ABSTRACT

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The amount of feedback required to learn a new task has been investigated for decades with mixed results (*cf.* Schmidt & Bjork, 1992; Van Merrienboer & Sweller, 2005). One possible explanation is the learner's cognitive resources and demands imposed by the task may determine feedback requirements (McLaughlin, Rogers, & Fisk, 2006). To test this model, a study was conducted that accounted for the learner's cognitive resources by comparing samples of populations with known differences, older and younger adults (Horn & Cattell, 1967; Salthouse & Babcock, 1991). To account for task demands, a simple rule-based cue learning task was created. The task required participants to learn how to identify fake Windows popups using two different cues, a visual cue and a verbal cue. Participants used different cognitive abilities to identify the cues. The visual cue required the use of fluid abilities while the verbal cue drew from participants' crystallized intelligence. Varying levels of feedback support were provided throughout the learning process. Results indicated younger adults benefited from increased feedback support, while older adults benefited from increased feedback support with the visual cue, but decreased feedback support with the verbal cue. One explanation for the current findings is specific cognitive abilities of the learner influence the demands of the task and thus influences feedback support requirements.

Feedback Support Requirements for Learning a Cognitive Task:
The Role of Cognitive Resources and Task Complexity

by
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BIOGRAPHY

Christopher M. Kelley was born in San Diego, CA on September 11, 1982. His family moved to Garner, NC in March of 1998 where he lived until finished with his last two years of high school. After a year of attending East Carolina University, he transferred to Appalachian State University where he graduated in 2005 with a Bachelor of Science in Business Administration – Computer Information Systems.

After a year hiatus, Chris returned to school to pursue a graduate degree at North Carolina State University in Human Factors and Ergonomics. Currently, he works in the Learning, Aging and Cognitive Ergonomics Lab under the direction of Dr. Anne McLaughlin where he studies older adults' feedback requirements for learning a new task.

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INTRODUCTION

Despite 100 yrs of research the amount of feedback that should be given during training or learning is still disputed by researchers (see Schmidt & Bjork, 1992), but most would agree some amount of feedback is required (see McLaughlin, 2007 for a review). Feedback can be defined as information from an external source about performance (Kluger & Denisi, 1996). Studies have traditionally looked at feedback in terms of “more” or “less” information. However, these terms have been used ambiguously and inconsistently. For the purpose of this manuscript, more or less feedback will be defined as providing more or less support, or specific guidance, to the learner during acquisition (McLaughlin, 2007). The results of feedback research are split into two categories; one category contends less feedback facilitates more learning, while the other says more feedback should be provided (*cf.* Schmidt & Bjork, 1992; Sweller, 1988).

One hypothesis for the mixed findings of feedback research is that feedback support is a function of the available cognitive resources of the learner (McLaughlin, 2007; McLaughlin, Rogers, & Fisk, 2006). In this view, a learner is seen to have a limited amount of cognitive resources (i.e. attention, working memory capacity, etc.) in which feedback and the demands of the task compete for a portion of these resources. Previous research has found individual differences in cognitive resources and a decline of these resources with age (Feldman-Barrett, Tugade, & Engle, 2004; Salthouse, 1996; Salthouse & Babcock, 1991).

According to the Administration on Aging (2007), the number of persons 65 years or older will number approximately 71.5 million by the year 2030 and represent roughly 20% of the U.S. population. It is imperative to understand how age-related declines in cognitive resources, such as working memory capacity, affect older adults' ability to learn new tasks (Salthouse & Babcock, 1991).

The purpose of the current research was to investigate the role of feedback support in learning a cognitive task for older and younger adults. Age-related cognitive declines (e.g. working memory capacity, speed of processing) are well documented in literature (Craik & Salthouse, 2000; Salthouse, 1996; Salthouse & Babcock, 1991); however, it is unclear how these declines affect the utilization of feedback for older adults learning a new task. If feedback support is related to the available cognitive resources of the learner, the decline of these resources should affect the feedback support requirements of older adults. Numerous studies revealed mixed results when investigating the role of feedback on older adults' ability to acquire a new motor task (Guadagnoli & Kohl, 2001; Swanson & Lee, 1992; van Dijk, Mulder, & Hermens, 2007; Wishart, Lee, Cunningham, & Murdoch, 2002); however, to date no studies have compared older and younger adults' feedback support requirements in learning a cognitive task.

Literature Review

Feedback Characteristics

A number of feedback variables will be referred to in this manuscript including content, frequency and complexity. Previous research results on each variable is mixed, prompting the variables be recategorized by the amount of support offered to the learner (McLaughlin, 2007). This helped to reorganize the research literature. When looked at in terms of providing more or less support to the learner, studies finding less feedback support beneficial generally used high ability learners, young adults, or were simple tasks. Support is the amount of guidance provided to the learner. Conversely, those studies finding more feedback support beneficial generally used remedial students, older adults, or complex tasks.

Feedback variables have generally been looked at by comparing the extremes of "more" or "less." In feedback content studies, the information contained within the feedback itself is manipulated. Examples of such manipulations include the amount of information, the type of information, or the presentation of the information contained in the feedback. However, providing more content in feedback, or even the same amount, does not necessarily provide more support to a learner. For example, Schooler and Anderson (1990) investigated feedback support in learning a computer programming language called LISP. Participants were randomly assigned to receive directive (more) feedback or nondirective (less) feedback. Directive feedback provided the correct answer for the incorrect part of the function, while nondirective feedback only indicated what part of the function was incorrect. Although the number of words contained in both feedback presentations was nearly identical, the amount of direction provided to the learner was different. Information contained in the directive feedback provided more support because it offered the correct answer, while the nondirective feedback offered less support because it only indicated a mistake had been made. Results indicated participants that received less feedback support during acquisition made fewer mistakes in retention and spent less time on the task.

Feedback frequency studies have looked at feedback in terms of the number of times feedback was provided (e.g. every trial vs. every five trials) (Butki & Hoffman, 2003; Park, Shea, & Wright, 2000; Winstein & Schmidt, 1990). For example, a study may provide feedback on 100%, 75%, 50% or 25% of trials respectively. Providing in frequent feedback offers less support to the learner as no knowledge of whether the answer is correct or incorrect has been given on trials with no feedback.

Task Complexity

Task complexity has been hypothesized and shown to contribute to feedback requirements (McLaughlin et al., 2006; Wulf, Shea, & Matschiner, 1998), however, researchers have often not provided a distinct definition of task complexity and how it related to their task. Wood (1986) defined task complexity as a result of three factors: component complexity, coordinative complexity and dynamic complexity. Component complexity is the number of actions that need to be carried out in a given task, coordinative complexity is whether or not actions within a task need to be done sequentially or concurrently, and dynamic task complexity refers to whether or not the individual will have to adapt their actions based on changes occurring within the task itself. As can be seen from Wood's (1986) definition, task complexity consists of many factors, and therefore can result in different degrees of complexity. In addition, it stands to reason that individual differences, such as cognitive resources, likely interact task complexity.

Learner Characteristics

The cognitive resources of the learner can be thought of as the fuel for processing information and has been positively related to learning success (Ackerman, 1988; Craik & Salthouse, 2000; Engle & Kane, 2004). Sweller (1988) suggested a learner has limited cognitive resources available and feedback support should be provided in order to reduce the cognitive load of the learner, thus freeing up resources for learning. The reduction of the learner's cognitive load can be achieved by providing more feedback and results in increased retention (see Van Merrienboer & Sweller, 2005 for a complete review). It is important to note a reduction in a learner's cognitive load can only be attained if the underlying task requires a high demand of cognitive resources. The task must be sufficiently complex that the available cognitive resources of the learner are being used. Studies supporting cognitive load theory have traditionally found as the amount of feedback increases, performance on retention tests increase (McLaughlin, 2007; Tuovinen & Sweller, 1999; Vollmeyer & Rheinberg, 2005). For example, Tuovinen and Sweller (1999) compared participants provided with worked examples (more support) to those who were told to learn by exploration (less support). Results indicated novices provided with worked examples (more support) performed significantly better on a retention test. Results of the study indicated the best way to guide a learner was through a reduction of cognitive load by providing more support in the form of worked examples. As can be seen from the above example, cognitive load theory does not deal with feedback support per se, but rather the learning process. Nonetheless, feedback support can be used to reduce the cognitive load in ways similar to the worked examples above resulting in more cognitive resources remaining for learning.

Historical Development of Feedback Theory

Feedback support was originally studied in the animal-learning domain in a stimulus-response paradigm (Thorndike, 1911). The law of effect states that positive reinforcement generally leads to improved performance (Thorndike, 1911). This idea is closely related to the theory of operant conditioning that proposes behavior increases if followed by positive reinforcement and decrease if followed by punishment (Skinner, 1953). Therefore, the learner should be provided with positive reinforcement to support performance (Thorndike, 1911). This theory dominated the scientific community most of the 20th century; however, Salmoni, Schmidt, and Walter, (1984) outlined a distinction between learning and performance that early feedback research failed to note. Salmoni, et al. (1984) indicated to measure learning there must be a period of time between training and retention testing or a transfer test.

Learning can be defined as a permanent change in the ability of an individual (Brosvic, Dihoff, Epstein, & Cook, 2006; McLaughlin, 2007; Salmoni et al., 1984; Schmidt & Bjork, 1992), while performance can be viewed as temporary transient effects, or what an individual does in an activity (Salmoni et al., 1984; Schmidt & Bjork, 1992). Therefore, in order to measure learning, one must administer a retention test after a period of time to ensure the effects of training are gone (Schmidt & Bjork, 1992). A transfer test of a similar concept, but not the same as the trained activity, is also acceptable. Consequently, retention tests should be administered without feedback present, or in some reduced form. This will ensure the change in the individual is relatively permanent, and a result of learning.

After the distinction between learning and performance had been made, Salmoni et al. (1984) proposed that feedback should be used to guide the learner in the acquisition phase of learning. According to the guidance hypothesis, feedback support is used as motivation to complete the task and to guide the learner in acquisition; however, providing too much feedback support results in the learner becoming dependent on feedback and poor performance in tests of retention or transfer (Salmoni et al., 1984). Studies investigating the guidance hypothesis generally provided feedback support in the form of knowledge of correct response (KCR) or delayed feedback and have commonly found as the amount of support decreased, performance on a retention test increased (Butki & Hoffman, 2003; Park et al., 2000; Schmidt, Young, Swinnen, & Shapiro, 1989; Winstein & Schmidt, 1990). For example, Schmidt, et al. (1989) used a motor task and provided participants with feedback after either every trial (most support), 5 trials, 10 trials or 15 trials (least support). The results indicated participants provided with less support (every 15 trials) performed better on a delayed no-knowledge of results (KR) transfer test than those provided with more support.

Depth of processing is another potential reason for why less feedback support in acquisition is beneficial for learning (Craik & Lockhart, 1973). Schmidt and Bjork (1992) stated acquisition performance was an imperfect predictor of retention performance. Previous research had shown practice and feedback support conditions that make it more difficult for the learner may facilitate retention and application of concepts to similar tasks (see Schmidt & Bjork, 1992). Schmidt and Bjork (1992) hypothesized that creating this challenge point, or "desirable difficulties," required the learner to engage in processing activities needed for retention (Guadagnoli & Dornier, 1996). This results in the learner practicing the retrieval of information during acquisition which should result in increased retention. For example, Winstein and Schmidt (1990) examined the effect of feedback support presented to participants in learning a motor task. They provided participants with feedback every trial (more support) or every other trial (less support). Results indicated participants who were provided with feedback on every other trial (less support) performed better on a retention test.

By now we can clearly see the two camps of feedback support research that have emerged from the literature. One states more feedback support should be provided to the learner; while the other says less feedback support should be given. The question still remains as to the best way to guide a learner in acquisition. It has been hypothesized the answer depends on the cognitive resources, or individual differences, of the learner (McLaughlin, 2007).

