**ABSTRACT**

KELLEY, CHRISOPHER MICHAEL. Moving Beyond the Verbal Learning Domain: An Empirical Investigation of the Effectiveness of Feedback Parameters on Learning. (Under the direction of Dr. Anne Collins McLaughlin).

The amount of support required for learning remains unclear. For example, some argue more support is necessary for learning as it frees the cognitive resources needed to learn (Sweller, 1988); others, however, contend less support adds "desirable difficulties" that force the practice of the retrieval processes necessary once support is removed (see Salmoni, Schmidt, & Walter, 1984; Schmidt & Bjork, 1992, for reviews). Despite the lack of a unifying theory for support requirements, a literature review revealed some general patterns regarding the parameters of feedback. The goal of the current research was to identify empirically based feedback principles that maximize learning in a higher-order learning task. The task was designed to require the learning of relationships, or rules required to differentiate legitimate emails from "phishing" emails. High and low levels of feedback content and timing were provided. Learning was assessed using a cued recall test and a test of transfer to novel stimuli. Additionally, signal detection theory (SDT) was used to further explore feedback effects. Results showed high feedback content led to an increase in the detection of phishing emails. In addition, while delayed feedback led to higher accuracy and better detection of phishing emails, this effect was not independent of feedback content.

Moving Beyond the Verbal Learning Domain: An Empirical Investigation of the Effectiveness of Feedback Parameters on Learning

by
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## Dedication

For Bo. You taught me so much. You will always be my buddy.

## Biography

Christopher M. Kelley was born in San Diego, CA. He graduated from Appalachian State University in 2005 with a Bachelor of Science in Business Administration – Computer Information Systems.

In 2007, Chris entered graduate school at North Carolina State University to pursue a degree in Human Factors and Ergonomics. While there, he worked in the Learning, Aging and Cognitive Ergonomics Lab under the direction of Dr. Anne Collins McLaughlin where he studied the role of feedback support while learning a new task. Chris received his Masters of Science in May, 2010 and graduated with a Doctorate in Philosophy in the fall of 2014.

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I would like to thank my advisor, Dr. Anne McLaughlin. Her guidance and support were instrumental throughout this journey. I couldn't have asked for a better advisor.

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**Table of Contents**

## List of Tables

## List of Figures

# Summary

## Critical Issues

The amount of instructional support required for learning remains unclear. Some advocate more support, such as immediate knowledge of results or providing worked examples, is necessary for learning as it frees the cognitive resources required to learn (Sweller, 1988); others, however, argue less support such as delayed feedback adds “desirable difficulties” that force the learner to practice the retrieval processes necessary when support is removed, such as on retention tests (see Salmoni, Schmidt, & Walter, 1984; Schmidt & Bjork, 1992), for reviews). Despite the lack of a unifying theory for feedback requirements, an examination of the literature revealed some general patterns regarding the parameters of feedback timing and content.

Benefits of delaying feedback, seen as providing less support, have primarily been found in studies that used associative learning tasks, verbal information tasks, or memorization tasks (*e.g.,* Butler, Karpicke, & Roediger III, 2007; Clariana, Wagner, & Roher-Murphy, 2000; Pashler, Rohrer, Cepeda, & Carpenter, 2007; Smith & Kimball, 2010). The amount of delay has varied between 5 seconds (Maddox & Ing, 2005) to a 1-day delay (Butler et al., 2007; Kulik & Kulik, 1988), to varied intervals of allowing the learner to answer-until-correct (Butler et al., 2007). In contrast, the benefits of immediate feedback have been found for learning applied tasks (*e.g.,* classroom tasks; Epstein, Epstein, & Brosvic, 2001), programming languages (Anderson, Conrad, & Corbett, 1989), and learning new concepts (Waldrop, Justen, & Adams, 1986). Thus, the literature suggests feedback timing is linked to the type of information being learned.

Feedback content is seen as more supportive when it provides information or explanation germane to the task. Content manipulations have included knowledge of response (KR; *e.g.*, Gilman, 1969), knowledge of correct response (KCR; *e.g.*, Kelley & McLaughlin, 2012), and elaborative feedback (Rosa & Leow, 2004). More supportive feedback content has most often improved learning for tasks that required learning concepts, relationships, or similar higher-order knowledge (*e.g.*, Kelley & McLaughlin, 2012; Pridemore & Klein, 1995; Vollmeyer & Rheinberg, 2005; Waldrop et al., 1986). Few studies have found *benefits* for less supportive feedback content; however, those that did either included participants with prior knowledge of the task, added irrelevant information to the "more" feedback condition, or used a variable other than learning (*i.e.*, strategy use) to show detrimental effects of feedback content (Goodman, Wood, & Hendrickx, 2004; Phye, Gugliemella, & Sola, 1976; Phye, 1989) Clariana, Ross, & Morrison, 1991; Phye et al., 1976). These findings are in congruence with prior research on cognitive load theory (CLT) that suggests any irrelevant information presented by instructional support imposes an extraneous load on a learners cognitive resources resulting in decreased levels of learning (Renkl, & Atkinson, 2003; Sweller, 1988). Accordingly, it appears feedback content is most effective when it encourages a learner to focus attention on the relationships within a task needed for performance.

Research has largely focused on comparing the effects of "more" or "less" feedback content *or* timing while learning a verbal information task (Mory, 2004; Schimmel, 1988). That is, feedback parameters have largely been studied in isolation. To that end, Mory (2004) called for future research to "examine how feedback functions within a wider variety of learning domains. Higher-order learning such as concept acquisition, rule use, problem solving, and the use of cognitive strategies offers a rich source for researchers to explore" (p.777).

**Research Question**

The goal of the current research was to identify empirically based feedback principles that maximize learning in a higher-order learning task. In addition, technological advancements have made distance learning and computer-based training increasingly common and as a result it is necessary to identify factors that may affect learning in non-traditional and autonomous environments. The experiment investigated the hypothesis that the type of information being learned affects the feedback parameters that maximizes learning with the following specific aims:

1. To investigate the effects of feedback content and timing in a higher-order learning task
    a. To test the hypothesis that content effects will be greater than timing effects when learning requires the application of concepts, or understanding, to novel situations
2. Evaluate the effects of feedback delivered in an online, autonomous learning environment

The task used in the current study was designed to require the learning of relationships, or rules required to differentiate legitimate emails from "phishing" emails. Training was delivered via a computer program in an online, autonomous environment. High and low levels of feedback content and timing were provided. Learning was assessed using a cued recall test and a test of transfer to novel stimuli. Additionally, signal detection theory (SDT) was used to further explore feedback effects.

Historically, SDT has been used to explain perceptual experiments in which subjects had to distinguish a visual or auditory signal from noise (Green & Sweats, 1966; Macmillan & Creelman, 2007). Fundamentally, however, it is a theory about how choices are made, and moreover, how choices are made in the face of uncertainty (McNicol, 1972). In the current study, SDT was used to gain insight into whether results were the result of *learning* to identify phishing emails, or due to changes in behavior from an increased *awareness* in the likelihood of encountering a phishing email (Sheng et al., 2007).

Results were expected to show the connection between the information being learned and effective feedback. In general, the literature suggests feedback timing affects learning more than content when task performance is primarily determined by memory strength as measured by a recognition test (*e.g.*, facts, word lists). However, it was expected the effects of feedback would be different when learning required constructing a mental model, or *understanding* (*e.g.*, the application of rules and concepts, higher-order learning tasks), as measured by the ability to apply the information learned to novel situations (*i.e.*, transfer test). Specifically, the effects of feedback content were predicted to be greater than the effects of timing on overall accuracy and the identification of phishing emails in particular. This pattern of results would be consistent with prior research that utilized complex learning tasks.

Results of the current experiment further our understanding of how feedback affects learning different types of information. For example, feedback timing effects have generally been found when learning facts, lists of words or similar information that can be learned from implicit association. Feedback content effects may be largest when learning requires understanding how relationships between components contribute to successful performance.

Therefore, the reasoning required for successful task performance may determine the effectiveness of feedback parameters.

**Contributions to Theory & Application**

This study offers multiple contributions to the scientific community. The design of this study was based on limitations of prior research identified from the literature. Past feedback research has generally focused on comparing "more" or "less" feedback and given little attention to the information being learned. As a result, feedback theories are largely based on studies from the verbal learning paradigm. The question of how the content and timing of feedback may affect learning different types of knowledge is an important one. As a result, the current study investigated feedback effects while learning concepts related to cybersecurity in a web-based environment.

Additionally, few studies, have utilized a factorial design to study the effects of content and timing. Thus, the present study employed a factorial design to allow for a comparison of content and timing effects. SDT was also used to provide a more complete picture by providing measures beyond accuracy or response time. This analysis helped clarify whether performance differences between feedback groups was from actually *learning* to identify phishing emails, or from a change in response bias due to an increased *awareness* in the likelihood of encountering a phishing email (Sheng et al., 2007).

The practical importance of this research is to investigate the effects of feedback while learning concepts related to cybersecurity in a web-based environment. Results will not only contribute to psychological and educational learning theories that focus on pedagogically sound instructional support, but also aid future development of effective and efficient instructional support for cybersecurity training programs. This research is useful for several reasons. First, it will help designers create efficient and effective instructional support that maximizes learning. This will help ensure individuals are trained to the highest level possible and help thwart cybersecurity related losses in the future. Second, it contributes to the refinement of psychological and educational theories that help create sound learning principles. Knowing how the information being learned affects the parameters of feedback that supports learning most not only contributes to learning theory in general, but also provides a framework that predicts what feedback parameter will maximize learning for a specific task. Such a framework would allow system designers, instructional technologists, and the like develop efficient and effective feedback interventions. These findings may be applied in computerized instruction, such as online courses, but also in the training of human tutors to apply optimal instruction and feedback. Second, it will demonstrate the efficacy of cybersecurity training in a self-regulated autonomous environment. From a training perspective, it would be helpful to know whether cybersecurity training delivered remotely is effective.

# Introduction

> "Behavior is complex. People learn to play chess, write computer programs, organize governments, and create soufflés. Learning theorists' strategy is to break down complex behavior into simple units, study these units, then put the behavior back together again. They believe that in this way complex behavior can eventually be understood."
>
> \- Miller, 1993, p. 200

## Feedback Parameters

The complexity of learning was well stated by Miller (1993). As such, it may come as little surprise that a century's worth of research has been unable to identify the amount of feedback required for learning. Feedback is information given to a learner about performance (e.g., Kluger & Denisi, 1996) and most would agree feedback is an essential part of the learning process.

Historically, studies have compared extremes of "more" or "less" support from feedback using the variables of content and timing. In feedback content studies, the information within feedback itself is manipulated. Examples include the amount of information, the type of information, or the presentation of the information contained in the feedback. However, simply increasing the number of words contained within the feedback does not necessarily provide more support to a learner. That is, more support provides more specific information about *why* an error occurred and results in higher performance. For the remainder of this article more or less feedback will refer to providing more or less *support*.

The timing of feedback (*e.g.,* immediately or delayed) has also been studied (see Salmoni et al., 1984; Kulik & Kulik, 1988 for reviews). These studies compared different intervals of time between a learner's response and when feedback is given. In terms of support, immediate feedback increases support because the context in which the error was made is still available to the learner (Bolton, 2007; Corbett, Koedinger, & Anderson, 1997).

**Learning Theories**

Increased amounts of information contained within feedback content generally leads to higher performance during training; however, those given less feedback frequently outperform those given more once training effects have dissipated (*e.g.*, tests of retention; see Salmoni et al., 1984; Schmidt & Bjork, 1992; van Merriënboer & Sweller, 2005). Indeed, Schmidt and Bjork (1992) stated training performance was an imperfect predictor of learning. Research results are split into two categories; those who contend more feedback facilitates learning while others in favor of less feedback (*cf.* Schmidt & Bjork, 1992; Sweller, 1988). In the section that follows, theories supporting each view will be discussed.

**Cognitive load theory**. CLT argues that more specific feedback reduces the demand, or intrinsic cognitive load, placed on a learner's cognitive resources and results in increased learning (Sweller, 1988); however, this is only true for tasks that require a high amount of cognitive resources. That is, a task must be sufficiently complex so that the available cognitive resources of the learner are depleted. In general, CLT does not focus on feedback, but rather the use of instructional support to free the cognitive resources needed to learn (Sweller, 1988), such as through worked examples that allow a learner to devote cognitive resources to *understanding* important features and relationships of the task as opposed to searching for possible solutions (Paas & van Gog, 2006; Tuovinen & Sweller, 1999). Applied to feedback, CLT would predict feedback that reduces the intrinsic load placed on a learner will benefit learning. Indeed, research supporting CLT has generally found as support increases in acquisition (*e.g.*, worked-examples or feedback), performance increases in retention (Kelley & McLaughlin, 2012; McLaughlin, 2007; Tuovinen & Sweller, 1999; Vollmeyer & Rheinberg, 2005). However, there are circumstances in which more support is detrimental to learning (see Renkl, & Atkinson, 2003).

Extraneous cognitive load can also be imposed by instructional support (Sweller, 2010). In this view, overall cognitive load is not only determined by the task, but the instructional support provided to learners. That is, a learner must devote cognitive resources to learning and the processing of instructional materials. For example, the redundancy effect often occurs when learners are presented with unnecessary or redundant information. Consider a task in which learners are required to memorize a list or words. Feedback that includes information beyond the correct answer contributes little, if any, to the encoding of information. Indeed, a study conducted by Phye et al. (1976) showed feedback comprised of the correct answer only was superior to feedback that added the original question and choices, or the correct answer with three new distractors. Taken together, these results imply feedback that imposes extraneous load by including irrelevant or distracting information can negatively influence learning (Mory, 2004).

**ACT-R.** Anderson's (1983) ACT-R theory proposes that learning is maximized when a learner follows an expert model of performance as accurately as possible. That is, *accurate* acquisition performance results in the most learning (Anderson, Corbett, Koedinger, & Pelletier, 1995). In this view, feedback is used to increase acquisition performance by intervening when a learner deviates from an expert model (Farquhar & Regian, 1994). While the old adage says "practice makes perfect," as Anderson et al., (1995), note "if one is practicing the wrong competences, one might say "practice makes imperfect (p. 15)."

**Temporal contiguity.** Temporal contiguity proposes that information regarding the accuracy of one's decision should occur in close proximity to when the decision was made (Bolton, 2008; Corbett, Koedinger, & Anderson, 1997; Guthrie, 1935). In other words, for feedback to be meaningful a learner must be able to establish the context in which the decision was made. Indeed, Gibson (2000) reported delayed feedback in a dynamic decision task was detrimental to learning and therefore immediate feedback should be provided.

**The spacing hypothesis**. The spacing hypothesis proposes the benefits of delayed feedback are the result of an additional stimuli presentation (Pashler et al., 2007; Smith & Kimball, 2010). According to the *spacing hypothesis*, the presentation of feedback provides an additional encoding opportunity, more so for delayed feedback than immediate feedback, as immediate feedback occurs too soon after to be considered a reactivation (Smith & Kimball, 2010). The theoretical foundation for the spacing hypothesis is derived from studies that have shown advantages for distributed practice compared to massed practice (see Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). Distributed practice occurs over multiple periods of time (*e.g.*, weeks or months) whereas massed practice occurs all at once or over a relatively short period of time (*e.g.,* hours or days). In general, research has shown benefits of distributed practice schedules over massed practice schedules because of the additional encoding opportunities distributed practice provides (Shute & Gawlick, 1995). From this perspective, immediate feedback is analogous to massed practice while delayed feedback is analogous to distributed practice. Studies supporting the spacing hypothesis have found advantages of delayed feedback over immediate feedback as measured by a retention test (Butler et al., 2007; Pashler et al., 2007; Smith & Kimball, 2010). For example, Smith and Kimball (2010) compared immediate and delayed feedback in the cued recall of trivia facts. Results showed benefits of delayed feedback compared to immediate. A conditional boot-strapping analysis was also used to suggest the benefits of delayed feedback were from an increase in the probability of remembering a correct answer.

