Aging and Associative and Inductive Reasoning Processes in Discrimination Learning

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AGING AND ASSOCIATIVE AND INDUCTIVE REASONING PROCESSES IN DISCRIMINATION LEARNING

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By
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AGING AND ASSOCIATIVE AND INDUCTIVE REASONING PROCESSES IN DISCRIMINATION LEARNING

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AGING AND ASSOCIATIVE AND INDUCTIVE REASONING PROCESSES IN DISCRIMINATION LEARNING

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Directed by: Sharon Mutter, Steve Hagggbloom, and Dan Roenker

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Abstract

The purpose of this study was to investigate how associative and inductive reasoning processes develop over trials in feature positive (FP) and feature negative (FN) discrimination learning. Younger and older adults completed initial and transfer tasks with either consistent or inconsistent transfer. Participants articulated a rule on every trial. The measure of discrimination learning was the number of trials it took participants to articulate the exact rule.

In the initial task, older adults articulated the rule more slowly than younger adults in FP discrimination and took marginally more trials to articulate the rule in FN discrimination than younger adults. Age differences were greater in FP discrimination than in FN discrimination learning because younger adults performed well in FP discrimination learning. In the transfer task, older adults articulated the FP rule more slowly than younger adults and both groups articulated the rule more quickly with consistent than inconsistent transfer. Older adults articulated the FN rule slower than older adults. The differences in trials to articulate the FN rule for the two groups were somewhat larger for inconsistent transfer than consistent transfer.

Discrimination learning was explained in terms of associative and inductive reasoning processes reasonably well. The measure of associative processes was forgotten
responses, whereas the measures of inductive reasoning processes were irrelevant cue
shifts and perseverations. In FP discrimination learning in the initial task, older adults
had a greater proportion of forgotten responses, irrelevant cue shifts, and marginally more
perseverations than younger adults. Therefore, older adults had more difficulty with
associative and inductive reasoning processes than younger adults in FP discrimination.

In FN discrimination, older adults had a greater proportion of forgotten responses
than younger adults. Older and younger adults had a similar number of irrelevant cue
shifts and perseverations. Therefore, in FN discrimination older adults had more
difficulty with associative processes than younger adults. Both groups had difficulty with
inductive reasoning processes.

In FP discrimination in the transfer task, older adults had a greater proportion of
forgotten responses, irrelevant cue shifts, and perseverations than younger adults, and
these proportions were similar in consistent and inconsistent transfer. Therefore, in FP
discrimination older adults had more difficulty than younger adults with both associative
and inductive reasoning processes. Both processes were similar with regards to
consistent and inconsistent transfer.

In FN discrimination, older adults had a greater proportion of forgotten responses
than younger adults, and the proportion of forgotten responses was greater in inconsistent
than in consistent transfer. Both groups made a similar number of irrelevant cue shifts,
and there was a marginal difference in consistent and inconsistent transfer for this
measure with a greater number in inconsistent transfer. Older adults had a greater
proportion of perseverations than younger adults. However, there were no differences in
the number of perseverations for consistent and inconsistent transfer. Thus, older adults
had difficulty with associative and inductive reasoning processes. Younger adults’ inductive reasoning skills improved. The associative and inductive reasoning processes in FN discrimination were not as efficient in inconsistent transfer as in consistent transfer.
CHAPTER 1

Introduction

Learning cue-outcome relationships is an important cognitive ability that underlies other cognitive tasks such as hypothesis testing (e.g., Klayman & Ha, 1987) and social attribution (e.g., Fazio, Sherman, & Herr, 1982). Most people seem to focus on cue occurrence rather than cue nonoccurrence in predicting outcomes. However, the absence of a cue can be just as important as the presence of a cue. For example, in consumer decision-making what is not said in an advertisement may be just as important as what is said, and in medical diagnosis the absence of a symptom can provide as much information as the presence of a symptom.

Older adults' ability to use cue nonoccurrence information in contingency judgment has been investigated in several studies. Making contingency judgments involves learning the probability that the presence or absence of a cue predicts an outcome. In a positive contingency, the presence of a cue predicts outcome occurrence, and in a negative contingency, the absence of a cue predicts outcome occurrence. Studies of contingency judgment indicate that increased age is associated with greater declines in the ability to use the nonoccurrence of an event as a predictive cue than the occurrence of an event (Mutter & Pliske, 1996; Mutter & Williams, 2004).

