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Learned Attention in Younger and Older Adults

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LEARNED ATTENTION IN YOUNGER AND OLDER ADULTS

A Thesis
Presented to
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Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts

By
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LEARNED ATTENTION IN YOUNGER AND OLDER ADULTS

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LEARNED ATTENTION IN YOUNGER AND OLDER ADULTS

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A relatively new phenomenon in learning research called highlighting occurs when participants show a seemingly irrational preference to attribute a stronger cue-outcome association to a later presented perfect predictor when it is paired with an imperfect predictor than that of an earlier presented perfect predictor paired with the same imperfect predictor (Kruschke, 1996). Current research suggests that the highlighting effect depends on the ability to learn to shift attention away from an irrelevant cue toward a more relevant cue in order to reduce errors in causal judgment and preserve an earlier formed association (Kruschke, 2003). Much research has suggested that older adults have difficulty disengaging attention from irrelevant information, which could be problematic in the highlighting procedure (Cohn, Dustman, & Bradford, 1984; Tipper, 1991; Mutter, Naylor, & Patterson, 2005). However, the results of the current experiment suggest that older adults can learn attentional shifts in order to guide associative learning and reduce errors in causal judgments. These data prove to be a problem for many models of associative learning (e.g., Mackintosh, 1975; Rescorla & Wagner, 1972; Van Hamme & Wasserman, 1994), but support a model proposed by Kruschke (2006).

LEARNED ATTENTION IN YOUNGER AND OLDER ADULTS

People use cues in their environment to predict every day events. When multiple cues are present in the environment, these cues must compete for the available associative strength of a particular outcome. Although the actual predictive value of a cue for an outcome would be the most logical way to determine how much associative value should be attributed to that cue, the perceived relevance of a cue plays an equally important role. This has been demonstrated in two associative learning phenomena known as blocking and highlighting (Kamin, 1969; Kruschke, 1996).

Kamin (1969) trained rats to learn that a particular conditioned stimulus (CS1) was associated with an unconditioned stimulus (US) of shock. The rats were then presented with a compound stimulus consisting of CS1 and a novel CS2 which predicted the same shock US. The results of his experiment revealed that when the rats were presented with both CS1 and CS2 individually after training, they showed a much stronger conditioned response to CS1 than they did to CS2. According to Kamin (1969), the previous learning of the CS1 → shock association blocked the learning of an association between CS2 and shock.

The Rescorla-Wagner model (Rescorla & Wagner, 1972) contends that this associative learning phenomenon can be explained in terms of the surprisingness of the US. That is, the more surprising a US is when a CS is present, the more is learned about the association between the CS and the US. According to the Rescorla-Wagner model, the blocking effect occurs because the previously trained association between CS1 and shock has made the occurrence of the shock US unsurprising. When CS2 is presented in later training with the same shock US, nothing is learned about this redundant CS

because it predicts nothing new. However, other evidence (e.g., Mackintosh & Turner, 1971) conflicts with Rescorla and Wagner's (1972) explanation. Mackintosh and Turner (1971) found that after a CS had been blocked, subsequent learning about the association between this blocked CS and a new outcome was attenuated. Because the Rescorla-Wagner model does not take an organism's prior experience with blocked CS into account (i.e., the blocked CS is redundant and should not be attended to), the model would have predicted normal learning, since the blocked CS would have acquired no associative strength at all during phase two training. This led Mackintosh (1975) to propose that the Rescorla-Wagner model be modified so that the salience of a CS is able to change based on the organism's prior experience with that CS.

Considerable research suggests that organisms are able to ignore a stimulus based on prior experience (e.g., Kruschke & Blair, 2000; Mackintosh & Turner, 1975). Moreover, there is evidence that organisms can also learn to *attend* to a stimulus based on prior experience, in a phenomenon known as highlighting (Kruschke, 1996). Kruschke (1996) presented participants with an imperfect predictor (I) and early perfect predictor (PE) of an early outcome (E) in an early training phase. In a second phase of training, he presented participants with the same imperfect predictor (I) and a new perfect predictor (PL), which predicted a new outcome (L). Upon testing cue I and the compound cue PE.PL, Kruschke's (1996) data showed that participants had a strong preference for E when presented with I, and a strong preference for L when presented with PE.PL. Similar to Mackintosh's (1975) explanation of blocking, Kruschke (2003) suggested that this effect is a result of a learned shift of attention. He proposed that when participants were presented with the compound cue I.PL \rightarrow L, they directed attention away from I and

toward PL in order to preserve the previously formed association between I and E. Thus, there is a weak relationship between I and L at test. Kruschke (2003) further contends that this occurs because the previous association between I and E in I.PL → L trials interferes with responding correctly.

Although there is much evidence suggesting that older adults show deficits in many areas of cognition, including attentional processes (Mutter & Pliske, 1994; Mutter et al., 2007; Mutter & Plumlee, 2009), there has been no research on whether older adults can rapidly learn to shift attention to newly relevant cues in the highlighting task in order to reduce errors in causal judgment. There is some evidence that suggests that older adults may have difficulty with this task. For example, Mutter, Strain, and Plumlee (2007) found that older adults are biased in their memory of new contingency evidence when it is consistent with their prior beliefs. They contend that this may be because older adults see contingency evidence that is inconsistent with their prior beliefs as being irrelevant, and therefore, pay less attention to this information. Similarly, Mutter and Plumlee (2009) showed that older adults are not as flexible in their ability to direct attention toward more relevant, new information in a contingency judgment task. Research on age related differences in performing the Stroop task has also yielded evidence suggesting that older adults may not be able to learn shifts of attention in the highlighting paradigm. The Stroop task requires participants to name the printed color of a color word (i.e., “blue”) as quickly as possible and consists of congruent trials (i.e., “blue” printed in blue) or incongruent trials (i.e., “blue” printed in red). Much research in this area has suggested that older adults have difficulty inhibiting attention to irrelevant lexical information in incongruent Stroop trials (Cohn, Dustman, & Bradford, 1984). All

of this evidence (Cohn et al., 1984; Mutter et al., 2007; Mutter & Plumlee, 2009) converges on the idea that older adults have difficulty inhibiting attention to prepotent information, which could prove to be problematic in the highlighting task.

On the other hand, there is some evidence that older adults can learn to use attentional strategies. Mutter, Naylor, and Patterson (2005) manipulated the list structure in a Stroop task and found that older adults were able to learn this list structure and adjust their attentional strategy in order to reduce error. These data imply that older adults may indeed be able to learn the attentional shifts required in the highlighting procedure.

The current study examined the effects of normal aging on older adults' ability to learn to rapidly shift attention from a stimulus with a previously formed association toward a more relevant novel stimulus in order to preserve this earlier formed association and reduce errors in causal judgment. The results of this study suggest that older adults are able to carry out these processes normally in the highlighting task.

Although prior research might have suggested a deficit in older adults' ability to learn shifts of attention, that research is not necessarily at odds with the findings presented here. Mutter et al. (2009) found that older adults have particular difficulty with preventative (i.e., the nonoccurrence of Event A predicts the occurrence of Event B), but not generative associations (i.e., the occurrence of Event A predicts Event B). Given that highlighting involves only generative associations, and that older adults are able to learn shifts of attention in the Stroop task in order to reduce error (Mutter et al., 2005), it makes sense then that older adults showed a robust highlighting effect. If older adults retain the ability to shift attention in the context of generative associations, but not preventative associations, the results presented here suggest that the failure of a mechanism other than

attentional shifting must be responsible for older adults' deficits in preventative causal judgments.

Mutter et al. (2009) suggested that older adults have trouble generating a representation of the absent information in contingency judgments with preventative associations. Further research in age differences in the retrospective revaluation of absent stimuli provides further support for this hypothesis (Mutter, Asriel, & Holder, 2010). In a series of experiments, examining a learning phenomenon called unovershadowing, Mutter et al. (2010) presented younger and older participants with $A.B \rightarrow X^+$ (X^+ denotes the occurrence of outcome X) in early training. Participants were then trained on $A \rightarrow X^-$ (X^- denotes the nonoccurrence of outcome X) trials. In a subsequent test phase, younger adults had revalued (by increasing) the association between B and X^+ during $A \rightarrow X^-$, even though B was not presented. Older adults, on the other hand, failed to revalue the $B \rightarrow X^+$ association. The findings of Mutter et al. (2010) in combination with the results of the current study prove to be a problem for many models of associative learning (e.g., Mackintosh, 1975; Rescorla & Wagner, 1972; Van Hamme & Wasserman, 1994).

The Rescorla-Wagner model fails to account for highlighting, predicting that individuals will show equal preference for E and L when presented with I and PE.PL. It is also unable to account for unovershadowing as it predicts that no learning will take place for an absent cue. Mackintosh's (1975) model, although able to account for the learned attentional shifts in highlighting, is also unable to account for unovershadowing as it, too, predicts no learning for an absent cue. A modification to the Rescorla-Wagner model by Van Hamme and Wasserman (1994), assigning a negative value to the learning rate parameter of an absent-but-expected cue, is able to account for unovershadowing, but

fails to predict highlighting. Moreover, according to Van Hamme and Wasserman's (1994) model, if older adults are able to learn shifts of attention in highlighting, they should also be able to shift attention to an absent cue in unovershadowing. Therefore this model does not have the necessary mechanisms to explain why older adults show a robust highlighting effect, while showing a deficit in retrospective revaluation. On the other hand, Kruschke's (2006) locally Bayesian learning model is able to account for both unovershadowing and highlighting, and also has the necessary mechanisms to explain older adults' failures and successes in these learning phenomena.