**The bifurcation model.** Recent feedback research has used models of memory to explain the effects of feedback timing (Kornell, Bjork, & Garcia, 2011). The bifurcation model was originally developed to explain testing-effects (Kornell et al., 2011; Roediger & Karpicke, 2006). Studies investigating testing-effects generally compare learning between a testing condition and a restudy condition (Butler et al., 2007; Pashler et al., 2007; Smith & Kimball, 2010). Participants in the restudy condition study material once, and then restudy after a predetermined delay. Participants in the testing condition, however, study material once, but are tested on the material (as opposed to restudying) after the same delay as the restudy condition. A "testing-effect" occurs when a restudy condition outperforms a testing condition on *immediate* retention tests while the testing condition outperforms the restudy condition on a *delayed* retention test.

The bifurcation model uses memory strength to explain the testing-effect. From this viewpoint, restudying results in a small increase in memory strength for all items; however, in the testing condition, items successfully recalled receive a large increase in memory strength due to successful recall while items not recalled receive no increase in memory strength. Consequently, the restudy condition has more items above the threshold required for recall on immediate tests of retention because the memory strength of *all items* was enhanced from restudying. However, on delayed tests of retention, the test condition has more items above recall threshold because the magnitude of the increase in memory strength for the items recalled previously resulted in fewer items falling below the threshold needed for recall.

The bifurcation model suggests feedback is most effective when provided after an incorrect response as feedback is similar to a restudy opportunity that increases the memory strength for the unrecalled response. In contrast, the increase in memory strength that occurs from the act of recall itself exceeds the increase provided by feedback resulting in minimal feedback effects.

**Interim Summary**

In sum, several theories were used to explain the effects of feedback on learning (Butler et al., 2007; Kornell et al., 2011; Smith & Kimball, 2010; Sweller, 1988). The bifurcation model and spacing hypothesis suggest feedback timing effects will be largest when learning primarily relies on memory strength (*e.g.,* vocabulary, trivia facts). CLT and ACT-R, however, suggest the effects of feedback content may be greatest when learning requires comprehension and the understanding of relationships or interacting task elements.

**Prior Research**

Despite some success explaining feedback effects, no theory has fully explained why some studies find “less” feedback support benefit learning yet others find “more” feedback beneficial. However, a review of the literature revealed some general patterns of feedback effects (Table 1).

Table 1.

*Sample of Research Examining Feedback Effects on Learning*

| Content Manipulations | | | |
|---|---|---|---|
| **More** | | **Less** | |
| **Authors** | **Task** | **Authors** | **Task** |
| Gilman, 1970 | Science concepts | Phye, Gugliamella & Sola, 1976[1] | Multiple-choice questions |
| Buff & Campbell,2002 | A low fidelity simulation of a Navy Combat Information Center | Smits, Boon, Sluijsmans, & van Gog, 2008[2] | Learning genetics |
| Astwood et al., 2008 | Simulated the tasks performed by the Forward Observer,FO | Goodman, Wood & Hendrickx, 2004 | Managerial decision making |
| Farquhar & Regian,1994 | Simulated operation of a crane | | |

| Timing Manipulations | | | |
|---|---|---|---|
| **Immediate** | | **Delayed** | |
| **Authors** | **Task** | **Authors** | **Task** |
| Epstein, Epstein, & Brosvic, 2001 | Introductory psychology course | Butler et al., 2007 | Cued-recall |
| Waldrop, Justen & Adams,1986 | Concept learning | Metcalfe et al., 2009 | Vocabulary words |
| Anderson, Conrad, and Corbett,1989 | Programming language | Schooler & Anderson,1990 | Programming language |
| Kulik & Kulik,1988 | Meta-analysis showed benefits for applied tasks (*e.g.*, classroom related) and list learning | Smith & Kimball, 2010 | Trivia Facts |

*Note*: [1]"More" feedback content consisted of information not relevant to the answer (*e.g.*, re-presentation of the question and all answer choices); [2]Result only applied to learners with high prior knowledge of the task.

Benefits of increased feedback content have been found when learning required understanding causal relationships or interacting elements. Examples include learning to program (Corbett & Anderson, 2001), science concepts (Gilman, 1969), and rule-learning (Kelley & McLaughlin, 2012). Hattie and Timperley (2007) state the effectiveness of feedback [content] depends on whether it reduces "discrepencies between current understandings and performance and a goal" (p. 86). In other words, effective content includes information about how to correct errors as well as knowledge of answer correctness. For example, imagine a task designed to teach how to identify fake and legitimate emails using multiple rules. Feedback consisting of answer correctness only would indicate whether an email is classified correctly, but provides no information about *why*. Was it because of the grammar used, incorrect headers, or the email contained a fraudulent link? Thus, it would appear the effects feedback content are greatest when a learner needs an accurate model, or understanding, of the causal relationships that contribute to successful performance. Kelley and McLaughlin (2012) investigated feedback requirements for learning a rule-based task with multiple cues. Participants learned to identify fake computer pop-ups. A correct decision was based on two cues learned throughout the study: a visual cue and a verbal cue. The visual cue required participants to identify differences in color between a real and fake icon. In contrast, while the verbal cue did not require participants to recall items directly, it required they use previous experience to recognize correct and incorrect grammar. Results showed feedback that indicated the correctness of a response and content including the reason *why* improved retention more than feedback that only indicated correctness of the response. However, when learning requires memorization only (*e.g*., associative or verbal learning tasks), studies often found minimal, if any, effects of content (Kulhavy, White, Topp, Chan, & Adams, 1985; Lee, 1985; Schimmel, 1983).

Benefits of delayed feedback have been found in studies in which learning is demonstrated by memory strength alone *(e.g.*, Butler et al., 2007; Metcalfe, Kornell, & Finn, 2009). Example tasks include the learning of lists, facts, categories, or similar memorization tasks (Mory, 2004; Smith & Ragan, 1993). The spacing hypothesis (Butler et al., 2007; Pashler et al., 2007; Smith & Kimball, 2010) and the bifurcation model (Kornell et al., 2011) discussed previously suggest the efficacy of feedback timing is determined by the cause of an error. Specifically, the bifurcation model predicts immediate feedback is effective when errors are the result of a weak memory trace (Kornell et al., 2011). Similiarly, the spacing hypothesis proposes delayed feedback is most effective when it acts as an additional (spaced) encoding opportunity (*c.f*., Butler et al., 2007; Smith & Kimball, 2010).

The learning of multiple, or causal, relationships (for reviews see Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Kulik & Kulik, 1988) have shown benefits of immediate feedback. Mory (2004) acknowledged "in most learning situations delayed feedback appears to function to hinder the acquisition of needed information" (p. 756) with Dempsey, Driscoll, and Swindell (1993) suggesting delaying feedback was analogous to withholding information a learner can use. A meta-analysis on feedback timing effects revealed immediate feedback typically resulted in more learning compared to delayed (Bangert-Drowns et al., 1991; Kulik & Kulik, 1988) with Kulik and Kulik (1988) concluding,

> "The experimental paradigms that show superiority of delayed feedback are very similar to paradigms used for testing effects of massed versus distributed practice.

> When experiments deviate from this paradigm, they show results similar to those in applied studies. In such experiments, immediate feedback produces a better effect than delayed feedback does (p. 94)."

**Interim Summary**

In review, not all learning is equal. Some information may be learned through memorization, yet others require understanding complex or interacting relationships. Therefore, it seems feedback effects may differ depending on the type of tasks. Specifically, the effects of feedback timing should be greatest when learning primarily relies on memory, while the effects of feedback content should be largest for tasks that require an understanding of casual relationships or element interactivity (*e.g.,* mental model; Sweller, 1988).

**Cybersecurity Education**

The majority of modern complex systems are used by people. As a result, users need to be knowledgeable of security threats and practices (Furman, Theofanos, Yee-Yin, & Stanton, 2012; Kwon, Jacobs, Cullinane, Ipsen, & Foley, 2012). To achieve such goals requires effective training programs based on psychological learning theories and sound pedagogical principles. In addition, technological advancements have made distance learning and computer-based training increasingly common and as a result it is necessary to identify factors that may affect learning in non-traditional and autonomous environments.

Unfortunately, some argue cybersecurity education is ineffective and doesn't work (Nielsen, 2004), yet others call for "basic training" (Kwon et al., 2012, p.50) programs that address 80% of standard principles and concepts. Given this discrepancy, it becomes important to identify the attributes of successful cybersecurity training programs.

Research on training users to spot phishing attempts has largely adopted an embedded training methodology (Kumaraguru, et al., 2007). Embedded training occurs in the real-world and is integrated in routine day-to-day tasks. Kumaraguru et al., (2007) sent fake emails to participants and provided training only if they fell for a phishing attempt. That is, participants were only given feedback when an error occurred. While this approach was in line with traditional research that viewed feedback as an error correction mechanism (*e.g.,* Thorndike, 1911), recent research has shown the benefits of delayed feedback for the maintenance of correct responses (*e.g.,* Butler, Karpicke, & Roediger, 2008). Additionally, although a meta-analysis of feedback effects in computer based instruction showed benefits of immediate feedback over delayed, it lacks empirical guidance on the design of feedback content (see Azevedo & Bernard, 1995; Mason & Bruning, 2001). Further, while studies have manipulated both the content and timing of feedback delivery in a web-based learning environment, to-date no study could be found that did so using a factorial design or investigated this question in the cybersecurity domain.

## Overview of the Study

The purpose of the current research is to examine the effects of feedback content and timing on a higher-order learning task. Prior research has generally focused on effects of learner characteristics (*e.g.,* working memory capacity), a single feedback parameter (*e.g.,* timing *or* content), or practice characteristics (*e.g.,* spaced vs. mass practice schedules). Additionally, learning has largely been limited to information in which performance (*e.g.,* recall accuracy) is primarily determined by memory strength. As a result, little is known about the interaction between content and timing and how they may impact the characteristics and conditions under which feedback parameter is most effective. Knowing how the how feedback parameters affect learning conceptual information would allow feedback recommendations based on the information being learned and help disambiguate previous mixed results.

To aid in this goal, signal detection theory (SDT) was used to explore feedback effects. SDT was developed to explain the processes involved in perceptual recognition (MacDonald & Balakrishnan, 2002). Since its original conception, however, it has been used as a conceptual model to help understand how decisions are made in a variatey of domains and psychological tasks (Benjamin, Diaz, & Wee, 2009; McNicol, 1972; Mueller & Weidemann, 2008 ). The utility of SDT is it provides quanitive measures of how people make decisions in the face of uncertainty: sensitivity and bias. It was hoped the analysis of these metrics would provide a more thorough understanding of feedback effects on learning concepts related to cybersecurity.

While prior research has evaluated the overall effectiveness of simulations and embedded training for learning in the cybersecurity domain, the current study seeks to identify the role of instructional support specifically. Some have argued cybersecurity education is ineffective and doesn't work (Nielsen, 2004), yet others call for "basic training" (Kwon et al., 2012), p.50) programs that address 80% of standard principles and concepts. Given this discrepancy, it becomes important to identify the attributes of successful cybersecurity training programs.

## Method

### Participants

One-hundred twenty-nine participants were recruited from Amazon's mechanical Turk (mTurk), an online marketplace where participants sign-up to complete jobs. The mTurk subject pool is largely more diverse than samples obtained from American university psychology classes (Buhrmester, Kwang, & Gosling, 2011) allowing increased generalizability across a larger range of ages and abilities (Pashler, Cepeda, Wixted, & Rohrer, 2005). Recruitment was limited to individuals over the age of eighteen with internet-protocol (IP) addresses within the United States. Participant demographics and characteristics are provided in Tables 2 & 3.

**Ability tests**. Participants completed the following ability tests: vocabulary (Shipley Institute of Living Scale; Shipley 1986), spatial ability (Mental Rotation Test; Vandenberg & Kuse, 1978; Peters et al., 1995) and the cognitive reflection test (Frederick, 2005; see Table 2 for descriptives).

***Cognitive reflection test***. The Cognitive Reflection Test (CRT) consists of three items designed to measure an individuals' ability to suppress an immediate thought for further reflection (Frederick, 2005). Prior research has shown higher CRT scores are related to greater detection and use of diagnostic cues and more sophisticated information search and encoding (Cokely, Parpart, & Schooler, 2009). CRT scores have also been shown to predict performance on a battery of heuristics-and-biases task where higher CRT scores were associated with better performance (Toplak, West, & Stanovich, 2011).

Table 2.

*Participant characteristics*

| | Low | | | | High | | | |
|---|---|---|---|---|---|---|---|---|
| | Immediate n = 32 | | Delayed n = 34 | | Immediate n = 32 | | Delayed n = 31 | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age | 36.75 | 10.19 | 36.50 | 13.37 | 31.53 | 12.73 | 30.88 | 10.11 |
| Highest Level of Education[1] | 4.88 | 1.86 | 4.94 | 1.67 | 4.28 | 1.49 | 1.00 | 1.46 |
| English is primary language[2] | .97 | .17 | 1.00 | .00 | 1.00 | .00 | 4.00 | 1.46 |
| Mental Rotation Test[3] | 12.72 | 4.28 | 11.24 | 4.27 | 12.24 | 3.85 | 13.56 | 3.65 |
| Shipley Vocabulary Scory[4] | 35.09 | 3.45 | 34.62 | 4.50 | 34.58 | 4.18 | 33.59 | 3.44 |
| Cognitive Reflection Test[5] | 1.81 | 1.18 | 1.82 | 1.14 | 1.73 | 1.13 | 1.81 | 1.15 |
| | Frequencies | | | | | | | |
| Gender | | | | | | | | |
| Male | 14 | | 14 | | 11 | | 22 | |
| Female | 18 | | 20 | | 21 | | 10 | |
| Race | | | | | | | | |
| Black | 2 | | 3 | | 0 | | 2 | |
| Asian | 4 | | 1 | | 3 | | 3 | |
| Caucasian/Non-hispanic | 25 | | 22 | | 25 | | 24 | |
| Caucasian/Hispanic | 0 | | 6 | | 4 | | 1 | |
| Native-American | 0 | | 1 | | 0 | | 0 | |
| Multi-racial | 1 | | 1 | | 0 | | 2 | |
| Occupational Status | | | | | | | | |
| Working Full-Time | 12 | | 12 | | 9 | | 13 | |
| Working Part-Time | 9 | | 5 | | 4 | | 9 | |
| Student | 3 | | 5 | | 8 | | 3 | |
| Homemaker | 4 | | 4 | | 5 | | 3 | |
| Retired | 0 | | 1 | | 2 | | 1 | |
| Volunteer Worker | 4 | | 0 | | 0 | | 0 | |
| Seeking Employment | 0 | | 6 | | 4 | | 3 | |
| Other | 0 | | 1 | | 0 | | 0 | |

*Note*: [1]Choices were: 1 = Did not graduate high school, 2 = High school graduate/G.E.D, 3 = Some college, 4 = Associate's degree, 5 = Bachelor's degree, 6 = Some graduate school, 7 = Master's degree, 8 = M.D, Ph.D., or some other advanced degree; [2]Choices were: 0 = No, 1 = Yes; [3]Mental rotation Test; [4]Shipley, 1986; [5]Frederick, 2005.

Table 3.