Contingency judgment is a difficult task because it requires the acquisition of multiple relationships and the integration of that information into a numerical representation. The age differences could be due to the processes involved in the task or the difficulty of the task. Therefore, Mutter, Haggbloom, Plumlee, and Schirmer (2006) conducted a study to determine whether older adults’ difficulties in contingency learning
tasks are due to a basic learning deficit or a difficulty in more complex judgment processes. They used a discrimination-learning task that is much simpler than the contingency judgment task. In their discrimination task, a series of stimulus displays containing four symbols were presented in pairs in left- and right-hand columns. The participants' task was to discover the rule that determined which pair was correct. In feature positive (FP) discrimination learning, the correct pair was the symbol pair containing a distinctive feature, and in feature negative (FN) discrimination learning, the correct pair was the symbol pair not containing this distinctive feature. These tasks typically result in significantly better learning for the FP than the FN condition, a result called the feature positive effect (FPE). The FPE is a robust phenomenon that has been obtained in animals (Hearst, 1988; Jenkins & Sainsbury, 1970), children (Bitgood, Segrave, & Jenkins, 1976; Norton, Muldrew, & Strub, 1971; Sainsbury, 1971; Sainsbury, 1973) and young adults (Nallan et al., 1981; Newman, Wolff, & Hearst, 1980).

In the Mutter et al. (2006) study, older, younger, and working memory loaded younger participants completed initial and transfer discrimination tasks with either consistent transfer, in which participants experienced FP or FN discrimination problems in both tasks (FP-FP, FN-FN), or inconsistent transfer, in which participants received FP discrimination learning in the initial task and FN discrimination learning in the transfer task or FN discrimination learning in the initial task and FP discrimination learning in the transfer task (FP-FN, FN-FP). Participants were told that there was a rule that determined which stimulus display was correct and their task was to try to discover that rule. Feedback was given after the participants made their choice. The number of trials it took participants to articulate a successful rule was measured. In the initial task, the FPE
occurred for all participants, but older adults and working memory loaded younger adults had more difficulty with both FP and FN learning than younger adults. There was no FPE for young adults in the transfer task, however, there was a FPE for older and working memory loaded younger adults. In the transfer task, younger adults articulated the FN rule as quickly as the FP rule, whereas older adults and working memory loaded younger adults articulated the FN rule more slowly than the FP rule. Older adults and working memory loaded younger adults were slower at both initial FP and FN discrimination, but with additional experience, they improved at FP but not FN learning (Mutter et al., 2006).

Discrimination learning in humans can involve both associative and inductive reasoning processes. Several studies have shown that working memory deficits are associated with decline in older adults’ inductive reasoning abilities (Babcock, 1994; Rhodes, 2004; Salthouse & Prill, 1987). Mutter et al. (2006) therefore suggested that due to age-related working memory decline, older adults might be less effective in using inductive reasoning processes and that this could be especially detrimental in FN discrimination learning.

In both FP and FN discrimination learning, associations are made between the outcome and most predictive cue. In FP discrimination, the distinctive feature is more predictive of the outcome than the common features. In FN discrimination, the common or background features are more predictive than the distinctive feature, and successful performance occurs only when a response is made when the distinctive feature is absent. Studies with animals (Jenkins & Sainsbury, 1970) and children (Sainsbury, 1971; Sainsbury, 1973) show support for the contribution of these associative processes to FN
learning. However, there is also evidence for inductive reasoning processes in children's discrimination learning (Bitgood et al., 1976; Sainsbury, 1973;) and from studies showing that young adults can transfer their initial discriminations to new problems (Nallan et al., 1981; Newman et al., 1980). Inductive reasoning involves forming hypotheses and evaluating them based on the feedback that is received. A correct response in FP discrimination restricts the set of hypotheses participants are concerned with while an incorrect response is used to test a hypothesis that was kept from a previous trial. However, in FN discrimination learning, correct responses lead participants to hypotheses that are wrong. An incorrect response can be used to discard a hypothesis retained from a prior trial, but it does not help participants determine the correct hypothesis. Therefore, inductive reasoning is more difficult in FN discrimination than in FP discrimination and may be especially difficult for individuals with impaired working memory.

The current study examined the contribution of associative and inductive reasoning processes to younger and older adults' FP and FN discrimination learning by investigating how their hypotheses evolved over trials. As in Mutter et al. (2006), younger and older adults completed FP or FN discrimination learning in the initial task and FP or FN discrimination learning in the transfer task. The transfer task can reveal whether younger and older participants learned a general rule in initial discrimination learning that could be transferred to new stimuli in transfer discrimination.