CHAPTER 1

Literature Review

On a daily basis, people must learn about and use cues in their environment to predict events. For example, investors in the stock market learn to predict when to buy or sell stocks based on the current sales of, new innovations in, and leadership roles in a company in which they have invested. Likewise, one would likely learn to predict that it would rain and prepare accordingly when one walks outside and there are dark clouds in the sky, and the neighbors and passersby are unpacking their umbrellas and wearing raincoats. When multiple predictive cues co-occur in the environment, one must take into account how well each cue predicts a particular outcome and whether or not information about one cue is dependent on another cue. This type of causal judgment phenomenon is known as cue competition. For instance, if one eats steak and potatoes for dinner and later developed hives, one would associate that meal as being the cause of the allergic reaction. If, on the next day, the same person were to eat a steak and hives did not develop, more than likely that person would develop a stronger association between the potatoes that were eaten and the allergic reaction. Thus, the causal value of the potatoes is dependent upon the causal value of the steak.

While it would be logical to learn about each cue equally well to make the best predictions based on the predictive values of each cue, much research suggests that this does not necessarily occur (Kamin, 1969; Kruschke & Blair, 2000; Kruschke 2001a; Kruschke, 2001b; Kruschke 2001c; Mackintosh & Turner, 1971). What is typically seen, when two or more predictive cues are simultaneously presented in the environment, is that one is more likely to learn more about a cue that is more salient or more likely to

reduce errors in judgment (Kamin, 1969; Rescorla & Wagner, 1972; Mackintosh, 1975; Kruschke, 2003).

Blocking

Although salience and predictive validity play a very important role in cue competition, the perceived relevance of a cue may also prove to be important in the acquisition of associations. Kamin (1969) demonstrated this with what he called the “blocking effect.” In his experiment, he presented rats with two training phases and a test phase. In the first training phase, rats were trained to form an association between a conditioned stimulus (CS1) and an unconditioned stimulus (US) of shock. In the second phase, a second stimulus (CS2) was added to the first to form a compound cue that predicted the same shock (i.e., CS1.CS2 → shock). In a third, and final phase of the experiment Kamin (1969) tested how the rats responded to each CS individually in regard to its ability to predict shock. The results of his experiment revealed that rats showed strong conditioned response to CS1, but a very weak conditioned response to CS2. Thus, the data suggested that the learning of an association between CS2 and shock had been “blocked” by the previously learned association between CS1 and shock. Kamin (1969) suggested that this was because the second cue was redundant and did not predict anything new. Specifically, after the first phase of training the shock was perfectly predicted by CS1 and was therefore not surprising when CS2 was presented in compound with CS1. Due to this lack of surprisingness of the US, no learning took place between CS2 and shock.

Although many current models of associative learning accurately predict the occurrence of the blocking effect, the underlying processes that occur during blocking

have been a topic of debate between the proponents of these different models. Rescorla and Wagner (1972) were the first to propose an explanation of the blocking effect using a model of associative learning. The Rescorla-Wagner model is a mathematical model that is based on the central idea of surprise that was proposed by Kamin (1969). The idea is that the association between a CS and US is guided primarily by the surprisingness of the occurrence of the US. That is, there is more learning about the occurrence of a US if the US is more surprising. Using the surprisingness of the US as its basis, the Rescorla-Wagner model (demonstrated below in Equation 1) can calculate the change in the associative strength between a CS and US on a given trial.

$$\Delta V_x^{n+1} = \alpha\beta(\lambda - \Sigma V) \quad (1)$$

In this equation, V represents the predictive value of a given stimulus (or stimuli). The ΔV term is the change in the associative strength that occurs on a given trial for a stimulus. ΣV represents the total amount of associative strength for all of the stimuli that are present on a given trial. The α and β terms are learning rate parameters based on the salience of the CS and US, respectively. The λ term is the maximum associative strength that is supported by a US, and is determined by the magnitude of the US. For instance, a certain US may be able to support more associative strength than another US. In a circumstance such as this, one particular US may be able support an associative value of 1, while a second US may only be able to support a fraction of that value. Therefore, a higher US magnitude raises the asymptote of the learning curve.

The $(\lambda - \Sigma V)$ quantity in the equation can be thought of as the calculation for the surprisingness of a US, given the presentation of a CS. As the ΔV term increases on each trial, the difference between λ and ΣV decreases to the point that, eventually, no more associative strength can be acquired between a CS and a US because the US is no longer surprising. The α and β learning parameters directly influence how steep the slope of the learning curve is, such that a greater salience of either a CS or US increases the slope of the curve. Essentially, the Rescorla-Wagner model is able to make predictions about behavior in learning, when given the salience of a CS and US, by multiplying these learning parameters by the difference of the λ term and ΣV term in each trial.

According to the Rescorla-Wagner model, CS1 blocks learning to CS2 because all of the available associative strength has already been acquired by CS1 in the first phase of training. That is, there is no associative strength available for an association to develop between CS2 and shock. However, should the salience (i.e., intensity) of the shock US increase or decrease, thus constituting surprise (since a decrease or increase would be unexpected), when CS1 and CS2 are presented in compound, CS2 would acquire either inhibitory or excitatory associative strength depending on the direction of the change in salience of the US. For example, an increase in shock intensity when CS1 and CS2 are presented in compound would result in CS2 acquiring excitatory associative strength with shock, whereas a decrease in intensity would result in the acquisition of inhibitory associative strength, thereby resulting in the unblocking of the redundant CS.

Although Rescorla and Wagner's (1972) model predicts the blocking effect, the results of a study conducted by Mackintosh and Turner (1971) are not congruent with the model's explanation of blocking. Mackintosh and Turner (1971) trained two groups of

rats to predict a shock US in the presence of a noise stimulus in the first phase of their experiment. After this initial phase, the experimental group of rats received an additional training phase in which a light stimulus was paired with the noise stimulus, which predicted the same shock (i.e., the typical second phase of a blocking procedure). The second (control) group of rats received no additional training during this phase. In the final phase of training, both groups were presented with the compound light and noise stimulus prior to receiving a more intense shock. Given the design of Mackintosh and Turner's (1971) experiment, the Rescorla-Wagner model would have predicted that both groups of rats should have developed the association between the light stimulus and the more intense shock. For the rats that received the second blocking phase, there should be no learning at all about the light stimulus in the second phase, but, because the intensity of the shock was increased in the third training phase (increasing surprise), an association should have been formed between the light and the high intensity shock. However, the results of Mackintosh and Turner's (1971) study demonstrated otherwise. Their data showed that rats that received the two phases of blocking training (i.e., the additional second phase of training) exhibited less responding to the light cue after the third phase of training than the group that did not receive any training in the second phase. Thus, learning to the light stimulus had been attenuated in the group that received training in phase two. Mackintosh and Turner (1971) suggested that this was because the rats in the experimental group recognized that the additional CS in the second phase did not predict anything new, and that this experience led them to ignore the redundant CS, both in Phase 2 training and in subsequent training. Thus, little was learned about the association between the redundant CS and the higher intensity shock in the third training phase.

Although the Rescorla-Wagner model was able to accurately predict the occurrence of the blocking effect, it was not able to account for the attenuation of learning to a redundant CS seen after blocking (e.g., Mackintosh & Turner, 1971). Rescorla and Wagner (1972) would have contended that CS2 should have normally developed an association to the novel outcome after having been blocked previously because the second CS did not acquire either inhibitory or excitatory associative strength during training and because its salience should have remained constant. However, the evidence from Mackintosh and Turner's (1971) study suggests that there may be more to the blocking effect than simply how surprising the US is, as suggested by Rescorla and Wagner (1972). This attenuation of learning seen after a cue has been blocked has led researchers (e.g., Mackintosh & Turner, 1971; Mackintosh, 1975; Kruschke & Blair, 2000) to suggest that something is learned about the blocked cue: inattention. If subjects learn to ignore the blocked cue, this could be a better explanation of the blocking effect and the subsequent attenuated learning. According to this view, when a redundant CS is presented in the second phase of training, subjects learn to ignore it because it does not provide new information. In subsequent learning trials in which the blocked cue is presented, learning is retarded because subjects have learned not to attend to that cue based on prior experience.

Although most early research on the blocking effect was conducted in animals, there is also much evidence that it occurs in human causal learning (e.g., Arcediano, Matute, & Miller, 1997). In one study, Arcediano et al. (1997) presented two groups of young participants with cue A in the first phase of training. The experimental group received normal blocking training where cue A perfectly predicted a US, while the

control group received training where cue A was uncorrelated with the occurrence of a US. In the second phase of training, both groups of participants were presented with the compound cue A.X (compound cues are denoted with a period between them), which perfectly predicted the occurrence of a US. In a subsequent test phase, participants in the experimental group showed less responding to cue X in the test phase than did the control group. Thus Arcediano et al. (1997) were able to demonstrate the blocking effect in human causal learning.

Kruschke and Blair (2000) conducted a series of experiments to test the cause of the attenuated learning to a previously blocked cue in a standard blocking procedure. The first experiment used a disease diagnosis paradigm arranged to test whether the retardation of acquisition occurred to a blocked cue in human causal learning. The paradigm consisted of symptoms (CS), which predicted a disease (US). In the first phase of the experiment, participants were given $A \rightarrow 1$ training followed by $A.B \rightarrow 1$ training in the second phase. During these first two phases participants were also presented with $D \rightarrow 3$ training trials in order to later assess attenuated learning to the blocked cue (i.e., cue B). A novel compound cue association, $H.I \rightarrow 6$, was presented in the second phase in order to assess blocking of cue B. In the third phase of the experiment, participants were presented with cue B.I and preferred outcome 6 to outcome 1, thus exhibiting the blocking effect. Participants were then presented with $A.B.C \rightarrow 2$ and $D.E.F \rightarrow 4$ training trials in the fourth phase of the experiment. If learning about the blocked cue (B) was attenuated, then when participants were presented with B.E in the final phase of the experiment they should prefer outcome 4 over outcome 2 because cue E had not been blocked and

should garner more attention than cue B. Indeed the results of the test of cue B.E yielded high responding to outcome 4 suggesting that learning had been attenuated to the blocked cue. In addition to these findings, the results of a second experiment suggested that the attenuated learning shown in their first experiment was not merely due to the novelty of the latter cues, and further implicated learned inattention to the blocked cue.