*Participants' Internet Experience*

| | Low | | | |
|---|---|---|---|---|
| | Immediate | | Delayed | |
| | *M* | *SD* | *M* | *SD* |
| Have you ever changed preferences or settings in a web browser[1] | .94 | .25 | .94 | .24 |
| Have you ever created a web page[1] | .53 | .51 | .56 | .50 |
| Have you ever helped someone fix a computer problem[1] | .84 | .37 | .82 | .39 |
| If a computer problem occurs while I am using the Internet, I usually know how to fix the problem | 4.03 | .69 | 4.00 | 1.00 |
| I know how to create a website | 3.25 | 1.52 | 2.97 | 1.47 |
| I know some good ways to avoid computer viruses | 4.22 | .61 | 4.09 | .84 |
| I am familiar with html | 3.19 | 1.42 | 3.26 | 1.48 |
| I know how to enable and disable cookies on my computer | 4.53 | .67 | 4.38 | 1.04 |
| I am able to download a plug-in when one is recommended in order to view or access something on the Internet | 4.75 | .44 | 4.59 | .56 |
| I can usually fix any problems I encounter when using the Internet | 4.13 | .87 | 4.03 | 1.00 |
| I help others who are learning to use the Internet | 4.10 | .91 | 3.68 | 1.30 |
| I download and install software updates from the Internet when necessary | 4.69 | .54 | 4.64 | .60 |
| I regularly update my virus protection software | 4.16 | 1.11 | 4.15 | 1.21 |
| I can design a nice background or signature for the e-mail messages I send | 3.55 | 1.12 | 3.32 | 1.47 |

Table 3 (continued)

| | High | | | |
|---|---|---|---|---|
| | Immediate | | Delayed | |
| | *M* | *SD* | *M* | *SD* |
| Have you ever changed preferences or settings in a web browser[1] | .94 | .25 | .97 | .18 |
| Have you ever created a web page[1] | .50 | .51 | .42 | .50 |
| Have you ever helped someone fix a computer problem[1] | .84 | .37 | .84 | .37 |
| If a computer problem occurs while I am using the Internet, I usually know how to fix the problem | 3.88 | .98 | 4.13 | .72 |
| I know how to create a website | 3.22 | 1.36 | 2.77 | 1.48 |
| I know some good ways to avoid computer viruses | 4.19 | .93 | 4.16 | .69 |
| I am familiar with html | 3.30 | 1.32 | 2.93 | 1.28 |
| I know how to enable and disable cookies on my computer | 4.59 | .67 | 4.53 | .57 |
| I am able to download a plug-in when one is recommended in order to view or access something on the Internet | 4.59 | .76 | 4.55 | .68 |
| I can usually fix any problems I encounter when using the Internet | 4.09 | .93 | 4.19 | .60 |
| I help others who are learning to use the Internet | 3.97 | 1.11 | 3.83 | .93 |
| I download and install software updates from the Internet when necessary | 4.44 | .67 | 4.29 | 1.04 |
| I regularly update my virus protection software | 4.20 | 1.03 | 4.19 | 1.08 |
| I can design a nice background or signature for the e-mail messages I send | 3.69 | 1.33 | 3.40 | 1.19 |

*Note:* [1]Answers were no (0) and yes (1); answers for all other items were 1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree.

**Questionnaires**. All questionnaires can be found in Appendix A. Questionnaires included participant demographics and a survey to assess internet experience (Potosky, 2007).

A multivariate analysis of variance (MANOVA) was conducted on ability test measures and responses to the internet experience survey to ensure participants in different feedback conditions did not differ systematically. No significant differences were found on any ability tests (Table 4) between content or delay conditions; however, results indicated a significant difference between content groups on an internet experience question related to the likelihood of downloading and installing software updates from the internet (Table 5). Specifically, participants in the low content group indicated they were more likely to download and install software updates from the internet when necessary than those in the high content group. This finding suggests participants in the low content group were more

Table 4.

*MANOVA Summary for Participant Ability Tests*

| Source | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| | | | Between Subjects | |
| Feedback Content (FB-C) | 3 | 1.10 | .03 | .35 |
| Mental Rotation Test[1] | 1 | 1.61 | .01 | .21 |
| Shipley Vocabulary Score[2] | 1 | 1.43 | .01 | .23 |
| Cognitive Reflection Test[3] | 1 | .13 | .00 | .72 |
| Feedback Timing (FB-T) | 3 | .37 | .01 | .78 |
| Mental Rotation Test | 1 | .15 | .00 | .70 |
| Shipley Vocabulary Score | 1 | .83 | .01 | .36 |
| Cognitive Reflection Test | 1 | .00 | .00 | .96 |
| FB-C x FB-T | 3 | .99 | .02 | .40 |
| Mental Rotation Test | 1 | 2.86 | .02 | .09 |
| Shipley Vocabulary Score | 1 | .05 | .00 | .82 |
| Cognitive Reflection Test | 1 | .00 | .00 | .99 |
| Error | 125 | | | |

*Note*: [1]Mental rotation Test; [2]Shipley, 1986; [3]Frederick, 2005.

Table 5.

*MANOVA Summary for Participant Internet Experience*

| | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| Content | 14 | 1.99 | .22 | .03 * |
| Have you ever changed preferences or settings in a web browser[1] | 1 | .01 | .00 | .94 |
| Have you ever created a web page[1] | 1 | 1.26 | .01 | .26 |
| Have you ever helped someone fix a computer problem[1] | 1 | .13 | .00 | .72 |
| If a computer problem occurs while I am using the Internet, I usually know how to fix the problem | 1 | .32 | .00 | .57 |
| I know how to create a website | 1 | .34 | .00 | .56 |
| I know some good ways to avoid computer viruses | 1 | .04 | .00 | .85 |
| I am familiar with html | 1 | .43 | .00 | .51 |
| I know how to enable and disable cookies on my computer | 1 | .35 | .00 | .55 |
| I am able to download a plug-in when one is recommended in order to view or access something on the Internet | 1 | 1.58 | .01 | .21 |
| I can usually fix any problems I encounter when using the Internet | 1 | .71 | .01 | .40 |
| I help others who are learning to use the Internet | 1 | .00 | .00 | .97 |
| I download and install software updates from the Internet when necessary | 1 | 8.04 | .07 | .01 * |
| I regularly update my virus protection software | 1 | .05 | .00 | .83 |
| I can design a nice background or signature for the e-mail messages I send | 1 | .17 | .00 | .68 |

Table 5 (continued)

| | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| Timing | 14 | .71 | .09 | .76 |
| Have you ever changed preferences or settings in a web browser | 1 | .00 | .00 | .99 |
| Have you ever created a web page | 1 | .04 | .00 | .83 |
| Have you ever helped someone fix a computer problem | 1 | .00 | .00 | .96 |
| If a computer problem occurs while I am using the Internet, I usually know how to fix the problem | 1 | .13 | .00 | .72 |
| I know how to create a website | 1 | 2.26 | .02 | .14 |
| I know some good ways to avoid computer viruses | 1 | .65 | .01 | .42 |
| I am familiar with html | 1 | .19 | .00 | .66 |
| I know how to enable and disable cookies on my computer | 1 | .90 | .01 | .35 |
| I am able to download a plug-in when one is recommended in order to view or access something on the Internet | 1 | .69 | .01 | .41 |
| I can usually fix any problems I encounter when using the Internet | 1 | .26 | .00 | .61 |
| I help others who are learning to use the Internet | 1 | 1.86 | .02 | .18 |
| I download and install software updates from the Internet when necessary | 1 | .42 | .00 | .52 |
| I regularly update my virus protection software | 1 | .09 | .00 | .77 |
| I can design a nice background or signature for the e-mail messages I send | 1 | 1.95 | .02 | .17 |

Table 5 (continued)

| | *df* | *F* | $\eta p^2$ | *P* |
|---|---|---|---|---|
| Content x Timing | 14 | .59 | .08 | .87 |
| Have you ever changed preferences or settings in a web browser | 1 | .68 | .01 | .41 |
| Have you ever created a web page | 1 | .59 | .01 | .44 |
| Have you ever helped someone fix a computer problem | 1 | 1.04 | .01 | .31 |
| If a computer problem occurs while I am using the Internet, I usually know how to fix the problem | 1 | .32 | .00 | .57 |
| I know how to create a website | 1 | .60 | .01 | .44 |
| I know some good ways to avoid computer viruses | 1 | .01 | .00 | .92 |
| I am familiar with html | 1 | 2.38 | .02 | .13 |
| I know how to enable and disable cookies on my computer | 1 | .11 | .00 | .74 |
| I am able to download a plug-in when one is recommended in order to view or access something on the Internet | 1 | .47 | .00 | .49 |
| I can usually fix any problems I encounter when using the Internet | 1 | .11 | .00 | .74 |
| I help others who are learning to use the Internet | 1 | .40 | .00 | .53 |
| I download and install software updates from the Internet when necessary | 1 | .01 | .00 | .94 |
| I regularly update my virus protection software | 1 | .02 | .00 | .88 |
| I can design a nice background or signature for the e-mail messages I send | 1 | .03 | .00 | .85 |
| Error | 110 | | | |

*Note:* * $p < .05$.

proactive about computer security. While it's possible this difference between content groups influenced results, it is unlikely given high content resulted in better performance than low content. Thus, it does not appear this difference had any impact on the results obtained in the present study.

**Instructions**. Participants received onscreen instructions describing the task and learning objectives (Appendix A).

**Experimental task**. A web-based computer program was developed for the current study. It presented acquisition trials, feedback, retention/transfer tests, all ability tests and questionnaires, and debriefing.

**Images**. Two different sets of 20 email images were created (Appendix): the first set was used in acquisition/retention only while the second was used in the transfer test. The topics and number of links within each email varied from image to image (Table 6). Topics were drawn from a variety of domains, but generally focused on topics participants would likely encounter in phishing attempts such as online banking, order confirmation, and password reset confirmation.

Participants were to learn rules that allowed them to decide whether a given email was 'real' or 'fake' by hovering-over and visually inspecting a URL (Figure 1). Correct answers were based on identifying three methods used in phishing attacks: the @ exploit, use of an internet-protocol (IP) address, and a random web address.

***The @ exploit***. One method participants learned pertains to using the @ symbol in a URL. The @ symbol is generally used for websites that requires a username and password. For example, if a username and password were required for site.com, one could login using http://myusername:mypassword@site.com. However, if a website does not require a username and password, everything before the @ symbol is ignored and the browser automatically redirects to site.com. A fake link using the @ symbol will generally take the following form: http://www.myrealsite.com@www.mybadsite.com.

Table 6.

*Frequencies for the Number of Links within Experimental Stimuli*

| | Number of Links | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 9 |
| Number of Stimuli (%) | 1 (6.25) | 5 (31.25) | 6 (37.50) | 3 (18.75) | 1 (6.25) |

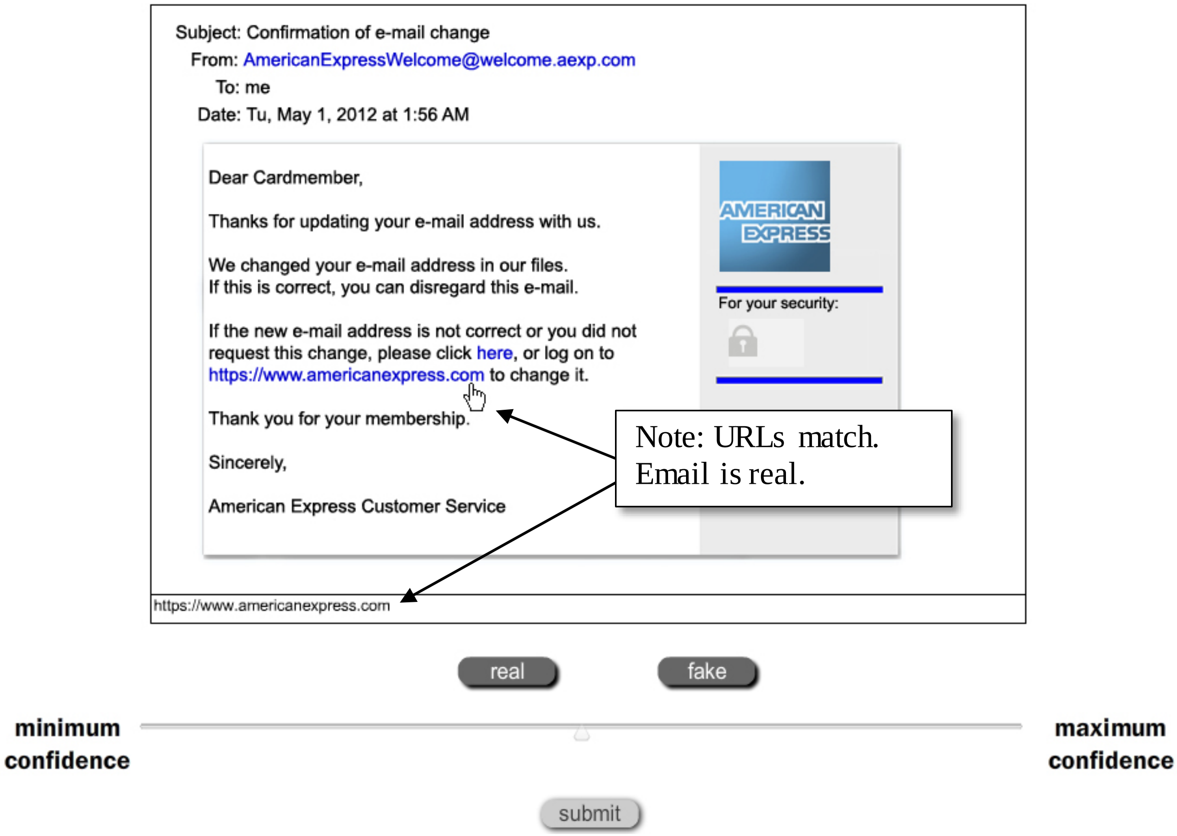


*Figure 1*. Example question where learning requires understanding rules that determine email authenticity. Each email was viewed individually for a trial, so no direct comparison could be made between correct and incorrect emails. Call-outs point out the comparison between URLs participants were required to make and were not present in the task.

***IP address***. Another method participants learned was the linking to an IP address instead of the actual domain name of a given website. For example, to visit Google's website one would usually enter www.google.com into the address bar of their web browser. Alternatively, however, 74.125.139.138 could be entered into the address bar with the same result. A fake link exemplifying this method will show an IP address instead of the domain name of a given site (*e.g.*, http://15.76.6.3/mybank/).

***Random web address***. The final method was the use of a random website. This involves linking to a website not associated with the assumed sender of the email. For example, an email claiming to be from Microsoft may contain a link to http://www.getcashnow.com instead of http://www.microsoft.com. The current experiment will use the same manner when demonstrating a fake link with this method.

***Ensuring rule use***. One potential strategy participants could use to identify fake links would be to confirm the URL of the link in the email text (*e.g.,* http://www.google.com) matches the link shown when the mouse pointer hovers over it. This is essentially a matching exercise and most likely would not promote rule learning other than "the email text should match the URL I'm shown when I hover over it." To prevent participants from using this strategy alone, approximately half of all links were "text based" and the other half non-text based. A text based link displayed the URL of a link within the text of the email text itself (see Figure 2). Conversely, non-text based links contained links that do not show the URL in email text. Examples include images containing links and links containing text with words similar to "Click Here," "login," "My Account," etc.