McLaughlin et al. (2006) proposed a framework in which feedback support requirements were contingent upon learner resources and task demands. After a review of feedback literature (see Figure 1) McLaughlin et al. (2006) concluded studies finding less feedback support to be more effective were generally simple tasks, and those finding more

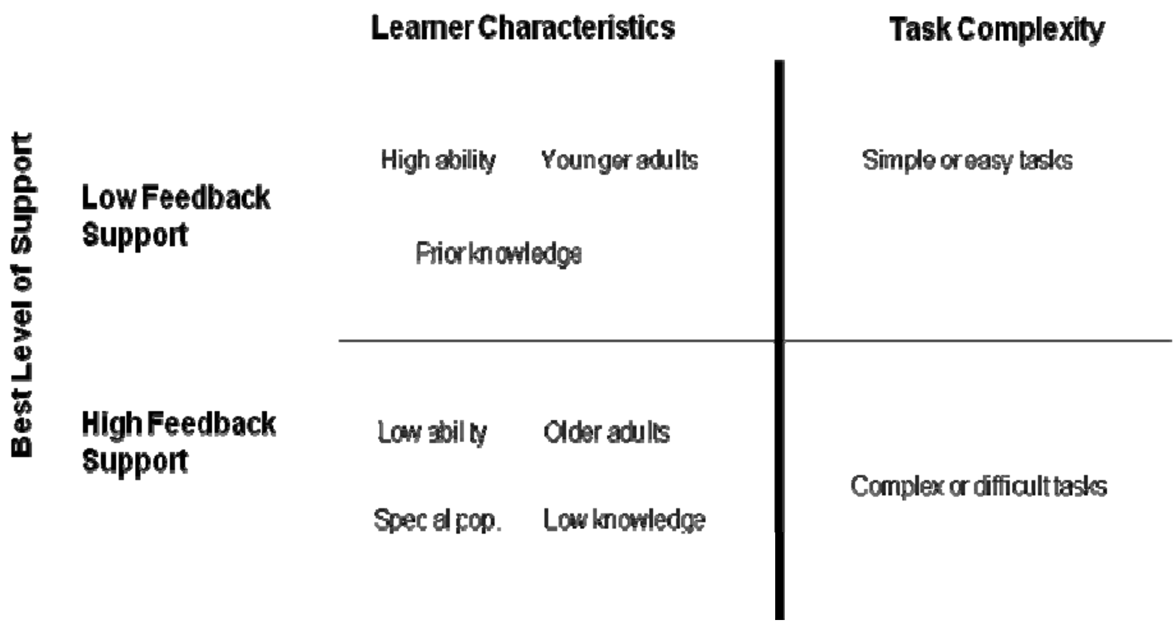

Figure 1. Feedback research results recategorized by cognitive resources and task complexity.

feedback support to be effective were either complex tasks or had participants with a reduced cognitive capacity (e.g. older adults, remedial students). In the proposed framework a learner is seen to have limited cognitive resources and the use of feedback support can be resource intensive. Thus, as shown in Figure 2, if a task is complex requiring a high amount of resources and utilization of feedback also requires a high amount of resources, few resources remain for learning. Therefore, feedback support that does not consume resources should be provided to reduce the cognitive load imposed by the task. However, providing too much feedback support could impede learning due to few resources remaining for learning the task.

McLaughlin (2007) tested the framework through the use of complex and simple tasks while controlling for working memory capacity (cognitive resources). The results indicated those provided with more feedback support, regardless of working memory capacity, performed better than those provided with less feedback performed better in acquisition and retention/transfer tests. However, the simple version of the task may not have been simple enough to fully test the framework. For complex tasks, both groups should benefit from increased feedback support, which occurred.

Interim Summary

The results of feedback research provide us with many questions and few answers. The question still remains as to whether or not more or less feedback support is better for learning, and if so, under what conditions. Salmoni et al. (1984) helped clarify the difference between performance and learning and stated feedback support should be used to guide the

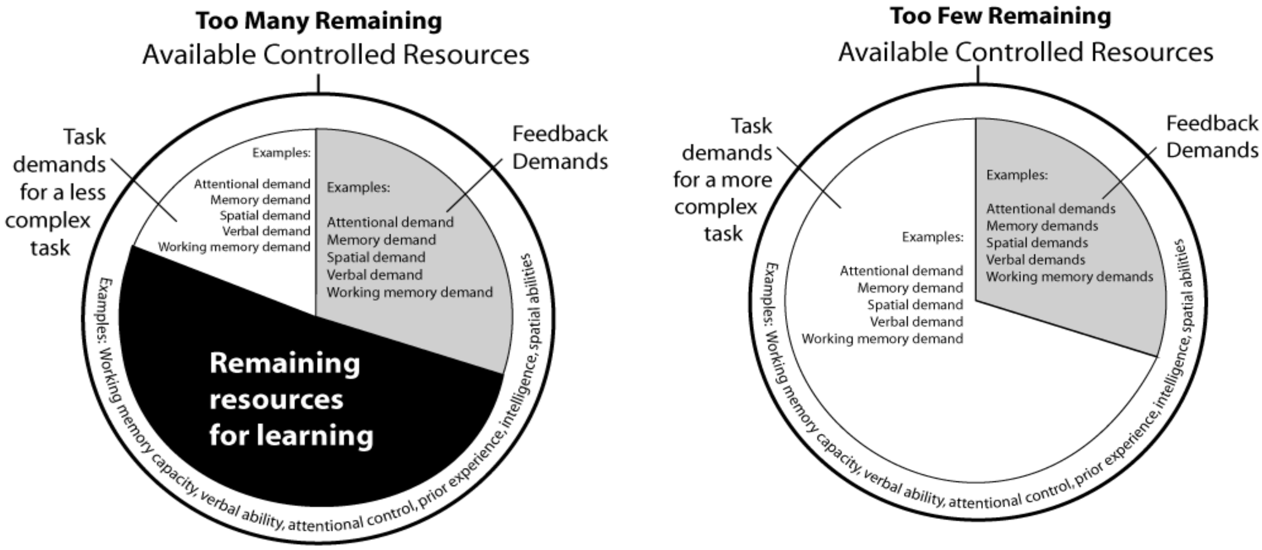

Figure 2. Feedback support requirements as a function of task complexity and cognitive resources.

learner in acquisition. Feedback support could motivate and guide learning, (Salmoni et al., 1984), free cognitive resources for learning, (Sweller, 1988), or inhibit learning due to a reduction in processing depth (Schmidt & Bjork, 1992). McLaughlin et al. (2006) attempted to bring all the theories together by theorizing feedback support requirements were contingent upon cognitive resources and task demands, but failed to find a benefit for reduced support in a simple cognitive task. Thus, the question of individual differences remains: do groups with different cognitive resources benefit from different amounts of feedback support. One population that tends to exhibit decreased cognitive resources is older adults.

Age Related Decline of Cognitive Abilities

Age-related differences in fluid abilities, working memory, and processing-speed are well documented in the cognitive aging research literature (Craik & Salthouse, 2000; Horn & Cattell, 1967; Salthouse, 1990, 1996; Salthouse & Babcock, 1991). However, it is not clear how a decline in these cognitive resources affects the learning process or how appropriate feedback can help attenuate these deficits.

Salthouse (1996) found older adults suffer from reduced processing speed as a result of two factors. The first factor is limited time mechanism, which states the time spent processing early activities directly reduces the time available to process later activities. The second factor is the simultaneous mechanism, which states that activities processed early may not be available for later processing because the information will be degraded to an unusable level. The reduction of these two factors contributes to the decline of fluid abilities in older adults (Salthouse, 1996). Fluid abilities, such as working memory capacity, are associated with the learning process (Horn & Cattell, 1967). If working memory capacity has declined, then older adults should be subject to an overload of working memory capacity more easily than younger adults. Therefore, the learning requirements for older adults to learn a new task may differ from younger adults. This leads to the question of how much feedback support is needed to help attenuate age-related cognitive changes such as working memory capacity.

Feedback Research with Older Adults

Feedback research with older adults shows mixed results as to the amount of support that should be provided to the learner. For example, a pilot study conducted by Wishart et al. (2002) investigated age-related differences with visual feedback support in the learning of a bimanual coordination patterns. The task consisted of participants, young and old, moving their upper limbs from side to side in front of their body. Participants performed 45, 15s trials per day over three consecutive days. Feedback support was provided after every fifth trial to both age-groups in the form of a spatial display of performance about the last trial completed. Retention tests were given one week and one month following the last acquisition session and consisted of two trials with no feedback.

The results indicated older adults were not able to learn the bimanual coordination pattern when feedback support was given after every fifth trial (low support) while younger adults were able to learn the task under this condition. These results are consistent with the resource framework presented earlier by McLaughlin et al. (2006). According to the framework, older should benefit from increased feedback support while younger adults decreased feedback support.

There was, however, a limitation with the Wishart et al. (2002) study. The retention tests should have consisted of more trials. This would help ensure participants did not suffer from any warm-up penalty.

In a subsequent study, Wishart et al. (2002) used the same task and gave participants feedback at the end of every trial versus feedback at the end of every trial and as the trial was occurring. Acquisition consisted of 35, 20s practice trials each for three consecutive days. Concurrent feedback was provided in the form of a visual representation of real-time performance. Retention tests were one week after the last acquisition trial and consisted of 10, 20s trials with no feedback. Older adults given concurrent feedback and end of trial feedback had significantly less variability than older adults given end of trial feedback only.

While there were no significant mean differences in performance between feedback groups, these results are important because there were differences in variability between feedback support groups for older adults, but not younger adults. That is, older adults receiving high feedback support (concurrent and end of trial feedback) performed more consistently in retention than older adults who received less feedback. This suggests that older adults receiving high feedback support may have learned the task better than older adults receiving lower feedback support. Populations with reduced cognitive resources (remedial students) benefited from higher amounts of feedback support (Dihoff, Brosvic, Epstein, & Cook, 2005). This finding supports the framework presented by McLaughlin et al. (2006) that predicts older adults need more feedback support.

Feedback Research with Simple Tasks

Schmidt et al. (1989) investigated the role of feedback support in learning a simple motor task. A timing task was used in which participants were required to move a lever back and forth through two zones as close to a predetermined time (550ms) as possible. Participants were given feedback after every trial (most support), 5 trials, 10 trials, or 15 trials (least support). Feedback was provided in terms of a visual graph with the difference between actual performance versus goal performance (i.e. +/- 13 ms) for each trial plotted. For example, if a participant was supposed to receive feedback after every five trials, then after the fifth trial they would be shown a graph with the performance for trials one through five. The difference between feedback conditions was when feedback was received (immediate versus delayed). Participants completed 90 trials with feedback, followed by a 10 minute rest after which they completed an additional 15 trials with no feedback. A retention test was administered two days later and consisted of 25 trials with no feedback. Retention results revealed a significant effect of feedback. Specifically, those that received feedback every fifteen trials performed best followed by those who received feedback every ten trials, five trials and every trial respectively.

The results obtained by Schmidt et al. (1989) provided evidence that less feedback support can increase retention for simple tasks. This is consistent with the framework presented by McLaughlin et al. (2006) that predicted a simple task required less feedback support and confirms the idea task complexity may determine feedback support requirements.

Feedback Research with Complex Tasks

Wulf et al. (1998) investigated the role of feedback support in the learning of a complex motor skill. The task consisted of a ski simulator in which the participants were required to make oscillatory movements with as large an amplitude as possible. Feedback support was provided concurrently during the trial via an oscilloscope. Participants were randomly assigned to receive high feedback support (100% of the time), low support (50% of the time), or to a control group (no feedback). The 50% feedback support group received faded feedback, or feedback that is gradually withdrawn, in which 60% of the trials on day 1 were provided with feedback support and 40% on the second day. Acquisition consisted of 10, 90s trials for two consecutive days. Retention was measured on the third consecutive day via a 10 trial retention test with no feedback support. Dependent variables were amplitude, frequency and relative force onset.

For amplitude in acquisition, main effects were found for both trial and day for amplitude. In addition, two two-way interactions (Day x Trial) and (Group x Trial) were also significant. That is, all groups performance improved significantly as both trials and days increased, with the 100% feedback support group performing the best. For frequency in acquisition, a main effect of day was found as well as a significant two-way interaction (Day x Trial). That is, all groups performed significantly better with time. No other main effects or interactions were found. For relative force onset in acquisition, the only main effect found was that of day, indicating all groups performed significantly better on Day 2 than on Day 1.

In retention, the only main effect found was for trial, indicating participants performed better as the number of trials increased. For frequency in retention, no main effects or interactions were significant. For relative force onset, a significant interaction of Group x Trial was found. Specifically, the 100% feedback support group's performance increased across retention, the 50% feedback support group's performance did not change and the control group's performance deteriorated across retention. Post hoc analysis indicated the 100% feedback support group had significantly better performance at the end of retention than the control group.