The results of Kruschke and Blair (2000) further reveal inconsistencies with the predictions of the Rescorla-Wagner model as it pertains to blocking. Their data suggest that there is indeed learned inattention to a blocked cue, whereas Rescorla and Wagner (1972) would have predicted no learning at all to the blocked cue. However, Kruschke and Blair's (2000) data are congruent with a model of learning proposed by Mackintosh (1975). Unlike the Rescorla-Wagner model, Mackintosh (1975) suggested that the learning parameter for the CS used in models of associative learning should be able to change based on previous experience. This modification allows attention to play a role in this type of conditioning, and thus it is able to account for the attenuation of learning to the blocked CS, since it allows subjects to learn to shift attention away from it.

In his theory of selective attention, Mackintosh (1975) suggests that it is not enough that models of associative learning simply allow for the physical salience of a CS (i.e., the α parameter in the Rescorla-Wagner model) to impact the degree to which associative strength is acquired between that CS and a US. He contends that it also must take into account prior experience with a CS. For instance, if a previous experience with a CS is correlated with a change in the US, then the salience of that CS will increase. On the other hand, if that prior experience is uncorrelated with a change in the US the salience of the CS will decrease. Although Mackintosh (1975) acknowledges that these

changes can occur inversely (i.e., if α for one CS increases, then the α for another CS that is present may decrease), his theory proposes that these changes may also occur independently. For example, if α for a CS is high, his theory does not necessarily imply that if the α parameter for a second CS decreases, that α for the first CS will increase as a result. Moreover, because Mackintosh (1975) allows α to change with experience, he allows learned attention to modulate the acquisition of associative strength between a CS and US. For instance, in his explanation of blocking, Mackintosh (1975) suggests that because the presentation of the second CS is not correlated with a change in the US, its α parameter decreases. At this point in the experiment, subjects have learned that the second CS does not predict anything surprising. Therefore, their prior experience with the redundant CS tells them that when that stimulus is present it will not predict anything new. Thus it receives less attention in phase three training and does not readily develop an association with the new US.

Kruschke, Kappenman, and Hetrick (2005) provided further support for the learned attention model proposed by Mackintosh in an eye-tracking study. Their experiment used the same blocking procedure as Kamin (1969), and eye gaze duration was monitored during both training phases and the test phase. The results of the study showed a strong correlation between the amount of time a participant gazed a stimulus and that participant's preference for the outcome associated with it. For instance, when participants viewed a compound CS (i.e., $A.B \rightarrow X$) in the second phase of training, and they spent more time attending to the earlier presented cue A, at test they were more likely to prefer the outcome associated with cue A and less likely to have a preference for

cue B, added in the second phase. These, results further implicate attention as a key mechanism of blocking.

Learned attention: the highlighting effect

The evidence suggesting that one can learn to shift attention away from a redundant, novel cue in a compound has led to recent research examining whether or not one can learn to shift attention toward a more predictive, newly added cue (e.g., Kruschke, 1996; Kruschke, 2001a; Kruschke, Kappenman, & Hetrick, 2005). Kruschke (1996) provides evidence suggesting that organisms can indeed learn to attend to a cue in a learning phenomenon called highlighting – an adaptation of the inverse base rate effect demonstrated by Medin and Edelson (1988). In Kruschke's (1996) experiment, participants received two phases of training and a test phase, similar to a blocking procedure. In the first phase of training, participants learned that a compound CS consisting of an imperfect predictor (I) and an early perfect predictor (PE) yielded a certain early outcome (denoted as $I.PE \rightarrow E$). In the second phase of the training, participants were presented with the same imperfect predictor paired with a new (late) perfect predictor (PL) of a new outcome (i.e., $I.PL \rightarrow L$). Cue I was considered to be imperfect because over the course of the experiment it was presented equally often with each outcome, and was not any more predictive of one outcome or the other. In the test phase of the experiment participants were presented with PE.PL and I to assess the associative strength of each cue. One might expect that participants would learn that I is an imperfect predictor of either outcome, that PE and PL are both perfect predictors of their respective outcomes, and that responding to both I and PE.PL would be equal for all outcomes. For instance, if PE and PL were recognized as being perfect predictors of

outcomes E and L, respectively, then they should acquire an equal amount of associative strength with those outcomes. When they are paired together (PE.PL) at test, they should elicit equal preference for E and L. On the other hand, if cue I was recognized as an imperfect predictor, it would have developed no associative strength with either outcome, and at test should also yield equal preference for E and L. However, the results of Kruschke's (1996) experiment revealed that participants had strong preference for the L outcome when presented with PE.PL and a strong preference for the E outcome when presented with I. Although there might be concern as to an effect of the frequency of the cue-outcome associations being presented (i.e., the base rate), a recent experiment conducted by Kruschke (2009) further suggests that this effect occurs regardless of stimulus base rate. In this study, the same highlighting paradigm was used, but the base rate of the cue-outcome associations were equalized across the entire experiment. These results suggest that, even with equal cue-outcome frequency, the highlighting effect is still present and robust.

The highlighting effect has proven to be a challenge for many models of associative learning (e.g., Rescorla & Wagner, 1972). The Rescorla-Wagner model is unable to explain why participants show stronger preference for L when PE.PL is presented and a stronger preference for E when I is presented. Indeed, Rescorla and Wagner (1972) would predict that learning would occur in a completely rational fashion, such that participants would learn that I is an imperfect predictor and that PE and PL are perfect predictors. Thus PE and PL would have equally high associative strength with their respective outcomes, while cue I would have little to no associative strength with

either outcome. Therefore, participants should show no outcome preference when presented with PE.PL or I upon test.

Kruschke (2003) suggests that the fundamental underlying process of the highlighting effect is the need for attention to be rapidly shifted away from the redundant stimulus, cue I, early on during later training (i.e., I.PL \rightarrow L) to preserve the association between I and E. Moreover, he suggests that these shifts in attention are learned so that when a participant is presented with an I.PL \rightarrow L association in later trials, the participant is more readily able to avoid errors and make more accurate predictions. According to Kruschke's (2003) hypothesis, if the shift was not rapid, then the association between I and E would deteriorate as cue I developed an association with L and, thus, cues PE and PL would have approximately equal associative strength to their respective outcomes. Thus, without this shift of attention, the associative values of the cues would be similar to that predicted by the Rescorla-Wagner model. Cue I would develop very weak associations with both E and L in later trials since it would not be a strong predictor of either outcome (i.e., cue I would eventually have an approximate associative strength of 0 between both E and L). On the other hand, this weakened association between cue I and outcomes E and L would allow cues PE and PL to develop associations of approximately 1 between E and L, respectively. However, to test this hypothesis one would need to examine whether or not attenuation of learning occurs for cue I in relation to cue PL.

The shifts in attention seen in both blocking and highlighting may seem irrational on the surface, but according to Kruschke (2003) these attentional shifts can be rationally explained in terms of error reduction. In a highlighting paradigm, if one is presented with I.PE \rightarrow E and is subsequently presented with I.PL \rightarrow L, then the previously formed

association of I with E should cause interference with the learning of $I.PL \rightarrow L$, thus increasing the potential for error. However, if one shifts attention away from cue I in favor of cue PL in the later $I.PL \rightarrow L$ trials, error is reduced by learning to ignore cue I and directing attention toward cue PL in this configuration. Similarly, in a blocking procedure, after the initial association between the initially presented CS1 and a US is made, and one is presented with the compound cue-outcome association $CS1.CS2 \rightarrow US$, shifting attention in favor of CS2 would cause weaker responding to the US since there is no existing association between CS2 and the US. Thus, learning to shift attention away from CS2 to CS1 helps to preserve the association between CS1 and the US, thereby reducing error.

This explanation of the rationale for the occurrence of the blocking and highlighting effects is consistent with the connectionist model of learning proposed by Kruschke (2001c). Based on the attentional model of learning proposed by Mackintosh (1975), Kruschke's (2001c) model, known as EXIT, is centered upon the ability of an organism to learn attention based on experience. This model suggests that each dimension of a stimulus has a learned attentional strength that is governed by its relevance in relation to an outcome. In short, dimensions that are more relevant to predicting an outcome will acquire more attentional strength than dimensions that are not. Kruschke (2003) suggests that when a cue is presented it activates dimensional nodes at the lowest layer of the nodal network. This activation then travels to an attentional gate where the strengths of attention to these dimensions are made available to modulate learning. Subsequently, associations between cue dimensions and outcome nodes are then made depending on how much attentional strength each dimension has acquired, such

that dimensions with greater attentional strength propagate a stronger association to the outcome node. It is at this point that a choice is made in responding. After the choice has been made, the organism will receive feedback, which will then guide the distribution of attentional strength appropriately in order to reduce future error.

According to the EXIT model, the correct response to a cue can be represented by an optimal activation of the outcome nodes, which is then modulated by attention. If responding to an outcome results in error, then attention will shift rapidly to compensate. Thus, more attention will be shifted to cues that reduce error. When the desired distribution of attention to cues or cue dimensions is met, the remaining error is reduced by the assignment (or reassignment) of associative weights to the outcomes. Therefore, this rationale of minimizing error in learning can apply to both learned attention and associative learning.

Kruschke et al. (2005) provide further evidence supporting this explanation of highlighting. Comparable to their eye-gaze experiment on blocking, Kruschke et al. (2005) found that when participants viewed PE.PL upon test, the duration of their visual attention was longer for cue PL than for PE. Similarly, when participants viewed I.PL, visual attention was shifted away from cue I and towards PL for a longer duration. These data further implicate learned attention as being at least one of the underlying mechanisms of the highlighting effect.

