



The forward effects of testing on eyewitness memory: The tension between suggestibility and learning

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ABSTRACT

Research has consistently demonstrated that taking a test prior to receiving misleading information can increase misinformation susceptibility (Chan, Thomas, & Bulevich, 2009). However, research has also demonstrated that testing enhances subsequent learning (e.g., Tulving & Watkins, 1974; Wissman, Rawson, & Pyc, 2011). The goal of the present study was to examine these seemingly contradictory effects of testing. In two experiments we tested the hypothesis that testing influences how post-test information is processed. Depending on the nature of the later memory test, test-related processing can result in either memory errors or enhanced learning effects. Experiment 1 indicated that testing may result in elaborative processing of post-test material, resulting an increase in misinformation suggestibility. Experiment 2 suggested that increased suggestibility after testing may be understood as test-related learning of post-test material. Taken together, the results suggest that interim testing occurring between an original event and post-event misinformation may enhance memory suggestibility, because testing results in elaborative processing of subsequent material. However, interim testing also helps segregate memory for each source, resulting in test-potentiated learning within the misinformation paradigm.

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Introduction

Eyewitness memory is often studied in the context of the misinformation paradigm, where participants witness an original event, encounter misleading post-event information, and then are tested on their memory for the original event (Frenda, Nichols, & Loftus, 2011 for review). The typical finding is that misleading post-event information negatively impacts memory for the original event. However, the standard misinformation paradigm omits an important factor that may very well influence the ability of eyewitnesses to accurately remember witnessed events. Eyewitnesses commonly engage in an initial retelling of the witnessed event to an emergency operator or on-the-scene officer. This initial retelling can be viewed as a memory test of the originally witnessed event. Considering the large literature on retrieval enhanced learning effects in verbal learning and education (for review see Roediger & Butler, 2011), a test on the witnessed event should improve retention of the witnessed event. However, research within the misinformation paradigm has consistently demonstrated that testing participants' memory immediately after they witness an event renders them more susceptible to mislead-

ing post-event information, and ultimately less accurate on subsequent memory tests. This test-related memory impairment is known as *Retrieval Enhanced Suggestibility* (RES) (Chan, Thomas, & Bulevich, 2009; Gordon & Thomas, 2014; Gordon, Thomas, & Bulevich, 2015; Thomas, Bulevich, & Chan, 2010).

In the RES paradigm, participants view a video of an event, then take an immediate memory test on the event. Next, participants read or listen to a post-event narrative. The narrative is a synopsis of the event that includes details both consistent and inconsistent with the original event. A final memory test for the original event follows. RES is typically demonstrated on this final memory test in two ways: retrieval-enhanced errors of omission and retrieval-enhanced errors of commission. When participants make errors of omission, they are less likely to recall original event details on a final memory test after exposure to misinformation in the narrative. Participants who take an interim test between the original event and the post-event narrative perform even worse compared to those who do not (e.g., Chan et al., 2009; Gordon & Thomas, 2014). This suggests that testing prior to the narrative may reduce accessibility of original event details (cf., Chan & LaPaglia, 2013). However, we caution that these retrieval-enhanced errors of omission in RES studies are not always found (see Chan & Langley, 2011; Chan, Wilford, & Hughes, 2012; Wilford, Chan, & Tuhn, 2013 for examples). Errors of commission also increase after taking

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an interim test in the RES paradigm (Chan et al., 2009; Gordon et al., 2015; Thomas et al., 2010). When participants make errors of commission, they are not simply unable to recall details from the original event, they instead report misleading event details suggested in the narrative. As this pattern of results increases when interim testing is implemented, it is plausible that taking an interim test may impact how well narrative information is learned (cf., Arnold & McDermott, 2013; Gordon & Thomas, 2014; Wahlheim, 2015; Wissman, Rawson, & Pyc, 2011). Further, in contrast to increased errors of omission, increased errors of commission are always demonstrated after interim testing in the RES paradigm.

The present study focused on how and why taking a test on a witnessed event consistently increases errors of commission. Studying errors of commission in this context has both applied and theoretical importance. Understanding the situational factors that may increase the likelihood of an eyewitness attending to and later reporting inaccurate post-event details can inform the procedures used to interview witnesses both at the scene, and at later points during an investigation. In addition, if prior testing impacts how well subsequently presented misinformation is learned in this paradigm, then this work provides an important extension of test-potentiated learning effects to the novel context of eyewitness memory. Further, it presents a new paradigm in which to test theories of the mechanisms underlying these effects.

Forward effects of testing

Research has consistently demonstrated that interim testing, or testing between learning episodes, influences learning of post-test material. This phenomenon has been characterized as a *forward effect* of testing (Pastötter & Bäuml, 2014), and both encoding and retrieval accounts attempt to explain this effect. The present manuscript examines both encoding and retrieval accounts of RES. Before doing so, we first present prior research examining forward effects of testing.