Participants' responses on each trial were also analyzed. Specifically, the stimulus displays were linked to the participants' responses on every trial. For the associative processes, a participant's response was categorized as a forgotten response if he or she gave an incorrect response for a given stimulus pair after having previously
seen that stimulus pair. The proportion of the total number of forgotten responses to the total number of opportunities to forget was calculated for each of the three pairs of symbols containing the distinctive feature. The overall proportion of forgotten responses was obtained by calculating the average of the three proportions. In the initial and transfer tasks, it was expected that older adults would have more forgotten responses than younger adults in both discrimination conditions. The proportion of forgotten responses should be greater in inconsistent transfer than in consistent transfer for both discrimination conditions.

For the inductive reasoning processes, participants' hypotheses were categorized according to irrelevant and relevant cue shifts, perseverations, and confirmation tests. The proportion of irrelevant cue shifts was obtained by calculating the total number of irrelevant cue shifts before the rule divided by the total number of cue shifts before the exact rule (relevant plus irrelevant). The proportion of perseverations was obtained by calculating the total number of perseverations before the rule divided by the total number of times the hypothesis was repeated before the exact rule (confirmation tests plus perseverations). In the initial task, it was expected that older adults would have a greater proportion of irrelevant cue shifts and perseverations than younger adults in both discrimination conditions.

In the transfer task, older adults should once again have a greater proportion of irrelevant cue shifts and perseverations than younger adults in both discrimination conditions. The proportion of irrelevant cue shifts and perseverations should be greater in inconsistent than consistent transfer for both discrimination conditions.
CHAPTER 2

Literature Review

Discrimination learning involves learning which stimulus in the environment predicts reinforcement. Feature positive (FP) discrimination learning refers to situations in which the presence of a distinctive feature predicts reinforcement and feature negative (FN) discrimination learning refers to situations in which the absence of a distinctive feature predicts reinforcement. Substantially slower discrimination learning in the FN condition compared to the FP condition is called the feature positive effect (FPE) (Hearst, 1991; Jenkins & Sainsbury, 1970).

The FPE was first shown using animals. Jenkins and Sainsbury (1970) examined this discrimination learning effect in pigeons by constructing asymmetrical displays that had common and distinctive features. They assigned the distinctive feature to either positive or negative trials. Specifically, if the distinctive feature was on a positive trial, the pigeon would be reinforced for pecking the stimulus display that contained the feature, and if the distinctive feature was on a negative trial, the pigeon would be reinforced for pecking the stimulus display that did not contain the feature. Discrimination learning was substantially better in the FP condition than in the FN condition. Also, in the FP condition, pigeons pecked at the distinctive feature, whereas in the FN condition, pigeons had a tendency to peck in areas away from the distinctive feature.

The FPE is very robust although many variables influence the size of the effect. Pace and McCoy (1981) investigated how requiring a response to both the distinctive feature and the common features of the stimulus display affected the FPE in pigeons.
the control group, the operant key was presented immediately after the simultaneous illumination of two stimulus keys. In the FP condition, these keys were illuminated red and green, with the feature being red. In the FN condition, the two stimulus keys were illuminated green. Therefore, in the control group, the presentation of the operant key occurred independently of the pigeons' behavior. In the experimental group, the stimulus keys were illuminated and the pigeons had to peck both keys prior to the presentation of the operant key. In other words, the presentation of the operant key was dependent upon these pigeons' responses to the stimulus displays. FP discrimination learning was better than FN learning only for the control group. A comparison between the experimental and control groups showed that there was no significant difference between the groups in FP discrimination learning, but performance in FN discrimination learning was better for the experimental group. The experimenters noted that the pigeons in the control group engaged in sign tracking, where they track the best signal of reinforcement. Preventing sign tracking in the experimental group of FN pigeons was probably the reason the FPE was not obtained with them.

In another study, Nallan, Pace, McCoy, and Zentall (1979) examined the temporal parameters of the FPE. In the FP condition, pigeons that pecked the response key when it was illuminated with a dot (the distinctive feature) received reinforcement, and pigeons that pecked at a plain white response key did not receive reinforcement. In the FN condition, pigeons that pecked at a plain white response key received reinforcement and pigeons that pecked at the response key illuminated with a dot did not receive reinforcement. All reinforcement was given according to a variable interval (VI) 60-second schedule. The duration of the trials and the intertrial intervals (ITI) were varied
between groups of pigeons. One group of pigeons had a trial duration and ITI of five seconds, another group had a trial duration of five seconds and an ITI of 30 seconds, a third group had a trial duration and ITI of 30 seconds, and the last group had a trial duration of 30 seconds and an ITI of 180 seconds. Those pigeons that received a trial duration and ITI of five seconds or a trial duration of five seconds and an ITI of 30 seconds had 36 sessions of discrimination training. Pigeons that had a trial duration and an ITI of 30 seconds or a trial duration of 30 seconds and an ITI of 180 seconds received six sessions of discrimination training. All of the pigeons received the same number of trials per day. Therefore, varying the number of sessions made the groups equal in terms of amount of stimulus exposure and reinforcement. Nallan et al. found that the FP pigeons learned faster when the trial duration was short, but variation in the ITI did not have a significant effect on FP or FN discrimination learning. When the trial duration was long, a FPE was not found despite the length of the ITI. These results suggest that the FPE is stronger with a short trial duration.