Aging and Attention

Although there is a great deal of evidence showing age related deficits in general causal learning (Mutter & Pliske, 1994; Mutter et al. 2007; Mutter & Plumlee, 2009), there has been very little research on aging and the attentional processes involved in the

highlighting effect. However, there is evidence from other studies that suggests that older adults may not show this effect. For example, recent research suggests that older adults ignore information that conflicts with a previous belief in a contingency judgment task. Mutter and Pliske (1994) found that older adults have better memory for contingency evidence that confirms a prior belief than evidence that disconfirms that belief. Similarly, Mutter et al. (2007) found that when older adults held a prior belief about the relationship between two events they were less likely to improve in a contingency discrimination when new information was presented that was contrary to their prior beliefs. Their data also suggested that older adults are biased in their memory toward contingency evidence that is consistent with their prior beliefs. In light of these findings, Mutter et al. (2007) proposed that this effect might occur because older adults perceive new evidence that is inconsistent with their prior beliefs to be irrelevant and therefore ignore that information.

In addition to the implications regarding the ability of older adults to adequately use attentional strategies in contingency judgments, there has been much research involving the effects of aging on attention to relevant cue dimensions in the Stroop task. In a typical Stroop design, participants are presented with a color word (i.e., “blue”) in either a congruent or incongruent color print. Participants are then required to name the color print of the word being presented as promptly as they can, since reaction time is typically measured. For example, in an incongruent trial, the experimenter might present the word “blue” printed in the color red. In this case, the participant would have to identify “red” as the color that the word is presented in. On the other hand, in a congruent trial, the participant might be presented with the word “blue” printed in blue and he or she would respond accordingly. The key underlying process taking place in the Stroop

task is the direction of a participant's attention to the most relevant dimension of the cue (i.e., the word, or the print color), given the goals of the task. As might be expected, in a typical Stroop task participants are usually faster and/or more accurate in a congruent trial than in an incongruent trial, since an incongruent trial requires a shift of attention from the word dimension to the color dimension to avoid responding to the conflicting information.

The literature on aging and the Stroop task has shown that older adults tend to perform much more poorly during incongruent Stroop trials than during congruent trials (Cohn et al., 1984; Mutter et al., 2005). This suggests that older adults have difficulty disengaging their attention from the irrelevant lexical cue dimension during incongruent trials. These findings, in combination with those found by Mutter et al. (2007), may suggest that older adults have more difficulty than younger adults inhibiting their attention to irrelevant prepotent information (i.e., lexical information, prior beliefs, etc.), since they may perceive less dominant information as being more relevant.

Additionally, a recent study examining age differences in contingency judgment (Mutter & Plumlee, 2009) found that older adults might not be as flexible in directing attention toward new evidence. Mutter and Plumlee (2009) examined the integration of contingency evidence in judgments of learning in younger and older adults. Younger and older participants were presented with contingency evidence that was either abstract or meaningful to examine whether or not there were age differences in the processing and integration of these types of information in their causal evaluation. For instance, meaningful contingency evidence might have been that when a certain fertilizer is used a particular plant would bloom, whereas abstract evidence would have been whether or not

an “Event A” occurred and whether or not a different “Event B” occurred. Their data showed no age differences in causal judgments based on abstract contingency information. On the other hand, while younger adults showed greater accuracy when presented with meaningful contingency information, older adults were less accurate in their predictions of preventative associations than younger adults. These findings suggest that older adults may not be as flexible as younger adults in their ability to direct attention toward evidence that may be more relevant.

On the other hand, there is some evidence (e.g., Mutter et al., 2005) that suggests that older adults can learn to adjust their attentional strategies based on the context of the Stroop task. In an experiment conducted by Mutter et al. (2005) younger and older adults were given one of two possible lists in the Stroop task. One list had 80% congruent trials and 20% incongruent trials, while the other had 80% incongruent trials and 20% congruent trials. Although older adults still showed a decline in performance during the incongruent trials as compared to younger adults, their performance in Stroop task increased as a result of the manipulated list structure. The results of this study suggest that when older adults were able to identify the list structure in the Stroop task they were able adjust their attentional strategy in order to reduce error and increase overall performance.

Current Study

There is much evidence to suggest that cognitive functioning, including attentional control, declines with age (e.g., Mutter et al., 2007; Mutter & Plumlee, 2009). Additionally, studies have shown that there is a marked decline in the ability of older adults to inhibit attention to irrelevant information (Cohn et al., 1984; Tipper, 1991;

Mutter et al., 2005). The purpose of the current study is to examine whether or not older adults can learn to direct attention toward a novel CS in order to preserve an earlier association, thereby exhibiting the highlighting effect. To our knowledge, no previous research has been conducted on the effects of aging on learned attention in a highlighting or related paradigm. However, there has been much research conducted regarding older adults' performance in tasks that may be related to their ability to shift attention (Mutter et al. 2005; Mutter et al. 2007; Mutter & Plumlee, 2009).

Mutter et al. (2005) and Mutter et al. (2007) found evidence that older adults have difficulty disengaging their attention from irrelevant lexical information in the Stroop task and from previously formed beliefs in contingency judgment. These findings suggest that older adults have greater difficulty than younger adults inhibiting attention to prepotent irrelevant information, which could be problematic in the highlighting task. Additionally, the results from Mutter and Plumlee (2009) suggest that older adults do not have the capacity to direct attention toward novel evidence of a causal relationship that is inconsistent with their prior beliefs. If older adults lack the attentional flexibility to inhibit their attention to irrelevant information (i.e., lexical information, prior belief, etc.), they may have difficulty learning to shift their attention toward more relevant information that conflicts with a previously learned association. This, in turn, might limit their ability to attend to the later presented cue in the highlighting task. If this is indeed the case, then older adults may exhibit a blocking effect, but should not show highlighting. For instance, consider the blocking effect in terms of contingency evidence. In the first phase of a blocking procedure older adults would learn a CS1 → US association that could be thought of as being analogous to the development of a prior belief (or prepotent

information). When they are subsequently presented with $CS1.CS2 \rightarrow US$, they can make their causal predictions based on that prior belief and easily ignore the redundant (or irrelevant) information (i.e., $CS2$). However, this type of inflexibility in attention shifting behavior could prove to be problematic for older adults in the highlighting task. The presentation of $I.PE \rightarrow E$ in the first phase of the highlighting procedure is somewhat analogous to the establishment of a prior belief, while the later presented cue-outcome association, $I.PL \rightarrow L$, is analogous to the addition of new, more relevant information. Since this new information would be inconsistent with the prior belief about cue I , and since older adults may be unable to adequately shift attention toward that information, they may be more likely to ignore this new information instead of learning to ignore their prior belief in favor of the new information. If, in the highlighting task, older adults view cue PL as being irrelevant and ignore it, instead of paying more attention to it, PL would develop a weaker association with the L outcome, and older adults would show less preference for L when presented with $PE.PL$ at test.

However, other evidence conflicts with this prediction. The results from Mutter et al. (2005) suggest that older adults were able to extrapolate information about the structure of a list in the Stroop task and learn to adjust their attention toward cue dimensions that were more relevant for the particular list in order to reduce errors and increase their performance. This finding suggests that, if older adults are able to recognize cue PL as being more relevant than cue I in the later training phases of the highlighting task, they might be able to learn how to appropriately shift their attention toward cue PL in order to reduce errors in causal judgment by preserving the association

between I and E. If this is the case then older adults should show the same response preference as younger adults during the test phase.

CHAPTER 2

Method

Participants

Twenty-four younger adults (ages 18-29) and 24 older adults (ages ≥ 60) were recruited to participate in the current study. Younger adults were recruited using the Western Kentucky University Department of Psychology Study Board system, and were rewarded with partial or extra class credit for their time. Older adults were recruited to participate via mailings throughout the community and were paid a small stipend for their time. The contact information for potential older participants was obtained from the voter registration database and from the directory of retired faculty of Western Kentucky University. Prior to participation in the study all participants were screened for the use of medications that could have an impact on cognitive ability. Additionally, older adults were screened for dementia via the Mini Mental State Examination (MMSE). All older adults who participated in the study met the passing criterion on the MMSE and no participants were excluded based on medication use. Demographic information and other cognitive tests that were possibly related to the experimental results of the study were also collected for all participants.

Since age and ethnicity were of no consequence to the design of this study, participants of both genders and of diverse ethnicities were included. Our sample of participants from the community and the university were approximately representative of those populations.

Design and Stimuli

The stimuli used in the present study were 22 five-letter nouns chosen from the MRC Psycholinguistic Database (http://www.psy.uwa.edu.au/mrcdatabase/uwa_mrc.htm) with concreteness, imagability, and familiarity ratings of at least 500. The words chosen from the pool had no apparent semantic relationship with any of the other words and all began with a different initial letter. The words used were: *apple, brain, cigar, daisy, elbow, frost, glass, house, ivory, judge, knife, linen, movie, nurse, ocean, phone, queen, radio, skate, tiger, uncle, world.*

All stimuli were presented to participants on an Apple iMac computer with a 22-inch screen. Participants' responses were made on a standard computer keyboard using either the F, G, H, or J keys. Stimulus pairs were positioned vertically on the computer screen (i.e., one word on top of the other) and the four possible responses (i.e., F, G, H, and J) were displayed in boxes, horizontally, on the bottom of the screen. Stimuli from the pool were randomly assigned to one of three cue types: an imperfect predictor (I), early perfect predictor (PE), or late perfect predictor (PL) in 12 separate orders. Two participants were run on each order.

The experimental design for the current study was canonical in nature, meaning that stimuli occurred with equal frequency throughout the procedure, as suggested by Kruschke (2009). The design incorporated the use of three training phases and one test phase (see Table 1). Each phase of the experiment contained a specified number of blocks (where each block consisted of two trials of each stimulus combination) organized to produce an equal frequency of presentation of the different cue types and outcomes

(i.e., early or late). Two sets of predictive cues and outcomes were used (i.e., I1.PE1→E1, I2.PE2→E2, etc.) for each training block.