Testing prior to restudy of a given item has been shown to facilitate performance on a subsequent test of that item (cf., Izawa, 1971; Karpicke, 2009) and also facilitate learning of new material (Wissman et al., 2011). This latter finding, the forward effect of testing, has routinely been captured in the A-B, A-D paired associate learning paradigm. In this paradigm participants study two lists of cue-target word pairs. Each list presents word pairs with the same cue word (word A), but the target word changes between List 1 (word B) and List 2 (word D). Using this paradigm, Tulving and Watkins (1974) found that when participants were tested on List 1 pairs before studying List 2 pairs, later recall of List 2 improved on both a direct test of List 2 and a modified modified free recall test (MMFR) where both List 1 and List 2 were recalled. In a misinformation effect study, which conceptually resembles an A-B, A-D paradigm, Gordon and Thomas (2014) demonstrated that including an immediate test of the originally witnessed event led to better recall of details from the post-event narrative on an MMFR test, compared to a condition where an immediate test of the original event was not included. Other recent research has replicated the forward effect of testing in a number of verbal learning and educationally relevant contexts (Arnold & McDermott, 2013; Aslan & Bäuml, 2016; Szpunar, McDermott, & Roediger, 2008; Wissman et al., 2011).

Encoding explanations for forward effects of testing

One theory proposes that testing facilitates learning of new material in verbal learning and education studies, because it improves encoding of the material. For example, encoding may be facilitated via the unconscious activation of related information

during initial testing (c.f., Carpenter, 2011; Chan, McDermott, & Roediger, 2006; Grimaldi & Karpicke, 2012; Hays, Kornell, & Bjork, 2013). That is, interim memory retrieval may activate the target and target-related information. That activation in turn may facilitate the incorporation of new information into memory. Relatedly, testing may change participants' conscious encoding strategies (e.g., Wissman et al., 2011), leading participants to prioritize rehearsing or reviewing information that is related to previous test questions.

Several studies point toward encoding explanations of forward testing effects. For example, interim testing is particularly effective when post-test material is related to the tested material (cf., Gordon & Thomas, 2014). Wissman et al. (2011) demonstrated that interim testing facilitated learning of prose material that was related to previously tested material. Kornell and colleagues (Hays et al., 2013; Kornell, Hays, & Bjork, 2009; Richland, Kornell, & Kao, 2009) demonstrated that tests can facilitate subsequent study episodes of relevant information, even when initial retrieval has failed. Additional studies have linked interim testing with changes in post-test encoding strategies. An early study demonstrated that individuals spent more time reading passages after interim testing (Reynolds & Anderson, 1982). A more recent line of research has found that interim testing results in sustained attention during subsequent study and reduces mind-wandering (Szpunar, Khan, & Schacter, 2013).

The aforementioned research suggests that test-related changes in the encoding and learning of post-test material, or forward effects of testing, may also occur in the context of the misinformation effect paradigm. However, when interim testing occurs between an original event and the presentation of post-event misinformation in an eyewitness memory paradigm, participants are typically tested on memory for the original event, and post-test learning is not directly queried as in a verbal learning study. In a misinformation paradigm, interim testing leads to an increase in misinformation suggestibility, as indicated by intrusions of narrative details, or errors of commission, on the test of the original event. Thus, in the RES eyewitness paradigm, test-potentiated learning is only indirectly measured via errors of commission.

While learning of post-test information has not directly been measured in a RES study, Gordon, Thomas, and colleagues have begun to examine an encoding explanation of test-related increases in suggestibility. For example, Gordon and Thomas (2014) found that interim testing affected the amount of time participants spent reading individual sentences in the post-event narrative. The difference in reading time associated with sentences that included misleading details as compared to neutral sentences that offered no specific details was greater for participants who took the interim test compared to standard misinformation participants. Gordon et al. (2015) extended these findings by demonstrating that participants who took the interim test spent more time reading sentences that included details directly relevant to the interim test questions (either consistent with or contradictory to the encoding event) compared to neutral sentences. A contingency analysis based on performance on interim test questions revealed that when participants were *correct* on interim test questions, they spent more time reading details that contradicted their responses. Finally, Gordon et al. yoked narrative sentence processing times to final test output. When participants who took an interim test produced misleading details on the final cued recall test, they had spent more time processing the misleading narrative sentences that introduced those details as compared to trials where they reported some other wrong answer on the final test. This difference was not present in the standard misinformation group who did not take an interim test. Taken together, these results suggest that the inclusion of interim testing changes the encoding strategy used to process the post-event narrative.

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