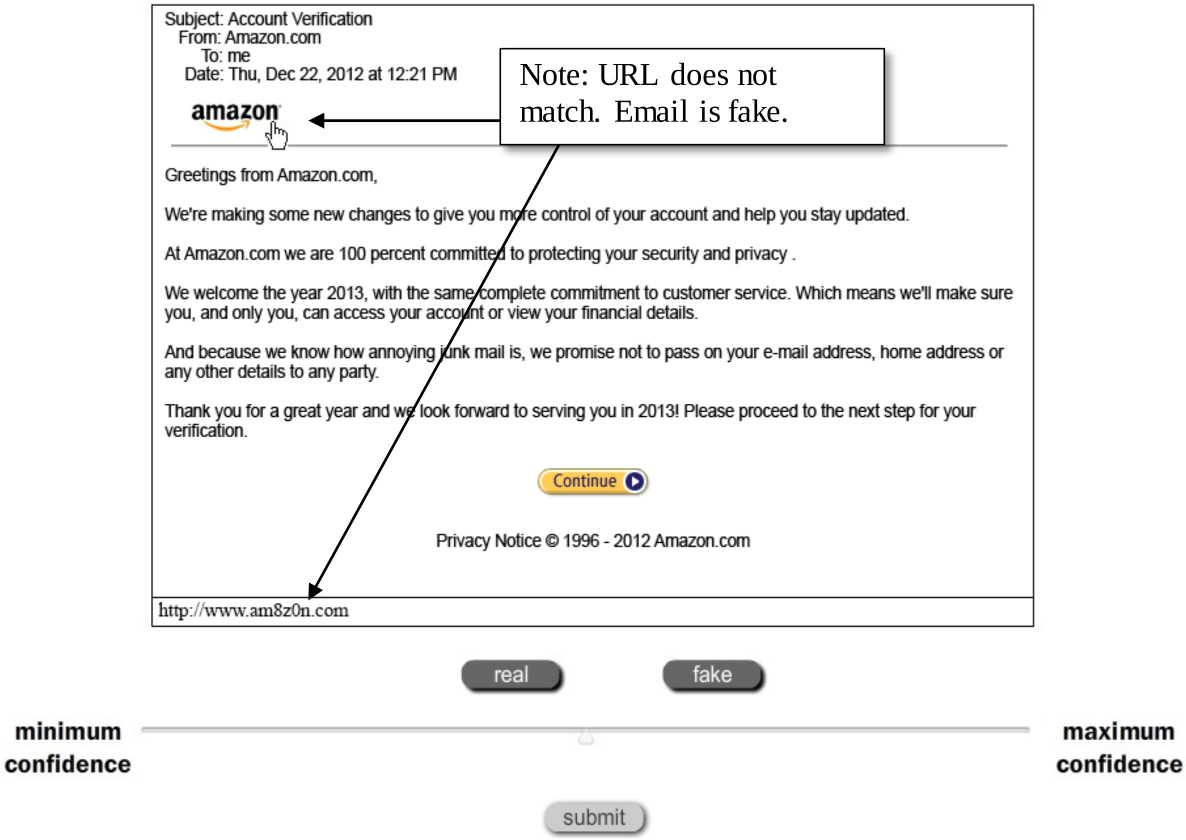


*Figure 2*. Example stimuli where participant had to hover the mouse cursor over 'Amazon' to display the destination of the link.

**Feedback conditions**. Feedback was operationally defined as being low or high on the parameters of content and timing. A total of four feedback conditions were created by manipulating the variables of content and timing with each variable containing a less supportive and more supportive condition (see Figure 3 for example content).

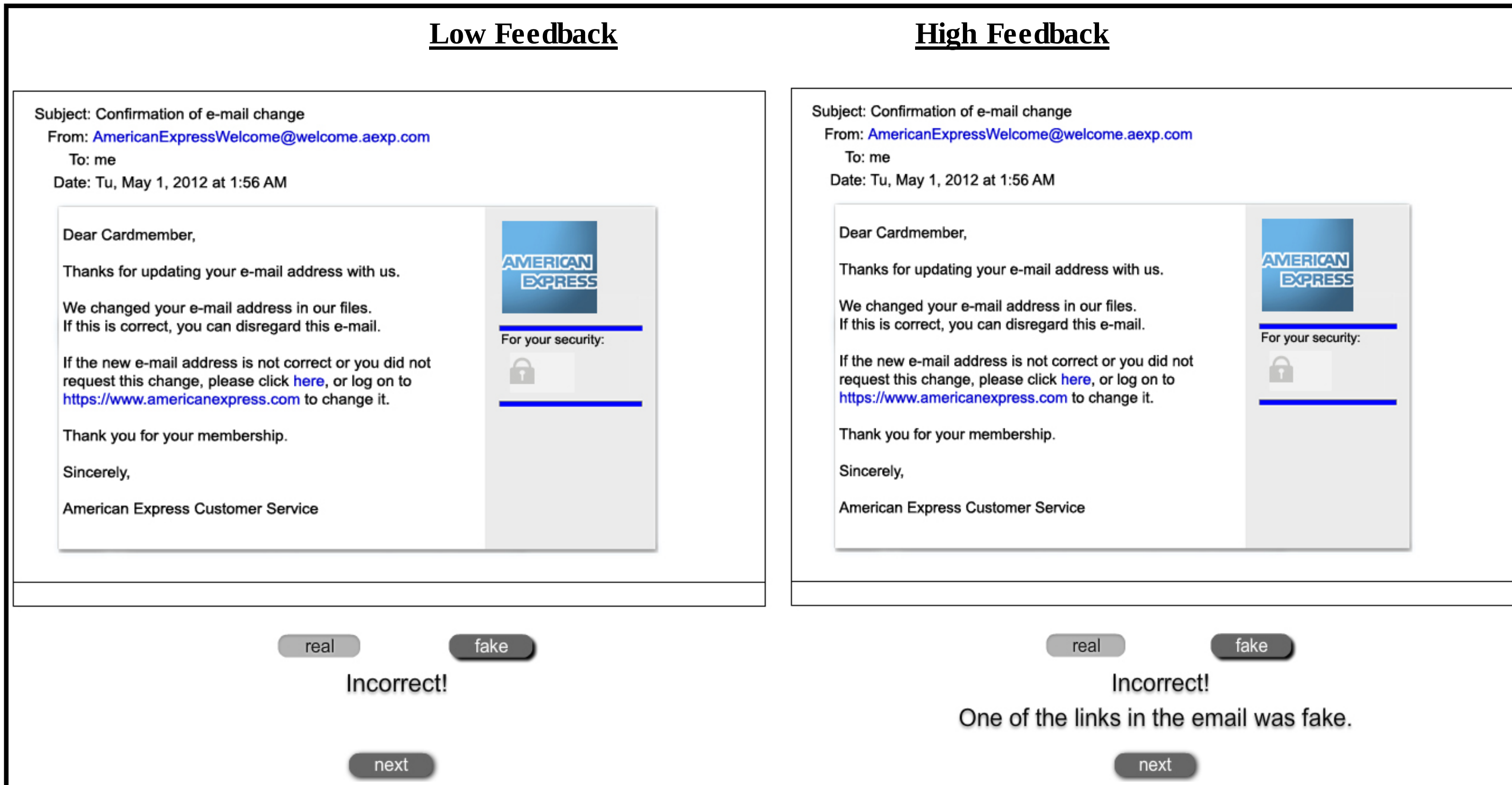


*Figure 3*. Example of feedback content where low (left) specified answer correctness only while high (right) provided answer correctness as well as the reason why.

***Immediate low***. This condition consisted of low feedback content delivered immediately after each response was submitted. Low content feedback indicated answer correctness only. That is, participants were required to determine why their answer was correct or incorrect.

***Immediate high***. This condition contained high feedback content delivered immediately after each trial. High content feedback indicated answer correctness as well as the reason for correctness.

***Delayed low***. This condition contained the same feedback content described in the low condition; however, there were a five second delay between the submission of a response and the presentation of feedback.

***Delayed high***. This condition contained the same feedback content described in the high condition; however, there was a five second delay between response submission and feedback presentation.

## Procedure

**Acquisition**. Participants followed a link via mTurk and were randomly assigned to one of four feedback conditions. After providing informed consent, they provided demographics, completed the Shipley Institute of Living Scale (Shipley, 1986) followed by five practice trials during which participants became acquainted with the actions necessary to perform the task. The acquisition phase followed immediately where participants were told their goal was to learn how to recognize a phishing email.

**Retention.** Retention occurred approximately 48 hours after acquisition and consisted of a cued-recall test with no feedback present. First, participants completed the internet experience survey (Potosky, 2007) and a test of spatial ability (Mental Rotation Test; Vandenberg & Kuse, 1978; Peters et al., 1995). Then five practice trials were completed followed by the cued-recall retention test.

**Transfer.** Immediately following retention, a twenty item transfer test with no feedback was used to assess learning with novel stimuli. Debriefing was provided once the transfer test was finished and participants were compensated within forty-eight hours.

### Design

The design used was similar to other feedback studies conducted online (Pashler et al., 2005). Feedback content and timing were manipulated as between-subjects factors and learning stage a within-subjects factor.

Performance accuracy, confidence, trial response time and time on task were measured during an acquisition session with feedback present, a retention session with feedback removed, and a transfer task with no feedback. Accuracy was the primary dependent variable of interest and defined as the average number of correct responses.

## Results

A 2 (Learning Stage: Acquisition and Retention) x 2 (Feedback Content: Low and High) x 2 (Feedback Timing: Immediate and Delayed) mixed-model multivariate analysis of variance (MANOVA) was conducted on accuracy, response time, and confidence. All interactions were decomposed with tests of simple main effects with a Bonferroni correction. Descriptive statistics are available in Table 7 and inferential statistics in Table 8.

**Acquisition and Retention**

Table 7.

*Mean Acquisition and Retention Results by Content and Timing*

| | | Accuracy | | Response Time (s) | | Confidence[1] | |
|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| | | Acquisition | | | | | |
| Content | Timing | | | | | | |
| Low | Immediate | .55 | .16 | 23.90 | 10.82 | 98.95 | 84.05 |
| | Delayed | .53 | .13 | 21.63 | 11.91 | 115.98 | 95.08 |
| High | Immediate | .64 | .19 | 23.32 | 11.11 | 103.08 | 121.99 |
| | Delayed | .71 | .18 | 19.31 | 11.42 | 139.99 | 110.70 |
| | | Retention | | | | | |
| Low | Immediate | .68 | .20 | 17.86 | 7.58 | 140.16 | 115.64 |
| | Delayed | .67 | .19 | 23.54 | 14.44 | 112.10 | 108.52 |
| High | Immediate | .64 | .20 | 17.43 | 8.43 | 127.02 | 107.64 |
| | Delayed | .76 | .22 | 18.52 | 7.92 | 136.42 | 118.49 |

*Note:* [1]Anchors were minimum confidence (-350) and maximum confidence (350).

Table 8.

*Mixed-Model MANOVA Summary for Acquisition and Retention by Content and Timing*

| Source | df | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| | Between Subjects | | | |
| Feedback Content (FB-C) | 3 | 8.17 | .16 | .00 * |
| Accuracy | 1 | 16.42 | .11 | .00 * |
| Reaction time | 1 | 2.25 | .02 | .02 * |
| Confidence | 1 | .63 | .01 | .43 |
| Feedback Timing (FB-T) | 3 | 1.48 | .03 | .22 |
| Accuracy | 1 | 4.18 | .03 | .04 * |
| Reaction time | 1 | .01 | .01 | .20 |
| Confidence | 1 | .51 | .00 | .83 |
| FB-C x FB-T | 3 | 3.96 | .09 | .01 * |
| Accuracy | 1 | 7.54 | .06 | .01 * |
| Reaction time | 1 | 1.30 | .01 | .26 |
| Confidence | 1 | 1.35 | .01 | .25 |
| Error | 129 | | | |
| | | Within subjects | | |
| Learning Stage (LS) | 3 | 7.05 | .14 | .00 * |
| Accuracy | 1 | 9.84 | .07 | .00 * |
| Reaction time | 1 | 4.80 | .04 | .03 * |
| Confidence | 1 | 1.03 | .01 | .31 |
| LS x FB-C | 3 | 2.22 | .05 | .09 * |
| Accuracy | 1 | 5.21 | .04 | .02 * |
| Reaction time | 1 | .27 | .00 | .60 |
| Confidence | 1 | .09 | .00 | .77 |
| LS x FB-T | 3 | 3.56 | .08 | .02 * |
| Accuracy | 1 | .28 | .00 | .60 |
| Reaction time | 1 | 7.01 | .05 | .01 * |
| Confidence | 1 | 1.63 | .01 | .20 |
| LS x FB-C x FB-T | 3 | .25 | .01 | .86 |
| Accuracy | 1 | .10 | .00 | .66 |
| Reaction time | 1 | .36 | .00 | .56 |
| Confidence | 1 | .10 | .00 | .76 |
| Error | 129 | | | |

*Note:* * $p < .05$; ** $p < .001$.

**Learning stage effects.** All groups learned, as evident by a significant multivariate effect of learning stage. Univariate results showed when collapsed across all feedback conditions, retention performance was better than acquisition with higher accuracy and faster response times. All effects on confidence were non-significant.

**Content effects.** There was a multivariate effect of content where high content yielded better accuracy and faster response times than low. There were no interactions of content, timing and learning stage, or content and learning stage; however, planned comparisons showed for the low content group, retention accuracy was higher than acquisition accuracy ($p < .001$). On the other hand, when collapsed across timing groups, high content resulted in better acquisition accuracy than low ($p < .01$).

**Timing effects**. There was a significant multivariate interaction of timing and learning stage (Figure 4). Univariate results showed the timing of feedback differentially affected response time between learning stages. Simple main effects analyses showed while delayed feedback yielded faster acquisition response times, the result was non-significant ($p > .05$). Immediate feedback, however, resulted in faster retention response times compared to delayed ($p < .01$), and a reduction in response times between learning stages ($p < .001$) when collapsed across timing groups, as well as both low and high content groups (*p's* < .05).

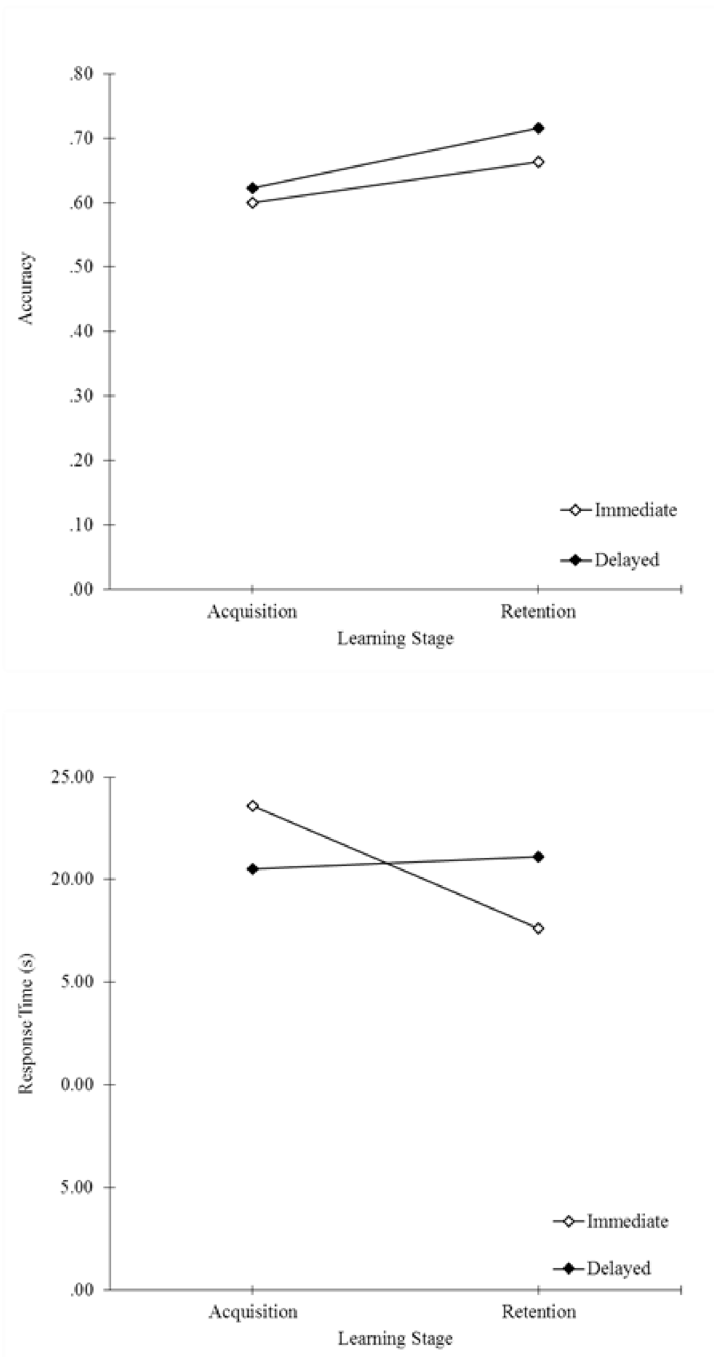


*Figure 4*. Effects of Timing and Learning Stage on Accuracy (top) and Response Time (bottom).