An interesting conclusion can be made from this study. Although task complexity is not defined, the nature of the task appears to play a role in feedback requirements. In contrast to the previously discussed research that less feedback support resulted in more learning, in the Wulf et al. (1998) study more feedback support lead to more learning. This finding supports the model proposed by McLaughlin et al. (2006). As shown in Figure 2, if the demands of the task increase, then the resources available for learning and the processing of feedback would subsequently decrease. One might argue by decreasing the feedback support provided to the learner you are freeing up resources needed for learning; however, the Wulf et al. (1998) results do not support this conclusion. In contrast, it would appear the only way to account for the increase in task complexity is to provide more feedback support to the learner in an effort to reduce the cognitive demands imposed by the task.

McKendree (1990) investigated the role of feedback support in tutoring complex math skills. The task required participants to complete geometry proofs in the fewest possible steps. Feedback support consisted of four conditions: whether or not the step was correct (minimal), an explanation as to why the answer is incorrect (condition violation), the correct answer (goal), or the information contained in both the condition violation and goal conditions (combined). Acquisition took place over three days. On the first day participants completed a 14 trial pretest. The pretest results were used as a covariate in the final analysis. Over the next 2 days participants completed 30 proofs. Retention was followed on the fourth day with the completion of 11 proofs. The dependent variable was errors. It was hypothesized some form of feedback would be more conducive to learning than no feedback, so the results of all feedback groups were collapsed and compared to the minimal (or lowest) feedback group. Acquisition results indicated participants who received minimal feedback performed worse than those who received more feedback. Retention results also showed the participants receiving minimal feedback performed worse than those who received the other forms of feedback. Contrasts showed a significant difference between the minimal group and goal group, and a marginally significant difference between the minimal group and combined group.

McKendree's (1990) study gives support to the notion that a complex cognitive task requires high amounts of feedback support. The study showed that performance in acquisition and retention increased as the level of feedback support increased.

While all of the reviewed literature attempts to add to the feedback requirements framework, confounding results continue to occur, likely due to the lack of focus and measurement of cognitive resources of the learners and the complexity of the task. These mixed results suggest cognitive resources and task complexity may be a determinant of the feedback support required to learn a new task. What remains unclear is the spectrum in which a task becomes complex enough or how limited the cognitive resources of the individual need to be, to require high amounts of feedback support.

Study Objectives

The present research added to the theoretical contributions of feedback support research by testing the hypothesis that feedback support depended on resources available to the learner. There is evidence that older adults require more feedback support in learning a new task (Wishart et al., 2002), however, the topic has not been systematically investigated as it relates to available learner resources and task complexity in general.

If feedback support requirements are contingent upon task complexity and cognitive resources, then feedback support requirements for older and younger adults doing a relatively simple task should differ. Specifically, older adults should learn more with high feedback support; while younger adults should learn more with less feedback support in a simple task. The current study accounted for task complexity and cognitive resources by including a population with reduced cognitive resources and a simple task.

Hypothesis

Predicted Pattern of Results

As shown in Figure 3, age was predicted to interact with feedback support level, where older adults would require more support than younger adults. In addition, younger adults should have learned more with less support compared to younger adults given more feedback support in acquisition.

METHOD

The experiment explored the potential interaction between feedback support, cognitive resources and task demand on learning a new task. Participants were grouped according to feedback support, low or high, and age group, younger and older. Participants completed several ability tests followed by 80-trials of practice on a simple cognitive task under differing levels of feedback specificity. They returned 4 days later and complete a 60 trial retention test. Acquisition performance and retention performance were measured as the mean number of correct and incorrect responses.

Participants

The study used two age groups, younger and older adults. Younger adults consisted of men and women recruited from the Raleigh community. Resources such as the classifieds, job boards, and craigslist were used to aid in the recruitment of participants. Younger adults

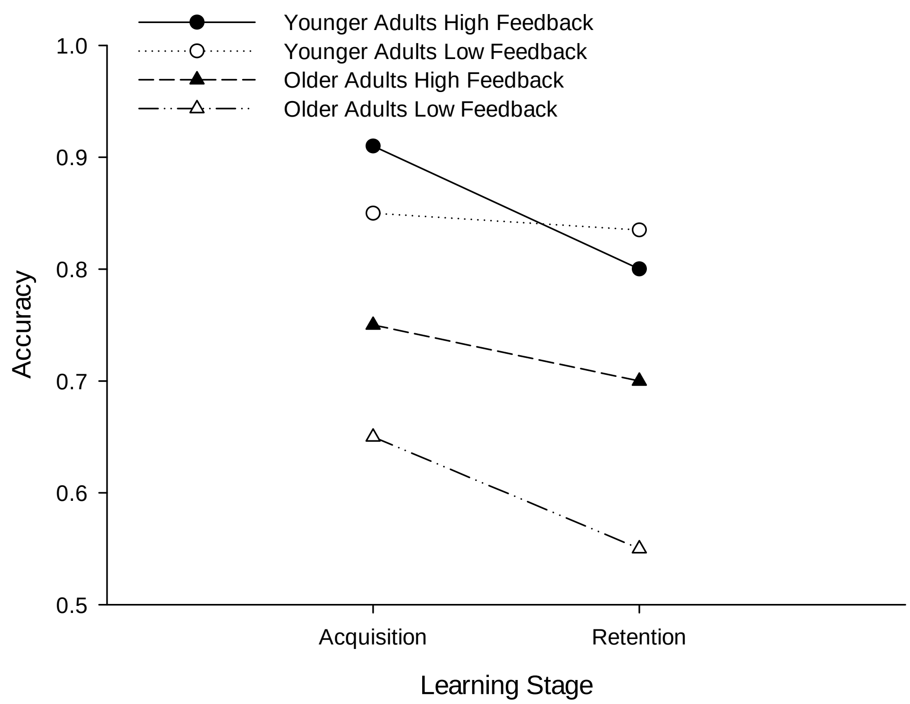

Figure 3. Expected interactions of feedback support and age.

ranged in age from 18 to 28 (*M* = 21.33, *SD* = 2.71) and were paid $35.00 for their participation. Older adults were recruited from around the Raleigh community and paid $40.00 for their participation. Older adults were paid more because it was expected it would take them longer to complete the study. They ranged in age from to 65 to 77 (*M* = 69.32, *SD* = 3.14). Age 65 is considered an acceptable minimum age in which age-related research can be conducted (Salvendy, 2006).

Excluded participants. Attrition rates for younger adults was approximately 30%, while only 1 older adult could not attend session 2. If attrition rates were due to the difficulty of the task we would expect the rates for older adults to be higher than younger adults'. Therefore, we can conclude that in general attrition rates were not related to the task, but to some other circumstance that affected younger adults more. Ten additional participants' data was excluded due to incomplete, missing or corrupt data, and 3 older adults were excluded from the final analysis because they were outside the specified age range.

Ability tests. Participants completed the following ability tests: Digit Symbol Substitution (Wechsler, 1997), Reverse Digit Span (Wechsler, 1997), Shipley Institute of Living Scale (Shipley, 1986), and an automated version of the operation span (Aospan) (Unsworth, Heitz, Schrock, & Engle, 2005) (see Table 1 for descriptives). The Digit Symbol Substitution test is a measure of perceptual ability. The Reverse Digit Span tests short-term memory and attention. The Aospan is a test of working memory capacity. The Shipley Institute of Living Scale is a measure of intellectual ability. These measures were analyzed using a multivariate analysis of variance (MANOVA) to ensure participants in different feedback conditions were not systematically different (Table 2 & Table 3). Significant differences were found on all ability tests between age groups; however, no main effect was found for Feedback and no differences were found for the Feedback x Age interaction. Therefore, we can conclude participants in the same age group did not differ on ability tests between feedback conditions.

Questionnaires. We also included a demographics form, a technology experience questionnaire and an exit interview (Table 1). The technology experience questionnaire consisted of some general questions designed to assess the participant's previous experience with technology and computers (see Appendix B). A multivariate analysis of variance was conducted to investigate the differences of participants' response on the technology experience questionnaire. Between subject factors were feedback condition and age group. Multivariate results revealed significant differences between age groups, $F(3, 67) = 8.57$, $p < .001$, $np^2 = .28$. Univariate between subjects tests showed younger adults reported having used computers longer, $F(1, 69) = 4.28$, $p = .04$, $np^2 = .06$, a higher max rate of computer use over any three month period, $F(1, 69) = 6.93$, $p = .01$, $np^2 = .09$, and higher computer usage over the previous three months, $F(1, 69) = 19.83$, $p < .001$, $np^2 = .21$, (see Table 2). A MANOVA was also conducted on the variables previously mentioned; however, participants were only compared to other participants within their own age group. Results revealed no significant differences between feedback conditions for either age group. Therefore, when compared to their own age group we can conclude participants computer usage did not differ between feedback conditions.

Table 1

Participant Characteristics divided by Feedback Condition and Age

	Young Adults				Older Adults			
	n = 20		n = 16		n = 19		n = 19	
	Low Feedback		High Feedback		Low Feedback		High Feedback	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	21.45	3.02	21.29	2.37	69.00	2.08	69.63	3.96
Highest Level of Education[1]	3.20	1.24	3.81	1.28	5.16	1.83	5.05	1.65
English is primary language[2]	.90	.31	.94	.25	1.00	.00	1.00	.00
Marital Status[3]	1.15	.67	1.25	.45	2.42	.84	2.42	.77
DSS[4]	68.90	9.97	64.62	11.63	51.43	12.77	49.00	5.36
RDS[4]	4.45	1.32	4.13	.89	3.71	.77	3.33	.62
Shipley[5]	31.85	3.42	31.38	3.86	36.00	2.18	34.47	3.46
Ospan[6]	46.90	17.16	43.75	14.66	35.47	20.43	33.20	9.89
Technology Experience Questionnaire[7]								
Indicate the total length of time you have used computers[8]	5.00	.00	4.92	.29	4.78	.55	4.61	.78
In the past, what was the highest frequency of your computer use over any 3-month period[8]	6.05	.76	6.00	.74	5.28	.96	5.65	.98
Have you used a computer in the last three months[8]	1.00	.00	1.00	.00	1.00	.00	1.00	.00
If yes how frequently[8]	4.65	.67	4.50	.67	3.39	1.04	3.78	1.17

Table 1 (continued)

	Young Adults		Older Adults	
	n = 20	n = 16	n = 19	n = 19
	Low Feedback	High Feedback	Low Feedback	High Feedback
	Frequencies			
Gender				
Male	9	11	8	8
Female	11	5	11	11
Race	4	2	0	2
Black	2	1	0	0
Asian	11	12	11	17
Caucasian/Non-hispanic	1	1	0	0
Multi-racial	2	0	0	0
Occupational Status				
Working Full-Time	0	0	1	1
Working Part-Time	1	4	0	2
Student	17	10	0	0
Homemaker	2	0	0	1
Retired	0	0	18	15
Volunteer Worker	0	1	0	0
Seeking Employment	0	1	0	0
Other	0	0	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 2 = yes; [3]Choices were: 1 = singe 2 = married 3 = widowed 4 = divorced; [4]Welscher, 1997; [5]Shipley, 1986; [6]Unsworth et al., 2005; [7]Czaja et al., 2002; [8]Picked time from a set multiple choice values (higher value indicates higher amount of time) (see Appendix B).

Table 2

Multivariate Analysis of Variance for Ability tests on Feedback and Age

Source	*df*	F	ηp^2	*p*	
		Between Subjects			
Feedback (FB)	4	1.08	.07	p = .37	
Digit Symbol Substitution	1	194.55	.03	p = .19	
Reverse Digit Span	1	2.05	.03	p = .14	
Shipley Institute of Living Scale	1	16.95	.02	p = .21	
Automated Operation Span	1	123.46	.01	p = .50	
Age (A)	4	20.13	.57	p < .001	*
Digit Symbol Substitution	1	42.24	.40	p < .001	*
Reverse Digit Span	1	10.65	.14	p < .01	*
Shipley Institute of Living Scale	1	220.35	.24	p < .001	*
Automated Operation Span	1	123.46	.11	p < .01	*
F x A	4	.96	.01	p = .96	
Digit Symbol Substitution	1	12.80	.00	p = .73	
Reverse Digit Span	1	.01	.00	p = .92	
Shipley Institute of Living Scale	1	4.71	.01	p = .51	
Automated Operation Span	1	3.25	.00	p = .91	

Note: * *p* < .05.

