vampires	drink	blood	soda	bottles	coral

Subject Category: Animals

Item	Subject	Verb	True	Semantic	Syntactic	False
1	Apes	peel	bananas	elephants	paste	lakes
2	Bears	catch	fish	streams	colds	dye
3	Beavers	gnaw	wood	sand	pencils	shrimp
4	Buffalo	roam	plains	deserts	hallways	wires
5	Cats	chase	mice	cages	deserts	moss
6	Cows	produce	milk	honey	art	rays
7	Crows	collect	string	pollen	stamps	cement
8	Dogs	chew	bones	glasses	gum	lemonade
9	Ducks	fly	south	underwater	packages	underground
10	Eagles	build	nests	dams	bridges	carpets
11	Elephants	crave	peanuts	cats	gadgets	pictures
12	Frogs	eat	insects	toads	dust	cliffs
13	Giraffes	nibble	leaves	lions	ears	plaster
14	Goats	scale	mountains	fences	buildings	sleeves
15	Horses	pull	wagons	tractors	all-nighters	clouds
16	Jaguars	stalk	prey	butterflies	actors	radios
17	Koalas	climb	trees	dunes	ladders	staplers
18	Lambs	grow	wool	antlers	wheat	walls
19	Lions	maul	villagers	spears	furniture	alarms
20	Mules	munch	hay	saddles	losses	helmets
21	Nightingales	serenade	mates	hatchlings	crowds	banks
22	Oxen	plow	fields	grass	snow	eagles
23	Porcupines	shoot	quills	fur	guns	watches
24	Pythons	strangle	rodents	whales	economies	socks
25	Raccoons	steal	trash	pinecones	cable	haircuts
26	Rats	spread	germs	toys	rumors	reefs
27	Squids	squirt	ink	water	jelly	sneakers
28	Squirrels	hoard	nuts	marbles	profits	beds
29	Tigers	prowl	grasslands	swamps	nightclubs	blueprints
30	Turkeys	lay	eggs	straw	bricks	clocks
31	Weasels	dig	holes	ditches	basements	wind
32	Whales	breathe	air	bubbles	words	scales

APPENDIX B: REVISED STIMULI FOR SEMANTIC-RELATEDNESS

Subject Category: Humans

Item	Subject	Verb	TRUE	Semantic	Syntactic	FALSE
1	Archers	shoot	arrows	bullets	drugs	sandals
2	Architects	design	houses	rulers	weddings	suits
3	Astronomers	study	stars	law	soccer	smiles
4	Attorneys	meet	clients	bailiffs	dates	poems
5	Babysitters	watch	toddlers	parents	sunsets	music
6	Barbers	cut	hair	wigs	steak	waves
7	Bartenders	mix	drinks	cakes	speeches	lakes
8	Brokers	pick	stocks	movies	apples	phantoms
9	Caterers	prepare	meals	bacteria	lessons	baths
10	Chefs	cook	pancakes	pears	wax	storms
11	Coaches	guide	athletes	soldiers	boats	gates
12	Cowboys	ride	horses	camels	bicycles	peacocks
13	Dancers	perform	waltzes	plays	karate	journals
14	Doctors	diagnose	patients	thermometers	engines	meadows
15	Farmers	raise	cows	pests	taxes	roads
16	Gardeners	plant	flowers	weeds	flags	clothes
17	Hunters	track	ducks	termites	expenses	paper
18	Janitors	clean	rooms	shoes	consciences	tape
19	Knights	rescue	princesses	villains	firefighters	aluminum
20	Lifeguards	protect	kids	sharks	cattle	books
21	Mechanics	fix	cars	toys	marriages	daylight
22	Novelists	write	books	music	laws	beads
23	Parents	lecture	children	pilots	audiences	vehicles
24	Plumbers	repair	faucets	trucks	skin	spoons
25	Postmen	deliver	mail	food	babies	oil
26	Runners	wear	shoes	helmets	perfume	boxes
27	Sailors	chart	voyages	highways	stocks	stoves
28	Shepherds	herd	sheep	bison	riots	motorcycles
29	Geographers	map	land	compasses	equations	paint
30	Teachers	instruct	students	principals	monkeys	cameras
31	Therapists	treat	depression	couches	dramas	darkness