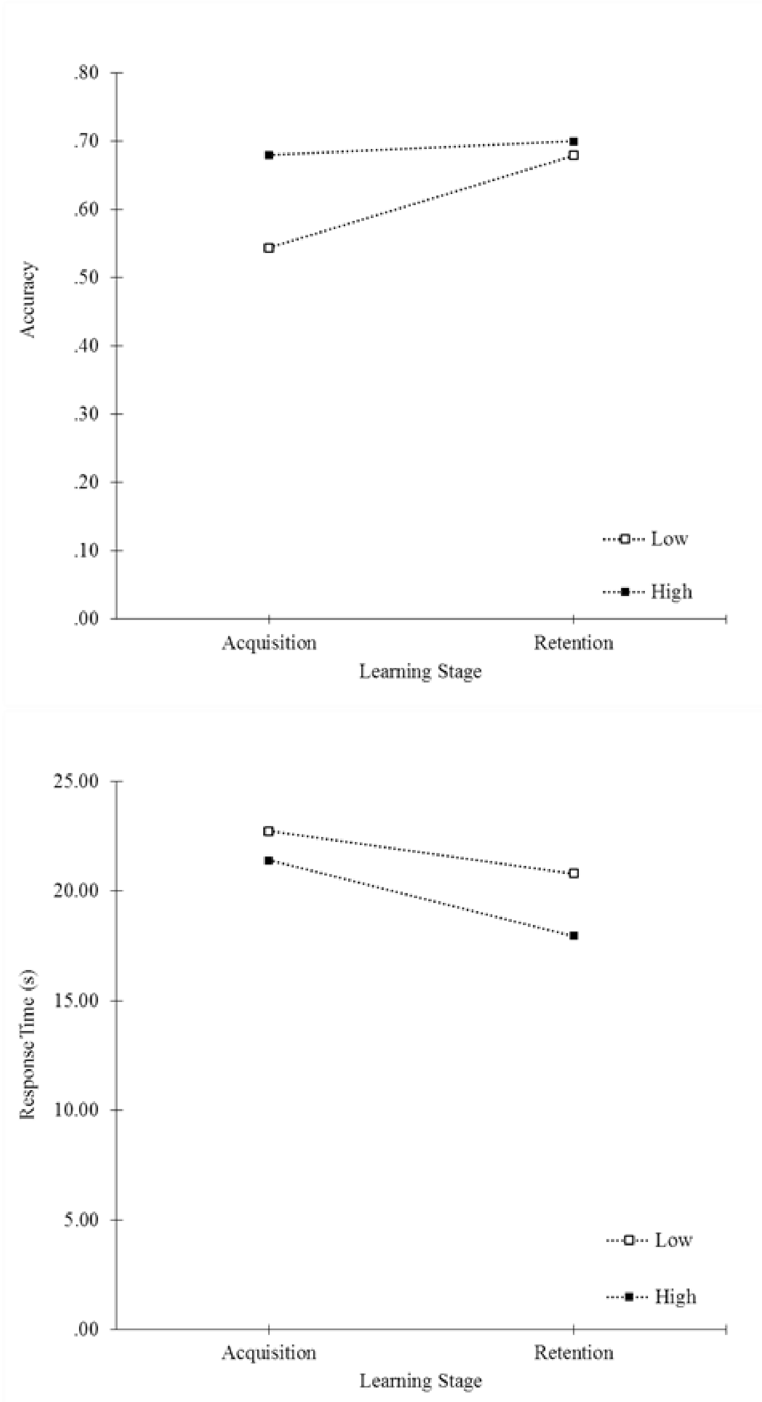


*Figure 5*. Effects of Content and Learning Stage on Accuracy (top) and Response Time (bottom).

Planned comparisons also showed delayed feedback led to higher overall accuracy than immediate ($p < .05$). Additionally, accuracy improved significantly between learning stages when feedback was delayed ($p < .05$), but not when immediate ($p < .05$). There were no significant effects on confidence.

**Content and timing interaction**. Performance also differed across content and timing groups (Figures 5 & 6) demonstrated by a significant multivariate interaction of content and timing. Univariate analysis indicated the content and timing of feedback differentially affected accuracy. Simple effects analysis showed accuracy was higher with high content when feedback was delayed compared to immediate ($p < .05$). Similarly, when feedback was delayed, accuracy was higher when content was high compared to low ($p < .001$).

Planned comparisons also revealed while the effects of high content were similar between timing groups in acquisition, retention accuracy differed where delayed feedback led to higher accuracy than immediate ($p < .05$).

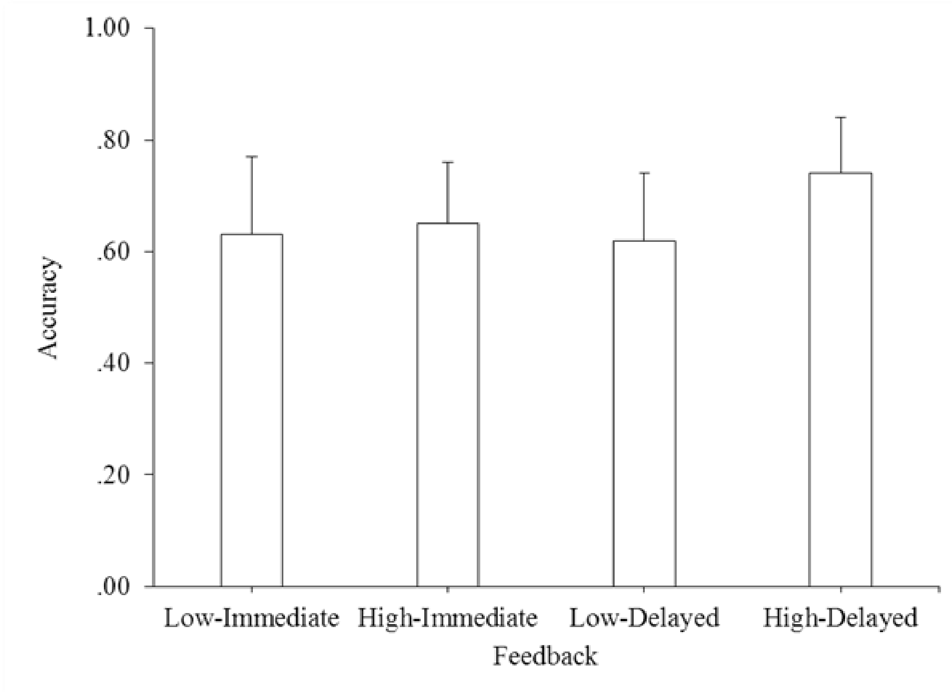


*Figure 6*. Effects of Feedback Content and Timing on Accuracy.

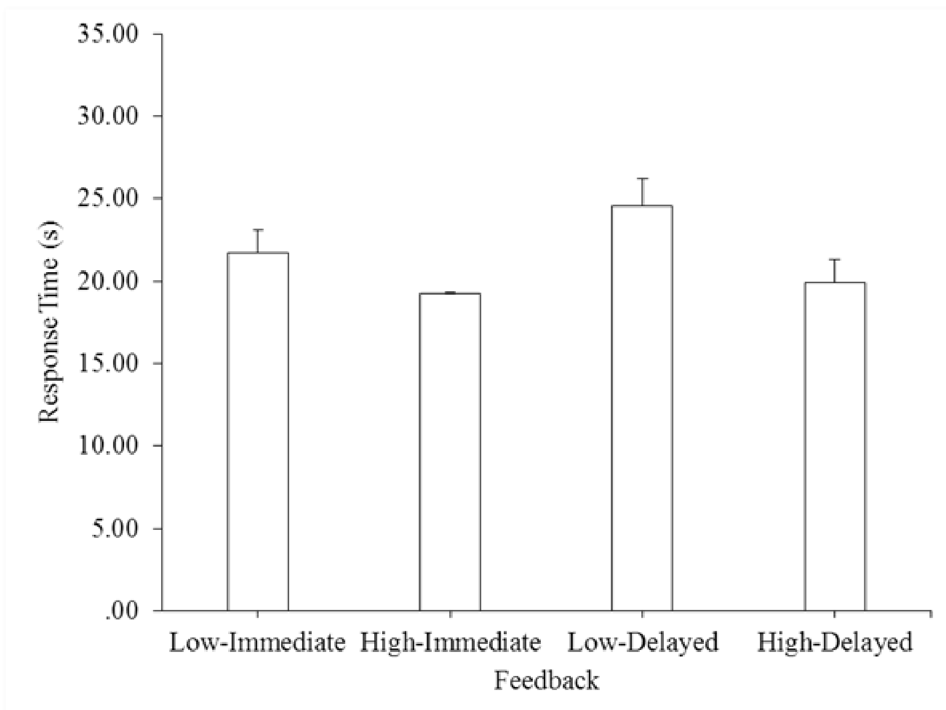


*Figure 7*. Effects of Feedback Content and Timing on Response Time.

**Interim Summary**

The goal of the analysis presented in the previous section was to investigate the effects of feedback content and timing while learning a concept based higher-order learning task. Cognitive load theory and ACT-R predicted increased content would maximize learning. On the other hand, the spacing hypothesis and bifurcation model suggest delayed feedback would provide an additional encoding opportunity resulting in more learning.

Results showed benefits of high content compared to low on accuracy. Low content led to a significant increase in accuracy from acquisition to retention; however, acquisition accuracy was significantly higher with high content compared to low content. Thus, it appears the improvement in accuracy between learning stages for those given low content was primarily due to initial accuracy being so low.

Results also showed retention accuracy was higher for participants given high content compared to low when feedback was delayed; however, for participants given high content, delayed feedback resulted in higher retention accuracy then immediate feedback. This result, and the lack of any significant difference in accuracy between timing groups when content was low, suggests accuracy differences between timing groups is the result of high content.

**Differences in Feedback Use**

Of additional interest was whether content and timing affected feedback use as measured by the time spent looking at feedback. Thus, an exploratory analysis was conducted to explore whether the use of feedback differed between content and timing groups. A 2 (Feedback Content: Low and High) x 2 (Feedback Timing: Immediate and Delayed) ANOVA was conducted on the total time participants spent looking at feedback. The total time participants spent looking at feedback was computed using the following equation:

$$total\ time\ looking\ at\ feedback =$$

$$([time\ on\ task - (RT_{t1} + RT_{t2} + RT_{t3} + \ldots + RT_{t20})] - [D_{t1} + D_{t2} + D_{t3} + \ldots + D_{t20}])$$

Time on task was collected by the program and referred to the total amount of time participants spent on the entire experimental task. The parameter *RT* denoted response times for each trial (*t*), indicating the time spent looking at the stimuli and clicking to indicate if the email was a phishing email. RTs were summed across trials and then subtracted from time on task. The parameter *D* represented the delay for each trial (*t*). While there was a five-second delay between a response and feedback presentation for the delayed group, the immediate group had a 5-second delay before beginning the next trial. Thus, the delay across all trials was removed from time on task leaving the total amount of time spent looking at feedback. Group means are given in Figure 8 and inferential statistics in Table 9.

**Timing effects.** Results showed a main effect of timing. Specifically, delayed feedback was looked at longer than immediate feedback whether it contained low ($p < .01$) or high ($p < .001$) content. There was no effect of content or interaction of content and delay on feedback use (*p's* > .05).

**Interim Summary**

An exploratory analysis was conducted to investigate whether feedback use differed between content and timing groups. Prior research has identified the amount of time feedback is processed is a function of the content contained within the feedback message, or feedback complexity, and the level of confidence one has in the correctness of their response (see Mory, 2004). Surprisingly, results of the current study appear to contradict the claim that feedback complexity affects feedback use. Specifically, results showed delayed feedback was looked at longer than immediate, whether it contained high or low content. While the spacing hypothesis suggests delayed feedback enhances performance through an additional encoding opportunity, no claims are regarding how feedbacks use are made. Thus, as suggested by Shute, (2008) it appears other mediating factors are involved in the use of feedback.

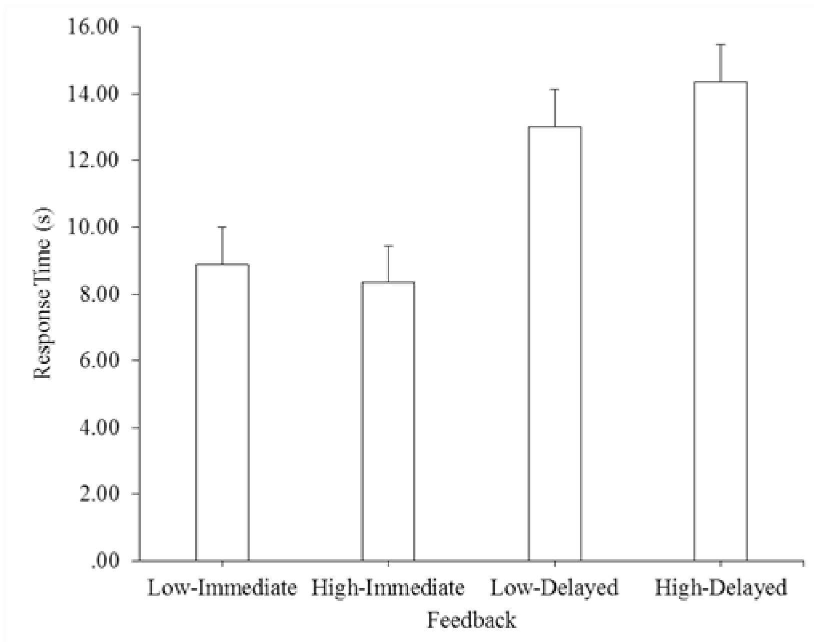


*Figure 8.* Mean Time Spent Looking at Feedback.

Table 9.

*ANOVA Summary for Time Spent Looking at Feedback by Content and Timing*

| Source | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| Feedback Content (FB-C) | 1 | .09 | .00 | .77 |
| Feedback Timing (FB-T) | 1 | 25.41 | .17 | .01 * |
| FB-C x FB-T | 1 | 1.29 | .01 | .26 |
| Error | 127 | | | |

*Note:* * $p < .01$

**Transfer**

A transfer test occurred immediately following completion of the retention test and included twenty additional trials with novel stimuli (10 real and 10 fake). No feedback was given during the transfer test. Results were analyzed using a 2 (Feedback Content: Low and High) x 2 (Feedback Timing: Immediate and Delayed) MANOVA with dependent variables of accuracy, response time, and confidence. A Bonferroni correction was applied to all tests of simple main effects and planned comparisons. Descriptive statistics are provided in Table 10 and inferential statistics in Table 11.

Table 10.

*Mean Transfer Results by Content and Timing*

| | | Accuracy | | Response Time | | Confidence[1] | |
|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Content | Timing | | | | | | |
| Low | Immediate | .67 | .17 | 23.33 | 13.81 | 130.51 | 108.22 |
| | Delayed | .65 | .19 | 28.51 | 16.25 | 99.64 | 96.84 |
| High | Immediate | .65 | .17 | 16.91 | 7.40 | 129.62 | 106.68 |
| | Delayed | .75 | .17 | 21.85 | 14.31 | 141.68 | 101.22 |

*Note:* [1]Question anchors were minimum confidence (-350) and maximum confidence (350).

Table 11.

*MANOVA Summary for Transfer Results by Content and Timing*

| Source | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| | | Between Subjects | | |
| Feedback Content (FB-C) | 3 | 4.40 | .09 | .01 * |
| Accuracy | 1 | 1.94 | .01 | .17 |
| Response Time | 1 | 8.32 | .06 | .01 * |
| Confidence | 1 | 1.32 | .01 | .25 |
| Feedback Timing (FB-T) | 3 | 2.13 | .05 | .10 |
| Accuracy | 1 | 1.81 | .01 | .18 |
| Response Time | 1 | 4.81 | .04 | .03 * |
| Confidence | 1 | .28 | .00 | .60 |
| FB-C x FB-T | 3 | 1.51 | .03 | .22 |
| Accuracy | 1 | 4.47 | .03 | .04 |
| Response Time | 1 | .00 | .00 | .96 |
| Confidence | 1 | 1.43 | .01 | .23 |

*Note:* * $p < .05$

**Content effects**. A significant multivariate effect was found for content. Univariate results showed when collapsed across timing groups, response times were faster on the transfer test for those given high content in acquisition compared to low.

**Timing effects**. Although the multivariate effect of timing was not significant, planned comparisons revealed response time was faster on the transfer test for those who received immediate feedback compared to delayed ($p < .05$).