Experimental Task

The study was presented as an exercise in learning how to identify legitimate Windows pop-ups from fake pop-ups that install malicious software. Participants were told their task was to decide whether a given popup was legitimate, generated by Windows, or fake, created by a virus. The correct decision was based on cues the participant learned in the study. There were two cues participants tried to learn in the experiment.

Visual cue. As shown in Table 3, one of the cues the participant had to learn was associated with the color of the icon contained in the pop-up and therefore required the use of participants' fluid abilities such as pattern recognition and memory. In the fake pop-up, the color of the icon had been changed from its original color to a different color. For example, in one of the pop-ups the color of the icon was changed from yellow to red. Two real icons and 2 fake icons were provided. Ten distinct messages were created and used in the pop-ups with each message being used twice, once in the real pop-up and once in the fake pop-up.

Verbal cue. The other cue the participants had to learn was associated with the language, or tone, of the message contained in the pop-up and drew from the crystallized intelligence of participants' such as vocabulary and verbal knowledge. The fake pop-up message contained an incorrect tone or other grammatical error. This was achieved by using messages the contained all capital letters, multiple exclamation points, or spelling mistakes. For example, in one of the fake pop-ups the message read ARE YOU SURE YOU WANT TO QUIT? Ten distinct messages were created and used for the real pop-ups. A similar version of the real pop-up was then created utilizing one of the above errors and used for the fake pop-ups.

Table 3

Icons used for Cue 1 - Color Condition

	
	

Task difficulty. The task used in the study was designed to be simple. The definition used for task difficulty was the ease in which the task is accomplished, while a complex task was defined as a task with numerous interacting elements. That is, a simple task has little to none interacting elements. Decisions participants made about the validity of a popup was based on *one* element at a time. Therefore, since the task used had no interacting elements it was categorized as a simple task.

Feedback Conditions

Lower support. As shown in Figure 4, in the low feedback support condition, participants were simply told whether their answer was correct or incorrect. The lower feedback support condition was similar to knowledge of results conditions in previous feedback studies. In this condition participants had to determine why their answer was correct or incorrect.

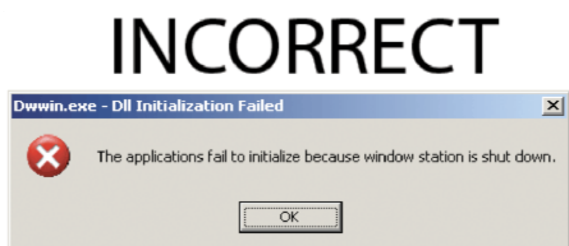

Figure 4. Example of lower feedback support.

Higher support. As shown in Figure 5, in the higher feedback support condition, participants received the same information given in the low feedback support condition as well as information regarding why their answer was correct or incorrect.

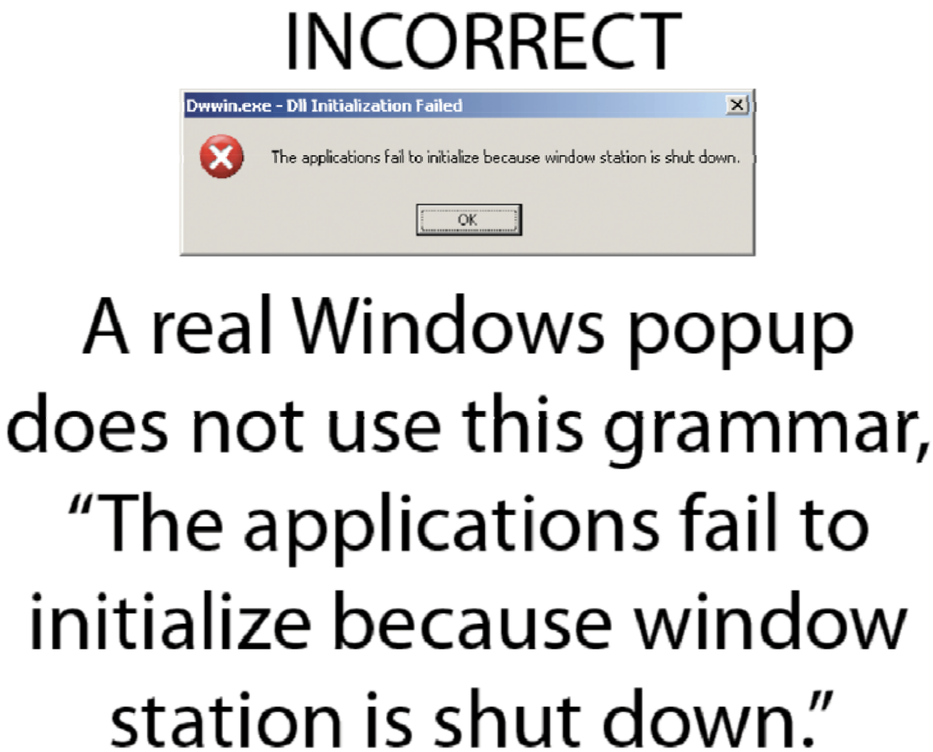

Figure 5. Example of higher feedback support.

Learning Stages

Acquisition. Acquisition occurred over an 80 trial practice task. Participants were randomly assigned to one of two levels of feedback specificity (lower or higher). They were informed their goal was to learn the cues behind identifying real and fake pop-ups.

Retention. Participants returned four days later and completed a 40 trial retention test. This ensured learning was being measured and not performance (Salmoni, et al., 1984). Participants received no feedback support during the retention test.

Transfer

Immediately following the retention test, participants completed a 40 trial transfer test. The transfer test was designed to investigate how participants applied the knowledge learned in acquisition to similar concepts.

Near transfer. The near transfer test consisted of stimuli comparable to those used in acquisition. For the Visual Cue, the icons were similar to those in Table 3; however, the color of the fake icons was different. For the Verbal Cue, the format of the text was the same, but new text was created.

Far transfer. The far transfer test consisted of stimuli that required the participant to apply the concepts learned in acquisition to different contexts and situations. In addition, the stimuli were not limited to popups. Visual and grammatical elements appeared in different locations and mediums than those used in acquisition. For example, one stimuli tested visual elements using a popup that did not look like the Windows generated popus used in acquisition (see Figure 6). Another stimuli tested verbal elements with a message that appeared in the Windows notification area (see Figure 7).

Figure 6. Example of far transfer test visual stimuli.

Figure 7. Example of far transfer test verbal stimuli.

Materials

Equipment. The experimental task was performed on IBM-compatible computers (1.80 GHz Pentium Dual-Core, 1.96 GM RAM). Screen size was 19" with a resolution of 1280 x 1024 pixels and a refresh rate of 60 Hz.

Instructions. Participants received on screen instructions describing the task (see Appendix A). They were told to try and learn the cues behind identifying real and fake pop-ups.

Design

The study was a 2 (feedback support: lower and higher) x 2 (age: young or older) design. Feedback support and age were between-participant factors. The primary dependent variables were acquisition performance, retention test performance and transfer test performance. In order to examine if there was a speed-accuracy tradeoff between younger and older adults, participant's response time was also measured. The main acquisition and retention measure was accuracy, defined as the average number of correct and incorrect responses to a question.

Procedure

Acquisition. Participants were randomly assigned to one of two feedback support conditions. In addition, participants were also stratified by age group (one younger adult to one older adult) to ensure there were equal amounts of younger and older adults in each feedback support condition. Attrition rates and the exclusion of other participants resulted in unequal feedback support conditions.

When participants arrived they were given two informed consent forms (Appendix A). They were instructed one copy was for them to keep. The experimenter then went over the form orally after which participants signed a copy and returned it to the experimenter. After all the consent forms were collected participants completed a technology experience questionnaire (Appendix B) designed to gather general information on computer use and technology experience (see Table 1 for means) (Czaja, Sharit, Charness, Fisk, & Rogers, 2001), followed by digit symbol substitution ability test, and the reverse digit span ability test (Wechsler, 1997). Following the reverse digit span, participants completed the experimental task. Once finished they completed the Shipley Institute of Living Scale ability test (Shipley, 1986; Unsworth, et al., 2005) and scheduled a retention test time.

Retention. Participants returned four days after acquisition and completed a sixty trial retention task with no feedback support. As they arrived for the retention session they completed a near vision test. When finished with the retention and transfer test participants completed an exit interview followed immediately by the Aospan (Unsworth, Heitz, Schrock, & Engle, 2005). Participants were then compensated, debriefed, and instructed they could leave.

Counterbalance. Popups were divided by cue and the presentation order alternated between participants. A repeated measures multivariate analysis of variance showed no effects, $F(2, 65) = .80$, $p = .46$, $np^2 = .02$, or interactions of counterbalance. That is, there was no difference in accuracy depending upon which cue participants saw first; therefore, the groups were collapsed for the final analysis.

Data Analyses

A 2 (Learning Stage: Acquisition and Retention) x 2 (Age: Younger and Older) x 2 (Feedback Support: Low and High) repeated measures multivariate analysis of variance (RM-MANOVA) was conducted. Learning Stage was a within-subjects factor while Age and Feedback were between subjects factors.

To analyze transfer test results, a 2 (Age: Younger and Older) x 2 (Feedback Support: Lower and Higher) multivariate analysis of variance (MANOVA) was conducted on near and far transfer accuracy. Age and Feedback were between subjects factors.

Additional analysis. An additional post hoc analysis was performed to examine if performance on the 2 cues differed between age or feedback conditions. A 2 (Learning Stage: Acquisition and Retention) x 2 (Cue: Color and Grammar/Tone) x 2 (Age: Younger and Older) x 2 (Feedback Support: Low and High) RM-ANOVA was conducted on the primary dependent variable of interest: accuracy. Learning Stage and Cue were within-subjects factors while Age and Feedback were between subjects factors.

To be included in the analyses a participant must have had a complete data set. A complete data set was defined as having finished Days 1 and 2 of the study.

RESULTS

Feedback effects and interactions. As expected, the main effect of Feedback was significant, $F(2, 69) = 3.84$, $p = .03$, $np^2 = .10$, where participants that received high feedback support were more accurate than those who received low feedback support, $F(1, 70) = 5.49$, $p = .02$, $np^2 = .07$ (see Table 4 for descriptives).

Age effects and interactions. There was a main effect of Age, $F(2, 69) = 44.57$, $p < .001$, $np^2 = .56$, where younger adults were more accurate, $F(1, 70) = 73.52$, $p < .001$, $np^2 = .51$, and responded faster, $F(1, 70) = 38.68$, $p < .001$, $np^2 = .36$, than older adults.

Other effects and interactions. There was a main effect of Learning Stage, $F(2, 69) = 13.72$, $p < .001$, $np^2 = .29$, with retention accuracy higher than acquisition accuracy, $F(1, 70) = 20.80$, $p < .001$, $np^2 = .23$, and acquisition response time faster than retention response time, $F(1, 70) = 21.42$, $p = .01$, $np^2 = .09$.

Interim Summary

As expected, those who received high feedback support were more accurate than those who received low feedback support (see Figure 8). Younger adults were more accurate than older adults. In general, participants responded faster in acquisition but more accurate in retention.

Table 4

Descriptives for Overall Learning Stage Accuracy and Individual Cue Accuracy divided by Age and Feedback

	Young Adults				Older Adults			
	n = 20		n = 16		n = 19		n = 19	
	Less Feedback		More Feedback		Less Feedback		More Feedback	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Overall Acquisition	.75	.11	.80	.11	.61	.07	.63	.10
Cue 1	.73	.15	.80	.13	.55	.08	.65	.14
Cue 2	.76	.15	.81	.14	.68	.13	.60	.13
Overall Retention	.82	.14	.90	.08	.62	.10	.67	.11
Cue 1	.83	.20	.88	.12	.51	.14	.67	.11
Cue 2	.81	.15	.92	.10	.73	.13	.68	.13
Transfer								
Near Transfer	.77	.11	.82	.11	.63	.14	.65	.16
Far Transfer	.77	.10	.79	.12	.66	.09	.63	.14

Transfer Test

There was a main effect of Age, $F(2, 69) = 19.34$, $p < .05$, $np^2 = .37$, where younger adults had higher accuracy than older adults . Univariate between subjects tests showed younger adults had higher accuracy for both near transfer, $F(1, 70) = 26.88$, $p < .05$, $np^2 = .28$, and far transfer, $F(1, 70) = 24.04$, $p < .05$, $np^2 = .26$ (Figure 9).

