The deceptive response: effects of response conflict and strategic monitoring on the late positive component and episodic memory-related brain activity

Ray Johnson, Jr.*, Jack Barnhardt, John Zhu

Department of Psychology, Queens College/CUNY, 65-30 Kissena Blvd., Flushing, NY 11367, USA

Received 3 June 2002; accepted 26 July 2003

Abstract

The cognitive processes and neural mechanisms underlying deceptive responses were studied using behavioral responses (RT) and event-related brain potentials (ERPs) while participants made truthful and deceptive responses about perceived and remembered stimuli. Memorized words were presented in a recognition paradigm under three instructional conditions: Consistent Truthful, Consistent Deceptive, Random Deceptive. Responses that conflicted with the truth about both perceived and remembered items produced the same pattern of slower RTs and decreased LPC amplitudes. When long-term response patterns were monitored, RTs became much slower and LPC amplitudes decreased greatly. The different behavioral and ERP changes in the two deception conditions suggested that two dissociable executive control processes, each requiring additional processing resources, can contribute to deceptive responses. The parietal episodic memory (EM) effect, thought to reflect recollection, was unaffected by whether participants responded truthfully or deceptively suggesting that it provides a measure of guilty knowledge.

© 2003 Elsevier B.V. All rights reserved.

Keywords: Deception, ERPs, LPC, Response conflict, Performance monitoring

1. Introduction

In the past 10 years, investigators have attempted to demonstrate that event-related brain potentials (ERP) can be used to detect concealed information in humans (for reviews, see...
Bashore and Rapo, 1993; Rosenfeld, 1995). These efforts can be characterized as falling into two general categories, those aimed at detecting the presence of guilty knowledge and those aimed at detecting when persons are feigning memory loss (i.e., malingering). The guilty knowledge studies have demonstrated that the late positive component (LPC, also known as the P300) of the ERP can provide a useful index of the presence of concealed memories (e.g., Allen and Iacono, 1997; Farwell and Donchin, 1991; Johnson and Rosenfeld, 1992). Similarly, because persons feigning amnesia are attempting to conceal particular memories, the LPC also reveals the true memory status of items in such persons (e.g., Allen, 2002; Allen et al., 1992; Allen and Movius, 2000; Rosenfeld et al., 1996, 1998, 1999).

All these studies focused on the LPC because the stimuli were presented in an “Oddball” paradigm in order to take advantage of the inverse relation between LPC amplitude and stimulus probability. That is, the items of interest (i.e., the “guilty knowledge” items) are presented infrequently and randomly with two other categories of control stimuli, one that is presented infrequently and the other frequently. If the person has guilty knowledge of the items of interest, the infrequent nature of these items will cause them to elicit a LPC like that for the infrequent control stimuli. However, if the person has no knowledge of the items, they will be perceived as belonging to the frequent stimulus set and thus elicit a LPC like that for the frequent control stimuli. Hence, all these studies are best characterized as “applied” because they took previously known aspects of the ERP and used them, albeit creatively, to devise methods to detect the presence of concealed information in “real-world” situations.

Despite this interest in detecting guilty knowledge, no “basic” ERP studies have been done to determine the nature of the cognitive processes involved when persons are deceptive. This is surprising given that the ERP technique has been used to investigate the neural basis of many aspects of cognition. To address this lack of knowledge, we conducted a series of experiments designed to identify the cognitive processes used during deceptive responding. Determining which cognitive processes are used during a behavior as complex and multi-faceted as deception is hampered by a number of factors. One initial problem is that there are many types of deception that vary considerably in nature and complexity (Vrij, 2001). This may account for another impediment for designing empirical studies of deception, that there appears to be no widely accepted definition of deception (for reviews, see Mitchell, 1986; Vrij, 2001). A further complication is the likelihood that the cognitive operations that different people use for any given type of deception will vary as a function of a variety of factors, including their personality and personal habits (e.g., how often they lie), and the circumstances surrounding the deception. In addition, non-cognitive processes, such as those related to processing of any emotional components of a deception, are also likely to be involved.

To create a conceptual framework for studying the cognition of deception, we attempted to categorize the general types of processes that might be used by a deceptive person. Although there is, to the best of our knowledge, no definition of deception that specifies the cognitive processes involved, it seemed to us that at least some definitions can be seen as implicitly or explicitly dividing deception operations into two broad categories: (1) the cognitive/emotional processes used to formulate such factors as, for example, the rationale, intent and strategies relevant to a deception, and (2) those used in the act of deception (cf., Furedy et al., 1988). Further, we hypothesized that, rather than being a unique process, both the intent and action components of deception likely draw on general purpose
processes used in other aspects of cognition. This view of deception is thus compatible
with conclusions, based on studies of autonomic nervous system responses, that there is
no unique pattern of autonomic responding associated with deception (i.e., "specific lie
response") (e.g., Ben-Shakhar and Furedy, 1990).

Regardless of the nature and extent of the cognitive/emotional processes that precede and
accompany a decision to deceive, all deceptions require the execution of a response that
is incompatible with the truth. Further, in contrast to the great variability in the nature and
amount of processing that precedes a deceptive act, we thought that the executive control
processes used in the output stages would be easier to specify and study. The control of
response selection and execution processes is a fundamental aspect of one's ability to
successfully interact with the environment in all situations. To do this, executive processes
are thought to play an important role in the control of actions by monitoring and resolving
response conflicts whenever interference arises from competing response tendencies (e.g.,
Luu et al., 2000). Hence, we reasoned that the unusual circumstances surrounding deceptive
responses would mean that such executive processes are likely play an even more important
role than during truthful responding. One reason for this is that the deceptive person must
not only perform all the usual task and response-related processes necessary to identify
the truthful response, but they must also perform the extra processes required to inhibit the
tendency to make this pre-potent response. In addition, falsifying a response means that the
deceptive person then must select a response that is incompatible (i.e., conflicts) with the
truth and execute this deceptive response.

To be deceptive, therefore, a person must make greater use of the executive control
processes that affect response inhibition, selection and execution. In addition, they may
well rely on these processes more heavily than in most other situations because of the
consequences that would follow from being caught in a lie if they do not successfully make
the intended deceptive response. Thus, even when these executive processes may comprise a
small part of the overall processing used in a deception, they are vital because not performing
them correctly carries the risk of voiding all preceding deception-related processing. Note
that, in many situations, these control processes may be the primary type of processing
performed at the time of the actual deception. That is, it is reasonable to posit that many
deceptions are such that a person is likely to do most of the processing related to a pending
deception (e.g., work out the details related to ones intent, strategies, etc.) well before the
time when one is interrogated and actually has to execute the deceptive responses. In such
situations, the need to perform additional deception-related processing in the pre-response
category is greatly reduced, leaving the executive control processes as the major remaining
cognitive component when the deceptive response is made.

The variable nature of the pre-response processing stages across deceptions noted above,
coupled with the fact that researchers have already studied the nature of the executive pro-
cesses used when persons must resolve conflicting response tendencies, led us to focus on the
cognitive processes used to execute and monitor deceptive responses. One major unknown
in this regard is whether the nature and effects of the conflicting response information that
arises in different situations engages the same cognitive processes. For example, it is possi-
ble to differentiate deceptive responses on the basis of whether the source of the conflicting
response information that must be monitored and overcome is internal or external. That
is, one can be deceptive either about perceptual experiences as they occur or about things
that one did or said at some time in the past. For example, when one responds falsely "the light was green" when it was actually red, the conflicting response information arises from external stimuli. In contrast, when one falsely states "I didn’t do that" about a past action, the source of the conflicting response information arises from the internal representation of the person’s memory of the event. Hence, in this conceptualization, the processing of conflicting response information and inhibition of truthful responses are necessary but not sufficient components of every deception, regardless of whether the subject of the deception is about perceived or remembered events.

Whereas, the effects of conflicting response information have been studied in a variety of situations, all manipulations to date have used perceptual events to convey the conflicting response information. Examples of such perceptually-driven response conflicts are those in which participants must make either compatible or incompatible responses to stimuli such as the words "left" and "right" (Magliero et al., 1984; McCarthy and Donchin, 1981), color-word stimuli in the Stroop task (Duncan-Johnson and Kopell, 1981), left and right facing arrows (Ragot and Lesèvre, 1986; Doucet and Stelmack, 1999), or left and right spatial locations (Leuthold and Sommer, 1998). These studies demonstrated that, compared to conditions containing no conflicting information, reaction times (RT) increased when the stimuli conveyed conflicting response information. At the same time, however, the concomitant increases in LPC latency were a small fraction of the changes in RT. In contrast, these same studies also showed that this dissociation between the RT and LPC measures of processing time was limited to response conflict situations because the increases in RT and LPC latency were nearly the same for manipulations of stimulus processing time (i.e., task effects). Although LPC amplitude has been quantified less frequently, both Doucet and Stelmack (1999) and Magliero et al. (1984) reported that smaller LPCs were elicited when conflicting response information was introduced into the task. Note that the monitoring processes used to deal with the conflicting response information in all these situations can be characterized as "tactical" because they are limited to those occurring within a trial (i.e., in the interval between the stimulus and the response to that stimulus).

Given that all the studies just reviewed used external events to deliver all the conflicting response information, the extent to which the same results would be found for memorial-based response conflicts characteristic of deceptions about one’s past experiences is not known. In other words, it is not known if there is one general purpose processor for conflicting response information or separate mechanisms for different types of response conflicts. No answers are provided by the guilty knowledge studies cited above because they did not isolate and/or quantify conflict-related ERP activity in those studies in which responses were required. Moreover, cognitive experiments generally require participants to make correct responses while keeping errors to a minimum. In contrast, when persons are deceptive, their intent is to make the incorrect response. Thus, the extent to which the processes used to resolve externally and internally based conflicting response information differ as a function of the intent to commit an error is also not known.

In addition to the executive control processes used to ensure that each individual response conforms to one’s goals, other processes are presumably involved when it is necessary to monitor how the individual responses fit into a series of responses. Hence, we hypothesized that more complex deceptions, such as those involving multiple responses and/or extended time intervals, probably engage additional control processes. We refer to them as long-term,
“strategic” monitoring processes and their function is to ensure that responses are consistent with one another and conform to the person’s longer-term goals.