**Content and timing interaction**. The multivariate interaction of content and timing was not significant; however, planned comparisons revealed when feedback contained high content, transfer accuracy was higher and response times lower for those who had received delayed rather than immediate feedback in acquisition ($p$'s $< .05$). Response times were faster with high content compared to low when feedback was immediate ($p < .05$) as well.

**Interim Summary**

A transfer test was used to assess feedback effects on the application of knowledge to novel stimuli. Results showed high content led to faster response time than low content. In addition, delayed feedback increased accuracy and reduced response times compared to immediate when feedback contained high content. That is, high content feedback given after a delay increased the transfer of knowledge demonstrated by higher accuracy and faster response times.

These results seem to suggest the feedback mechanisms that contribute to enhanced transfer test performance were the result of an interaction of content and timing. In accordance with cognitive load theory, increased feedback content supported learning. However, while there were benefits of high content, effects on accuracy were only present when feedback was delayed. Taken together, these results imply the benefits of an additional encoding opportunity as predicted by the spacing hypothesis are, to some extent, influenced by the contents of feedback.

**Application of Signal Detection Theory**

Signal detection theory (SDT) was used to further investigate the effects of feedback on learning to identify a phishing email. The measures used were the same utilized by Sheng et al. (2007) to explore the effects of different anti-phishing training: sensitivity (*d'*) and criterion (*C*). Sensitivity refers to the ability to distinguish a signal (a phishing email) from noise (a real email). Sensitivity increases as the ability to distinguish a signal from noise increases. In the current study, higher values of sensitivity indicate a better ability to detect phishing emails.

Criterion, or response bias, reflects the degree to which one response (*i.e.,* signal present) dominates over another (*i.e.,* signal absent). Applied to the present study, criterion values represented the propensity to respond either signal present (fake email) or signal absent (real email). That is, criterion values also characterize *response bias*. A positive criterion indicated a tendency to respond "real email" while a negative criterion indicated the tendency to respond "fake email."

Sensitivity and criterion values were calculated for each participant and subjected to a 2 (Learning Stage: Acquisition and Retention) x 2 (Feedback Content: Low and High) x 2 (Feedback Timing: Immediate and Delayed) mixed-model MANOVA. Bonferroni corrections were applied to all tests of simple main effects and planned contrasts. Means and inferential statistics are provided in Tables 12 and 13 respectively.

**Acquisition and Retention**

Table 12.

*Mean Sensitivity and Criterion Levels divided by Feedback Content and Timing*

| | | *d'* | | | | *C* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Acquisition | | Retention | | Acquisition | | Retention | |
| | | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Content | Timing | | | | | | | | |
| Low | Immediate | .28 | .95 | 1.13 | 1.30 | .21 | .46 | .26 | .49 |
| | Delay | .21 | .77 | 1.02 | 1.21 | .34 | .42 | .12 | .35 |
| High | Immediate | .84 | 1.13 | .84 | 1.24 | .17 | .36 | -.04 | .40 |
| | Delay | 1.35 | 1.11 | 1.68 | 1.43 | .26 | .31 | .01 | .36 |

**Learning stage effects.** There was a multivariate effect of learning stage, where sensitivity increased from acquisition to retention. Additionally, planned comparisons showed response bias decreased between learning stages. That is, although the ability to detect phasing emails increased between learning stages; participants were more likely to indicate an email was fake in retention than acquisition. Planned comparisons also showed delayed feedback led to higher sensitivity than immediate ($p < .05$).

**Content effects.** Results showed a multivariate effect of content, where sensitivity was higher with high content ($M = 1.18$, $SD = .74$) than low content ($M = .66$, $SD = .79$). Criterion values were also lower with high content ($M = .10$, $SD = .25$) than low content ($M = .23$, $SD = .31$) indicating participants given high content were more likely to indicate an email was fake.

Table 13.

*Mixed-model MANOVA Summary for Sensitivity and Criterion*

| Source | *df* | *F* | $\eta p^2$ | *p* |
| --- | --- | --- | --- | --- |
| <u>Between Subjects</u> | | | | |
| Feedback Content (FB-C) | 2 | 10.70 | .15 | .00 ** |
| Sensitivity | 1 | 16.05 | .11 | .01 * |
| Criterion | 1 | 7.03 | .05 | .01 * |
| Feedback Timing (FB-T) | 2 | 2.94 | .05 | .06 |
| Sensitivity | 1 | 5.65 | .04 | .02 * |
| Criterion | 1 | .42 | .00 | .53 |
| FB-C x FB-T | 2 | 4.78 | .07 | .01 * |
| Sensitivity | 1 | 8.68 | .07 | .00 ** |
| Criterion | 1 | .55 | .00 | .46 |
| Error | 127 | | | |
| <u>Within Subjects</u> | | | | |
| Learning Stage (LS) | 2 | 8.93 | .13 | .00 ** |
| Sensitivity | 1 | 10.07 | .08 | .00 ** |
| Criterion | 1 | 9.90 | .07 | .00 ** |
| LS x FB-C | 2 | 3.56 | .06 | .03 * |
| Sensitivity | 1 | 4.42 | .03 | .04 * |
| Criterion | 1 | 2.06 | .02 | .15 |
| LS x FB-T | 2 | 1.34 | .02 | .26 |
| Sensitivity | 1 | .20 | .00 | .65 |
| Criterion | 1 | 2.63 | .02 | .11 |
| LS x FB-C x FB-T | 2 | .94 | .02 | .39 |
| Sensitivity | 1 | .34 | .00 | .56 |
| Criterion | 1 | 1.38 | .01 | .24 |
| Error | 127 | | | |

*Note:* * $p < .05$; ** $p < .01$.

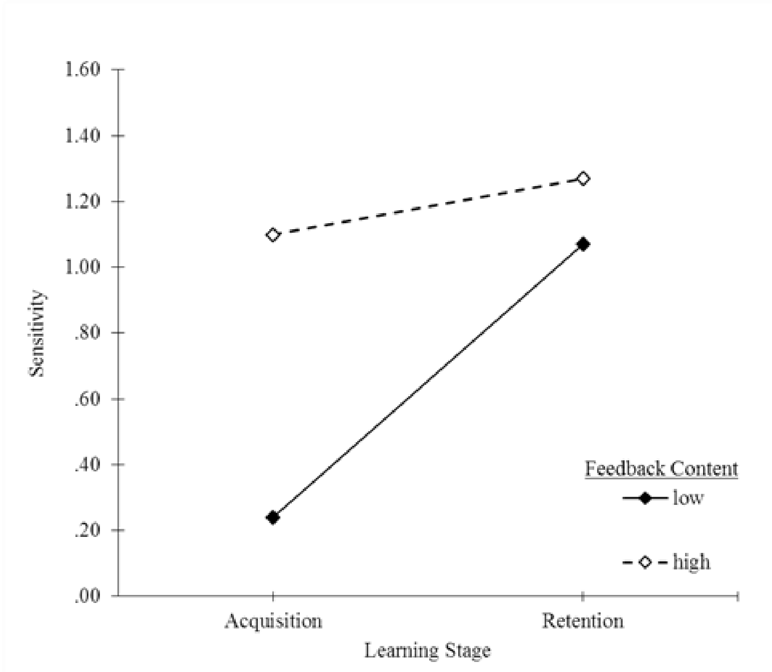


*Figure 9*. Effects of Content and Learning Stage on Sensitivity Levels.

As shown in Figure 9, there was a multivariate interaction of learning stage and content on sensitivity indicating feedback content differentially affected the detection of phishing emails at different learning stages. Simple main effects analysis revealed acquisition sensitivity was higher with high content compared to low ($p < .001$), and for both the immediate ($p < .05$) and delayed ($p < .001$) groups given high content. At retention, however, the difference between content groups dissipated ($p > .05$) as sensitivity increased significantly from acquisition to retention for those given low content ($p < .001$).

Additionally, planned comparisons indicated criterion values decreased between learning stages with high content ($p < .01$) resulting in lower criterion at retention ($p < .05$; $M = -.01$, $SD = .37$) compared to those given low ($M = .18$, $SD = .43$).

**Timing effects.** While neither the multivariate interaction of content, timing and learning stage or timing and learning stage were significant, planned comparisons revealed sensitivity was higher ($p < .05$) when feedback was delayed ($M = 1.05$, $SD = .83$) compared to immediate ($M = .77$, $SD = .76$). As shown in Figure 10, there was a significant increase in the ability to detect phishing emails (sensitivity) from acquisition to retention for participants given delayed feedback ($p < .05$) and a marginal increase ($p = .06$) for those given immediate feedback.

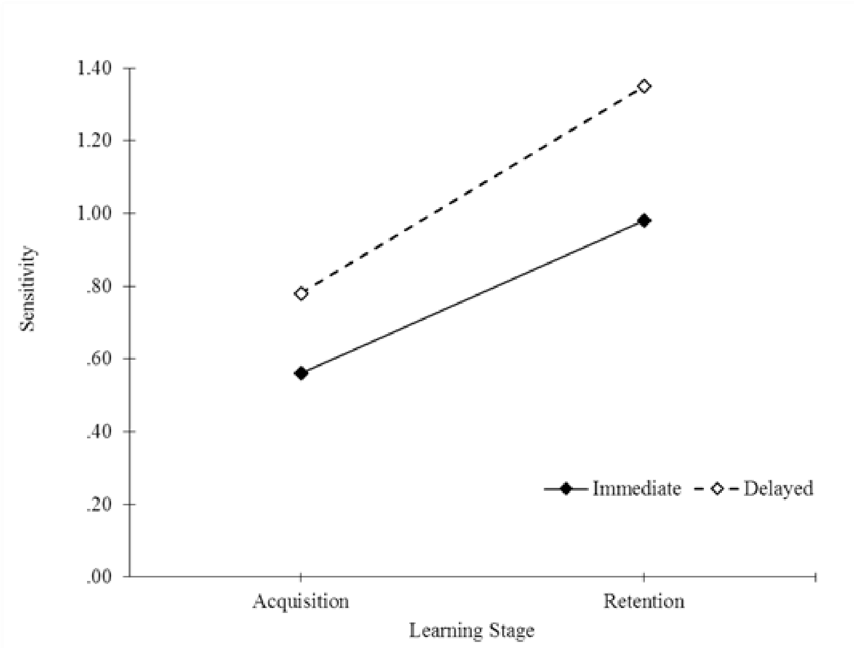


*Figure 10*. Effects of Feedback Timing and Learning Stage on Phishing Identification.

**Content and timing interaction**. There was a multivariate interaction of feedback content and timing on sensitivity. Simple effects analysis showed when feedback contained high content, identification of phishing emails was better ($p < .001$) when feedback was delayed ($M = 1.52$, $SD = .66$) compared to immediate ($M = .84$, $SD = .66$). Similarly, when feedback was delayed, identification of phishing emails was enhanced ($p < .001$) with high content (*M* = 1.52, *SD* = .66) compared to low (*M* = .62, *SD* = .74). Planned comparisons also showed when content was high, delayed feedback increased the ability to identify phishing emails in retention more than immediate ($p < .05$). Additionally, criterion values were lower with high content (*M* = .07, *SD* = .27) compared to low (*M* = .24, *SD* = .36) when feedback was immediate ($p < .001$).

**Interim Summary**

A Signal Detection Theory analysis was conducted on sensitivity and bias measures to investigate the role of feedback while learning concepts related to cybersecurity. Cognitive load theory and ACT-R suggested high content would maximize learning. The spacing hypothesis predicted benefits of delayed feedback due to an additional encoding opportunity.

As predicted by CLT and ACT-R, high content increased the ability to detect phishing emails more than low content. Predications made from the spacing hypothesis appeared to be supported as well: delayed feedback also increased discrimination between real and fake emails and led to a significant increase in phishing detection between learning stages. However, when the effects of content are taken into consideration, the benefits of delayed feedback become less clear.

The variables of content and timing interacted resulting in differential effects on sensitivity. When feedback contained high content, phishing detection increased whether feedback was delayed or immediate. However, for the delayed feedback group, phishing detection was enhanced with high content but not low. Taken together, these results suggest high content is responsible for the interaction of content and delay.

Participants given high content were also more likely to indicate an email was fake. That is, high content led to more cautious behavior overall and at retention. Despite more cautious behavior, it could be argues the response bias for participants given high content more readily approached the 'ideal' value. This interpretation and further implications of these findings are addressed in the Discussion.

**Transfer**

Sensitivity and criterion values were calculated for transfer and examined with a 2 (Feedback Content: Low and High) x 2 (Feedback Timing: Immediate and Delayed) MANOVA. Bonferroni corrections were applied to all tests of simple main effects and planned comparisons. Inferential statistics are provided in Table 14 and means in Figures 11 and 12.

There was a multivariate interaction of content and timing. Univariate analysis indicated significant differences in criterion levels and marginal differences in sensitivity. Simple main effects analysis showed criterion levels differed between content groups when feedback was immediate ($p < .05$) but not delayed ($p > .05$). Specifically, participants were more likely to indicate an email was fake with high content compared to low and when feedback was immediate. Criterion values also differed between timing groups when feedback contained low content ($p < .01$), where those given delayed feedback were more likely to indicate an email was fake than those given immediate. In other words, delayed feedback led to more cautious behavior than immediate feedback.

Table 14.

*MANOVA Summary for Transfer Sensitivity and Criterion*

| Source | *df* | *F* | $\eta p^2$ | *p* |
|---|---|---|---|---|
| Content | 2 | 2.62 | .04 | .08 |
| Sensitivity | 1 | 2.38 | .02 | .13 |
| Criterion | 1 | 3.62 | .03 | .06 |
| Timing | 2 | 1.84 | .03 | .16 |
| Sensitivity | 1 | 1.72 | .01 | .19 |
| Criterion | 1 | 2.52 | .02 | .12 |
| Content x Timing | 2 | 4.71 | .07 | .01 * |
| Sensitivity | 1 | 3.32 | .03 | .07 |
| Criterion | 1 | 4.84 | .04 | .03 * |
| Error | 127 | | | |

*Note:* * $p < .05$.

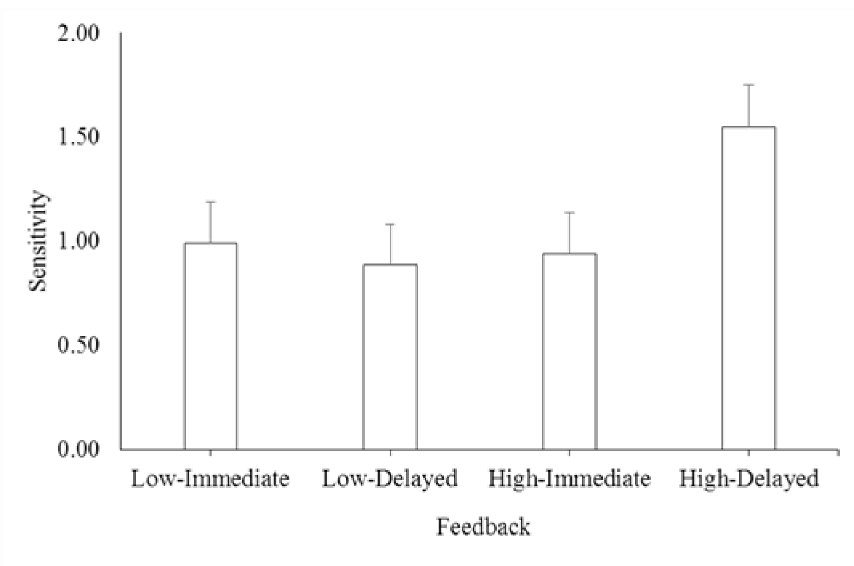


*Figure 11*. Effects of Feedback on Transfer Sensitivity.