Interim Summary

There was a main effect of age where younger adults were more accurate than older adults on both transfer tests. Near transfer test results were in the expected direction where participants that received higher feedback support were more accurate than those who received lower feedback support, however, the results failed to reach significance. Far transfer test results showed younger adults that received higher feedback support were more accurate than younger adults that received lower feedback support. Conversely, older adults that received less feedback support were more accurate than older adults that received more feedback support.

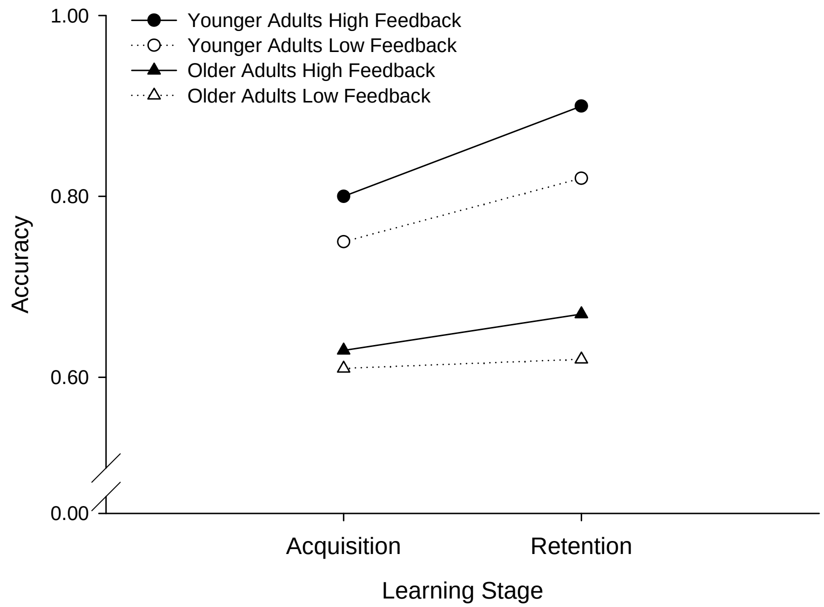

Figure 8. Accuracy between sessions divided by Feedback and Age where more feedback support benefited both age groups.

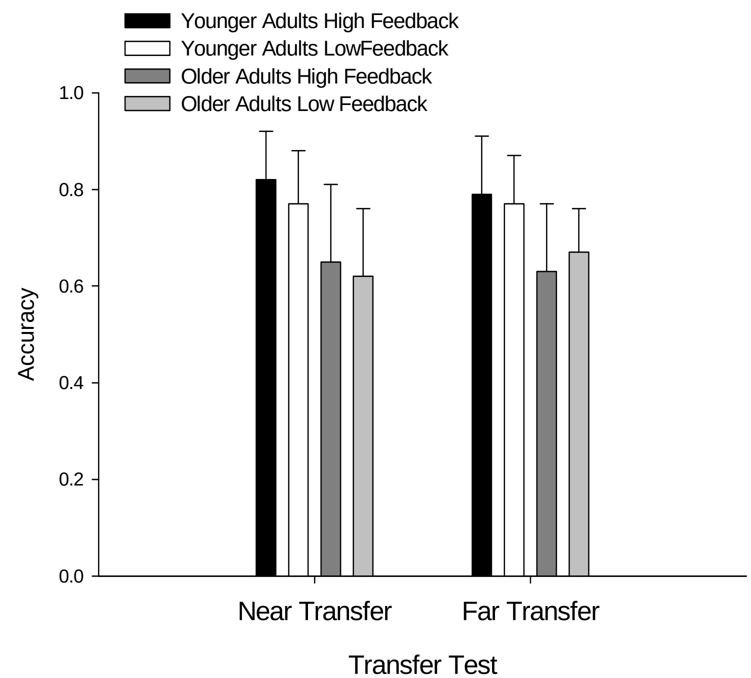

Figure 9. Accuracy for transfer tests divided by Feedback and Age where more feedback support benefited younger adults in both transfer tests, and more feedback benefited older adults with near transfer while lower feedback benefited far transfer.

Analysis by Cue

Feedback effects and interactions. As shown in Table 5, there was a main effect of Feedback, where participants that received high feedback support were more accurate than those that received low feedback support. There was a significant Feedback x Cue interaction, where for the Visual Cue those who received more feedback support were more accurate than those who received less feedback support (see Figure 10). There was a significant Feedback x Cue x Age interaction, where younger adults benefited from increased feedback support for both cues, while older were more accurate with higher feedback support with the Visual Cue and lower feedback support with the Verbal Cue (see Figure 11).

Age effects and interactions. There was a main effect of Age, where younger adults were more accurate than older adults. There was a significant Learning Stage x Age interaction where younger adults improved their accuracy more from acquisition to retention than older adults (see Figure 12).

Table 5

Repeated Measures Analysis of Variance for Cue divided by Feedback and Age

Source	*df*	F	ηp^2	*p*
		Between Subjects		
Feedback (F)	1	5.43	.07	.02
Age (A)	1	73.48	.51	< .001
F x A	1	.83	.01	.37
Error	70			
		Within subjects		
Cue (C)	1	7.63	.10	.01
Learning Stage (L)	1	20.86	.23	< .001
C x A	1	4.15	.06	.05
C x F	1	7.35	.10	.01
C x A x F	1	10.60	.13	< .01
L x A	1	5.34	.07	.02
L x F	1	1.41	.02	.24
L x A x F	1	.05	.00	.82
C x L	1	1.28	.02	.26
C x L x A	1	2.90	.04	.09
C x L x F	1	.22	.00	.33
C x L x A x F	1	.97	.01	.33
Error	70			

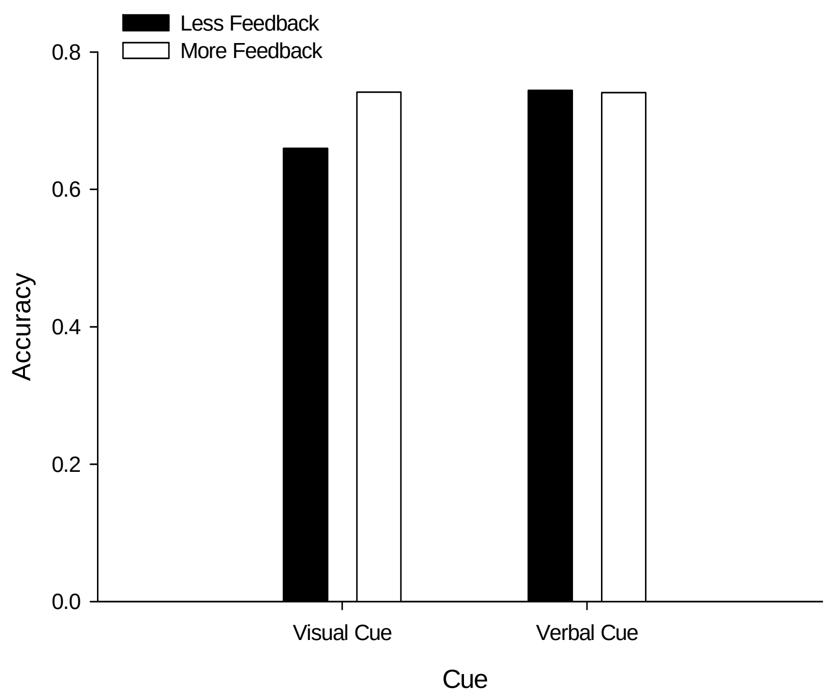

Figure 10. Accuracy by Cue and Feedback where more feedback support was beneficial for the Visual Cue and less feedback support for the Verbal Cue.

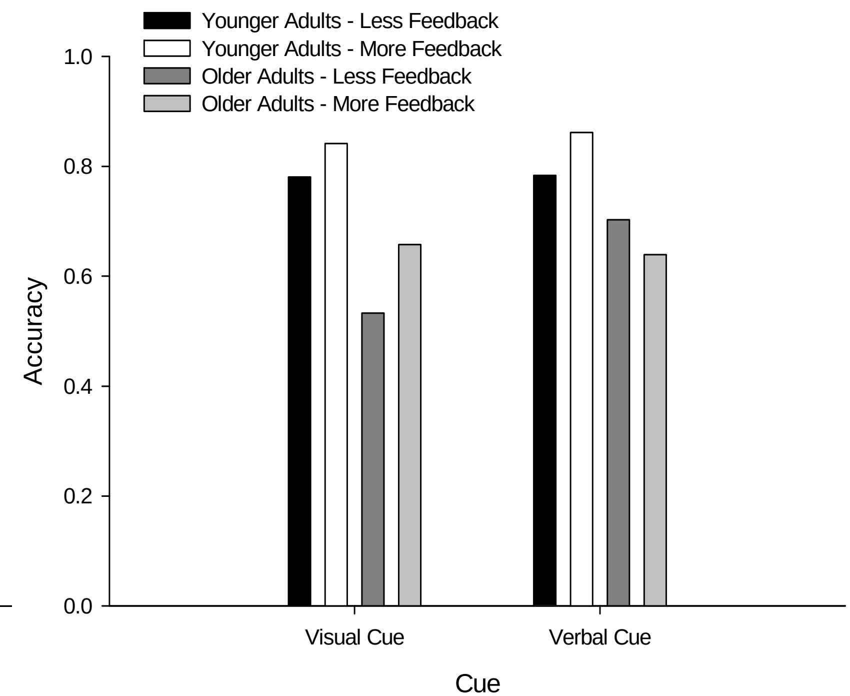

Figure 10. Accuracy divided by Feedback, Cue and Age where younger adults benefited from increased feedback while older adults' accuracy was higher with less feedback for the Verbal Cue and more feedback for the Visual Cue.

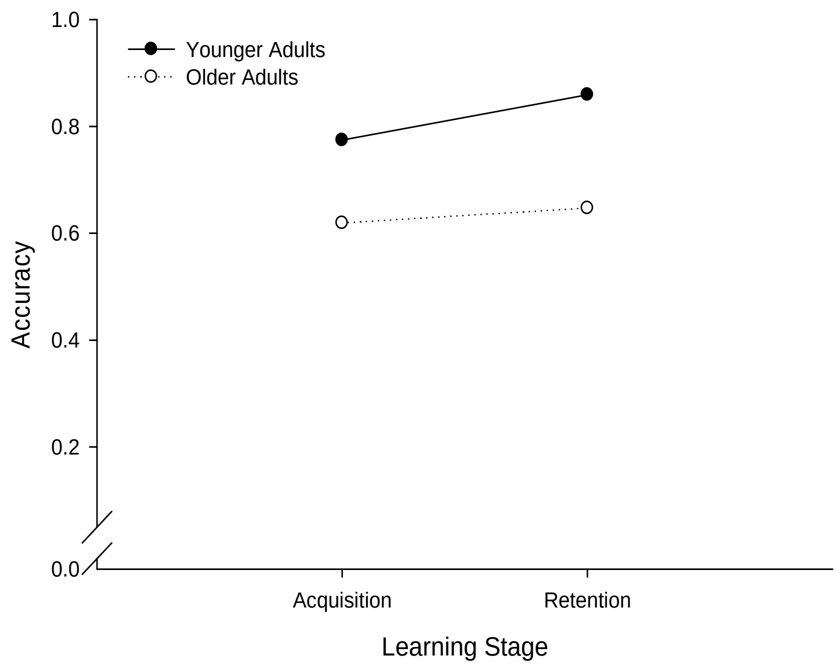

Figure 11. Accuracy divided by age group where younger adults increased their accuracy more from acquisition to retention than older adults.

Cue effects and interactions. There was a main effect of Cue where accuracy for the Verbal Cue was higher than accuracy for the Visual Cue. There was a marginal interaction of Cue x Age where older adults' accuracy was higher for the Verbal Cue compared to the Visual Cue while younger adults accuracy for both cues was comparable (see Figure 13).