Clearly, the need to engage tactical and strategic monitoring processes during deceptive responding necessitates the use of additional processing resources. Using these extra control processes would, therefore, be equivalent to engaging in a secondary task that the deceptive person must perform in addition to the primary task of responding truthfully. We reasoned, therefore, that deceptive responses may be distinguishable from truthful responses by the fact that they require more controlled processing resources. Previous ERP studies have demonstrated that LPC amplitude can provide a sensitive measure of how processing resources are allocated between two simultaneously performed tasks (for reviews, see Johnson, 1986, 1993). The sensitivity of LPC amplitude to the allocation of processing resources was demonstrated elegantly in a series of studies showing that primary-task LPC amplitudes decreased in a graded manner as attentional resources were systematically diverted away from the primary task toward a secondary task (Isreal et al., 1980a,b; Kramer et al., 1985; Wickens et al., 1983). Based on these results, we expected that LPC amplitudes would be reduced for stimuli that elicited deceptive responses compared to those that elicited truthful responses, in proportion to the amount of deception-related processing that was performed.

Studies of the ERP activity associated with retrieval of long-term episodic (i.e., personal) memories have revealed differential patterns of brain activity depending on the study status of the items being recognized (for reviews, see Friedman and Johnson, 2000; Johnson, 1995a; Rugg and Allan, 2000). When previously learned (i.e., old) items are correctly recognized (i.e., old) items are correctly recognized, they elicit larger LPCs over left parietal scalp than unlearned (i.e., new) items in the interval between 500 and 800 ms post-stimulus (e.g., Johnson et al., 1985; Johnson, 1995b; Smith, 1993; Van Petten et al., 1991; Wilding et al., 1995). This greater amount of LPC activity elicited by old words is referred to as the episodic memory (EM) or old/new effect. In addition, old words typically elicit earlier LPCs (Johnson et al., 1985; Rugg et al., 1992) and shorter RTs (Johnson, 1995b; Johnson et al., 1998) than new words. More importantly, old words misclassified as new and new words misclassified as old both elicit LPCs like those of new, rather than old, words (Johnson et al., 1998; Smith, 1993; Wilding et al., 1995). These results indicate that the parietal EM effect reflects the actual memory status of the item, rather than what the participant declares as the item’s memory status. However, given that all the error responses in these studies were unintentional, it remains possible that the same results may not obtain when items are deliberately misclassified. Additional subcomponents of the EM effect have been identified over left frontal (300–500 ms) (e.g., Johnson et al., 1998; Smith, 1993; Tendolkar et al., 1997) and occipital (300–500 ms) scalp (Friedman and Johnson, 2000). A general conclusion summarizing the roles of these different patterns of ERP activity is that the parietal, left frontal and occipital aspects of the EM effect reflect processes related to recollection, familiarity, and sensory priming, respectively (Friedman and Johnson, 2000; Rugg and Allan, 2000). Thus, an advantage of using an old/new recognition paradigm to identify brain activity related to deception is that it provides multiple measures of whether items actually reside in a person’s episodic memory. In fact, Tardif et al. (2000) reported that the parietal EM effect was not significantly altered in participants who feigned amnesia.

In the study reported here, we measured both behavioral performance and ERPs while participants responded truthfully and deceptively in various memory conditions using a list
of previously learned "old" words. In the Consistent Truthful condition, participants performed a standard old–new recognition paradigm and correctly categorized the old and new words. The tactical and strategic monitoring aspects of deceptive responding were studied in two separate conditions (Consistent Deceptive and Random Deceptive, respectively). The present paradigm and instructions were similar to those used previously to study malingering and differed from those used in the guilty knowledge studies by our use of two stimulus categories instead of three. The other main difference was that we did not use an oddball paradigm, preferring instead to use two equally probable stimulus categories in order to eliminate the confounding effects of stimulus probability.

To investigate the effects of response conflict, participants performed a Consistent Deceptive condition in which they responded opposite of the truth for all old and new items. Previous studies intended to detect guilty knowledge used a similar paradigm in which participants were instructed to respond opposite of the truth (i.e., "do not know") for a subset of the stimuli (e.g., items from one specific list) (e.g., Allen et al., 1992, 2000; Farwell and Donchin, 1991; Rosenfeld et al., 1991). This type of "directed lie" paradigm has also been used to study the autonomic concomitants of deception (e.g., Furedy et al., 1988). Hence, the present paradigm differs from those used in these past studies primarily on the basis of the proportions of truthful and deceptive responses. Given that previous approaches dictated the use of rare and frequent stimulus categories, their participants made deceptive responses on about 14–17% of the trials. However, because we did not want the effects of probability confounded with those of response conflict and memory status, participants in the Consistent Deceptive condition responded opposite of the truth for all memory stimuli.

Given that our participants were instructed to press opposite of the truth for all memory stimuli, there would be nothing to prevent them from simply reversing the stimulus-response assignments given to them. Because the use of such a strategy would effectively eliminate the conflicting response information, we introduced catch trials to prevent this. The catch trials, consisting of the words "OLD" and "NEW," appeared at random on 20% of the trials in all memory conditions and participants were instructed to respond correctly on all catch trials. The presence of the catch trials meant, therefore, that even in the Consistent Deceptive condition, participants were required to make truthful responses 20% of the time. Thus, although the probability of truthful and deceptive responses were reversed between the present and past ERP guilty knowledge studies, the effect of manipulating the probability of a lie response is unclear. This is because, in all these "directed lie" studies, the participant’s decisions about which items would elicit truthful and deceptive responses were all made prior to the presentation of any stimuli. As discussed above, this condition provides a reasonable analog to those cases when the person decides in advance that they will give deceptive responses to any and all items about, for example, a specific incident.

Strategic monitoring processes were studied in a Random Deceptive condition in which participants were instructed to lie randomly for half the old words and half the new words, while still responding truthfully on the catch trials. The strategic monitoring task was created by instructing participants specifically to maintain a random pattern of responding and to monitor the overall pattern of their responses in order to meet the goal of making about 50% truthful and 50% deceptive responses over the entire series. To distinguish between these two response outcomes, we refer to them as the Random Truthful and Random Deceptive responses. The Random Deceptive condition thus elicited cognitive processes relevant to
maintaining a deception over time because there was a constantly changing set of stimulus and response information that participants needed to monitor in order achieve specific response-related goals. Because none of the old and new words was repeated within the series, participants only needed to monitor the general pattern of their responses over time, and not the manner in which they responded to particular items. Trials in this condition differed from those in the Consistent Deceptive condition in that, in addition to the monitoring the nature of their decisions, participants had to decide, on a trial-by-trial basis, whether to respond truthfully or deceptively.

Although the strategy of lying randomly is not useful in most circumstances, it actually provides a realistic model of the type of deception used by malingerers, who tend to simulate a memory deficit by responding randomly about items in their memory. Hence, the malinger studies reviewed above also required their participants to respond randomly while trying to attain rates of deceptive responding ranging from 50% (Rosenfeld et al., 1999; Tardif et al., 2000) down to 10–25% (Rosenfeld et al., 1998). The presence of catch trials meant that participants made deceptive responses 40% of the time in the Random Deceptive condition (i.e., on half the memory trials, which constituted 80% of the total trials), a rate that falls roughly in the middle of those used in past experiments. Note that none of these past experiments was concerned with studying monitoring processes. Further, it would be impossible to determine the effects of monitoring from their results because the data from all participants were included in the analyses, even when their response proportions deviated considerably from the goals explicitly stated by the experimenter. In contrast, because of our specific interest in the ERP activity associated with strategic monitoring processes, participants whose performance indicated that they failed to monitor their responses accurately were dropped from the analyses.

The Consistent Deceptive and Random Deceptive conditions, along with the Consistent Truthful condition and two perceptual conditions, were designed to provide four specific comparisons to isolate different response-related control processes that would be involved in making deceptive responses. First, the extent to which the same executive processes used to resolve response conflicts arising from perceptual and remembered information was assessed. This was done by comparing performance and ERP activity in a perceptual task (“left” and “right” discrimination) with that in a memory task (old-new recognition) when compatible (truthful) and incompatible (deceptive) responses were made in separate conditions. To ensure that the decisions in the memory tasks were based on information contained in the subject’s episodic memory, only the old items from the Consistent Truthful and Consistent Deceptive conditions were used in this comparison. Due to the large differences in difficulty between the perceptual and memory tasks, in addition to differences in memory status, a second within-task comparison was made using only data from the memory conditions when the differences in task difficulty were much less. This comparison contrasted the results of the Consistent Truthful and Consistent Deceptive conditions used in this comparison. Due to the large differences in difficulty between the perceptual and memory tasks, in addition to differences in memory status, a second within-task comparison was made using only data from the memory conditions when the differences in task difficulty were much less. This comparison contrasted the results of the Consistent Truthful and Consistent Deceptive conditions to isolate the relative effects of response compatibility responses (truthful versus deceptive) and memory status (old versus new). Taken together, the outcomes of these two comparisons also provide information on whether the processing of conflicting response information varies as a function of task difficulty. The third comparison was designed to determine if there were differences in performance and brain activity as a function of the type of monitoring processes (tactical versus strategic) that were used in task performance (Consistent Deceptive
versus Random Deceptive). Because participants made the same deceptive responses to the same stimuli in both these conditions, differences across conditions could not be attributed to such extraneous factors as stimulus differences, the presence of conflicting response information or the need to make a conflicting response. The final comparison, based on the fact that it was necessary to perform the strategic monitoring processes continuously for all the events in the series, used the data from the two types of trials within the Random Deceptive condition (Random Truthful responses versus Random Deceptive responses). The continuous nature of the strategic monitoring task led us to expect greater similarity between the truthful and deceptive responses within the Random Deceptive condition than in the conditions requiring only tactical monitoring processes.

The present paper addresses the effect of deception-related processing on the behavioral responses and LPC amplitude and latency. In addition, the effects of making deceptive responses on the three aspects of the episodic memory effect and catch trial responses are also assessed. The role of executive processes in deception, as indexed by the medial frontal negativity component of the ERP, is described elsewhere (Johnson et al., 2003a).