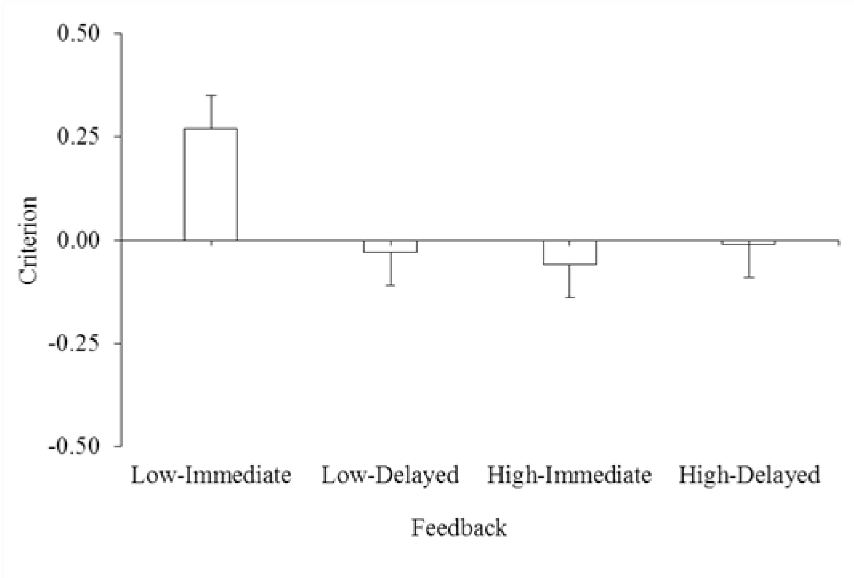


*Figure 12*. Effects of Feedback on Transfer Criterion.

Results also indicated sensitivity differences between content groups when feedback was delayed ($p < .05$). Specifically, identification of phishing emails was enhanced when delayed feedback contained high content compared to low content. Similarly, when feedback contained high content, delayed feedback led to better detection of phishing emails than when feedback was immediate ($p < .05$). Finally, high content led to a marginal increase over low content ($p = .06$) in the discernibility of phishing emails.

**Interim Summary**

Signal detection theory was used to assess feedback effects on the application of knowledge to novel stimuli. Key findings were high content led to a marginal increase in phishing detection compared to low. When feedback was delayed, however, high content significantly increased identification of phishing emails. Similarly, when feedback was delayed, discrimination between real and fake emails was enhanced. However, unlike retention, results did not show a significant differences in phishing identification between low and high content groups. These results suggest delayed feedback may foster the transfer of knowledge to novel situations.

## Discussion

A century's worth of research has yet to determine the feedback required for learning. A review of the literature revealed differences in studies finding benefits of increased feedback content versus those that showed benefits of delayed feedback. These differences were generally in the type of information being learned. Studies that found benefits of delayed feedback were generally associative or verbal learning tasks that required participants to memorize only. On the other hand, studies that showed advantages of increased feedback content tended to include more complex higher order learning tasks that required the understanding of concepts or relationships.

The differences in learning tasks utilized in prior studies led to an exploration of feedback effects based on the type information being learned. Learning can require memorization or understanding. Adjusting feedback parameters can support these requirements. The current study focused on how the cognitive requirements of a task are affected by feedback. The task used was a higher order learning task that required the understanding of relationships or concepts. It was designed to prevent learners from engaging in rote memorization only as required in associative or verbal learning tasks. Feedback was manipulated using the parameters of content and timing. If the type of information being learned impacts feedback effects, results were expected to show the benefits of content would be greater than the timing of feedback.

Overall, results demonstrate the effectiveness of feedback as participants in all groups improved from acquisition to retention; however, accuracy was higher for those given high content compared to those given low. A SDT analysis also showed participants given high content were better at detecting phishing emails. One possible explanation supported by cognitive load theory is high content reduced intrinsic cognitive load allowing learners to focus on understanding the relationships required for performance (Renkl & Atkinson, 2003; Sweller, 1988; Sweller, 2010). High content specified answer correctness as well as the reason why. Thus, it provided information regarding cause and effect relationships that contributed to successful task performance supporting the claim that feedback should provide information about cause and effect relationships (Jonassen & Ionas, 2008).

Another explanation provided by the ACT-R framework is high content allowed learners to experience more correct responses resulting in performance that more closely resembled that of ‘experts’ (Anderson, 1993, 1996). As a result, it’s possible the benefits of high content were due to more time practicing the skills needed for successful performance.

The bifurcation model also provides an explanation for the benefits of high content (Kornell et al, 2011). As discussed previously, the bifurcation model suggests successful retrieval increases the storage strength for a given item. Given the finding in the present study that high content led to higher acquisition accuracy, the implied result is it also led to more successful retrieval attempts. Thus, benefits of high content may result from increased encoding strength due to a higher number of successful retrieval attemps in acquisition.

Delayed feedback also led to higher accuracy and better detection of phishing emails than immediate feedback. As discussed earlier, benefits of delayed feedback have generally been found for tasks in which performance is primarily governed by memory strength. The results obtained here would seem to contradict this account of feedback timing effects. However, when one considers the information required for task performance, this interpretation of feedback timing effects appears to be supported.

If timing effects were independent of content, similar results would be expected whether content was high or low. Yet, this was not the case: when feedback contained low content, there were no instances in which delayed feedback resulted in better performance than immediate. Conversely, there were numerous findings in which high content resulted in better performance whether it was delayed or immediate. These results suggest the conditions under which the spacing hypothesis apply need further qualification (Butler et al., 2007; Smith, & Kimball, 2010). Specifically, aaccording to ACT-R, the act of encoding is only beneficial when the correct information is encoded (Anderson, 1993, 1996). Thus, its likely high content provided the information needed for participants to take advantage of the additional encoding opportunities.

Further support for this notion comes from the finding that when feedback with high content was delayed, the transfer of knowledge to novel stimuli was enhanced. Specifically, overall accuracy was higher and participants demonstrated better discrimination of phishing emails from real emails. Surprisingly, there were no effects of feedback content on these measures. This seems to indicate the underlying mechanisms contributing to the interaction of content and timing are not due to the effects of content only. Providing that learners have the information necessary for successful task performance, it appears delayed feedback may provide an additional encoding opportunity that results in more adaptable knowledge. This, however, would need to be studied further.

Finally, findings from the current study also suggested feedback affects response bias. Specifically, high content was associated with more cautious behavior where participants were more likely to indicate an email was fake when collapsed across learning stage and in retention. Additionally, high content resulted in significantly more cautious behavior in retention than acquisition. In similar research, Sheng et al. (2007) interpreted a non-significant change in criterion as an indication of learning. They further suggested,

> "when presented with the training, a user may shift the decision criterion (C) to the left, to be more cautious. This might lead to fewer false negatives at the expense of false positives. Alternatively a user may learn to distinguish the phishing websites better, in which case there will be an increase in *d'*."

Given the effects of content on response bias in present study, one might argue the benefits of high content were the result of more cautious behavior. However, this is not likely because the ability to discriminate between phishing emails and real emails (*d'*) was enhanced with high content. If participants were simply behaving more cautiously, the false alarm rate would increase leading to decreased sensitivity. Yet, sensitivity was highest for participants given high content.

An alternative explanation is high content provided more information concerning the number of real and fake emails thus changing participants' response bias. The criterion value that maximizes performance is determined by the frequency, or base rate, in which each category of stimuli (*e.g.*, real or fake) appear (MacDonald & Balakrishnan, 2002). In the current study, the base rates of real and fake emails were equal, resulting in an 'optimal' criterion value of zero.

While high content contained information about the causal relationships contributing to answer correctness, it also explicitly indicated whether a given email was real or fake. In contrast, low content provided information regarding answer correctness only. That is, it did not specify whether an email was real or fake. Participants may have inferred this information based on answer correctness, but it was not explicitly provided. Consequently, high content may have offered more information concerning the relative frequencies of real and fake emails resulting in an adjustment of response bias. This, however, requires further investigation.

**Potential Limitations**

The most obvious limitation of the current study is the use of unsupervised participants. Prior research has suggested they may be less attentive than supervised participants in the lab (Oppenheimer et al., 2009; Paolacci, Chandler, & Ipeirotis, 2010). Other studies, however, have indicated participants recruited from Mechanical Turk have comparable behavior to those recruited in the traditional fashion (Horton, Rand, & Zeckhauser, 2011; Paolacci, Chandler, & Ipeirotis, 2010). In addition, Paolacci, Chandler, & Ipeirotis, (2010) showed participants recruited from Mechanical Turk exhibit the same heuristics and biases as participants in the lab and follow directions similarly.

It's possible effects of delayed feedback were due to an increase in the amount of time participants spent processing the information. On average, delayed feedback was looked at for 13.77 seconds while immediate feedback only 8.43 seconds. While prior research has shown the time spent processing information does not necessarily lead to greater retention (*e.g.*, Amlund, Kardash, & Kulhavy, 1986; Callender & McDaniel, 2009), this explanation for the benefits of delayed feedback cannot be ruled out nonetheless.

**Future Research**

The future of feedback research is promising and findings from the current study present some intriguing research questions. First, future studies should further explore feedback effects on different types of knowledge acquisition. One possible avenue of exploration is the extent to which the effects of feedback content are determined by the number of interacting elements within a task that contribute to successful performance (Sweller, 1988). It

Teachers, instructional designers, and the like should also consider the consequences of an error when designing feedback interventions. In the current study, one could argue the consequences of an error are severe enough that an increase in FA is an acceptable, perhaps even desirable, outcome. This may not be the case in all tasks though.

Finally, it will be particularly important for future studies to examine feedback effects on the acquisition of knowledge in a variety of domains and map those relationships onto individual differences. This includes identifying the knowledge learners are expected to acquire *and* the cognitive processes required for performance (Smith & Ragan, 1999). Once this process is complete, then focus should turn to identifying the most effective method to support learning (*e.g.*, feedback).

**Practical Application**

The use of computer based training and simulation based training are likely to increase with advances in technology. Examining how the information being learned affects feedback will allow system designers, instructional technologists, and the like develop efficient and effective feedback interventions.

Feedback should aid learner understanding of how relationships within a task affect performance. Indeed, Clark (2009) defined instructional support "as providing students with accurate and complete procedural information (and related declarative knowledge) that they have not yet learned in a demonstration about how to perform the necessary sequence of actions and make the necessary decisions to accomplish a learning task and/or solve a problem" (p. 161). Results of the current studies indicate feedback interventions designed with these principles in mind would be particularly beneficial. Specifically, when learning requires an accurate mental model, increased amounts of feedback content will enhance learning. However, delayed feedback is most effective when the encoding of information is the primary objective. Finally, despite the claim that cybersecurity is ineffective (Nielsen, 2004), the current study showed training concepts related to cybersecurity in web-based learning environment was effective. Therefore, results can be used to aid in the design of basic training programs related to cybersecurity education.

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**Appendices**

## Appendix A: Participant Material

## Informed Consent

**North Carolina State University**
**INFORMED CONSENT FORM for RESEARCH**

Title of Study
Task dependent feedback.

Principal Investigator
Dr. Anne McLaughlin (919) 521-6802

Experimenter
Chris Kelley (919) 513-2709

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**What are some general things you should know about research studies?**
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

**What is the purpose of this study?**
The purpose of the research is to investigate the effects of feedback on learning.

**What will happen if you take part in the study?**
If you decide to participate, you will take part in a research study. You will complete some general tests that measure abilities. For example, we will measure vocabulary and spatial ability. In addition, you will learn how to identify real emails from deceptive, or fake, emails. You will accomplish this by looking at different emails presented on the screen and trying to distinguish their authenticity. Different people in the study will receive different levels of feedback about their answers.

**Risks**
Participation in this study involves minimal risk or discomfort to you. Risks are minimal and do not exceed those of normal office work. If you experience eyestrain we recommend that you look around the room for about thirty seconds so that your eyes focus at different distances.

**Benefits**
There are no direct benefits to participating in the study.

**Confidentiality**
To better understand the participants in the study, we may collect some or all of the following information:

1. The Internet Protocol (IP) address of the computer you are currently using and connection speed; 2. The type of browser and operating system you use; 3. The date and time you participated in the study; 4. Your screen resolution; 5. Your preferred user-interface language as set in your operating system;

The information collected will be kept strictly confidential to the extent allowed by law. Data will be stored securely in locked files and only study staff will be allowed to look at them. No reference will be made in oral or written reports that could link you to the study. You will NOT be asked to write your name on any study materials so that no one can match your identity to the answers that you provide.

Additionally, I understand that as on online participant in this research there is always a risk of intrusion, loss of data, identification, or other misuse of data by outside agents. Though these risks may be minimized by the researcher, I understand they exist.

**Compensation**
For participating in this study you will receive $1.00.

**What if you have questions about this study?**
If you have questions at any time about the study or the procedures, please contact the Principal Investigator, Dr. Anne McLaughlin, Box 7650, NCSU, Raleigh, NC 27695, or 919-513-2434.

**What if you have questions about your rights as a research participant?**
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator, Box 7514, NCSU Campus (919/515-4514).

**Consent To Participate**

☐ By clicking this checkbox, I confirm I have read and understood the above information. I understand my participation is voluntary and I am free to withdraw at any time, without giving a reason and without cost. I voluntarily agree to take part in this study.

[print] [submit]

**Participant Instructions**

INTRODUCTION

In this task your goal is to learn how to identify phishing emails from real emails. Doing so will require you to identify 3 methods commonly used in phishing attacks.

You will begin by completing 5 practice trials where you will become familiar with the actions necessary to complete the task. Immediately following you will complete 16 trials where your goal is to identify 3 methods used in phishing attacks. During each trial, you will be presented with an email image, the choices real or fake, and a confidence scale. First, choose whether the given email is real or fake, and then indicate your confidence in the accuracy of your answer using the scale provided.

After your response you will be given feedback indicating whether your answer was correct or incorrect. Use this feedback to figure out the 3 methods used in phishing attacks.

It is important you DO NOT press the Back Arrow OR the Refresh button on your Internet Browser. Doing so will cause an error and you will not be able to complete the study. Again, DO NOT press the Back Arrow OR the Refresh button on your Browser.

When you're ready you may begin by pressing "NEXT" located at the bottom of the screen.

**Debriefing**

Thank you very much for participating in this experiment. We could not conduct our research without your help. This study was designed to examine what type of feedback is best suited depending on the task. People in the current study received either high or low levels of feedback delivered immediately after a response or after a delay.

Prior research has shown feedback is crucial to learning; however, feedback's effects on the learning process as a whole are not well understood. We think that feedback after an incorrect response may be used differently than feedback after a correct response. Therefore, some participants learned the task with feedback on incorrect responses only, while others received feedback on correct responses only.

You also completed several different ability tests, such as the vocabulary test. We are interested in determining whether individuals need different amounts of feedback while learning. For example, perhaps people with high verbal skills learn better when given very little feedback on how they are doing while others need feedback more often.

Please keep in mind the information you learned in the study are only some of the guidelines for identifying fake emails. There are other cues not covered in this study that can identify a fake email. When in doubt, you should always treat an email as fake. Visit the Anti-Phishing Workgroup at http://www.antiphishing.org/ for more information.

We will use the results of this study to recommend the best type of feedback for groups of people on particular tasks. Again, we would like to thank you for your participation. If you have any questions about the study or any suggestions, please do not hesitate to contact one of the directors of the project:

Dr. Anne McLaughlin: (919) 513-2434
Chris Kelley: (919) 513-2709

Thanks again for your participation!

**Demographics**

1. What is your age?

2. What is your gender?
   - Male
   - Female

3. Is English your primary language?
   - Yes
   - No

4. What is your highest level of education completed?
   - Did not graduate high school
   - High school graduate/G.E
   - Some college, or trade/technical/business school
   - Associate's degree
   - Bachelor's degree
   - Some graduate work
   - Master's degree
   - M.D., J.D., Ph.D., other advanced degree

5. What is your race/ethnicity?
   - Black
   - Asian
   - Caucasian/Non-hispanic
   - Caucasian/Hispanic
   - Pacific Islander
   - Native Indian
   - Middle eastern
   - Multi-racial

6. What is your occupational status?
   - Working full-time
   - Working part-time
   - Student
   - Homemaker
   - Retired
   - Volunteer worker
   - Seeking employment, laid off, etc.
   - Label

**Computer-Expert Screening Questions and Internet Experience**

Please read each statement carefully and then answer yes or no to each question.