The first phase of training was designed to ensure that participants received exposure to the early perfect predictors before being trained with the late perfect predictors. In this phase, participants were presented with 12 blocks of both I1.PE1 → E1 and I2.PE2 → E2 items. In the second phase of training, participants were introduced to the late perfect predictors (i.e., I.PL→L). During this phase the early stimuli were presented for a total of 36 blocks and the late stimuli were presented for 12 blocks. This ratio helped to solidify the previous associations made with the early stimuli, while providing an adequate amount of training for participants to begin forming the later associations. The third phase of training was the longest, containing 36 trial blocks with early stimuli and 108 blocks with the later items. Feedback accompanied all responses during all three phases of training.

The test phase of the experiment contained two blocks of trials in which I.PE → E and I.PL → L items were presented with no feedback to ensure that each participant had accurately learned the associations. These blocks were intermixed with 1 block of presentations of each imperfect predictor alone and a pairing of both perfect predictors (also with no feedback) as a test for outcome preference. A total of 246 trials were used throughout the experiment.

Procedure

All participants in the study were tested individually in the Cognition Laboratory during a single session that lasted about three hours. When the participants arrived, they were asked to carefully read and complete an informed consent form, and a biographical

and health questionnaire, which included questions concerning education, marital status, employment, socioeconomic status, and current health and wellness.

Participants were then seated at a comfortable viewing distance from the computer screen. They were told that their task was to learn which key to press when a certain word or pair of words was displayed on the computer screen, and that when these words were presented they should respond by pressing either the F, G, H, or J key on the computer keyboard. They were then shown where those keys were located on the keyboard. Participants were also informed that feedback would be given on each of the trials during training, but not during the test phase of the procedure.

On each trial, participants viewed stimuli as previously described, and made their response by pressing a corresponding key on the keyboard. They had as much time as they liked to view the stimuli and make their response. When participants made their response in the training phases, it was followed by immediate feedback. If the response was correct, the phrase “Yes! The correct answer is [letter]” appeared on the screen between the cue stimuli and the response choices on the bottom of the screen. If they responded incorrectly, the phrase “Wrong! The correct answer is [letter]” was displayed. Responses in the test phase were followed by the phrase “Your response has been recorded.”

Participants were asked to complete a series of other cognitive tasks, their performance on which might be related to their performance on the highlighting task. The test types, measures of cognitive ability, dependent variables, and order of the protocol are displayed in Table 2. A short break was provided to all participants between the Digit Symbol Incidental Learning task and Reading Span task. All participants were debriefed

after completing both the experimental and subsequent cognitive tasks. All recruitment, tests, methodological procedures, and informed consent forms, were approved by the WKU Human Subjects Review Board (see Appendix 1). Informed consent forms for younger and older adults are listed in Appendix B and Appendix C, respectively.

Table 1

Highlighting design

Experiment Phase	# of Blocks	Items Presented	Frequency
Phase One	12	I1.PE1 → E1	x2
		I2.PE2 → E2	x2
Phase Two	6	I1.PE1 → E1	x3
		I2.PE2 → E2	x3
		I1.PL1 → L1	x1
		I2.PL2 → L2	x1
Phase Three	18	I1.PE1 → E1	x1
		I2.PE2 → E2	x1
		I1.PL1 → L1	x3
		I2.PL2 → L2	x3
Test Phase	2	I1.PE1 → ?	x2
		I2.PE2 → ?	x2
		I1.PL1 → ?	x2
		I2.PL2 → ?	x2
		I1 → ?	x1
		I2 → ?	x1
		PE1.PL1 → ?	x1
		PE2.PL2 → ?	x1

Table 2

Assessments of related cognitive abilities in younger and older adults

Assessment	Measure of Cognitive Ability	Measures
Pattern Comparison	Processing Speed	Total score of correct responses
Paired Associate Learning	Proactive Interference	Total score of correct associations
Wisconsin Card Sorting Task	Working Memory and Executive Functioning	Total number of correct responses, errors, perseverative responses, perseverative errors, nonperseverative errors, conceptual level responses
WAIS Digit Symbol	Processing Speed	Total score of correct responses
WAIS Digit Symbol Incidental Learning	Learning and Memory	Total score of correct responses
Reading Span	Working Memory and Executive Functioning	Total score of correct responses
Controlled Oral Word Association	Working Memory and Executive Functioning	# of words and strategies
Mill Hill Vocabulary	Crystallized Verbal Knowledge	Total score of correct responses
Conditional Associative Learning	Learning and Memory	Total score of successful responses, retained responses, forgotten responses, discrimination failures, perseverations, and unsuccessful guesses

CHAPTER 3

Results

All of the analyses were conducted using an alpha level of $p \leq .05$ as the criterion of significance. The hypotheses underlying this study relied on the assumption that participants learned $I.PE \rightarrow E$ and $I.PL \rightarrow L$ associations (Kruschke et al., 2005). Participants were given $I.PE \rightarrow E$ and $I.PL \rightarrow L$ trials intermixed with I and PE.PL test trials. Given that participants received a total of eight trials of $I.PE \rightarrow E$ and $I.PL \rightarrow L$ during the test phase, they should respond correctly on six of those trials (75% correct) to be above chance according to the criterion set by Kruschke et al. (2005). There were four participants (two older and two younger) who did not reach this criterion in the test phase of the experiment. These participants were excluded from further analyses. Two of the excluded participants (one older and one younger) were subsequently replaced with new participants who met the learning criterion, leaving 23 participants in each group.

Overall accuracy on the test trials for $I.PE \rightarrow E$ and $I.PL \rightarrow L$ was high for both groups. Mean accuracy for younger adults was 98.37% on $I.PE \rightarrow E$ trials and 97.83% on $I.PL \rightarrow L$ trials. For older adults, mean accuracy was 94.57% for $I.PE \rightarrow E$ trials and 94.02% for $I.PL \rightarrow L$ trials. Overall mean accuracy for younger adults was 98.10% and overall mean accuracy for older adults was 94.84%. Younger adults showed significantly greater overall accuracy than older adults, $F(1, 44) = 4.03, p = 0.05, MSE = 30.34, \eta^2 = 0.08$. However, older adults' accuracy was still very high and met the learning criterion.

Highlighting Analyses

Each participant received a total of four I trials in the test phase of the experiment. The choice preference for I test trials was calculated based on the procedure used in

Kruschke et al. (2005). The total number of E responses was counted and the total number of L responses was subtracted from this sum. The resulting difference was then divided by the total number of I test trials to provide a percentage choice preference for the E outcome during I trials. This percentage is denoted I_c . Participants also had the option of choosing outcomes that did not correspond with original cues (i.e., $I1 \rightarrow L2$, $I1 \rightarrow E2$, etc.). These instances of erroneous responses accounted for 8.70% of responses for younger adults and 10.87% of responses for older adults. These responses were not included in calculating choice preference.

The outcome preference data for I indicated that both younger and older adults had a reliably greater preference for the E outcome during I test trials. Younger adults showed a mean response preference of 68.48% for E and a mean response preference for L of 23.91% during I test trials. The mean difference for younger adults, $I_c = 44.57\%$, was reliably greater than zero, $t(22) = 4.37$, $p < 0.001$. Older adults showed similar results with a 66.30% preference for E and 22.83% preference for L during I test trials. The mean difference for older adults, $I_c = 43.48\%$, was also reliably greater than zero, $t(22) = 4.59$, $p < 0.001$. Age differences in outcome preference for I were examined using a between subjects one-way ANOVA comparing younger and older adults' mean difference scores for I_c . This analysis indicated no difference in the preference of younger and older adults for E when presented with I test trials, $F(1, 45) < 1$, $MSE = 2220.85$.

Each participant was presented with a total of four PE.PL trials in the test phase of the study. A mean difference score indicating choice preference, denoted as $PEPL_c$, was calculated by adding the total number of L responses and subtracting the number of E

responses. This difference was then divided by the total number of PE.PL test trials to produce a percentage choice preference for PE.PL trials. Similar to the I test trials, participants sometimes chose outcomes that did not correspond to the test items (i.e., PE1.PL1 \rightarrow E2, PE1.PL1 \rightarrow L2, etc.). These responses accounted for 1.09% of younger adult responses and 2.17% of older adult responses. These data were not used in calculating PEPLc.

The outcome preference data for the PE.PL test trials indicated that younger and older adults alike had a reliably greater preference for the L outcome than the E outcome during PE.PL test trials. Younger adults showed a mean response preference of 64.13% for L and a mean response preference of 34.78% for E during PE.PL test trials. The mean difference for younger adults, PEPLc = 29.35%, was reliably greater than zero, $t(22) = 2.48, p < 0.025$. Older adults showed a mean response preference of 65.22% for L and a mean response preference of 32.61% for E during PE.PL test trials. The mean difference for older adults, PEPLc = 32.61%, was also reliably greater than zero, $t(22) = 2.526, p < 0.025$. Age comparisons were conducted using a between subjects one-way ANOVA comparing younger and older adults' mean difference scores for PEPLc. These data indicated no difference between the two age groups in preference for L when presented with PE.PL test trials, $F(1, 44) < 1, MSE = 3525.20$.

Upon closer examination of the highlighting data, it appeared that Ic was typically larger than PEPLc for both groups. To determine if this difference was significant and if it varied for the two age groups a 2 (Age) x 2 (Preference type) mixed factorial ANOVA was conducted. No significant difference was observed in choice preference for the two cues, $F(1, 44) = 1.52, MSE = 226956.52, n.s.$ nor did this preference vary by age, $F(1, 44)$

< 1 , $MSE = 1583.50$.

In summary, both younger and older adults showed a robust highlighting effect. Both age groups preferred the early-learned outcome when presented with I and the later-learned outcome when presented with PE.PL. Additionally, no age differences were observed in the degree of these outcome preferences individually or in the degree of the overall highlighting effect.