2. Methods

2.1. Participants

Twenty-five graduate and undergraduate students (15 females) at Queens College were paid US$ 10.00/h for their participation. All participants were right-handed native English speakers with normal or corrected-to-normal vision. The data from four participants were excluded based on their performance in the Random Deceptive condition (see below) and the mean age of the remaining participants was 21.6 years (S.D. = 3.1). Participants were thoroughly briefed about the nature of the experiment and signed informed consent was obtained from each in accord with Queens College Institutional Review Board procedures.

2.2. Procedure

One week prior to the experimental session, participants were given a list of 60 unrelated words to memorize (“old” words). After electrode placement, participants were seated in a dimly-lit room where they performed a standard old/new recognition paradigm under three instructional conditions: Consistent Truthful, Consistent Deceptive and Random Deceptive. In the Consistent Truthful condition, participants pressed one button when they saw an old word and the other button when they saw a new word (i.e., one not on the list). The response box contained two side-by-side buttons, one each to the left and right of the centerline.

In the Consistent Deceptive condition, participants were instructed as follows: “This is another recognition test with a different list of new words. The main difference is that, although I’ve told you to press the left button for old words, you are going to lie or try to hide what you know by pressing opposite of my instructions. Thus, although I’ve told you to press the left button for the old words, you are going to press the right button. Similarly, although I’ve told you to press the right button for the new words, you are going to press the left button. Remember to press as quickly as
you can. We will try to keep you honest by giving you catch trials 20% of the time. These are the words “OLD” and “NEW.” You must press left as quickly as you can when you see the word “OLD” and press right as quickly as you can when you see the word “NEW.” On the catch trials, it is important that you try hard to always press correctly so it will not be obvious that you are pressing the opposite buttons.”

In the Random Deceptive condition, participants were instructed as follows: “This is another recognition test with a different list of new words. The main difference is that, although I will instruct you to press the left button for old words and the right button for the new words, you are going to lie or try to hide what you know by ignoring my instructions. In this condition, I want you to lie or hide what you know by pressing randomly. That is, half the time when you see an old word, you will press the left button as quickly as you can, in accord with the instructions. But, for the other half of the old words, you will press the right button as quickly as you can. You will do the same for the new words. The important thing in this series is that you try to hide what you know by being as random as possible. That means you will need to keep track of the proportions of correct and incorrect responses you’ve already made for both the old and new words so you don’t make too many responses in any one category.” In addition, they were given the same instructions about the catch trials as in the Consistent Deceptive condition. Note that participants were told to keep track of the proportions, rather than an exact count, of the truthful and deceptive responses. The pairing of responding hand with the response buttons was counterbalanced across participants, with each participant using the same old/new button assignments in all three memory conditions.

In each memory condition, 58 of the 60 old words were randomly presented along with 58 new words on a CRT for 300 ms in all uppercase letters using white letters on a black background (2750 ms average trial duration). Although the same list of memorized old words was used throughout, different lists of new words were used for each test. New word lists were picked from a pool of 15 lists that were constructed by randomly selecting words from a master list, with all lists balanced for word frequency (Carroll et al., 1971). The list of old words was also drawn from this set of 15 lists. The particular list of new words used in each condition was selected randomly (without replacement) for each participant. In addition, each series contained 29 catch trials on which either the word “OLD” or the word “NEW” was presented randomly and equally often. Thus, overall stimulus probabilities were 40% old words, 40% new words, 10% catch “OLD” and 10% catch “NEW.”

Participants also performed two perceptual conditions in which the words “LEFT” and “RIGHT” appeared randomly and equiprobably on a CRT for 300 ms, using white letters on a black background (2750 ms average trial duration). In the Perceptual Compatible condition, participants pressed the button on the side indicated by the stimulus while in the Perceptual Incompatible condition, participants pressed the button on the side opposite that indicated by the stimulus (e.g., right button for “LEFT”). There were 40 trials for each type of stimulus.

Over the session, the Consistent Truthful, Consistent Deceptive and Random Deceptive conditions were performed twice. To determine how well participants knew the word list at the beginning of the session, the Consistent Truthful condition was always performed first, with half the participants performing the Consistent Deceptive condition before the Random Deceptive condition with the other half receiving the opposite order. For the second repetition, the order of all three memory conditions was randomized across participants. Because
significant differences in ERP activity have been found to occur early in a sequence of recognition tests (Johnson et al., 1985, 1998) that would serve to exaggerate possible differences between the truthful and deceptive conditions, only the data from the second repetition of the memory conditions are presented here. Since a comparison of the results from the first and second repetitions is beyond the scope of this paper, they are presented elsewhere (Johnson et al., 2003b). Half the participants performed the two perceptual conditions before any of the memory conditions and half after completing the memory conditions. Since there were no stimulus-related differences in either perceptual condition for the behavioral or ERP measures, the data for the “LEFT” and “RIGHT” trials were collapsed. For the same reason, the data for the “OLD” and “NEW” catch trials were collapsed in each memory condition.

2.3. ERP recordings and quantification

ERP activity was recorded from 32 scalp sites, all referred to a left pre-auricular electrode, using tin electrodes embedded in an elasticized cap. The sites (Fp1, Fp2, F7, F3, Fz, F4, F8, F5, Fc1, Fc2, Fc6, T7, C3, Cz, C4, T8, C5, C6, P7, P3, Pz, P4, O1, O2, Cb1, Cb2, right pre-auricular, E1, E2) were located in accord with the American Electroencephalographic Society Guidelines (1991). To reduce the presence of electromyographic artifacts, the Cb1 and Cb2 electrodes were placed 1.2 cm above their standard International 10–20 System locations. Participants were grounded with a forehead electrode. The EEG was amplified 20,000 times with a bandpass of 0.01–35 Hz (−3 dB/octave) and sampled at 100 Hz. Eye movements (EOG) were recorded from above (FP1) and 2 cm below the outer canthus of the left eye (E1). Trials contaminated with EOG artifacts (signals greater than 50 μV during any six sampling points) were excluded from the averages. During averaging, all scalp-recorded activity was digitally re-referenced to an average of the left and right pre-auricular sites. All averages were based on data from trials with correct performance, except in the Random Deceptive condition when all trials were used. Stimulus-locked ERPs were calculated for a 2150 ms epoch, beginning 150 ms prior to stimulus onset. Response-locked ERPs were calculated for a 1150 ms epoch, extending from 650 ms before the response (including a 150 ms baseline) until 500 ms after the response. In calculating the response-locked ERPs, the baseline was removed (i.e., shifted to 0 V) from each single-trial waveform by subtracting the average voltage in the pre-stimulus interval from every sample point, before shifting the waveforms. Thus, for trials with RTs less than 500 ms, zeros could be added to fill out the pre-baseline points as needed without altering the pre-stimulus activity.

ERP activity in both stimulus- and response-locked waveforms was quantified by calculating waveform areas in different temporal epochs, after subtracting the activity in the 150 ms baseline. Latency differences across conditions in the stimulus-locked ERPs meant that LPC areas were calculated between 300–500 and 500–700 ms in the perceptual and memory conditions, respectively. In the response-locked ERPs, LPC area was measured between 100 ms pre-response and 100 ms post-response in both tasks (to use an interval of equal duration to that used in the stimulus-locked analyses). LPC area in all cases was quantified at the Cz, C1, C2, P3, Pz, P4, O1, O2 sites. LPC latency was quantified in the stimulus-locked ERPs by finding the largest positive peak at Pz within these intervals. The area of the left frontal EM effect was calculated between 300 and 500 ms at the F3, Fz, FC1 and FC2 sites.
while the area of the occipital EM effect was calculated between 300 and 500 ms at the O1, O2, P3, Pz and P4 sites. The area data from each temporal epoch were analyzed in separate three-way repeated-measures ANOVAs using the factors Condition, Stimulus/Response and Electrode. Because using data from multiple electrode sites may lead to a violation of the sphericity assumption, all ANOVA results were corrected using the Greenhouse-Geisser procedure. Additional separate repeated-measures ANOVAs were done on the RT and memory performance data using the same design, without the electrode factor.

3. Results

3.1. Subject exclusion criteria

The monitoring demands made the Random Deceptive condition somewhat difficult and some participants had trouble making equal numbers of responses in each category. Because the validity of comparisons involving the Random Deceptive condition are dependent on the extent to which the monitoring task was performed successfully, the number of trials in each of the four response categories was assessed for each participant. Four participants produced Truthful/Deceptive ratios of around 3:1 or 1:3, rather than the ideal of 1:1, and thus were dropped from the analyses. Even without this criterion, however, the extent of their category imbalances would have meant that there were too few trials to generate ERP averages for the under-represented categories. The data presented here are based on the remaining 21 participants.

3.2. Overview of the memory conditions

The RTs for all three memory conditions are shown in Fig. 1. An omnibus test on these data was performed using a two-way ANOVA with the factors Condition (Consistent Truthful, Consistent Deceptive, Random Truthful responses, Random Deceptive responses) and Stimulus (Old, New). This test revealed that there were significant differences in RT as a function of Condition \( F(3, 60) = 13.2, \epsilon = 0.382, P < 0.002 \) and that RTs for new words were significantly slower than those for old words \( F(1, 20) = 22.3, P < 0.0002 \).