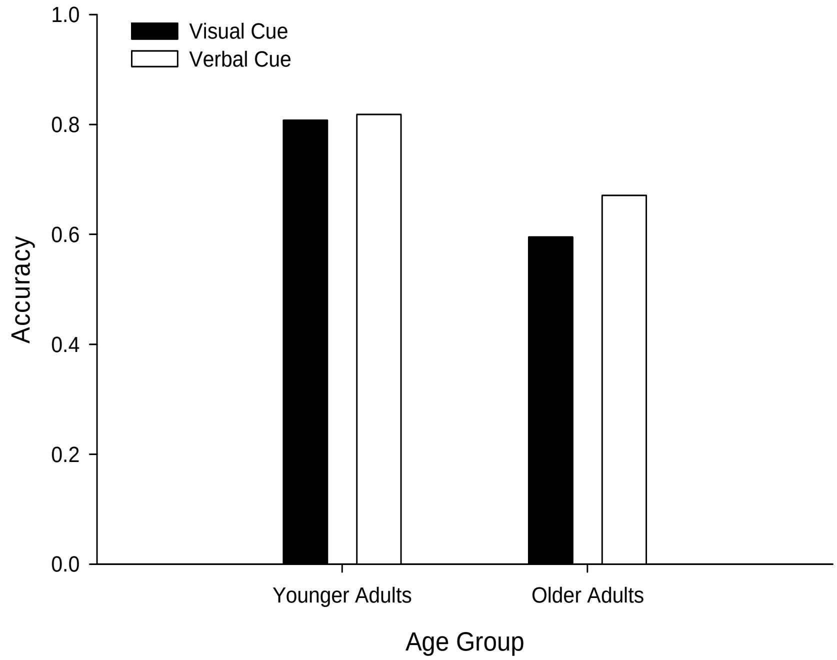

Figure 12. Accuracy divided by cue and age group where older adults' accuracy was higher for the Verbal Cue was than their accuracy for the Visual Cue.

Other effects. There was a main effect of Learning Stage, where retention accuracy was higher than acquisition accuracy.

Post Hoc Analysis for Cue

As shown in Figures 14 and 15, after performing the main analysis it became clear performance differed between cue by feedback and age groups. To better understand these differences a 2 (Learning Stage: Acquisition and Retention) x 2 (Cue: Visual and Verbal) x 2

(Feedback Support: Low and High) RM-ANOVA was conducted on the dependent variable of accuracy for each age group. That is, participants were only compared to their age group. Learning Stage and Cue were within-subjects factors while feedback was a between-subjects factor.

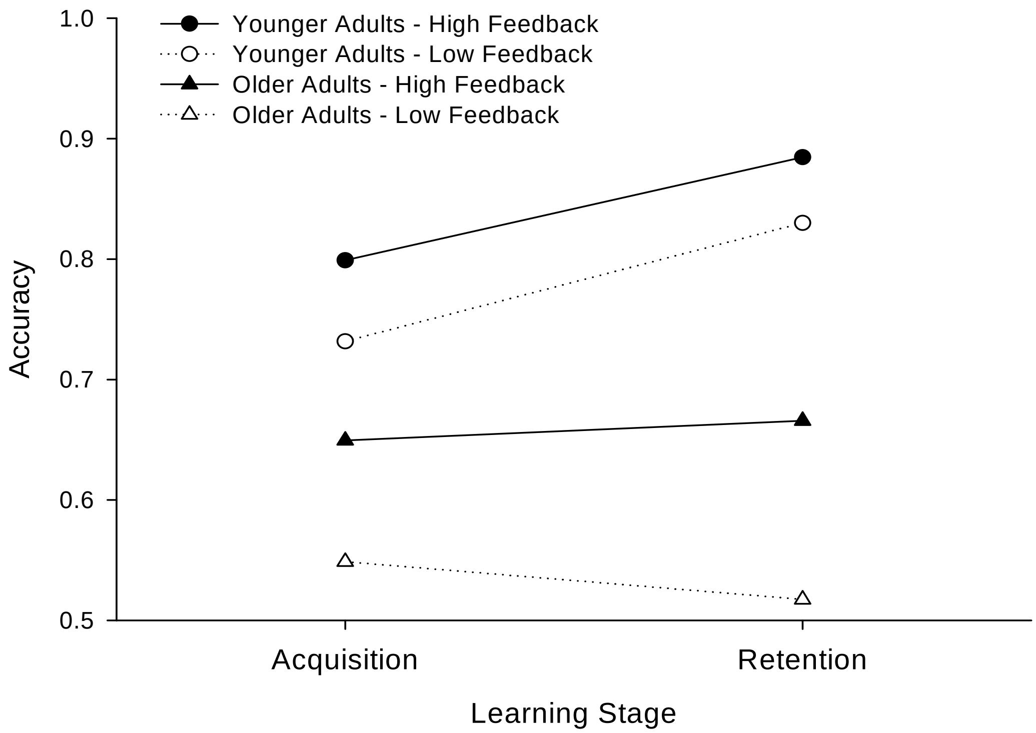

Figure 13. Visual Cue Accuracy divided by Feedback and Age where more feedback support benefited both age groups.

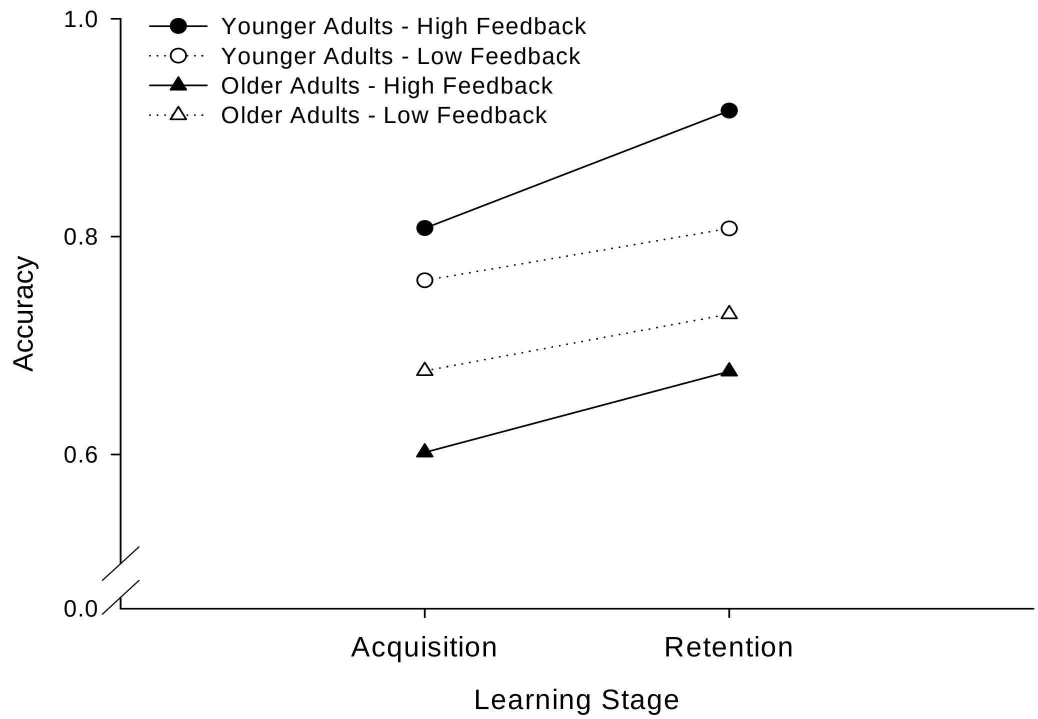

Figure 14. Verbal Cue Accuracy divided by Feedback and Age where more feedback support benefited younger adults and less feedback support benefited older adults.

Younger adults. As shown in Table 6, there was a main effect of feedback where participants that received higher feedback support were more accurate than those that received lower feedback support. There was also a main effect of Learning Stage, where participants were more accurate in retention than acquisition.

Older adults. As shown in Table 7, there was a main effect of cue, where accuracy of the Verbal Cue was higher than the Visual Cue. There was a main effect of Learning Stage, where retention accuracy was higher than acquisition accuracy. There was a significant Cue x Feedback interaction where participants benefited from higher feedback support with the Visual Cue, but lower feedback support with Verbal Cue (see Figure 16). There was a significant Cue x Learning Stage interaction where accuracy for the Verbal Cue increased from acquisition to retention while accuracy for the Visual Cue decreased (see Figure 17).

Interim Summary

Analysis by Cue revealed younger adults were more accurate than older adults. Participants that received more feedback support were more accurate than those who received less feedback support. For the Visual Cue, participants that received more feedback support were more accurate than those who received less feedback support. Results also showed more feedback support benefited younger adults for both cues, while older adults found more feedback support advantageous for the Visual Cue, but less feedback support for the Verbal Cue. Accuracy for the Verbal Cue was higher than accuracy for the Visual Cue, and older adults accuracy was marginally higher for the Verbal Cue compared to the Visual Cue while younger adults accuracy for both cues were approximately the same.

When split by age, post hoc analysis showed younger adults who received more feedback support were more accurate than those who received less feedback support, and participants were more accurate in retention than acquisition. Results for older adults showed accuracy was higher for the verbal cue compared to the visual cue and accuracy was higher in retention than acquisition. In addition, more feedback was beneficial for the Visual Cue and less feedback support for the Verbal Cue.

Table 6

Younger Adults Summary of Repeated Measures Analysis of Variance for Cue divided by Feedback

Source	*df*	F	*ηp*^{2}	*p*
		Between Subjects		
Feedback (F)	1	4.96	.13	.03
Error	34			
		Within subjects		
Cue (C)	1	.26	.01	.62
Learning Stage (L)	1	13.52	.29	< .01
C x F	1	.14	.00	.71
L x F	1	.27	.01	.61
C x L	1	.14	.00	.72
C x L x F	1	.88	.03	.35
Error	34			

Table 7

Older Adults Summary of Repeated Measures Analysis of Variance for Cue divided by Feedback

Source	*df*	F	*ηp*^{2}	*p*
		Between Subjects		
Feedback (F)	1	1.07	.03	.31
Error	36			
		Within subjects		
Cue (C)	1	11.85	.25	< .01
Learning Stage (L)	1	7.67	.18	.01
C x F	1	18.33	.34	< .001
L x F	1	3.01	.08	.09
C x L	1	4.92	.12	.03
C x L x F	1	.16	.00	.69
Error	36			

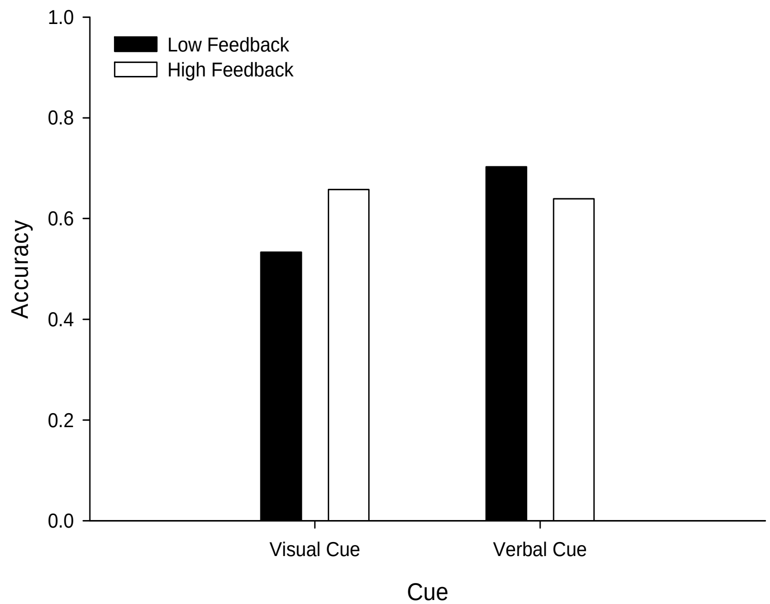

Figure 15. Older adult accuracy divided by Cue and Feedback where higher feedback support was resulted in higher accuracy for the Visual Cue while lower

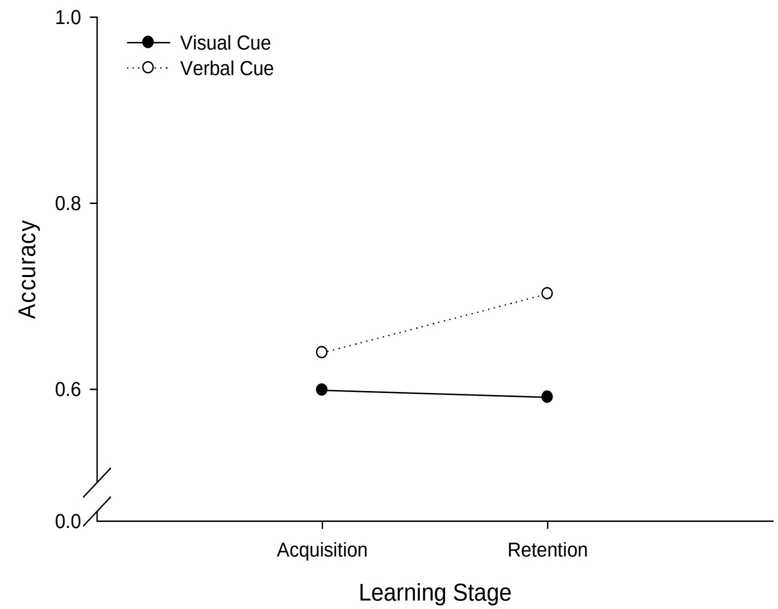

Figure 16. Older adult accuracy divided by Cue where accuracy increased from acquisition to retention for the Verbal Cue while decreasing for the Visual Cue.