32	Vampires	drink	blood	soda	bottles	coral

Subject Category: Animals

Item	Subject	Verb	True	Semantic	Syntactic	FALSE
1	Apes	peel	bananas	elephants	paste	lakes
2	Bears	catch	fish	streams	colds	dye
3	Beavers	gnaw	wood	sand	pencils	shrimp
4	Buffalo	roam	plains	deserts	hallways	wires
5	Cats	chase	mice	cages	deserts	moss
6	Cows	produce	milk	honey	art	rays
7	Crows	collect	twigs	pollen	stamps	cement
8	Dogs	chew	bones	glasses	gum	lemonade
9	Ducks	fly	south	underwater	packages	underground
10	Eagles	build	nests	dams	bridges	carpets
11	Elephants	crave	peanuts	cats	gadgets	pictures
12	Frogs	eat	insects	toads	dust	cliffs
13	Giraffes	nibble	leaves	lions	ears	plaster
14	Goats	scale	mountains	fences	buildings	sleeves
15	Horses	pull	wagons	tractors	all-nighters	clouds
16	Jaguars	stalk	prey	butterflies	actors	radios
17	Koalas	climb	trees	dunes	ladders	staplers
18	Lambs	grow	wool	antlers	wheat	walls
19	Lions	maul	zebras	spears	furniture	alarms
20	Mules	munch	hay	boots	losses	helmets
21	Nightingales	serenade	mates	branches	crowds	banks
22	Oxen	plow	fields	trees	snow	eagles
23	Porcupines	shoot	quills	fur	guns	watches
24	Pythons	strangle	rodents	whales	economies	socks
25	Raccoons	steal	trash	pinecones	cable	haircuts
26	Rats	spread	germs	toys	rumors	reefs
27	Squids	squirt	ink	water	jelly	sneakers
28	Squirrels	hoard	nuts	marbles	profits	beds
29	Tigers	prowl	grasslands	swamps	nightclubs	blueprints
30	Turkeys	lay	eggs	straw	bricks	clocks
31	Weasels	dig	holes	birds	basements	wind
32	Whales	breathe	air	bubbles	words	scales

APPENDIX C: STIMULI FOR LINGUISTIC-EXPECTANCY

Item	Subject	Verb		Object	
		Cloze-Probability		Truth-Value	
	Animals	low	high	True	False
1	Apes	grasp	peel	bananas	peanuts
2	Beavers	gnaw	chomp	wood	sand
3	Bees	visit	pollinate	flowers	graves
4	Birds	travel	migrate	south	underwater
5	Cats	scare	chase	mice	bears
6	Chickens	guard	lay	eggs	rocks
7	Cows	contain	produce	milk	honey
8	Dogs	retrieve	bury	bones	chairs
9	Dolphins	inhale	breathe	air	dust
10	Eagles	repair	build	nests	dams
11	Frogs	follow	catch	flies	birds
12	Monkeys	ascend	climb	trees	dirt
13	Oxen	work	plow	fields	caves
14	Possums	appear	play	dead	clean
15	Raccoons	disturb	scavenge	garbage	gasoline
16	Rats	cause	spread	disease	medicine
17	Seals	seek	eat	fish	mice
18	Snakes	watch	eat	mice	whales
19	Ticks	need	suck	blood	bones
20	Tigers	prowl	rule	jungles	deserts

Item	Subject	Verb		Object	
		Cloze-Probability		Truth-Value	
	Humans	low	high	True	False
1	Archers	prepare	shoot	arrows	bullets
2	Architects	sketch	design	buildings	mountains
3	Astronomers	record	study	stars	law
4	Babies	need	drink	milk	soda
5	Bakers	mix	roll	dough	mud
6	Brokers	buy	pick	stocks	movies

7	Butchers	utilize	sharpen	knives	arrows
8	Cowboys	own	ride	horses	elephants
9	Farmers	raise	milk	cows	bugs
10	Gardeners	fertilize	water	plants	snow
11	Janitors	clean	mop	floors	lawns
12	Lifeguards	safeguard	protect	swimmers	sharks
13	Mailmen	manage	deliver	mail	houses
14	Mechanics	repair	fix	cars	gloves
15	Novelists	create	write	books	music
16	Parents	carry	discipline	children	doctors
17	Pirates	own	bury	treasure	aircraft
18	Sailors	operate	steer	ships	planes
19	Shepherds	buy	herd	sheep	wolves
20	Tailors	alter	sew	clothes	pictures

APPENDIX D: STIMULI FOR EMBEDDED-CUE

Item	Subject	Verb		Object	
		Cloze-Probability		Truth-Value	
	Animals	low	high	True	False
1	Beavers	gnaw	chomp	wood	sand
2	Bees	visit	pollinate	flowers	graves
3	Birds	travel	migrate	south	underwater
4	Cats	scare	chase	mice	bears
5	Chickens	guard	lay	eggs	rocks
6	Cows	contain	produce	milk	honey
7	Dogs	retrieve	bury	bones	chairs
8	Eagles	repair	build	nests	dams
9	Frogs	follow	catch	flies	birds
10	Monkeys	ascend	climb	trees	dirt
11	Raccoons	disturb	scavenge	garbage	gasoline
12	Rats	cause	spread	disease	medicine
13	Seals	seek	eat	fish	mice
14	Snakes	watch	eat	mice	whales
15	Ticks	need	suck	blood	bones
16	Tigers	prowl	rule	jungles	deserts

Item	Subject	Verb		Object	
		Cloze-Probability		Truth-Value	
	Humans	low	high	True	False
1	Archers	prepare	shoot	arrows	bullets
2	Architects	sketch	design	buildings	mountains
3	Astronomers	record	study	stars	law
4	Babies	need	drink	milk	soda
5	Bakers	mix	roll	dough	mud
6	Brokers	buy	pick	stocks	movies
7	Butchers	utilize	sharpen	knives	arrows
8	Gardeners	fertilize	water	plants	snow
9	Janitors	clean	mop	floors	lawns
10	Mailmen	manage	deliver	mail	houses

11	Mechanics	repair	fix	cars	gloves
12	Novelists	create	write	books	music
13	Parents	carry	discipline	children	doctors
14	Pirates	own	bury	treasure	aircraft
15	Sailors	operate	steer	ships	planes
16	Tailors	alter	sew	clothes	pictures