The ERP data elicited at the 31 electrode sites in all memory conditions are shown for the old and new words in Figs. 2 and 3, respectively. These waveforms reveal the usual pattern of memory-related ERP activity that is dominated by a large positivity, the LPC, that was maximal over posterior scalp at around 600 ms. Compared to the truthful condition, LPCs were smaller by varying amounts in the two deception conditions. To assess condition effects on LPC amplitude, an omnibus ANOVA was done using the factors Condition (Consistent Truthful, Consistent Deceptive, Random Truthful responses, Random Deceptive responses), Stimulus (Old, New) and Electrode (31). The results revealed that LPC amplitude varied significantly across Conditions \( F(3, 60) = 114, \epsilon = 0.812, P < 0.0001 \), that old words elicited larger LPCs than new words \( F(1, 20) = 61.0, P < 0.00001 \) and that LPC amplitude varied as a function of site \( F(30, 600) = 31.9, \epsilon = 0.106, P < 0.00005 \). The Condition × Electrode \( F(90, 1800) = 12.9, \epsilon = 0.086, P < 0.002 \) and Stimulus × Electrode \( F(30, 600) = 19.3, \epsilon = 0.106, P < 0.0005 \) interactions were
significant suggesting possible differences in the pattern of generator activity for both the condition and stimulus effects. However, neither the Condition $\times$ Stimulus ($P = 0.09$) nor the Condition $\times$ Stimulus $\times$ Electrode ($P = 0.12$) interactions was significant indicating that there were there no overall amplitude or distributional differences, respectively, for the old and new words as a function of condition. Based on these significant effects, we performed the series of planned comparisons described above.

3.3. Role of response conflict and task difficulty in deceptive responding comparison of response conflict elicited by perceptual and memory tasks

To determine the extent to which the processes used to monitor perceptually- and memory-based response conflicts are similar, the data from the two perceptual conditions were compared with those from the Consistent Truthful and Consistent Deceptive conditions. Because the new words were not in the participant’s episodic memory, only the data for the old words were used in these comparisons. The data were compared in ANOVAs using the factors Task (Perception, Memory) and Response (Truthful, Deceptive). Note that, in contrast to the clear use of truthful/deceptive instructions in the memory tasks, the responses in the perceptual tasks are most accurately characterized as being compatible and incompatible with the stimuli. However, to avoid circumlocution, the terms truthful and deceptive will be used for the responses in both the perceptual and memory tasks.

3.3.1. Behavioral measures

As evident from the data in Table 1, although overall accuracy was quite high, both the task and response manipulations had small effects on response accuracy. For example, accuracy decreased by an average of 2.5% for deceptive responses [$F(1, 20) = 10.3, P < 0.005$]
Fig. 2. ERP waveforms from all 31 recording sites elicited by the old words in all three memory conditions. Note that vertical EOG artifact information can be obtained from the ERPs at FP1 and FP2 sites (located directly above the left and right eyes, respectively) and horizontal FOG artifact information can be obtained from the E1 and E2 sites (located immediately lateral to the left and right eyes, respectively). In this and subsequent figures, negative voltages are plotted as upward deflections and the vertical line in the waveforms represents stimulus onset.
Fig. 3. ERPs from all 31 recording sites elicited by the new words in all three memory conditions.
Table 1

Mean percent correct (S.D.) as a function of condition/response type

<table>
<thead>
<tr>
<th>Perceptual condition</th>
<th>Memory condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatible</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Truthful</td>
<td>Deceptive</td>
</tr>
<tr>
<td>Left/right</td>
<td>98.1 (2.6)</td>
</tr>
<tr>
<td>New</td>
<td>91.6 (13.8)</td>
</tr>
</tbody>
</table>

* For the Perceptual Incompatible, Consistent Deceptive and Random Deceptive response categories, percent correct refers to the percentages of responses where subjects correctly complied with the instructions. Thus, in the Perceptual Incompatible condition this represents the percentage of responses with the opposite hand whereas in the Consistent Deceptive and Random Deceptive conditions, this represents the percentage of deceptive responses indicating non-recognition of OLD words and recognition of NEW words. For the memory conditions, these percentages were determined based on the known status (OLD or NEW) of the stimuli.

b For the Random Deceptive condition, these headings refer to the two response possibilities within that condition.

and responses were about 4% less accurate overall in the memory tasks compared to the perceptual tasks \(F(1, 20) = 5.7, P < 0.05\). The magnitude of the accuracy reduction related to making deceptive responses was not, however, affected by the difficulty of the tasks in which they were performed (Task × Response: \(F < 1\)).

As shown in Fig. 1, RT also varied as a function of task and response type. Overall, deceptive trials were an average of 58 ms slower than truthful trials \(F(1, 20) = 32.2, P < 0.00002\). Compared to the response manipulation, the task manipulation had a much greater effect. That is, due to the greater controlled processing demands of the memory task (i.e., every stimulus was different and the requirement to search personal memory), RTs were an average of 188 ms slower than those in the perceptual task \(F(1, 20) = 419.8, P < 0.00001\). However, despite this large difference in task difficulty, the extent of RT slowing for deceptive responses was not different for the two tasks (Task × Response: \(P = 0.12\)).

The presence of significant main effects for both the task and response factors, but no interaction, in the ANOVAs on the accuracy and RT results indicates that the effects of making a deceptive response on response accuracy and speed were independent of, and additive to, the effects of performing the perceptual and memory tasks. Thus, the magnitude of the accuracy and RT changes for deceptive responses remained unaffected by the large differences in processing demands between the perceptual and memory tasks.

3.3.2. Late positive component results

The LPCs elicited at Pz in the perceptual and memory tasks are shown in Fig. 4. In accord with the RT data and the results of previous ERP studies with perceptually-based response conflicts, LPC latency was dramatically affected by the change in task but little affected by the need to process conflicting response information (Table 2). LPC latency increased from an average of 418 ms in the perceptual tasks to an average of 591 ms in the memory tasks, 92% of the concomitant change in RT \(F(1, 20) = 175.6, P < 0.00001\). In contrast, LPC latency only slowed by a non-significant 18 and 14 ms in the perceptual and memory tasks, respectively, when participants made deceptive responses \(P = 0.26\). These changes in
LPC latency were thus less than 28% of the concomitant RT changes that resulted from making deceptive responses and their magnitude was unaffected by the differences in task difficulty (Task × Response: \( P = 0.28 \)).

The waveforms in Fig. 4A reveal that significantly smaller LPCs were elicited for deceptive responses \( F(1, 20) = 10.4, P < 0.005 \), although LPC area was not significantly different across tasks \( (P = 0.17) \). There was also a significant effect of electrode \( F(7, 140) = 21.5, \ e = 0.318, P < 0.00001 \), with the largest LPCs found near Pz. Although the amplitude difference between the LPCs elicited by truthful and deceptive responses appeared to be somewhat larger in the perceptual task, the magnitude of the LPC amplitude reduction for deceptive responses was also independent of the large differences in task difficulty \( (P = 0.09) \). There was a significant Task × Electrode interaction due to the fact that LPC amplitude decreased more rapidly in the anterior direction in the memory tasks than in

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mean (S.D.) P300 latency (ms) as a function of condition/response type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptual condition</strong></td>
<td><strong>Memory condition</strong></td>
</tr>
<tr>
<td>Compatible</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Compatible</td>
<td>Incompatible</td>
</tr>
<tr>
<td>Left/right</td>
<td>409 (31)</td>
</tr>
<tr>
<td>New</td>
<td>636 (40)</td>
</tr>
<tr>
<td>a For the Random Deceptive condition, these headings refer to the two response possibilities within that condition.</td>
<td></td>
</tr>
</tbody>
</table>
the perceptual tasks \( F(7, 140) = 4.7, \varepsilon = 0.318, P < 0.05 \). The Response × Electrode interaction, however, was not significant \( (P = 0.16) \).

The fact that RTs were more variable when participants made deceptive responses raised the possibility that the smaller LPCs for deceptive responses were an artifact of increased latency variability across trials. However, as shown in Fig. 4B, response-locked ERPs reveal the same amplitude trends as the stimulus-locked ERPs. Thus, LPC amplitudes were significantly smaller for deceptive responses \( F(1, 20) = 8.9, P < 0.01 \) and larger LPCs were elicited in the memory tasks \( F(1, 20) = 8.3, P < 0.01 \). Again, there was no evidence of any differential effect of task on the magnitude of the deception-related LPC amplitude decrease \( (Task \times Response: F < 1) \).

3.4. Effects of response conflict as a function of memory status

As mentioned above, new words are typically categorized more slowly than old words, indicating that memory status influences task difficulty. To determine if the results of the Perceptual-Memory comparisons also obtained when difficulty was varied within a task, the old and new word data from the Consistent Truthful and Consistent Deceptive conditions were tested in a series of ANOVAs using the factors Response (Truthful, Deceptive) and Stimulus (Old, New).

3.4.1. Behavioral data

The data in Table 1 show that overall accuracy in the Consistent Truthful and Deceptive conditions was not different \( (F < 1) \). As evident from Fig. 1, RTs for both the old and new stimuli in the Consistent Deceptive condition were slower than those in the Consistent Truthful condition, by an average of 52 ms \( F(1, 20) = 28.3, P < 0.00005 \). In accord with the results of past studies, RTs for new words were an average of 44 ms slower than those for old words in both memory conditions \( F(1, 20) = 21.0, P < 0.0002 \). These significant main effects, coupled with the lack of a Stimulus × Response interaction \( (F < 1) \) indicate that the effect of response conflict on RT was independent of whether participants were deceptive by falsely denying knowing words they did know or falsely claiming to know words that they did not know.

3.4.2. Late positive component results

The ERPs elicited at all electrode sites in the Consistent Truthful and Consistent Deceptive conditions by the old and new words are superimposed in Figs. 2 and 3, respectively. These waveforms reveal that deceptive responses elicited smaller LPCs for both old and new words \( F(1, 20) = 6.4, P < 0.05 \) and that old words elicited larger LPCs than new words \( F(1, 20) = 118.4, P < 0.00001 \). The Response × Stimulus interaction was again not significant \( (F < 1) \). LPCs were largest over midline parietal scalp \( F(7, 140) = 19.6, \varepsilon = 0.336, P < 0.00001 \) and there were no distributional differences as a function of response \( (P = 0.12) \). However, the Stimulus × Electrode interaction was borderline significant due to the fact that the maximal amplitudes of the LPCs elicited by the old words were somewhat more posterior than those for the new words \( F(7, 140) = 3.1, \varepsilon = 0.336, P = 0.056 \). This distributional effect of memory status was not affected by whether participants made truthful or deceptive responses \( (Response \times Stimulus \times Electrode: P = 0.31) \). To ensure that
these LPC amplitude effects were not due to differences in RT variability across conditions, response-locked ERPs were quantified and all analyses on these data produced the same results.