Exit Interview

At the conclusion of the study participants answered exit interview questions to evaluate their experience in the study (see Appendix D).   It contained some general questions about various cues the participant could have learned pertaining to the experimental task. In addition, we also attempted to ascertain how participants used the feedback they were provided with by asking them a series of open-ended and multiple choice questions. A MANOVA was conducted to investigate participants' answers to Likert scale questions. Feedback support (low or high) and age groups (younger or older) were between subjects variables.

Age. As shown in Table 8, there was a main effect of age where younger adults were more confident in their ability to identify fake popups at the beginning and end of the study than older adults. Younger adults also indicated they had more previous experience than older adults that helped them identify fake popups. In addition, younger adults found the feedback they received more useful in learning how to identify fake popups than older adults (see Table 9 for descriptive statistics).

Results also indicated younger adults were more likely to report they learned the rules behind real and fake popups from the feedback they received and were more likely tell others to use the feedback provided. In addition, older adults were more likely to report becoming frustrated during the study than younger adults (see Table 9 for descriptives).

Table 8

Multivariate Analysis of Variance for Exit Interview –only Significant Between Subject Effects are Shown

Source	df	F	hp^2	*p*
		Between Subjects		
Feedback (FB)	8	1.94	.20	.07
Question Number				
8. At the end of each trial you were given feedback telling you how to identify real popups from fake popups. The following questions refer to that feedback:				
B. Using the scale below, indicate how useful the feedback was in learning to identify fake popups[1]	1	10.66	.14	< .001
Age (A)	8	7.73	.50	.001
Question Number				
5. Indicate your level of confidence in identifying a FAKE popup from a real popup BEFORE the study[2]	1	9.12	.12	< .001
6. Indicate your level of confidence in identifying a FAKE popup from a real popup AFTER the study[2]	1	51.08	.44	< .001
7. How much did your prior experience with popups help in identifying real and fake popups[3]	1	6.22	.09	.01
8. At the end of each trial you were given feedback telling you how to identify real popups from fake popups. The following questions refer to that feedback:				
B. Using the scale below, indicate how useful the feedback was in learning to identify fake popups[1]	1	31.82	.32	< .001
F x A	8	1.92	.20	.07

Note: [1] Rated usefulness on a Likert scale where 0 = not at all useful and 8 = extremely useful; [2]Rated confidence on a Likert scale where 0 = no confidence and 8 = extremely confident; [3] Rated helpful on a Likert scale where 0 = not at all helpful and 8 = extremely helpful (see Appendix D).

Table 9

Means for Exit Interview divided by Feedback and Age

Question Number	Age Group				Feedback Group			
	Younger		Older		Lower		Higher	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1. Indicate your level of effort at the start of the study[1]	5.17	1.80	4.79	1.80	4.85	1.69	5.11	1.92
2. Indicate your level of effort at the end of the study[1]	5.03	1.48	5.34	1.85	5.15	1.57	2.22	1.82
3. Indicate your level of motivation at the start of the study[2]	5.50	1.65	5.76	1.50	5.61	1.55	5.66	1.61
4. Indicate your level of motivation at the end of the study[2]	5.06	2.00	5.02	2.00	4.92	2.00	5.17	2.00
5. Indicate your level of confidence in identifying a FAKE popup from a real popup BEFORE the study[3]	3.94	2.10	2.34	2.00	2.92	2.04	3.31	2.34
6. Indicate your level of confidence in identifying a FAKE popup from a real popup AFTER the study[3]	4.97	1.72	2.24	1.59	3.26	2.06	3.91	2.20
7. How much did your prior experience with popups help in identifying real and fake popups[4]	4.14	2.14	2.64	2.12	3.33	2.14	3.44	2.39
8. At the end of each trial you were given feedback telling you how to identify real popups from fake popups. The following questions refer to that feedback:								
B. Using the scale below, indicate how useful the feedback was in learning to identify fake popups[5]	5.17	2.24	2.51	2.12	3.11	2.61	4.60	2.25
C. Did you learn the rules of identifying fake popus from the feedback you were given at the end of each week[6]	.14	.35	.75	.44	.57	.50	.31	.47
D. Would you tell someone else to pay attention to the information contained in the feedback[7]	.14	.35	.44	1.00	.43	.50	.14	.36
9. At any time during the study did you become frustrated because you didn't understand what was going on[6]	.73	.45	.34	.48	.46	.51	.60	.50

Note: [1]Rated effort on Likert scale where 0 = no effort and 8 = extreme effort; [2] Rated motivation on Likert scale where 0 = not at all motivated and 8 = extremely motivated; [3] Rated confidence on Likert scale where 0 = no confidence and 8 = extremely confident; [4] Rated helpful on a Likert scale where 0 = not at all helpful and 8 = extremely helpful; [5] Rated usefulness on a Likert scale where 0 = not at all useful and 8 = extremely useful; [6] Choices were: 0 = yes and 1 = no; [7]Choices were: 0 = yes, it is helpful and 1 = no, it is not helpful (see Appendix D).

Feedback support. As shown in Table 8, the main effect of Feedback approached significance where participants who received high feedback support found the feedback they received more useful in identifying fake popups.

Results also showed participants who received higher feedback support were more likely to indicate the feedback they received helped learn the rules behind real and fake popups than those who received lower feedback support. At the conclusion of the study participants who received higher feedback support were more confident in their ability to identify fake popups than those who received lower feedback support. Higher feedback support participants were also more likely to try and memorize the feedback they received, while low feedback support participants were more likely to ignore the feedback they received. Lower feedback support participants indicated they were more likely to tell others to ignore the feedback support given at the end of each trial while higher feedback support participants would tell others to pay attention to the feedback (Table 9).

DISCUSSION

The current experiment explored the idea that feedback requirements depend upon the cognitive resources of the learner. Cognitive resources were controlled for by using populations with known cognitive differences, younger and older adults, and also measured with a test of working memory capacity. Task complexity was controlled for by using a simple cognitive task. Feedback support was manipulated by providing learners with one of two distinct feedback levels, low or high. It was expected that feedback support would differentially affect age groups. Specifically, younger adults would learn more with less feedback support and older adults learn more with higher feedback support. Different learning theories predicted different results. If feedback requirements are determined by the cognitive resources of the learner, younger adults should learn more with less feedback support and older adults more feedback support.

Key findings were, participants benefited from increased feedback support. Both feedback groups demonstrated learning; however, those who received higher feedback support learned more than those who received less feedback support and were more confident in their ability to identify fake popups at the conclusion of the study. Participants who received higher feedback support increased their accuracy from the end of retention to acquisition; the accuracy for participants that received low feedback support remained either flat or declined from the end of acquisition to retention.

These results support cognitive load theory that predicted participants given higher feedback support would learn more than those given lower feedback support (Sweller, 1988). In addition, results partially support the model offered by McLaughlin et el. (2006) that predicted older adults would benefit from higher feedback support and younger adults less feedback support.

When broken down by cue, younger adults that received higher feedback support benefited from the increase in support more with the Verbal Cue than with the Visual Cue. One possible explanation is the Verbal Cue may have been harder to learn because of a lower crystallized intelligence, or acquired knowledge, resulting in more consumption of cognitive resources. Thus, the increased feedback support was more beneficial to younger adults in particular for the Verbal Cue because it freed the cognitive resources required to learn. These results partially support the model proposed by McLaughlin et al. (2006). The model states increased feedback support should be provided when there are not sufficient cognitive resources required to learn; however, the model predicts in this case because we have a simple task lower feedback support should have resulted in more learning. One possible explanation is younger adults lower crystallized intelligence resulted in the task not being simple. This idea lends itself to suggest the specific cognitive abilities required to learn a task contribute to the overall demands of the task. This aspect of task demands is not accounted for by the McLaughlin et al. (2006) model. In addition, it may have been harder to identify the problems with the Verbal Cue for younger adults because the rules behind real and fake popups were not always as clear cut as they were with the Visual Cue. Fake popus for the Verbal Cue did not always have a purely visual element. Sometimes a popup was fake because it used incorrect grammar, making it not sound quite right. It may have been harder to identify for those who received less feedback support because they were only given information as to whether or not their answer was correct or incorrect, but not why it was correct or incorrect. Conversely, although increased feedback support benefited younger adults for the Visual Cue, the result was not as profound as for the Verbal Cue. This may have occurred because of younger adults fluid abilities. That is, increased fluid abilities made it easier for younger adults to identify the patterns between correct and incorrect popups and remember, or learn, the difference. This also supports the idea specific cognitive abilities required to learn a task contribute to the consumption of cognitive resources.

On the other hand, as shown in Figure 14, older adults benefited more from increased feedback support with the Visual Cue than they did with the Verbal Cue. This may be because of their decreased fluid abilities. That is, because of the decline in fluid abilities associated with the aging process, older adults may have found it more difficult, or did not have the cognitive resources required, to identify the patterns of the Visual Cue, or *learn* the rules. Older adults that received less feedback support for the Visual Cue was the only group to decline, or not learn, from acquisition to retention. This may have resulted from the lack of fluid abilities associated with aging; consequently, cognitive resources were used at a faster rate and increased task demands and not enough resources remained for learning. In this view, increased feedback provided environmental support by cuing older adults to the relevant information in the task (Morrow & Rogers, 2008). The result would be a reduction in the demands of the task and an increase of the resources required to learn. This would explain why older adults that received increased feedback support learned while those who received less did not.

Conversely, older adults that received less feedback support learned more for the Verbal Cue than those that received more feedback support. This may be because of the cognitive resources required to identify fake popups for this particular cue. Specifically, the Verbal Cue tapped into older adults' crystallized knowledge. It did not require them to learn anything, per se, but use their past experiences to draw conclusions as to whether a given popup was real or fake. This result supports the idea of desirable difficulties proposed by Schmidt and Bjork (1992). In addition, it also partially supports the model proposed by McLaughlin et al. (2006) that predicts because older adults lower cognitive resources they would learn more with increased feedback support. However, the model fails to account for specific abilities needed to learn a task. Thus, it is possible older adults' increased crystallized intelligence led to an increase in cognitive resources available to learn the Verbal Cue resulting in a decrease of task demands. In addition, because of the increased crystallized intelligence of older adults they may have been the only participants that experienced a truly simple task. In this case, the model would predict less feedback support would be beneficial. That is, desirable difficulties, as proposed by Schimidt and Bjork (1992), are beneficial when learning a simple task. An alternate explanation is because older adults have higher crystallized intelligence, high feedback may have lowered the germane cognitive load of older adults for the verbal cue and made the task too simple. Germane cognitive load is the load required in the learning process for schema acquisition (Ayers, 2006). A reduction in germane cognitive load can result in a lack of engagement and subsequently reduce learning. As a result, a reduction of germane cognitive load is a possible explanation as to why high feedback was not beneficial to older adults that received higher feedback support for the verbal cue. Therefore, high feedback may be beneficial only when it does not lower the germane cognitive load of the learner. Consequently, this leads to the conclusion feedback requirements are not only a product of cognitive resources and the complexity of the task, but the experience of the learner as well.

The current pattern of results suggests specific abilities needed to learn a particular task are related to feedback requirements because they influence the demands of the task. That is, a lack of abilities needed to learn a task results in an increase of task demands. If the demands of the task increase enough to sufficiently use the resources needed for learning then feedback support may be used to free these resources. This would explain why older adults benefited more from increased feedback support with the Visual Cue, and younger adults benefited more from increased feedback support with the Verbal Cue.

In conclusion, high ability learners, or younger adults, benefited from increased feedback support in *all* instances. This effect was most pronounced for the cue they had the least amount of experience with, the Verbal Cue. Older adults benefited from increased feedback for the Visual Cue, but less feedback support for the Verbal Cue. More feedback support may have lowered older adults' germane cognitive load, disrupted their ability to draw from their crystallized knowledge, or recall previous experiences; however, it provided the crutch they needed to *learn* the rules behind the Visual Cue.