Individual Differences Comparisons and Correlations

Although no age differences were found in the highlighting effect, this could simply have been an artifact of having collected a non-representative sample of high performing older adults. To examine this possibility, analyses of age differences in the individual difference measures (Pattern Comparison, Paired Associate Learning [PAL], Wisconsin Card Sorting Task [WCST], WAIS Digit Symbol, WAIS Digit Symbol Incidental Learning, Reading Span, Controlled Oral Word Association [FAS], Mill Hill Vocabulary, Conditional Associative Learning [CAL]) given after the highlighting task were conducted. The mean score for younger and older adults on each measure along with the outcomes for each age comparison are displayed in Table 3. Age differences were found for each measure except for FAS, WCST-failure to maintain set, and Mill Hill Vocabulary. Younger adults showed overall better performance on each of the tasks in which age differences were found. These differences are consistent with previous data collected in our lab on these measures in other studies. Therefore, the data suggest that our results are not merely an artifact of testing a sample of high performing older adults.

Correlational analyses were also conducted to determine whether performance on the highlighting task was related to performance on the individual difference measures. In

order to conduct these analyses, the Ic and PEPLc mean difference scores were summed for each participant. This measure was then correlated each individual difference measure's dependent variable(s). These correlations are reported in Table 4. No significant correlations were found between highlighting performance and any of the other cognitive tasks.

Table 3

Comparisons of age differences in individual difference measures

Measure	<i>M</i> - Younger	<i>SD</i> - Younger	<i>M</i> - Older	<i>SD</i> - Older	<i>t</i> -value	<i>df</i>
Digit Symbol	89.74	17.83	61.04	12.95	6.56***	44
Digit Symbol Incidental Learning	23.39	4.44	18.48	6.02	3.26**	44
Pattern Comparison	63.36	10.37	44.00	6.54	7.94***	43
Reading Span	4.09	1.84	2.57	1.59	3.01**	44
Controlled Oral Word Associations	43.26	11.16	41.00	12.38	0.65	44
CAL – %Forgotten	8.07	-3.98**	25.68		-3.98**	44
CAL - %Discrimination Failure	14.78	-1.94	23.55	-1.94	-1.94	44
CAL - %Perseverations	6.00	-2.20*	12.59	-2.20*	-2.20*	44
Mill Hill	35.78	6.27	38.30	7.92	-1.178	44
WCST – Categories Completed	4.14	1.22	3.00	1.25	3.19**	42
WCST – Trials to Complete 1 st Category	11.64	2.33	16.41	14.52	-2.05*	42
WCST – Failure to Maintain Set	0.36	0.66	0.59	0.66	-1.139	42
WCST – Perseverative Errors	5.64	1.80	8.36	4.13	-2.794**	42
Paired Associate Learning	105.61	10.01	85.87	15.59	5.119** *	44

Note. T-values assume equal variance. * $p < .05$. ** $p < 0.01$. *** $p < .001$.

Table 4

Correlations between highlighting and individual difference measures

Individual Difference Measure	Highlighting		
	Ic	PEPLc	Ic + PEPLc
Digit Symbol	-.10	.13	.04
Digit Symbol Incidental Learning	.03	-.04	-.01
Pattern Comparison	.03	.07	.07
Reading Span	.02	-.02	-.01
Controlled Oral Word Association	.18	.20	.25
CAL - %Forgotten	-.12	.22	.09
CAL - %Discrimination Failure	.05	.18	.16
CAL - %Perseverations	-.29	.21	-.02
Mill Hill	.02	-.01	.01
WCST – Categories Completed	-.02	-.20	-.16
WCST – Trials to 1 st Category	.06	.09	.11
WCST – Failure to Maintain Set	.01	-.08	-.05
WCST – Perseverative Errors	.05	.20	.18
Paired Associate Learning	.16	-.03	.07

Note: No correlations listed above are significant.

CHAPTER 4

Discussion

The current study examined potential age differences in the highlighting effect in order to determine whether older adults were able to learn rapid shifts of attention to modulate associative learning. Younger and older adults received I.PE \rightarrow E training trials in the first phase of the learning paradigm. In subsequent training phases, they were presented with I.PL \rightarrow L trials. Because cue I previously developed an association with the early-learned outcome E, the initial presentations of this cue causes errors in causal judgments. Thus, participants must learn to rapidly shift their attention away from cue I and toward PL in order to reduce errors and preserve the earlier formed association between I and E. After this learned attentional shift has occurred, cue PL is said to be attentionally highlighted. In subsequent tests of learning, participants were presented with cue I alone and the compound cue PE.PL. Because cue PL had been attentionally highlighted in later training (resulting in the preservation of the earlier formed I \rightarrow E association), participants should have preferred outcome L, when presented with PE.PL and outcome E when presented with cue I during test trials.

In the present study, younger and older adults showed a robust highlighting effect, preferring the early-learned outcome E, when presented with I and the later-learned outcome L, when presented PE.PL test trials. Moreover, there were no age differences in the degree of preference for either of these outcomes. Given that age differences in highlighting performance might have been expected based on previous evidence suggesting that older adults have difficulty with attention shifting and inhibition of attention to prepotent irrelevant information (Cohn et al., 1984; Mutter & Pliske, 1994;

Mutter et al., 2005; Mutter et al., 2007; Mutter & Plumlee, 2009), it was necessary to investigate the possibility that a non-representative sample of high performing older adults may have been collected. The results of additional analyses examining age-related differences in the individual difference measures given to all participants indicated that the older participants recruited for the current study were representative of the population. Therefore, the absence of age differences in highlighting was not an artifact of collecting data from a sample of high performing older adults.

Prior to this study, no research had examined older adults' ability to use learned shifts of attention in order to modulate associative learning. The predictions concerning the present study were necessarily ambiguous because research in some areas indicated that the processes involved in attentional highlighting decline with age (Cohn et al., 1984; Mutter & Pliske, 1994; Mutter et al., 2005; Mutter et al., 2007; Mutter & Plumlee, 2009), while other research suggested that these attentional mechanisms might be preserved (Mutter et al., 2005). For example, evidence from the literature on aging and the Stroop effect indicated that although older adults have greater difficulty inhibiting attention to prepotent word information and shifting their attention toward more relevant color information, they are able to learn about variations in list structure and use this information to modify their attentional strategies and optimize performance (Mutter et al., 2005). On the other hand, research on aging and contingency judgment has suggested that older adults are both unable to inhibit attention to prepotent information that disconfirms their prior beliefs about the relationship between two events. (e.g., Mutter & Pliske, 1994; Mutter et al., 2007) and inflexible in directing their attention to relevant contingency evidence (Mutter & Plumlee, 2009). In contrast to these findings, the present results

suggest that the mechanisms necessary to adjust attentional allocation across multiple cues in the environment, and thereby modulate the strength of the associations formed between those cues and their respective outcomes, are preserved with age.

It may be the case, however, that older adults are able to adjust attentional allocation only for cues that are physically present in the environment. For example, Mutter et al. (2007) examined age differences in the ability to integrate contingency evidence in generative (i.e., Event A causes Event B), and preventative (i.e., the absence of Event A causes Event B) contingencies in both abstract and meaningful contexts. They found that for the generative contingencies, older adults' judgment performance was similar to younger adults' performance in both the abstract and meaningful contexts. However, for the preventative contingencies, there were no age differences in the abstract context, but older adults' judgment performance was worse than young adults' performance in the meaningful context. In the abstract context, neither group attended to or integrated the evidence for the preventative contingencies, whereas in the meaningful context, the young adults attended to and integrated this information but older adults did not. Older adults may be able to shift attention for the purpose of optimizing performance in generative contingencies when the most predictive events are cues that are physically present but not in preventative contingencies when the most predictive events are cues that are absent.

Older adults seem to show little or no deficit in causal judgment when dealing with generative relationships (Mutter & Plumlee, 2009; Mutter, 2009; Mutter et al., 2005), suggesting that they are capable of learning attentional shifts in the context of generative relationships between cues and outcomes, but perhaps not in the context of

preventative relationships. Taken in this context, the present findings are consistent with the results of earlier contingency judgment experiments because the canonical highlighting paradigm is designed around generative causal learning. In this paradigm, cue I, cue PE, and cue PL are always physically present when the outcome occurs. Older adults learned to inhibit attention to cue I and to direct their attention to cue PL in later trials in order to reduce errors in causal judgment. Thus the attentional processes involved in adjusting cue salience based on prior experience for physically present cues appear to be intact in older adults (e.g., Kruschke 2001c; Mackintosh, 1975). However, if older adults are able to learn to shift their attention to guide the formation of associations, then the failure of some other mechanism must be responsible for the deficit in their ability to shift attention to the information that is important for developing preventative associations (e.g., the absence of cause is most predictive of the outcome). Mutter and Plumlee (2009) suggested that older adults might have difficulty generating a representation of absent information. If this were the case, then older adults would not be able to shift attention to such a representation, and would thus fail to properly determine the probability of an absent cue predicting the presence of an outcome. This hypothesis seems to be a plausible explanation, given that highlighting does not involve the manipulation of the associative strength of absent cues.

Recent research on age differences in retrospective revaluation (specifically, unovershadowing) provides further support for this hypothesis (Mutter et al., 2010). Unovershadowing occurs when learners are first trained with $A.B \rightarrow X^+$, and subsequently trained with $A \rightarrow X^-$. During this latter training phase, cue A indirectly activates the representation of the missing cue B. Because cue A predicts the

nonoccurrence of the initially trained outcome, the absent cue B is a more accurate predictor of the outcome and the associative value of this cue increases. Mutter et al. (2010) found that older adults failed to revalue the associative link between B and X^+ , and hypothesized that this was because older adults had difficulty indirectly activating the representation of the absent cue. In the final experiment of the study, Mutter et al. (2010) provided participants with a small image in the corner of the screen of the “absent cue.” When older adults no longer had to activate the representations of the absent cues, age differences in unovershadowing were eliminated. From the current attentional perspective, if older adults are unable to indirectly activate the representations of absent cues, they will not be able to allocate attention to those representations. Thus, they will also be unable to adjust the predictive value of these cues. However, when the need to activate the representation of an absent cue is eliminated, older adults are able to shift attention to the “absent cue,” and revalue its associative strength.