As can be seen in Table 2, LPC latencies were, on average, a non-significant 12 ms later for the deceptive responses compared to truthful responses ($P = 0.24$). However, the average LPC latency for new words (635 ms) was significantly longer than for old words (591 ms) ($F(1, 20) = 14.9, P < 0.001$), although there was no Response $\times$ Stimulus interaction ($F < 1$).

3.5. Comparison of effects of different executive processes: tactical versus strategic monitoring

To compare the relative effects of tactical and strategic monitoring processes, the results from the Random Deceptive responses were compared with those from the Consistent Deceptive condition in a series of ANOVAs using the factors type of Monitoring (Tactical, Strategic) and Stimulus (Old, New). In addition, a second, within-condition, comparison was made to assess the effects of response conflict during strategic monitoring by comparing the results from the Random Truthful and Random Deceptive responses for both old and new stimuli.

3.6. Consistent Deceptive versus Random Deceptive responses

3.6.1. Behavioral measures

Only qualitative comparisons of accuracy rates for the Consistent Deceptive and Random Deceptive conditions can be made because participants were instructed to make errors on half the trials in the latter condition (Table 1). However, the nearly 50/50 response proportions in the Random Deceptive condition indicate a high level of task performance that compares favorably with the high accuracy rates seen in the Consistent Deceptive condition. The addition of the strategic monitoring task greatly increased task difficulty as evidenced by fact that RTs for the Random Deceptive responses were about 100 ms slower than those in the Consistent Deceptive condition ($F(1, 20) = 9.1, P < 0.01$). Overall, RTs for new words were an average of 47 ms slower than for old words ($F(1, 20) = 15.2, P < 0.001$) and this slowing did not differ as a function of the type of monitoring processes used (Monitoring $\times$ Stimulus: $F < 1$).

3.6.2. Late positive component results

The Consistent Deceptive ERPs elicited at Pz are superimposed on those for the Random Deceptive responses, separately for old and new words, in Fig. 5 (left column), with the waveforms from all sites in Figs. 2 and 3. For the Random Deceptive responses, the LPCs elicited by both the old and new words were much smaller than those elicited in the Consistent Deceptive condition ($F(1, 20) = 30.5, P < 0.00005$). Nevertheless, regardless of the type of monitoring participants engaged in, old words continued to elicit larger LPCs than new words ($F(1, 20) = 67.9, P < 0.00001$). There was a significant Monitoring $\times$ Stimulus interaction ($F(1, 20) = 5.7, P < 0.05$) because the amplitude difference between the old and new words was somewhat less when participants strategically monitored their responses.
Fig. 5. Stimulus- (left column) and response-locked (right column) ERPs at Pz showing the LPCs elicited by the old (top row) and new (bottom row) words for the Consistent Deceptive (heavy solid line), Random Truthful (dashed line) and Random Deceptive (thin solid line) responses.

Electrode again had a significant effect \( F(7, 140) = 15.6, \eta = 0.302, P < 0.00002 \), with the largest potentials elicited near Pz. There was also a significant Monitoring \( \times \) Electrode interaction due to the fact that the differences in LPC amplitude across conditions became less as LPC amplitude decreased in the anterior direction \( F(7, 140) = 6.8, \eta = 0.302, P < 0.005 \) (see Figs. 2 and 3). The Stimulus \( \times \) Electrode interaction was not significant \( P = 0.18 \), indicating no distributional differences between the two stimuli.

The fact that the RTs for the Random Deceptive responses were much more variable than Consistent Deceptive RTs again raised the possibility that the stimulus-locked LPC amplitudes were reduced simply as a result of increased latency variability across trials. However, analysis of the response-locked LPC activity (Fig. 5, right column) revealed that the condition differences were greater rather than less. This finding suggests that the principal contributions to LPC amplitude in the memory conditions were due to the stimulus-locked processes of stimulus categorization and memory access.

A comparison of the LPC latencies obtained for the Consistent Deceptive and Random Deceptive responses (Table 2) revealed that, although latencies were an average of 23 ms longer for the Random Deceptive responses, this difference was not significant \( F(1, 20) = 3.2, P = 0.09 \). However, LPC latency remained significantly longer overall for new words \( (646 \text{ ms versus } 615 \text{ ms, respectively}) F(1, 20) = 6.7, P < 0.02 \), and this was not different across conditions (Monitoring \( \times \) Stimulus: \( P = 0.20 \)).
3.7. Random Truthful versus Random Deceptive responses

3.7.1. Behavioral measures

As can be seen in Fig. 1, within the Random condition, RTs for Random Deceptive responses were an average of 26 ms longer than for Random Truthful responses ($F(1, 20) = 13.6, P < 0.002$). In addition, RTs for new words were an average of 29 ms longer than RTs for old words ($F(1, 20) = 7.5, P < 0.02$). Although the degree of RT slowing appeared to be less for old words, the Response × Stimulus interaction was not significant ($P = 0.17$).

3.7.2. Late positive component results

It is evident from the stimulus-locked ERPs in Fig. 5 (left column; see also Figs. 2 and 3) that there was little difference between the LPCs elicited by the Random Truthful and Random Deceptive responses while participants were engaged in the strategic monitoring task ($F < 1$). Nevertheless, memory status continued to have its usual effect since old words elicited significantly larger LPCs than new words ($F(1, 20) = 26.9, P < 0.00005$). The absence of any Response × Stimulus interaction ($F < 1$) confirmed the visual impression that there were no differences in LPC amplitude as a function of whether participants made truthful or deceptive responses in this condition. Analyses of the response-locked ERPs (Fig. 5, right column) produced the same results. Consistent with the lack of amplitude differences, LPC latency also did not vary as a function of either type of response or the memory status of the words (Table 2).

3.8. Memory measures

To determine whether the truthfulness of participant’s responses affected the EM effect, ERP areas for the parietal, frontal and occipital aspects of the EM effect were tested in separate three-way ANOVAs using the factors Condition, Stimulus (old, new) and Electrode.

3.8.1. Parietal episodic memory effect

As stated above, the parietal EM effect consists of an enhanced positivity for old words compared to new words over posterior scalp in the 500–800 ms interval. This difference is shown for the left parietal (P3) electrode site in Fig. 6 where the ERPs for old words are superimposed on those for new words for all conditions. Note that the ANOVA results for the Consistent Truthful versus Consistent Deceptive comparison (Fig. 6, top row) were presented above in the section on response conflict as a function of memory status. Planned comparisons on these data revealed that old words elicited larger LPCs than new words in both the Consistent Truthful ($F(1, 20) = 87.4, P < 0.00001$) and the Consistent Deceptive ($F(1, 20) = 61.6, P < 0.00001$) conditions. The ANOVA comparing the LPCs elicited by old and new words in the Consistent Truthful and Random conditions (Fig. 6, top left versus bottom right) revealed that LPCs were significantly smaller for the Random Deceptive responses ($F(1, 20) = 32.4, P < 0.00002$) and that old words elicited larger LPCs than new words ($F(1, 20) = 108.9, P < 0.00001$). Despite the reduced amplitudes of the LPCs for the Random Deceptive responses, neither the magnitude of the old–new difference (Response × Stimulus: $P = 0.139$) nor the scalp
distribution of old and new word LPCs was significantly affected when deceptive responses were made in the Random Deceptive condition (Response × Stimulus × Electrode: $P = 0.136$). The lack of any effects of making deceptive responses on old and new word LPC scalp distributions is also evident in the overall across-condition similarity of the brain activity in this interval (Fig. 7). Note that a primary difference in these maps is in the number of contour lines over posterior scalp, which reflects the LPC amplitude differences across conditions. The other difference in these maps is that, unlike the maps for old words, the maps for new words are characterized by the presence of a negativity that was maximal near the Fz electrode. It is also evident from these maps that there were no condition effects on the magnitude or scalp distribution of this negativity. As would be expected from the ERPs in Fig. 6 and the maps in Fig. 7, essentially the same results were obtained when the LPCs from the Consistent Truthful condition were compared to those for the Random Truthful responses. Planned comparisons revealed that old words elicited larger LPCs than new words for both the Random Truthful [$F(1, 20) = 8.2, P < 0.01$] and Random Deceptive responses [$F(1, 20) = 31.0, P < 0.00005$]. Thus, the data indicate that the magnitude of the parietal EM effect was remarkably insensitive to the other experimental factors such as whether participants responded truthfully or deceptively, whether they tactically and/or strategically monitored their responses, the probability of the deceptive responses and the speed and variability of their responses.
3.8.2. Left frontal episodic memory effect

The left frontal EM effect (Fig. 8) consists of a greater negativity in the 300–500 ms interval elicited by new words relative to old words. The two-way ANOVA comparing the left frontal ERPs elicited by old and new words in the Consistent Truthful and Consistent Deceptive conditions (Fig. 8, top row) replicated the usual result by showing that there was significantly more negativity elicited by new words \[ F(1, 20) = 32.5, P < 0.00002 \]. There were no amplitude (Response \times Stimulus: \( P = 0.36 \)) or scalp distribution differences as a function of the truthfulness of the responses (Response \times Electrode: \( P = 0.21 \); Response \times Stimulus \times Electrode: \( P = 0.54 \)). Planned comparisons revealed that new words elicited significantly larger frontal negativities than old words in both the Consistent Truthful \( F(1, 20) = 31.4, P < 0.00005 \) and Consistent Deceptive \( F(1, 20) = 21.9, P < 0.00002 \) conditions.

The ANOVA comparing the frontal EM effects for the Consistent Truthful and Random Deceptive responses (Fig. 8, top left versus bottom right) revealed that there was significantly more negativity for new words than old words \( F(1, 20) = 16.2, P < 0.001 \). Although the old–new difference was smaller for the Random Deceptive responses, due to the presence of less negativity for new words, the requirement for participants to strategically monitor their deceptive responses did not significantly alter the overall old–new difference (Response \times Stimulus: \( P = 0.12 \)) or the scalp distribution of the frontal negativity (Response \times Stimulus \times Electrode: \( P = 0.31 \)). Essentially the same results were obtained for the comparison of the Consistent Truthful versus Random Truthful responses.
Fig. 8. ERPs at the F3 electrode site showing the left frontal episodic memory effect for the Consistent Truthful (top left), Consistent Deceptive (top right), Random Truthful (bottom left) and Random Deceptive (bottom right) responses. The ERPs for the old words (solid lines) are superimposed on those for the new words (dashed lines). The bracket over each pair of waveforms at 300–500 ms indicates the temporal interval used to quantify the ERP activity.