1. Have you ever changed preferences or settings in a web browser?
2. Have you ever created a web page?
3. Have you ever helped someone fix a computer problem?

Please read each statement carefully, and then use the rating scale below to indicate the extent to which you agree or disagree with each statement.

1 = strongly disagree
2 = somewhat disagree
3 = neither agree nor disagree
4 = somewhat agree
5 = strongly agree

1. If a computer problem occurs while I am using the Internet, I usually know how to fix the problem
2. I know how to create a website
3. I know some good ways to avoid computer viruses
4. I am familiar with html
5. I know how to enable and disable cookies on my computer
6. I am able to download a "plug-in" when one is recommended in order to view or access something on the Internet
7. I can usually fix any problems I encounter when using the Internet
8. I help others who are learning to use the Internet
9. I download and install software updates from the Internet when necessary
10. I regularly update my virus protection software
11. I can design a nice background and/or signature for the e-mail messages I send
12. I know what a browser is
13. I have changed the settings or preferences on my computer that pertain to my Internet access

From: Potosky, D. (2007). The Internet knowledge (iKnow) measure. *Computers in Human Behavior*, *23*, 2760-2777.

## Appendix B: Experimental Stimuli

Subject: Account Password Change
From: Big Board
Date: Sat, Mar 28, 2012 at 9:19 PM

# BIG BOARD ACCOUNT PASSWORD CHANGE

This email is to confirm that you recently changed the password to your account.

If you did not change your password recently, please contact us immediately at 1-800-666-7837, or use our LiveChat function.

Be sure to keep your password secure - never reveal it to anyone, and never respond to an email asking for your password information. For more help with password security, visit our Security Center.

Your email address and contact information will not be shared with any third parties without your permission, unless we are required to do so by law or we need to perform necessary site functions (e.g., send information to our web servers or process credit card payments). Learn more about our privacy policies here.

The Big Board Team
moving your career up the ladder

---

Subject: Your Jungle Order
From: The Jungle
Date: Mon, Mar 2, 2012 at 1:16 PM

Thanks for your order!

Want to manage your order online?
If you need to check the status of your order or make changes, please visit our home page and click on Your Account at the top of any page.

## Purchasing Information:

| | | |
|---|---|---|
| Order #: | 105-2663293-0772205 | Delivery estimate: Mar. 7, 2012 |
| Shipping Method: | Two-Day Shipping | 1 "Griffin Technology GC17097 USB Mini-Cable Kit" |
| Subtotal of Items: | $12.87 | Personal Computers; $12.87 |
| Shipping & Handling: | $ 0.00 | In Stock |
| ------- | | |
| Total for this Order: | $12.87 | |

Need to print an invoice?

Visit www.jungle.com/your-account and to view your orders. Click "View order" next to the appropriate order. You'll find a button to print an invoice on the next page.

Sent: Fri, Jul 8, 2012 at 7:21 AM
From: LinkedIn Invitations <invitations@linkedin.com>
Subject: Reminder about your invitation

LinkedIn

REMINDER

This pending invitation is awaiting your response:

- Jerry Douglas

Accept

Don't want to receive email notifications? Adjust your message settings.

© 2012, LinkedIn Corporation

---

Subject: Microsoft account security code
From: Microsoft account team <account-security-noreply@microsoft.com>
To: me
Date: Mon, Mar 26, 2012 at 8:21 PM

Hi,

Thanks for helping us verify your Microsoft account!

Here is your code: 4336305

If you didn't request this code, please follow these steps:
1. Reset your password by going to https://account.live.com/password/reset
2. Rename your account by going to https://account.live.com/

Thanks,
The Microsoft account team

Subject: You have new Progressive policy documents
From: Progressive <customerservice@email.progressive.com>
To: me
Date: Fri, Jan 6, 2012 at 10:14 PM

PROGRESSIVE
DIRECT

**You have new documents for your policy**

New policy documents are now available online:

- RIGHT TO PURCHASE HIGHER UM/UIM LIMITS
- UNDERWRITING NOTICE
- NORTH CAROLINA PERSONAL AUTO POLICY
- DECLARATIONS PAGE
- PRIVACY POLICY
- IMPORTANT UNDERWRITING NOTICE
- WELCOME LETTER
- CLEAN DRIVER
- PROVIDER NETWORK PROGRAM NOTIFICATION

View Your Documents

---

Subject: Order Confirmation
From: SendFunds <service@payments.sendfunds.com>
Date: Mon, Mar 2, 2012 at 1:16 PM

SendFunds

You sent a payment of $9.99 USD to Spotify USA, Inc.

It may take a few moments for this transaction to appear in your account.

Merchant
Spotify USA, Inc.

Merchant contact: spotify-usd@us.spotify.com

| Description | Unit price | Qty | Amount |
|---|---|---|---|
| | $9.99 USD | 1 | |
| | | **Subtotal** | $9.99 USD |
| | | **Total** | $9.99 USD |
| | | **Payment** | $9.99 USD |

Invoice ID: 436602351

Issues with this transaction?
You have 45 days from the date of the transaction to open a dispute in the Resolution Center.

Subject: Order Confirmation
From: TechDirect <info@techdirect.com>
Date: Mon, Mar 2, 2012 at 1:16 PM

Thank you for your order.

* Below is your order confirmation. Please keep a copy for your records.

Order Summary
Sales Order Number: 170295658
Sales Order Date: 4/2/2012 10:08:14 AM
Shipping Method: Tech Saver (4-7 Days)
1 x ($41.99) G.SKILL Ripjaws X Series (2 x 4GB) 240-Pin DDR3 SDRAM DDR3 1333 (PC3 10666)

1 x ($-6.30) DISCOUNT FOR PROMOTION CODE $-6.30
Subtotal: $ 35.69
Tax: $ 0.00
Shipping & Handling: $ 0.00
Total Amount: $ 35.69
---------------------------

We reserve the right, in its sole discretion, to cancel the order at any time prior to shipment without liability. If you have any questions or did not place this order, send an email to order_help@techdirect.com.

Subject: Your receipt from TransUnion (Order #13EB53340R9Z)
From: TransUnion <transunion@email.truecredit.com>
To: me
Date: Tu, May 8, 2012 at 12:07 AM

TransUnion.

Thank you for choosing TransUnion to help you achieve your credit management goals. You can view your credit report online for the next 30 days. To view it now, click here.

If you haven't done so already, we recommend that you return to the site and print a copy of your report for your records. To print a copy now, click here. Enter your username and password to login. Then, click on the "Credit Report" tab.

ORDER DETAILS
==========================================
Free Personal Credit Report
----------------------------------------
SUB TOTAL
$0.00
----------------------------------------
State SalesTax
$0.00
----------------------------------------
TOTAL
$0.00
==========================================

Best regards,
The TransUnion Team

Subject: State Return Rejected - Action Needed!
From: IntuitElectronicFilingCenter@intuit.com
To: me
Date: Thu, Feb 4, 2012 at 12:21 PM

TurboTax Choose Easy.

Received — Rejected by State

What do I do now?
Sign into TurboTax and take a look at your rejected return. You'll see details on what caused the problem. We'll walk you through fixing the return and e-filing again.

If you are not able to e-file the return again, we'll help you get it filed by mail.

To track your status at any time, visit:
https://turbotax.intuit.com/efile/efilestatus/lookupemail.jsp?tn=94871ab18d843899ac2ba7

Subject: Account Change Notification Available in My Verizon
From: AccountNotify@verizonwireless.com
To: me
Date: Thu, Mar 29, 2012 at 8:38 PM

verizonwireless

IMPORTANT ACCOUNT INFORMATION FROM VERIZON WIRELESS.

As a result of your recent feature change, your confirmation letter, which provides an updated summary of your service, is available online.

>View Your Letter

Thank you for choosing Verizon Wireless.

P.S. Confirmation letters and other account notifications can also be found in the Account Change Notification section of My Verizon's My Documents & Receipts page.

My Verizon is also available 24/7 to assist you with:
- Viewing your usage
- Updating your plan
- Adding account members
- Paying your bill
- And much, much more ...

From: Wake Federal Savings <alerts@security.wakefederal.com>
Subject: Wake Federal Password Disabled

March 22, 2012

Your password has been disabled

Recently someone incorrectly attempted to login to your account three times. For your security, we have disabled your password.
To change your password, visit our website and click on "Username/Password Help" under the sign on fields.

Wake Federal is dedicated to protecting your information. Learn about our security measures and what we do to protect your accounts online.

If you have any questions, we are available 24 hours a day, 7 days a week at 1-800-956-4442, or email us at customer_service@wakefederal.com.

Sincerely,
Wake Federal Customer Service

---

Subject: Account Verification
From: Amazon.com
To: me
Date: Thu, Dec 22, 2012 at 12:21 PM

amazon

Greetings from Amazon.com,

We're making some new changes to give you more control of your account and help you stay updated.

At Amazon.com we are 100 percent committed to protecting your security and privacy .

We welcome the year 2013, with the same complete commitment to customer service. Which means we'll make sure you, and only you, can access your account or view your financial details.

And because we know how annoying junk mail is, we promise not to pass on your e-mail address, home address or any other details to any party.

Thank you for a great year and we look forward to serving you in 2013! Please proceed to the next step for your verification.

Continue

Privacy Notice © 1996 - 2012 Amazon.com

Subject: Confirmation of e-mail change
From: AmericanExpressWelcome@welcome.aexp.com
To: me
Date: Tu, May 1, 2012 at 1:56 AM

Dear Cardmember,

Thanks for updating your e-mail address with us.

We changed your e-mail address in our files.
If this is correct, you can disregard this e-mail.

If the new e-mail address is not correct or you did not request this change, please click here, or log on to https://www.americanexpress.com to change it.

Thank you for your membership.

Sincerely,

American Express Customer Service

AMERICAN EXPRESS

For your security:

Subject: Your AT&T wireless bill is ready to view
From: AT&T Customer Care
To: me
Date: Sun, May 6, 2012 at 6:51 AM

att.com | Support | My AT&T Account

Your wireless bill is ready to view

Dear Customer,

Your monthly wireless bill for your account is now available online.

Total Balance Due: $170.40

Log in to my AT&T to view your bill and make a payment. Or register now to manage your account online. By dialling *PAY (*729) from your wireless phone, you can check your balance or make a payment - it's free.

Smartphone users: download the free app to manage your account anywhere, anytime.

Thank you,
AT&T Online Services
att.com

Contact Us - AT&T Support - quick & easy support is available 24/7.

Subject: Better Business Bureau - Complaint
From: Better Business Bureau
To: me
Date: Mon, Oct 8, 2012 at 9:21 AM

Owner/Manager,

The Better Business Bureau has received a complaint from one of your customers regarding their dealings with you. The details of the consumer's concern are provided here. Please review this matter and advise us of your position.

In the interest of time and good customer relations, please provide the BBB with written verification of your position in this matter by November 29, 2012.

Your cooperation in responding to this complaint becomes a permanent part of your file with the Better Business Bureau. Failure to promptly give attention to this matter may be reflected in the report we give to consumers about your company.

We encourage you to click here, answer the questions and respond to us.

Sincerely,

BBB The Better Business Bureau Complaint Department

www.bbb.org | 30 East 33rd St., 12th Floor | New York, NY 10016 | Office Hours: 9-5, Monday - Friday | 212.533.6200

---

Subject: Your Order 1340546103
From: The Cosmetic Emporium
Date: Mon, Mar 2, 2012 at 1:16 PM

Dear Customer,

Thanks for your order! Your confirmation number is 1340546103.

Your products will be shipped within 1 to 2 business days. If you ordered a Gift Card, it will be sent separately from any merchandise that may have been ordered. If you purchased an eGift Certificate, the recipient will receive it via email within 24 hours.

At www.cosmeticemporium.com, you can always check your order status by clicking on the My Account link located at the top of every page. After signing in, your most recent order status will appear on the Order Status page.

---

Your order reads as follows:

---

Shipment #: 1130948017-01

| Item# | Qty | Price | Description |
|---|---|---|---|
| 1365493 | 1 | $42.00 | Buxom/More To Love ($85 Value)/More To Love |

Merchandise Total: $42.00
Gift Wrap Total: $0.00

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Subject: Password Change
From: FreeDNS
Date: Thu, Mar 26, 2012 at 5:34 PM

Dear Customer:

Your login password has been successfully changed. The new password is not printed here to protect your privacy, but your username is confirmed below.

Username: user101

If you have not requested this change, your account most likely has already been compromised and you should immediately request a password reset at https://account.freedns.com/resetpass/. We'd recommend not using a dictionary word or other easy to guess word as your password.

IMPORTANT NOTE: You must keep the email address we have on file for you up-to-date. Any accounts which cause bounced emails will be terminated. Click here to update your account information.

Thanks,

FreeDNS.com
twitter.com/FreeDNS

Please do not reply to this email. If you have additional questions, please visit http://freedns.com/support/.

Subject: Dropbox password reset confirmation
From: Dropbox <no-reply@dropbox.com>
To: me
Date: Sat, Feb 11, 2012 at 2:21 AM

Dropbox

You recently requested a link to reset your Dropbox password.
Please set a new password by following the link below:

https://www.dropbox.com/password_reset?reset_key=9_ylnpe9ycVJnTAo-18ZhKyJZooNV-b4

If you did not make this request, please click here.

Thanks,
- The Dropbox Team

Subject: Confirm Your Registration with Progress Energy
From: Internet.Registration@pgnmail.com
To: me
Date: Thu, Mar 22, 2012 at 12:21 PM

**Progress Energy**

Thank you for registering your account with Progress Energy. This e-mail is being sent as confirmation of your registration.

To complete the process and return to the login page click here.

We appreciate your business, and thank you again for registering with us.

If you are experiencing issues with the link above, please copy this link into a new browser window:
https://www.progress-energy.com/ws/selfservice/UserValidate.jsp?token=%7BENC%7DkUJwotJbYhnXw0MeyT4HnupZVSZ%2F0Ne0v9GND0qX5OPPh63TCftehM7xOzTx0PkmAzL1Ek6cw2zHwRwcu3Rt2zZi0qgpDwexpPP16OP9fySr0QIDZ2In5kpubSGC9vcX8MV6Xlgqvjh5WAq9Z88BtOnVjw%2BaY0NZkqd3mmYgwnxUARxbmpizM6Fs%2BYNo035OjSB3NWZAj6oiCMftejlJcaJI79tWQnnu7tativ1AqDg%3D%3D

* Please note: This invitation will expire in 7 days.

Subject: Bill Pay Notification
From: Wake Federal Online
To: me
Date: Thu, Mar 22, 2012 at 12:21 PM

**Your Enrollment is Complete**

Welcome to Wake Federal Banking. Your enrollment is complete and you may begin using Online Banking immediately, with 24/7 online access to your paper statements. Your Online BillPay service will take one to three business days to be activated.

As an Online Banking customer, you can also access your accounts through financial management software such as Quicken ® and Microsoft ® Money. Learn more by visiting our website.

If you have any questions, please call us at (800) 450-3696 or email electronic.services@wakefederal.com. We're available to assist you 24 hours a day, seven days a week.

We hope you enjoy banking online with Wake Federal.

Sincerely,
Wake Federal Customer Service

Subject: Changes to your account
From: First City National Bank <password_change@fcnb.com>
Date: Thu, Mar 26, 2012 at 5:34 PM

Dear Customer,

This is a courtesy notice to let you know that your password has been changed. No response is needed.

If you or anyone with authorized access to your account did not make this change, please send an email to password_change@fcnb.com.

The password change request was made from:

IP address: 24.36.9.153
ISP host: 10.35.93.151

Thanks,
First City National Bank

FCNB

A Member of FDIC and an Equal Housing Lender
www.fcnb.com

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Subject: Password Change
From: Total Insurance
Date: Sat, Mar 28, 2012 at 9:19 PM

Your password for accessing our website has been updated

If you have not updated or reset your password and believe that you are receiving this message in error, please reply to password_change@totalinsurance.com.

Visit our website to:

- Make changes to your policy
- See how changes will affect your rate before you make them
- Report or monitor your claim
- Get copies of your insurance ID card, Declarations Page, and more
- Change your e-mail address or mailing address