Retrospective revaluation is comparable to preventative learning insofar as it involves the manipulation of absent cue information. Specifically, retrospective revaluation requires that attention be shifted toward the absent information (in the case of unovershadowing) or away from absent information (in the case of backward blocking). In contrast, highlighting does not require older adults to make use of absent cues. All the predictive information is present on each trial of the highlighting paradigm. Participants are not required to make attentional shifts toward or away from any absent cues. Instead, they are merely required to divide attention equally between cues in earlier training and shift attention toward a more relevant cue in later training. Because the information needed to guide the formation of associations in highlighting is physically present, older

adults do not have to indirectly activate absent cue representations in order to modify the attentional and associative strength between the cues and outcomes.

The finding of age differences in retrospective revaluation and no age differences in highlighting suggests that many models of learning are insufficient in accounting for these phenomena, if they are able to account for them at all. If the models are unable to account for the phenomena, then they are most decidedly unable to explain older adults' successes and failures in these learning paradigms. The Rescorla-Wagner model can predict simple excitatory and inhibitory relationships in causal learning (e.g., overshadowing, conditioned inhibition, extinction, etc.). However, it is unable to account for highlighting, predicting that individuals will show no outcome preference for cue I, and will prefer outcomes E and L for cues PE and PL, respectively. It is also unable to explain the retrospective revaluation of absent information as the model predicts that no learning will take place for an absent cue. Similarly, although Mackintosh's (1975) model may be able to account for the learned attentional shifting effects such as blocking and highlighting, it, too, fails to account for unovershadowing as it also predicts no learning for absent information.

The shortcomings of these models in dealing with these effects led other researchers (e.g., Van Hamme & Wasserman, 1994) to posit that the salience of an absent-but-expected cue be set to a negative value. In doing so, these models can then account for the acquisition of associative strength between the absent-but-expected cue and the outcome it was initially presented with in the opposite direction a cue that is presented. However, Van Hamme and Wasserman's (1994) model fails to predict highlighting. In the canonical highlighting design presented here (and in Kruschke,

2009), the presentation of $I.PE \rightarrow E$ and $I.PL \rightarrow L$ trials occur equally often. Therefore, there are no absent-but-expected cues in the paradigm, and Van Hamme and Wasserman's (1994) model reduces to the original model developed by Rescorla and Wagner (1972). In addition, although the Van Hamme and Wasserman (1994) model accurately predicts the existence of retrospective revaluation effects in learning, it does not have the necessary mechanisms in place to explain why older adults are unable to revalue the associative strength of an absent cue. According to Van Hamme and Wasserman (1994), in the second phase of unovershadowing, the associative value of the presented cue decreases, and the salience of the now absent, but expected cue becomes negative instead of positive. Van Hamme and Wasserman's (1994) model requires that individuals code an absent-but-expected cue as being absent and allocate attention to the now salient representation of the absent-but-expected cue in order to adjust its associative strength.

Older adults' ability to learn attentional shifts in highlighting, but not in retrospective revaluation poses a problem for the model proposed by Van Hamme and Wasserman (1994). This is because Van Hamme and Wasserman's (1994) model has no mechanism in place that could explain both older adults' successes in learning to shift attention when cue information is physically present and their deficit in shifting attention when the cue information is absent (Mutter et al., 2010). On the other hand, Kruschke's (2001c, 2006) connectionist models of learning do have such a mechanism. Although Kruschke's (2001c) EXIT model does not accurately account for unovershadowing, a more recent model (Kruschke, 2006) based on the idea of locally Bayesian learning has been shown to accurately model human behavior in both unovershadowing and backward

blocking, as well as highlighting. Bayesian learning incorporates the use of Bayesian probability theory to explain the development and updating of associations between cues and outcomes. With a Bayesian approach, learners update their prior belief about the relationship between a cue and outcome by forming a posterior belief when feedback about their prior belief is given. When individuals begin a learning experiment such as highlighting, the probability that any of the multiple cues presented are paired with a given outcome is the same. Therefore, an individual's prior belief about the relationships between these cues and outcomes assumes no knowledge of an association. After receiving feedback on a given trial, individuals form a posterior belief and update their prior belief about the likelihood of outcome occurrence when a given cue is presented. Associations are developed based on the consistency of the feedback with the previously learned belief. If the feedback is consistent with the prior belief, the association is strengthened, whereas feedback that is inconsistent with the prior belief weakens the association. Associations are thus formed based on the individual's updated belief about the cue-outcome association.

Kruschke (2006) suggests that Bayesian learning occurs between the lower nodes of the network representing all the cues and "hidden" nodes representing attentionally filtered duplicates of the cue nodes, and also occurs between these hidden nodes and the nodes representing the possible outcomes at the top most layer of the network.

Kruschke's (2006) model also suggests that Bayesian learning takes place between local layers of the network. That is, Bayesian learning does not occur globally within the model. Instead, learning is based upon its local information. According to this model, retrospective revaluation occurs because learners use Bayesian updating between local

layers of the network in order to guide learned attentional shifts and the formation of associations. For instance, in highlighting, the model predicts that, feedback from the presentation of $I.PL \rightarrow L$ trials will be inconsistent with the prior belief that $I \rightarrow E$. Individuals then shift attention away from this inconsistent evidence toward belief confirming evidence (e.g., $PL \rightarrow L$). The model then predicts that there is a learned mapping of this attentional shift that takes place between the cue nodes and the hidden nodes (the attended cues), and a learned mapping from the hidden nodes (the attended cues) to the outcome node so that the latter learned mapping represents the association between the attentionally filtered cue and the outcome.

The model is able to account for the retrospective revaluation effects in causal learning along with the mechanisms involving their learned attentional allocations. In order for the lower layer of the network to become active, thus propagating any kind of signal to the attentionally filtered duplicates or outcome nodes, the individual must generate and maintain a representation of the cue. These representations are generated based on what is consistent with the individual's current belief. That is, if an individual's current belief is that $A.B \rightarrow X^+$, and $A \rightarrow X^-$ is presented, then a representation of cue B is generated, and the individual updates the belief in the hypothesis that $B \rightarrow X^+$. The key to the ability of Kruschke's (2006) model to explain older adults' deficits in dealing with absent cues lies in the activation of the bottom layer of the nodal network. If older adults have difficulty generating and maintaining a representation of the absent information, then the lower layer of the network representing the absent cue will not be active and cannot propagate a signal to the middle and upper layers of the network.

Kruschke's (2006) model does seem to be able to explain older adults' successes in failures in these learning paradigms. The highlighting paradigm does not require that older adults generate a representation of absent information for the purposes of manipulating that information. Rather, individuals allocate more attention to the later presented perfect predictor (PL) in later training in order to preserve the earlier-formed I.PE \rightarrow E association. Therefore, older adults only need to manipulate attentional and associative weights of presented information. If older adults' deficits in generating a representation of absent information are the cause of their difficulty in revaluing absent information, then Kruschke's (2006) model would accurately predict their failure to show unovershadowing, while predicting their success in highlighting.

In conclusion, the results of the present study suggest that older adults' ability to learn error-driven shifts of attention that modulate associative learning remains intact. Given older adults' success in generative causal learning and highlighting and deficits in preventative causal learning and retrospective revaluation, future research should look more closely at the question of whether older adults are able to learn attentional shifts when preventative or negative associations are involved in the blocking and highlighting paradigms. It could be the case that older adults would be unable to perform these tasks when preventative/negative causal judgments were used in the design. Moreover, the results presented here, in combination with recent data collected by Mutter et al. (2010), suggest that models that only assign a negative salience value to absent cues in order to account for retrospective revaluation effects are missing a mechanism for the activation and maintenance of absent information (e.g., Van Hamme & Wasserman, 1994). On the other hand, Kruschke's (2006) implementation of locally Bayesian learning in a similar

connectionist framework as his previous models (e.g. Kruschke 2001c) seems to be able to account both for older adults' success in generative causal learning and highlighting and their failure in preventative causal learning and unovershadowing.

References

- Arcedanio, F., Matute, H., & Miller, R. R. (1997). Blocking of pavlovian conditioning in humans. *Learning and Motivation*, 28, 188–199.
- Cohn, N. B., Dustman, R. E., & Bradford, D. C. (1984). Age related decrements in Stroop Color Test performance. *Journal of Clinical Psychology*, 40, 1244-1250.
- Kamin, L. J. (1969). Predictability, surprise, attention and conditioning. In Campbell, B. A., & Church, R. M. (Eds.), *Punishment and aversive behavior*. (pp. 279-296). New York: Appleton-Century-Crofts.
- Kruschke, J. K. (1996). Base rates in category learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 22, 3-26.
- Kruschke, J. K. (2001a). *Cue competition in function learning: Blocking and highlighting*. Talk presented at the 3rd International Conference on Memory, July 2001, Valencia, Spain. (Available from the author's web site.)
- Kruschke, J. K. (2001b). The inverse base-rate effect is not explained by eliminative inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27, 1385-1400.
- Kruschke, J. K. (2001c). Towards a unified model of attention in associative learning. *Journal of Mathematical Psychology*, 45, 812-863.
- Kruschke, J. K. (2003). Attention in learning. *Current Directions in Psychological Science*, 12, 171-175.
- Kruschke, J. K. (2006). Locally Bayesian learning with applications to retrospective revaluation and highlighting. *Psychological Review*, 113, 677-699.
- Kruschke, J. K. (2009). Attentional highlighting: A canonical experiment. *The*

Psychology of Learning and Motivation.