(Fig. 8, top left versus bottom left). However, the smaller old–new differences for both truthful and deceptive responses within the Random Deceptive condition led to a finding of no significant difference in this left frontal activity as a function of memory status in the planned comparisons for either the Random Deceptive ($P = 0.13$) or Random Truthful responses ($P = 0.22$).

3.8.3. Occipital episodic memory effect

The occipital EM effect is characterized by an increased negativity for new words in the 300–500 ms interval that is maximal over primary visual areas (Fig. 9). The ANOVA comparing the occipital ERPs elicited by the old and new words in the Consistent Truthful and Consistent Deceptive conditions (Fig. 9, top row) revealed that there was significantly more negativity elicited by new words compared to old words ($F(1, 20) = 43.6, P < 0.00001$). As for the other aspects of the EM effect, there were no amplitude (Response × Stimulus: $P = 0.83$) or scalp distribution differences as a function of the truthfulness of their responses (Response × Electrode: $P = 0.30$, Response × Stimulus × Electrode: $P = 0.29$). Planned comparisons revealed that new words elicited significantly larger negativities than old words over occipital scalp in both the Consistent Truthful ($F(1, 20) = 45.6, P < 0.00001$) and Consistent Deceptive ($F(1, 20) = 26.4, P < 0.00001$) conditions.

The ANOVA comparing the occipital EM effects elicited by the Consistent Truthful and Random Deceptive responses (Fig. 9, top left versus bottom right) revealed that there
Fig. 9. ERPs elicited at the O1 electrode site showing the occipital episodic memory effect in the Consistent Truthful (top left), Consistent Deceptive (top right), Random Truthful (bottom left) and Random Deceptive (bottom right) responses. The ERPs for the old words (solid lines) are superimposed on those for the new words (dashed lines). The bracket over each pair of waveforms at 300–500 ms indicates the temporal interval used to quantify the ERP activity.

was significantly more negativity for new words than old words \( F(1, 20) = 33.2, P < 0.0002 \) and an overall effect of condition \( F(1, 20) = 23.4, P < 0.0002 \). Although the magnitude of the negativity elicited by the new words was about the same in both conditions, the overall old-new difference was smaller for Random Deceptive responses due to the increased negativity elicited by old words (Response × Stimulus: \( F(1, 20) = 4.9, P < 0.05 \)). However, this difference, seen clearly in Fig. 2, did not lead to any significant differences in scalp distribution as a function of type of response (Response × Electrode: \( P = 0.08 \); Response × Stimulus × Electrode: \( P = 0.22 \)). As would be expected from the ERPs in Fig. 9, essentially the same results were obtained when ERP data from the Random Truthful responses were compared with those from the Consistent Truthful condition. Within the Random Deceptive condition, planned comparisons indicated that there was a small but significant occipital EM effect for Random Deceptive responses \( F(1, 20) = 8.7, P < 0.01 \), with no difference for Random Truthful responses (\( P = 0.17 \)).

3.9. Catch-trial performance

Despite the fact that catch trials occurred more rarely than memory trials (20% versus 80%, respectively), it is possible to assess the relative RT differences across trial types. That is, countering the expected slower RTs for the less probable catch stimuli was the fact that, unlike the memory trials, there was no need to perform an episodic memory search to
classify these stimuli correctly. We expected, therefore, that catch trial RTs would be as fast or faster than those on memory trials. Note that, if participants did alter the stimulus-response assignments in either deception condition in order to make non-conflicting responses on the majority of trials (i.e., the memory trials), this would be evident as decreased accuracy and slower RTs on catch trials compared to memory trials.

The behavioral data for the catch trials are presented in Table 3 where it is clear that performance was quite good regardless of whether they occurred in a truthful or deceptive condition. Percent correct ranged from 92.4 to 95.1% with no differences as a function of condition ($P = 0.23$). However, the condition effects on RT and RT variability for the memory trials described above spilled over into the catch trial results. Thus, there were significant differences as a function of condition in both RT ($F(2, 40) = 20.4, \epsilon = 0.958, P < 0.0001$) and RT variability ($F(2, 40) = 6.4, \epsilon = 0.865, P < 0.02$), as shown in Table 3, unlike for the regular trials, catch trial RTs showed the greatest slowing in the Consistent Deceptive condition when the level of response conflict was greatest. Post hoc tests revealed that catch RTs were significantly faster in the Consistent Truthful condition compared to both the Consistent Deceptive ($F(1, 20) = 45.1, P < 0.0001$) and Random Deceptive ($F(1, 20) = 22.7, P < 0.0005$) conditions. Additional post-hoc tests on RT variability revealed that, although catch trial RTs were significantly less variable in the Consistent Truthful condition relative to the Consistent Deceptive condition ($F(1, 20) = 20.1, P < 0.0005$), variability was not different between the Consistent Truthful and Random Deceptive conditions ($F(1, 20) = 3.6, P = 0.07$).

To determine if participants altered the given stimulus-response assignments, catch trial RTs were compared with those for new words in their respective conditions (Fig. 1). These tests revealed that participants responded 60 ms faster on catch trials in the Consistent Truthful condition ($F(1, 20) = 22.0, P < 0.0002$), a non-significant 34 ms faster in the Consistent Deceptive condition ($F(1, 20) = 14.9, P < 0.001$). Note that the new word data were used in these comparisons to avoid any contaminating effects of episodic memory. Compared to the memory trials, catch RTs were less variable in the Random Deceptive condition when RT variance was unusually high ($F(1, 20) = 20.9, P < 0.0002$), but not in either the Consistent Deceptive ($P = 0.49$) or Consistent Truthful ($P = 0.64$) conditions. Importantly, tests directly comparing the results from the Consistent Deceptive and Random Deceptive conditions showed no significant differences in catch RTs ($P = 0.29$) or RT variability ($P = 0.20$) between the two deception conditions.

The LPCs elicited on catch trials were analyzed to determine if their amplitudes were affected by the use of tactical and strategic monitoring processes on the surrounding memory trials in the deception conditions. As can be seen in Fig. 10A, the use of either type of monitoring process had no affect the LPCs elicited on catch trials. Instead, unlike the memory

<table>
<thead>
<tr>
<th></th>
<th>Consistent Truthful</th>
<th>Consistent Deceptive</th>
<th>Random Deceptive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correct (%)</strong></td>
<td>95.1 (4.8)</td>
<td>93.9 (7.3)</td>
<td>92.4 (7.4)</td>
</tr>
<tr>
<td><strong>Reaction time (ms)</strong></td>
<td>579 (102)</td>
<td>660 (133)</td>
<td>644 (121)</td>
</tr>
</tbody>
</table>

Table 3: Mean (S.D.) percent correct and reaction time (ms) for the catch trials as a function of condition.
Fig. 10. (A) ERPs elicited by the catch trials in all three memory conditions. The ERPs elicited by the catch trials are superimposed on the ERPs elicited by the new words in the Consistent Truthful (panel B), Consistent Deceptive (panel C) and Random Deceptive (panel D) conditions.

trials, LPC amplitudes were remarkably similar across conditions. In all cases, catch trials elicited larger and earlier LPCs than memory trials due to their being less probable. As would be expected from the waveforms, LPC area (400–700 ms) was not significantly different as a function of condition ($F < 1$) and, although amplitude varied significantly as a function of electrode [$F(7, 140) = 15.3, \epsilon = 0.290, P < 0.0001$], there was no Condition × Electrode interaction ($P = 0.34$) indicating a lack of distributional differences across conditions. The direct comparisons of the catch and memory trial ERPs elicited in each condition, shown in Fig. 10B–D, reinforce the conclusion that although the memory trials were processed differently in the various conditions, the randomly occurring catch trials were clearly processed in the same manner regardless of what was happening on the other trials in the series.
4. Discussion

The present study has elucidated some of the executive control processes used when persons falsely respond regarding the nature of perceived and remembered information. Although the processes used to execute deceptive responses are only a part of the overall processing used when persons are deceptive, unlike the more variable aspects relating to the intent to deceive, every deception requires that specific processes be engaged in order to inhibit truthful responses and execute incompatible responses. Using experimental manipulations similar to those used previously in studies of guilty knowledge and malingering, we found evidence for two dissociable response-related processes, tactical and strategic monitoring. The findings also revealed that, compared to truthful responses, deceptive responses produced a number of independent and additive effects on behavioral measures (response accuracy and speed) and brain activity (LPC amplitude and latency). Together, the behavioral and LPC results suggest that using the processes required to inhibit truthful responses in order to make a deceptive response takes attentional and/or processing resources away from the primary task of responding truthfully. The data further suggest that the processes used to make deceptive responses are general purpose in nature since the same pattern of altered behavioral and ERP results obtained regardless of whether participants responded deceptively about perceived or remembered items. Finally, we found that making deceptive responses had no significant effect on the parietal EM effect, thought to reflect the recollection processes elicited when a cue makes contact with a memory trace. Thus, the data indicate that at least the parietal subcomponent of the EM effect can be used to provide an objective and involuntary measure of whether items are in a person’s personal memory, independently of whether a person lies about knowing particular items or falsely responds that they know items that they do not know.

4.1. Role of executive processes in deceptive responding

In our conceptualization of deception, the requirement to make a response that conflicts with the truth means that executive control processes play a vital role. This is because these processes play an essential role in resolving conflicting response tendencies, inhibiting the pre-potent truthful response, and selecting and executing a deceptive response. Although the pre-response processing aspects of deception are what most people think of first, this does not alter the necessity, nor reduce the importance, of these response-related processes to the act of deception. As noted above, for deceptions in which the person decides on the nature of their deceptive response prior to an interrogation, these executive processes are likely to comprise a large portion of the deception-related cognitive processes that are actually used at the time when the deceptive response is executed. It was this type of situation that the Consistently Deceptive condition was designed to model.