Limitations of the Current Experiment

One limitation of the current experiment is the unequal sample sizes between feedback and age conditions. This may have resulted in the failure to find an effect that was actually present.

In addition, although participants were asked how useful they considered the feedback they received to be, it was not specifically manipulated or measured. It's possible participants that received lower feedback support did not see the benefits of the feedback and therefore ignored it. As a result, it remains unclear as to how and when participants used the feedback they deemed not useful and the effect it had on their accuracy.

Lastly, every attempt was made to design a simple task like those used in previous feedback experiments with motor tasks, however, it's possible the task used was not simple for all participants. It's likely that because of their higher crystallized intelligence, older adults received the closest form of a simple task with the verbal cue. Conversely, results suggested the verbal cue may not have been simple for younger adults. This raises the question – is it possible for a cognitive task to be simple for all participants?

Future Research

Future research should not only attempt to deal with the limitations of the current experiment, but also identify why the current pattern of results are different from those that have found less feedback support beneficial. One possible explanation is different tasks and/or cognitive resources change the amount or type of feedback required. In addition, the idea specific cognitive abilities and previous experience play a role in feedback requirements should also be explored. Specifically, how do the cognitive abilities of a learner interact with the task to determine feedback requirements? Does a learner with high spatial ability benefit from high feedback support on highly spatial task? It may be learners with high scores on ability tests that are highly correlated with a task require different amounts of feedback than those who score low on the same ability tests.

In addition, there is evidence to suggest the learning process of motor tasks is different from cognitive tasks (Kelly & Garavan, 2005), although not all agree (Rosenbaum, Carlson, & Gilmore, 2000). Previous research has shown synaptic changes in the brain are different for cognitive tasks and motor tasks (Kelly & Garavan, 2005). That is, both tasks activate different parts of the brain. Therefore, it is reasonable to suspect the cognitive requirements to perform each task may be different. Future research should attempt to identify if feedback support requirements differ between motor and cognitive tasks.

Lastly, there is a question as to whether or not learners disregard feedback because they think it is not useful. Some participants in the current experiment who received lower feedback support responded they disregarded the feedback they received. If learners are specifically instructed to pay attention to the feedback they receive and apply it to the task does that impact the amount and rate at which they learn? Do learners disregard feedback they deem as not useful when in fact it is useful? If so, at what point does feedback become not useful?

Application

Feedback requirements based on the cognitive resources of the learner, specific ability levels of the learner, and prior experience would benefit teachers, tutors and system designers. The results of the current study suggest more feedback is appropriate when a learner has little experience with a task or low levels of abilities associate with the task. Conversely, less feedback may be appropriate if a learner has experience with a given task, or high levels of ability associated with the task. Automated training methods can be developed based on learners ability levels and adapted to fit their needs.

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APPENDICIES

Appendix A

Consent Form

North Carolina State University
INFORMED CONSENT FORM FOR RESEARCH

Title of Study
Learning a new task through feedback.

Principal Investigator	Experimenter
Dr. Anne McLaughlin (919) 521-6802	Chris Kelley (919) 513-2709

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. A copy of this consent form will be provided to you. 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 two-day study. On the first day, you will complete some general tests that measure abilities. For example, we will measure vocabulary and speed of responding. Some of these tasks are done using paper and pencil whereas others will be completed on a computer. In addition, you will learn how to identify real internet pop ups from fake pop-ups. You will accomplish this by looking at pop ups presented on the screen and trying to distinguish their authenticity. Different people in the study will receive different levels of feedback about their answers. When you return two days later, you will continue to try and distinguish between real and fake pop-ups. Each session will take approximately 1 and ½ hours.

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 during a session, we recommend that you look around the room for about thirty seconds so that your eyes focus at different distances. The experimenter will explain when breaks are scheduled. Please tell us if you are having trouble with any task.

Benefits

There are no direct benefits to participating in the study. After the end of the study, we will share the results with you by mailing a newsletter to all the participants.

Confidentiality

The information in the study records 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.

Compensation

For participating in this study younger adults will receive $35.00 and older adults $40.00. In addition, students participating have the option of receiving $35.00 OR class credit. If class credit is chosen you will receive 1 credit per ½ hour spent in the study. If you withdraw from the study prior to its completion, you will be compensated for the time you spent in the study. Students receiving credit have the option of writing a research paper instead of participating. Contact your professor for more information.

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), or Joe Rabiega, IRB Coordinator, Box 7514, NCSU Campus (919/515-7515).

<u>Consent To Participate</u>

"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may choose not to participate or to stop participating at any time without penalty or loss of benefits to which I am otherwise entitled."

Participant Name________________________________

Participant's signature_____________________________ Date ____________

Investigator's signature_____________________________ Date ____________

If you must cancel a scheduled time to come to the lab, please call:
(919) 513 -2709.

Appendix B

Technology and Computer Experience Questionnaire

The purpose of this questionnaire is to assess your familiarity and experience with technology. Please answer all questions by placing a check mark at the appropriate response.

1. Please check all of the following devices that you have used.

- ☐a Answering Machine
- ☐b Cellular Phone
- ☐c Compact Disk Player
- ☐d Copy Machine
- ☐e Cruise Control (in your car)
- ☐f Fax Machine
- ☐g Microwave Oven
- ☐h On-line Card Catalog System (at the library)
- ☐i Phone-in Banking (e.g., press "1" for "yes")
- ☐j Video Cassette Recorder
- ☐k Video Camera
- ☐l Voice Mail
- ☐m Automatic Teller Machines
- ☐n Home Securities Systems
- ☐o Pay at the Pump Systems
- ☐p Clock Radio/Alarm
- ☐q Video Arcade Games
- ☐r ------ *None of the Above* --------

2. Please check which of the following items you own.

☐a Answering Machine
☐b Cellular Phone
☐c Compact Disk Player
☐d Cruise Control (in your car)
☐e Fax Machine
☐f Microwave Oven
☐g Video Cassette Recorder
☐h Video Camera
☐i Clock Radio/Alarm
☐j Home Computer
☐k ------ *None of the Above* --------

3. Have you had any experience with computers?

☐ Yes ☐ No

4. Of the input devices listed below, please indicate **ALL** devices with which you have had experience (check all that apply).

☐a Keyboard
☐b Mouse
☐c Light-pen
☐d Trackball
☐e Touch Screen
☐f Voice Input System
☐g Joystick
☐h ------ *None of the Above* --------

5. Indicate the total length of time you have used computers.

☐1 Less than 6 months
☐2 6 months but less than 1 year
☐3 1 year but less than 3 years
☐4 3 years but less than 5 years
☐5 At least 5 years

6. In the past, what was the highest frequency of your computer use over any 3-month period?

☐1 Once every few months
☐2 Every month
☐3 Once per week
☐4 Several days per week
☐5 Daily, but infrequently during the day
☐6 Daily, frequently during the day
☐7 Daily, most of the day

7. Have you used a computer in the last three months?

☐ Yes ☐ No

If **<u>Yes</u>**, how frequently?
☐1 Less than one hour a week
☐2 1 hour but less than 5 hours a week
☐3 5 hours but less than 10 hours a week
☐4 10 hours but less than 15 hours a week
☐5 At least 15 hours a week

If **<u>No</u>**, when was the last time you used the computer?
☐1 Less than 6 months ago
☐2 6 months, but less than a year ago
☐3 1 year but less than 3 years ago
☐4 3 years but less than 5 years ago
☐5 At least 5 years ago

8. Of the basic computer operations listed below, please indicate all with which you are proficient (check all that apply).

   - ☐a Insert a disk
   - ☐b Open a file
   - ☐c Delete a file
   - ☐d Save a file
   - ☐e Transfer files
   - ☐f Use a printer
   - ☐g ------ *None of the Above* --------

9. Of the items listed below, please indicate all with which you are proficient (check all that apply).

   - ☐a Computer graphics (e.g., Photoshop, AutoCAD)
   - ☐b Database management (e.g., Access, Filemaker, Lotus 123, etc.)
   - ☐c DOS
   - ☐d Electronic mail
   - ☐e Macintosh
   - ☐f Presentation software (e.g., PowerPoint, Freelance, etc.)
   - ☐g Programming package (e.g., Basic, C++, Fortran, etc.)
   - ☐h Spreadsheet (e.g., Excel, Quattro Pro, etc.)
   - ☐i Statistical package (e.g., SPSS, SAS, etc.)
   - ☐j UNIX
   - ☐k Windows
   - ☐l Word processing (e.g., Microsoft Word, WordPerfect, etc.)
   - ☐m Other (please specify) ______________________________
   - ☐n ------ *None of the Above* --------

Appendix C

Instructions

INTRODUCTION

- Today you will learn how to identify legitimate Windows pop-ups from fake pop-ups.

- First, you will complete 5 practice trials in which you will become acquainted with the keyboard and mouse.

- You will then complete 80 trials in which you will be asked if a pop-up presented on the screen is real or fake.
- After your response you will be given feedback indicating whether your answer was correct or incorrect.

- You will be notified on the screen when it's time to take a break.

- If you have any questions or problems during the study notify your experimenter by raising your hand.

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

PRACTICE OVER

This concludes the practice portion of the study.

You will now begin to identify real Windows popups from fake popups. You will see a picture on your screen. Your task is to decide whether this popup is a legitimate popup, generated by Windows, or an imposter, created by a virus. Click on the box that contains your answer. After you answer, you will receive feedback. Each popup will contain a cue to help you determine whether it is real or fake. Try to learn this cue.

When you are ready to start, press the 'Begin' button below.

Appendix D

Exit Interview

1. Indicate your level of effort at the start of the study (please be honest):

0	1	2	3	4	5	6	7	8
no effort		some effort		effort		lots of effort		extreme effort

2. Indicate your level of effort at the end of the study (please be honest):

0	1	2	3	4	5	6	7	8
no effort		some effort		effort		lots of effort		extreme effort

3. Indicate your level of motivation at the start of the study (please be honest):

0	1	2	3	4	5	6	7	8
not at all motivated		somewhat motivated		motivated		very motivated		extremely motivated

4. Indicate your level of motivation at the end of the study (please be honest):

0	1	2	3	4	5	6	7	8
not at all motivated		somewhat motivated		motivated		very motivated		extremely motivated

5. Indicate your level of confidence in identifying a FAKE popup from a real popup BEFORE the study:

0	1	2	3	4	5	6	7	8
not at all confident		somewhat confident		confident		very confident		extremely confident

6. Indicate your level of confidence in identifying a FAKE popup from a real popup AFTER the study:

0	1	2	3	4	5	6	7	8
not at all confident		somewhat confident		confident		very confident		extremely confident

7. How much did your prior experience with popups help in identifying real and fake popups.

0	1	2	3	4	5	6	7	8
not at all helpful		somewhat helpful		helpful		very helpful		extremely helpful

8. At the end of each trial you were given feedback telling you how to identify real popups from fake popups. The following questions refer to that feedback:

a) How did you ***primarily*** use the information contained in the feedback (Check only one)?

___ I tried to memorize it
___ I ignored it
___Other

If other, please explain.

____
____
____
____

b) Using the scale below, indicate how useful the feedback was in learning to identify fake popups:

0	1	2	3	4	5	6	7	8
not at all useful		somewhat useful		useful		very useful		extremely useful

c) Did you learn the rules of identifying fake popus from the feedback you were given at the end of each week?
___ Yes
___ No
d) Would you tell someone else to pay attention to the information contained in the feedback?

___No, it is not helpful
___Yes, it is helpful

e) Did the feedback affect your motivation (Check only one)?

___ Yes, positively
___ Yes, negatively
___ No effect on my motivation

9. At any time during the study did you become frustrated because you didn't understand what was going on?

___ Yes
___ No

10. In your own words, how would you tell someone else to identify real popups from fake popups?

____
____
____
____
____

11. In your own words, write out the 2 cues you learned.

____
____
____
____
____

12. Is there anything we should have asked you about how you figured out this task?

____

13. Did you use any strategies or shortcuts that we didn't mention? If so, what were they?

14. Did you do anything you felt you "weren't supposed to" during the experiment? It's ok if you did, we just want to know! This would include daydreaming, trying to get it over with, etc. We will use this information to make the task better.

15. Do you have any general suggestions about how we could improve our study?