- Kruschke, J. K., & Blair, N. J. (2000). Blocking and backward blocking involved learned inattention. *Psychonomic Bulletin, & Review*, 7, 636-645.
- Kruschke, J. K., Kappenman, E. S. & Hetrick, W. P. (2005). Eye gaze and individual differences consistent with learned attention in associative blocking and highlighting. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 31, 830-845.
- Mackintosh, N. J. (1975). A theory of attention: variations in the associability of stimuli with reinforcement. *Psychological Review*, 82, 276-298.
- Mackintosh, N. J., & Turner, C. (1971). Blocking as a function of novelty of CS and predictability of UCS. *Quarterly Journal of Experimental Psychology*, 23, 359-366.
- Medin, D. L., & Edelson, S. M. (1988). Problem structure and the use of base-rate information from experience. *Journal of Experimental Psychology: General*, 117, 68–85.
- Mutter, S. A., Asriel, M., & Holder, J. M. (2010, April). *Age differences in updating causal beliefs*. Poster session presented at the Cognitive Aging Conference, Atlanta, Georgia.
- Mutter, S. A., Naylor, J. C., & Patterson, E. R. (2005). The effects of age and task context on Stroop task performance. *Memory & Cognition*, 33, 514-530.
- Mutter, S. A., & Pliske, R. A. (1994). Aging and illusory correlation in judgments of co-occurrence. *Psychology and Aging*, 9, 53-63.
- Mutter, S. A., Strain, L. M., & Plumlee, L. F. (2007). The role of age and belief in

contingency judgment. *Memory and Cognition*, 35, 875-884.

Mutter, S. A., & Plumlee, L. F. (2009). Aging and integration of contingency evidence in causal judgment. *Psychology and Aging*.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: variations in the effectiveness of reinforcement and nonreinforcement. In Black, A.H., & Prokasy, W.F. (Eds.), *Classical conditioning II: Current theory and research* (pp. 64-99). New York: Appleton-Century-Crofts.

Tipper, S. P. (1991). Less attentional selectivity as a result of declining inhibition in older adults. *Bulletin of the Psychonomic Society* 29, 45-47.

Van Hamme, L. J., & Wasserman, E. A. (1994). Cue competition in causality judgments: The role of nonrepresentation of compound stimulus elements. *Learning and Motivation*, 25, 127-151.

Appendix A



A LEADING AMERICAN UNIVERSITY WITH INTERNATIONAL REACH
HUMAN SUBJECTS REVIEW BOARD

In future correspondence, please refer to HS10-046, September 29, 2009

Jared M. Holder
c/o Dr. Mutter
Psychology
WKU

Jared M. Holder
& Dr. Mutter:


Your research project, *Learned Attention in Younger and Older Adults*, was reviewed by the HSRB and it has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is required; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data. (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

This project is therefore approved at the Expedited Review Level until September 29, 2010.

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Sponsored Programs at the above address. Please report any changes to this approved protocol to this office. A Continuing Review protocol will be sent to you in the future to determine the status of the project. Also, please use the stamped approval forms to assure participants of compliance with The Office of Human Research Protections regulations.

Sincerely,


Paul J. Mooney, M.S.T.M.
Compliance Coordinator
Office of Sponsored Programs
Western Kentucky University



cc: HS file number Holder HS10-046

HSRB APPLICATION # 10-046
APPROVED 9/29/09 to 9/29/10
EXEMPT EXPEDITED FULL BOARD
DATE APPROVED 9/29/09

The Spirit Makes the Master

Office of Sponsored Programs | Western Kentucky University | 1906 College Heights Blvd. #11026 | Bowling Green, KY 42101-1026
phone: 270.745.4652 | fax: 270.745.4211 | e-mail: paul.mooney@wku.edu | web: http://ored.wku.edu/Research_Compliance/Human_Subjects/

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Appendix B

S

INFORMED CONSENT TO PARTICIPATE IN RESEARCH PROJECT/STUDY

Name of project/study: Age Differences in Learning and Judgment

1. I, _____, agree to participate in a research project conducted by scientists at Western Kentucky University. I understand that the project involves research and that the purpose of the research is to study how the processes of learning and judgment vary across the life span.

2. I understand that the procedures to be followed are: I will first complete questionnaires concerning my background (e.g., age, education, and income) and general health. I will then be administered several tasks designed to assess my ability to make judgments and perform related mental operations. I understand that these tasks will be simple and well within my ability to complete. I will also be given tasks that measure cognitive abilities such as my vocabulary and extent of my general knowledge. All of these tasks will be drawn from standard psychological test batteries and from published psychological studies. Finally, I will complete a questionnaire concerning my own perception of my ability to make judgments.

I understand that these tasks and questionnaires will be administered to me in the Cognition Laboratory at Western Kentucky University.

3. I understand that I may decline to answer specific questions in any of the questionnaires administered in this study if I so choose and that by completing these questionnaires I give my consent for use of these data by the researchers.

4. I understand that the tasks and questionnaires that will be administered in this study are experimental in nature. They may not be related to my ability to carry out normal daily activities or job-related duties.

5. I understand that my scores on the tasks in this study will be available only to researchers who are associated with this study. I also understand that my scores will be combined with those of other participants to obtain group scores and that information on group performance will be available to me, if I so desire, in written reports of the results of this research.

6. I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. No information identifying me or indicating the fact of my participation in this study will be released without my permission. A statistical report of the results of this research project/study may be disclosed in a scientific paper, however, participants will not be identified by name.

7. I understand that the only foreseeable risks or discomforts to me as a result of participation in this study may be a feeling of boredom during the procedure or a feeling of not doing well. I understand that there is nothing unusual about these feelings and that I may discuss any perceptions and feelings that I have about the research with the interviewer if I so desire.

8. I understand that the benefits to me or to others, which may be reasonably expected from the research, are: a chance to contribute to the understanding of how important psychological processes change with age.

9. I understand that I will receive course credit or extra credit and if applicable, monetary compensation for my participation. I further understand that the primary costs I will incur as a result of participating in this research are in time spent with the interviewer -- approximately one to four hours are required to complete all tasks.

10. I understand that my participation in this research study is voluntary, that my refusal to participate will involve no penalty or loss of benefits to which I might be otherwise be entitled and that I may discontinue my participation at any time without penalty or loss of credits already obtained.

S

11. I understand that my current class standing and grade will not be affected by my decision to withdraw from this research study.

12. I understand that there are no anticipated circumstances under which my participation may be terminated by the investigator without regard to my consent.

13. I understand that significant new findings developed during the course of this research but prior to my own participation, and which may relate to my willingness to continue participation, will be provided to me prior to my beginning the task.

14. I have had an opportunity to ask _____ questions about the research project. I understand that I may contact Dr. Sharon Mutter, tel. (270) 745-4389 for additional information about this research and for any questions I might have concerning the conduct of this study.

15. I have received a signed copy of this consent form.

Signature of Participant _____

Witness _____

Date and Time _____

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY THE WESTERN KENTUCKY UNIVERSITY HUMAN SUBJECTS REVIEW BOARD (HSRB).

Sean Rubino, MPA, Compliance Manager, (270) 745-2129

Appendix C

C

INFORMED CONSENT TO PARTICIPATE IN RESEARCH PROJECT/STUDY

Name of project/study: Age Differences in Judgment and Decision Making

1. I, _____, agree to participate in a research project conducted by scientists at Western Kentucky University. I understand that the project involves research and that the purpose of the research is to study how the process of making judgments and decisions varies across the life span.

2. I understand that the procedures to be followed are: I will first complete questionnaires concerning my background (e.g., age, education, and income) and general health. I will then be administered several tasks designed to assess my ability to make judgments and perform related mental operations. I understand that the judgment task that I am given will be simple and well within my ability to complete. I will also be administered tasks that measure cognitive abilities such as my vocabulary and the extent of my general knowledge. All of these tasks will be drawn from standard psychological test batteries and from published psychological studies.

I understand that these tasks and questionnaires will be administered to me in the Cognition Laboratory at Western Kentucky University.

3. I understand that I may decline to answer specific questions in any of the questionnaires administered in this study if I so choose and that by completing these questionnaires I give my consent for use of these data by the researchers.

4. I understand that the tasks and questionnaires that will be administered in this study are experimental in nature. They are not related to my ability to carry out normal daily activities or job-related duties.

5. I understand that my scores on the tasks in this study will be available only to researchers who are associated with this study. I also understand that my scores will be combined with those of other participants to obtain group scores and that information on group performance will be available to me, if I so desire, in written reports of the results of this research.

6. I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. No information identifying me or indicating the fact of my participation in this study will be released without my permission. A statistical report of the results of this research project/study may be disclosed in a scientific paper, however, participants will not be identified by name.

7. I understand that the only foreseeable risks or discomforts to me as a result of participation in this study may be a feeling of boredom during the procedure or a feeling of not doing well. I understand that there is nothing unusual about these feelings and that I may discuss any perceptions and feelings that I have about the research with the interviewer if I so desire.
8. I understand that the benefits to me or to others which may be reasonably expected from the research are: a chance to contribute to the understanding of how important psychological processes change with age.
9. I understand that I will receive monetary compensation for my participation. I further understand that the primary costs I will incur as a result of participating in this research are in time spent with the interviewer -- approximately one to four hours are required to complete all tasks.
10. I understand that my participation in this research study is voluntary, that my refusal to participate will involve no penalty or loss of benefits to which I might be otherwise be entitled and that I may discontinue my participation at any time without penalty or loss of benefits to which I am otherwise entitled.
11. I understand that the consequences of my decision to withdraw from the research study and the procedures for orderly termination of my participation are: none.
12. I understand that the anticipated circumstances under which my participation may be terminated by the investigator without regard to my consent are: none.
13. I understand that significant new findings developed during the course of this research, which may relate to my willingness to continue participation, will be provided to me.
14. I have had an opportunity to ask _____ questions about the research project. I understand that I may contact Dr. Sharon Mutter, tel. (270) 745-4389, for additional information about this research and for any questions I might have concerning the conduct of this study.
15. I have received a signed copy of this consent form.

Signature of Participant _____

Witness _____

Date and Time _____