In accordance with the results of previous studies of perceptually-based response conflict, we found that LPC latency was differentially sensitive to task and response processing factors. As reviewed above, large changes in RT and LPC latency are typically associated with variations in task processing demands while much smaller changes are associated with manipulations of response processing demands (Doucet and Stelmack, 1999; Duncan-Johnson and Kopell, 1981; Leuthold and Sommer, 1998; Magliero et al., 1984;
McCarthy and Donchin, 1981; Ragot and Lesèvre, 1986). For example, the 15–40 ms LPC latency increases associated with processing of response conflicts in these previous studies compares favorably with the 14–18 ms latency increases we found for incompatible responses to our left-right stimuli. In contrast, the concomitant 58 ms change in RT found here was several times greater. These findings conform to previous conclusions that, compared to RT, LPC latency is relatively unaffected by the need to process conflicting response information. Conversely, as in previous studies, task manipulations produced nearly equal changes in RT and LPC latency (188 and 173 ms, respectively). Finally, consistent with the results of Doucet and Stelmack (1999) and Magliero et al. (1984), we also found that the processing of perceptually-delivered conflicting response information was also associated with reductions in LPC amplitude.

We extended these results by showing that virtually the same pattern of changes in RT accuracy, speed and variability and LPC amplitude and latency found in the perceptual task also obtained when participants made deceptive responses about remembered items. The present data thus represent an important extension of previous results because, in contrast to the objectively conflicting response information contained in the externally presented stimuli, the same effects of response conflict were found when the sole source of conflicting response information was subjective (i.e., from the participant’s own memory). Hence, unlike the perceptual task when every one experiences essentially the same response conflict, whether or not a person experiences response conflict in the memory task depends entirely on the nature of their own past experiences. This point is reinforced by the fact that the items for each word list were randomly selected, along with the stimulus-response assignments, so there was nothing to distinguish any word from any other except that some items were in the participant’s memory.

One notable finding revealed by the overall pattern of results from the Perceptual-Memory task comparisons is how independent the tactical monitoring processes are from a variety of other cognitive processes. That is, the same RT increases and LPC amplitude decreases were found regardless of variations in stimulus (left-right versus all different words) or task (perceptual versus memory) processing demands, and regardless of the memory status of the items (i.e., whether participants denied having particular items in memory or falsely claimed that they knew items that were not in memory). Perhaps most surprisingly, variations in the probability of making incompatible responses also had no detectable effect on any behavioral or ERP measures. This finding was evident in the lack of RT or LPC differences between the perceptual and memory tasks, despite across-task differences in the probability of incompatible responses (100% versus 80%, respectively). This lack of probability effects on these executive processes raises the possibility that, although our deceptive responses were much more probable than the 14–17% levels used in previous directed lie studies (e.g., Allen et al., 1992, 2000; Farwell and Donchin, 1991; Rosenfeld et al., 1991), this may not be a meaningful difference. Based on all these results, it appears reasonable to conclude that the executive processes used to resolve response conflicts operate independently of the processes used to perform these other cognitive operations. Hence, the data suggest that these are likely to be general purpose processes that are used in a variety of situations, including when a person executes a deceptive response.

In contrast to the tactical (within-trial) response monitoring processes modeled in the Consistent Deceptive condition, the Random Deceptive condition was designed to model
the kind of strategic monitoring processes that would be used when persons need to keep
track of the pattern of their responses over longer time intervals. To isolate better the effects
of the strategic monitoring processes, the results from the Random Deceptive condition were
compared to those from the Consistent Deceptive condition, rather than to the Consistent
Truthful condition. This comparison revealed that, in addition to RTs becoming much slower
and more variable, LPC amplitude decreased considerably for both Random Truthful and
Random Deceptive responses when participants had to select and monitor their responses
over the 145 events in the series. The magnitude of these behavioral and ERP changes
across conditions indicates that the demands associated with the strategic monitoring task
were considerably greater than those required for tactical monitoring. It is also evident
that, had we compared the data from the Random Deceptive condition with those from
the Consistent Truthful condition, the magnitudes of the differences between truthful and
deceptive responses would have been even greater. At least one artifactual explanation for the
large LPC amplitude decrements seen in the Random Deceptive condition, that they were due
to increased latency jitter, was ruled out when we showed that similar amplitude decrements
were also present in response-locked LPCs. Thus, the different patterns of results associated
with tactical and strategic monitoring operations found here are consistent with the results of
previous studies that suggested that these two executive processes may depend on different
brain circuits located in the anterior cingulate cortex (e.g., Turken and Swick, 1999).

The relative magnitudes of the RT increases and LPC amplitude decreases in the Consis-
tent Deceptive and Random Deceptive conditions fit well with the results of experiments in
which the processing requirements of both tasks in a dual-task situation were systematically
manipulated (Israel et al., 1980a,b; Kramer et al., 1985; Wickens et al., 1983). As in those
studies, LPC amplitudes here decreased as processing resources were drawn away from the
primary task of responding truthfully in order to perform the executive processes necessary
to respond deceptively. Also replicating the results of previous studies, the LPC amplitude
decrements in the present experiment were graded and proportional to the increases in RT
in each deception condition. Thus, whereas relatively small but significant RT increases
and LPC amplitude decreases were found for the Consistent Deceptive and Perceptual In-
compatible conditions, much larger changes were found in the Random Deceptive condition
when participants also had to perform the more demanding strategic monitoring task. Taken
together, the results from all three conditions suggest that there are continuums for altered
response speed and variability and LPC amplitude that reflect the extent of deception-related
processing that a person engages in. Based on the present data, the Consistent Truthful and
Random Deceptive conditions provide the endpoints of these continuums, with the values
from the Consistent Deceptive condition falling more toward the truthful end of the scale.
The LPC results described here also fit well with the concurrently recorded medial frontal
negativity (MFN) recorded in the response-locked ERPs over frontal scalp (Johnson et al.,
2003a). The MFN peaks around 70 ms after a response and its amplitude is thought to
reflect the use of executive processes involved in monitoring and processing conflicting
response tendencies and/or error correction (e.g., Falkenstein et al., 2000; Gehring et al.,
1993; Scheffers and Coles, 2000). It was initially found to be elicited only on error trials
and thus labeled the error-related negativity (ERN) (e.g., Falkenstein et al., 1991, 1994;
Gehring et al., 1993). Subsequent studies have revealed that similar negativities are also
elicited on correct trials (Gehring and Knight, 2000; Vidal et al., 2000), particularly when
there was ambiguity about how stimuli should be categorized (Scheffers and Coles, 2000). However, the negativity elicited on correct trials, referred to by some as the MFN (Gehring and Willoughby, 2002), appears to have a different pattern of generator activity than the ERN (Ullsperger and Von Cramon, 2001; Johnson et al., 2003a). A comparison of the amplitude changes for both the LPC and MFN components, which arise from different brain areas, indicates that the magnitude of the increases in MFN amplitude found in both the perceptual and memory tasks were mirrored by proportionately similar LPC amplitude decreases. In addition, in every case where we found that the MFN amplitude increases occurred in a manner that was independent of, and additive to, the other stimulus and task variables, the same additive relations were found for LPC amplitude decreases. One possibility raised by these results is that performing the additional executive processes reflected by the MFN may be at least part of the reason that processing resources are drawn away from the primary task of responding truthfully, leading to the decreases in LPC amplitude.

4.2. Catch trials

The catch trials, which have not been used previously in studies intended to detect either guilty knowledge or feigned memory loss, represent an important addition to our deception conditions because they required participants to make truthful responses at least 20% of the time regardless of what else they were doing. They also allowed us to address a potential criticism of the Consistently Deceptive condition, namely that participants might have re-mapped their stimulus-response assignments to eliminate the conflicting response information. This would have been an obvious and advantageous option since the deceptive responses occurred 80% of the time in the Consistent Deceptive condition. If this strategy was used, however, it would have been detectable in a number of ways. For one, if the participants re-mapped their stimulus-response assignments in the Consistent Deceptive condition, then the assignments would have been identical to those used in the Consistent Truthful condition. It follows then, that because the processing for the memory stimuli would have been the same in both conditions, there should have been no differences in RT or LPC amplitude between them. Clearly, this result did not obtain. Due to the presence of the catch trials, however, it would have been impossible for the participants to completely eliminate all response conflict from the Consistent Deceptive condition. Instead, a direct consequence of such a re-mapping would have been to transfer the response conflict from the memory trials to the catch trials, along with the attendant RT and LPC changes. Again, no such results were found; catch trial RTs were still significantly faster than memory trial RTs and catch trial LPCs were not significantly smaller than those in the Consistent Truthful condition. Finally, all the changes in RT and LPC amplitude found in the perceptual task, when no re-mapping was possible, were also present in the Consistent Deceptive condition for both old and new words. Taken together, all the data are consistent with the idea that participants performed the Consistent Deceptive as instructed, without re-mapping their responses to eliminate the response conflict on the memory trials.

Another important result here is the dissociation of the effects of the catch and memory stimuli on LPC activity in the deception conditions. That is, in contrast to all the other significant differences that were found between the truthful and deceptive conditions for the
memory trials, the catch trial LPCs in both deception conditions were essentially identical to those elicited in the Consistent Truthful condition. This finding therefore reinforces the idea that the RT and LPC changes found for the memory trials in the deception conditions were indeed specific to the cognitive processes used to make deceptive responses, rather than to general factors such as task difficulty. This specificity occurred not only across conditions but also within conditions because the catch trial LPCs were entirely unaffected by the increased task demands for the surrounding memory trials in both deception conditions. This result obtained even in the Random Deceptive condition when participants had to monitor continuously, and over many trials, the pattern of their responses to the memory stimuli. In addition, the lack of any differential responses on catch trials in the deception conditions is further consistent with the idea that being deceptive is analogous to performing a secondary task. That is, since there was no need to process conflicting response information and/or monitor response patterns on catch trials, this eliminated the basis for a secondary task. Hence, there was no reason to expect the same types of altered ERP activity that were present on memory trials in the deception conditions to occur on the catch trials.

The lack of any differential LPC activity for the catch trials in the Consistent Deceptive condition relative to those in the Consistent Truthful condition supports the idea that truthful responses actually are the pre-potent response. This is because, if participants viewed the situation as one in which they switched back and forth between responding truthfully on the catch trials and deceptively on the memory trials, then task switching operations, which also require processing resources, would be necessary for every switch from memory to catch trial and vice versa. The additional processing associated with such task switching operations would have been evident in two ways. First, catch trial LPCs in the Consistent Deceptive condition should have been smaller than those in the Consistent Truthful condition because no switching was required in the latter condition. Second, the magnitude of the LPC amplitude decrement associated with making a deceptive response could not be the same in the memory and perceptual tasks (as was the case) if task switching had occurred in the Consistent Deceptive condition. That is, task switching operations would further add to the secondary task processing, thereby causing an even greater LPC amplitude decrement than what could occur in the perceptual comparison when the absence of catch trials obviated the need for task switching. Thus, the data are entirely consistent with the idea that truthful responses are the pre-potent responses and that the participants did not engage in any task switching to avoid performing the tasks as instructed.

4.3. Guilty knowledge measures

One advantage of using the old/new recognition paradigm in the assessment of guilty knowledge is that there is a large body of research that has used this paradigm to characterize the cognitive processes associated with the different memory-related patterns of ERP activity (for reviews, see Friedman and Johnson, 2000; Rugg and Allan, 2000). In accord with previous results, we found that old words produced significantly different amounts of ERP activity over parietal, frontal and occipital scalp areas. The best studied aspect of the EM effect, that items in episodic memory elicit larger LPCs over parietal scalp than items not in memory, was found to be not significantly reduced in either of our deception conditions (cf., Tardif et al., 2000). Hence, despite the fact that the old and new words were miscategorized
in the deceptive conceptions, the parietal EM effect was not significantly different from that elicited when the same items were categorized truthfully. The present findings extend previous results showing that the parietal EM effect reflects the true, rather than the stated, memory status of the items (Johnson et al., 1998; Smith, 1993; Wilding et al., 1995) to the case in which the miscategorizations are made intentionally, rather than unintentionally. They thus further reinforce the idea that this brain activity reflects an obligatory explicit memory process, probably recollection. In addition, given that Tardif et al. (2000) elicited their deceptive responses in a random condition, we extended their results by showing that the parietal EM effect was also present for high-probability deceptive responses when there was no requirement to strategically monitor one’s responses. The fact that the parietal EM effect was not significantly affected regardless of whether participants denied having particular items in their memory or falsely claimed to know items that they did not know suggests that it may be possible to use it to determine the type of deception that a person is trying to perpetrate.

A second aspect of the EM effect, the left frontal component, in which new words elicit more negativity than old words, was similarly unaltered by deceptive responses in the Consistent Deceptive condition (cf., Johnson et al., 1998; Smith, 1993; Tendolkar et al., 1997). The results were less consistent when participants strategically monitored their responses, although this may have been due to spatial overlap with the much greater amounts of MFN generator activity maximal nearby in medial prefrontal scalp in this condition (Johnson et al., 2003a). The third aspect of the EM effect, the larger negativity over occipital scalp for new words, thought to reflect perceptual priming processes (Friedman and Johnson, 2000), was also unaffected by the execution of Consistent Deceptive responses. In a surprising and significant deviation from this pattern of activity, old words in the Random Deceptive condition elicited nearly as much negativity as the previously unseen new words. At present, we have no explanation for why a process like perceptual priming would be affected by the Random Deceptive task.

The results of recent ERP studies on directed forgetting and false memories are somewhat analogous to the deceptive responses elicited here for the old and new words, respectively. In directed forgetting studies, participants are exposed to two sets of intermixed items with the instructions that they are to forget the items in one of the two sets. One idea holds that directed forgetting is an active and conscious inhibitory process that is intended to inhibit information that exists in memory. In this way, directed forgetting is similar to the inhibitory processes that must be used in the Consistent Deceptive condition, with the important distinction that it is the participant, rather than the experimenter, who decides which information to inhibit. In an ERP study of directed forgetting, Ullsperger et al. (2000) found that, unlike for the to-be-remembered items, the to-be-forgotten items did not elicit a parietal EM effect. However, they also reported that the to-be-forgotten items did elicit a normal left frontal EM effect, indicative of normal familiarity. Based on these, albeit limited, results, it appears that the processes underlying directed forgetting, although similar in some ways, must be fundamentally different from what we found for deceptive responses. That is, although the presence of a normal left frontal EM effect was common to both paradigms, the differential presence of the parietal EM effect suggests that the directed forgetting paradigm is not a good model of what occurs when persons are deceptive.
The responses in false memory paradigms are also similar in some respects to those for
the new words in the Consistent Deception condition. False memory paradigms create the
illusion that “lure” items have been previously experienced by, for example, using lists
of words that are all semantically related to the never presented lure items. Under these
conditions, participants typically falsely classify the lure items as having been presented.
Thus, participant’s responses to new words falsely categorized as being old in false memory
studies can be seen as similar to those in our deception conditions when new words were
categorized deceptively as old. To date, the findings of the false memory studies are largely,
but not entirely consistent with those of the present study. Thus, while false memories were
found to elicit a parietal EM effect that was the similar to that for the true memories in some
studies (Fabiani et al., 2000; Nessler and Mecklinger, 2003), it was significantly smaller
than that elicited by true memories in most studies (Curran et al., 2001; Gonsalves and
Paller, 2000; Nessler et al., 2001; Miller et al., 2001). The findings of reduced parietal EM
effects in false memory studies, but not in our deception conditions, likely reflects the fact
that, because all the old words had been experienced multiple times over the preceding
week, participants in our experiment had more than one basis for distinguishing between
the old and new words.

There does appear to be a behavioral similarity in the RTs for deceptive responses and
false memory responses. The present study demonstrated that, relative to truthful responses,
RTs for deceptive responses were longer and more variable, particularly in the Random De-
ceptive condition. In studies with choice RT tasks comparable to ours, false memories
also produced longer and usually more variable RTs (Fabiani et al., 2000; Gonsalves and
Paller, 2000, Nessler et al., 2001; Nessler and Mecklinger, 2003). Further, Gonsalves and
Paller (2000) found that, although the RT distributions for true and false memory items
largely overlapped, the shapes of the distributions were substantially different. That is,
in contrast to the usual slightly skewed Gaussian RT distribution for true memories, the
RT distribution for false memories was relatively rectangular (see their Fig. 5). We found
similar differences in the RT distributions for the Consistent Truthful and Random Decep-
tive conditions, respectively, with the distribution for the Consistent Deceptive condition
in between (i.e., less rectangular and more Gaussian). Similarly, Ullsperger et al. (2000)
found that to-be-forgotten items were also associated with significantly longer RTs than
the to-be-remembered items. It is reasonable to speculate that the slowed RTs in all three
of these paradigms reflect the increased conflicting response information created by the
memory and deception manipulations. However, the nature of the conflict is likely to be
quite different, with the conflict in the deception task being caused by too much input
from memory compared to there being too little memory information in the other two
cases.

5. Conclusion

The present experiment represents a first step at empirically specifying the cognitive
processes used when persons are deceptive. To isolate better these processes, deceptive
responses were made under restricted conditions involving deceptions that may be described
as simulated because both the participants and the experimenter knew the truth and the
participants knew that. However, we believe that the fact that the same pattern of results was
obtained in both the perceptual and memory tasks, as well as in both deception conditions,
supports the idea that the cognitive processes used to inhibit the truthful response and make
a conflicting response, basic components of all deceptions, depend on general purpose
processors. Although the Random Deceptive condition was intended primarily to create a
strategic monitoring task, it also provided a somewhat more realistic simulation because
the participants determined, according to their own criteria, whether to respond truthfully
or deceptively on any given trial. Despite the seemingly simplistic nature of our deception
conditions, they both required the types of response processes that would presumably be
used in any deception and it is difficult to see how more realistic scenarios would somehow
obviate the need for the executive processes studied here.

Whereas the present results provide support for the idea that basic studies of the processes
that contribute to deceptions can provide useful information, they represent only a beginning
and more realistic scenarios need to be tried. Given that executive processes have been
shown to be essential for dealing with conflicting response tendencies in a broad range of
circumstances, more realistic deception scenarios are likely to either produce exaggerations
of the altered activity described here and/or add additional components (e.g., those related
to the much greater salience of deceptive responses in real-world situations). An important
addition for future studies would be attempts to introduce an emotional component, a normal
aspect of most deceptions. Thus, based on the present results, it is reasonable to expect that
studies of more realistic deceptions would reveal additional differences, such as those
related to the intent to deceive or the emotional components of deception.

Overall, the present results have demonstrated that, despite the complexity of deception, a
functional approach can be used advantageously to provide information about the cognitive
processes and neural mechanisms involved when persons are deceptive. We identified the
neural-behavioral correlates of at least one process that is central to all deceptions, the tacti-
cal monitoring processes used to overcome the pre-potent truthful response in order to make
a deceptive response. In addition, we found evidence for a second independent, strategic
monitoring process that would be invoked in order to keep track of the pattern of one’s past
truthful and deceptive responses. Taken together, the results indicate that making deceptive
responses about perceived and remembered items engages some apparently general purpose
cognitive processes that are used to deal with conflicting response information generated in
a variety of circumstances and across a range of task difficulty. The LPC results, combined
with our previous MFN results, suggest that, in a real-world situation, even an attempt to
respond with a consistent or well-practiced deception that requires no special planning or
monitoring may be detectable.

Acknowledgements

We want to thank Chanpreet Singh for assisting during data collection and Yury Lehman
for his technical assistance. We also gratefully acknowledge the helpful comments of the
John Allen and four anonymous reviewers who devoted an uncommon degree of effort to
their reviews and provided many insightful comments that improved the manuscript. This
research was supported by the Research Foundation of the City University of New York.
References