Reberg (1978) investigated the effects of compound stimulus arrangements on FP and FN discrimination learning. Groups of rats were trained to discriminate simultaneous (darkness and noise presented at the same time) or sequential compounds (a 1-min presentation of noise preceded a 1-min presentation of darkness, so the offset of noise coincided with onset of darkness) from a single stimulus (darkness). Simultaneous or sequential compounds signaled shock in the FP condition and signaled no shock in the FN condition. Discriminations were learned more rapidly when the compound stimulus signaled shock for both simultaneous and sequential discriminations (FP). However, when the rats were trained with the sequential compound signaling reinforcement, weak
and unstable differential suppression was produced, and when trained with the sequential compound not signaling reinforcement, the rats did not learn the discrimination. This weak FPE for sequential discrimination could be due to the longer trial duration in this condition than in the simultaneous discrimination condition (Nallan et al., 1979).

The size of the common and distinctive features can also influence the FPE. Morris (1977) investigated the effects of changing the spatial relationship between the distinctive features and common features. A FPE was found when discrimination training consisted of a small distinctive feature and a large common feature. The learning rate of pigeons in the FN condition decreased as the size of the feature decreased relative to the size of the common features; however, the learning rates of those in the FP condition were not affected. In a second experiment, Morris also examined the spatial relationship between the distinctive and common features, but held the relationship between the stimulus components and the locus of response constant. These results were consistent with the first experiment suggesting that FN learning rates are influenced by the spatial relationships between the distinctive and common features during observation of the stimulus display. The smaller the size of the distinctive feature relative to the common features, the slower FN learning occurred.

The proximity of the displays is important as well. Sainsbury (1971) conducted a study with pigeons to find out whether spatial proximity of features is advantageous for FN discrimination learning as compared to FP discrimination learning and whether proximity leads to discrimination based on the entire pattern of elements or to a greater influence of one feature on another. Half of the pigeons were presented stimulus displays where the distinctive feature was in close proximity to the common features of the
display (compact displays), and the other half were presented displays where the distinctive feature was not in close proximity to the common features of the display (distributed displays). For half of the pigeons, responses to displays containing the distinctive feature were reinforced (FP), and for the other half, responses to displays not containing the distinctive feature were reinforced (FN). For FP discrimination, pigeons localized their responses on the distinctive features for both compact and distributed displays. Pigeons in the distributed FN condition localized their responses on the common features of the displays, but did not learn the discrimination. With the compact displays, FN discrimination learning was better, but a FPE still occurred.

The FPE also occurs with humans. Norton, Muldrew, and Strub (1971) conducted a study with nursery school children and adults to determine if the FPE occurs in species other than pigeons. In their first study, children were instructed to point to “good” pictures to receive money that could later be exchanged for a chocolate bar. In the FP condition, a white dot on a black circle was “good” while the black circle presented alone was “not good.” In the FN condition, the black circle alone was “good” and the black circle with the white dot on it was not. The children learned the FP discrimination better than the FN discrimination. Norton et al. conducted a second study with adults using the same stimuli and procedure as before. Once again, a FPE was found.

Bitgood et al. (1976) examined the effect of explicit verbal feedback for incorrect responses in FP and FN conditions using three- to five-year-old children. Participants were instructed to find the “good display” and touch it. The stimulus displays contained black triangles and squares, one in each quadrant, with the triangle being the distinctive
feature. Each time the “good display” was picked, they received a poker chip, and all of the poker chips obtained were exchanged for a toy at the end of the experiment. There were two conditions: a yes-blank condition and a yes-no condition. In both conditions, each correct response was followed by verbal feedback such as “good” or “that’s right” and a poker chip. For each incorrect response, the experimenter said nothing in the yes-blank condition and said “no” or “that is wrong” in the yes-no condition. With explicit feedback for incorrect responses, all participants solved the FP task with very few errors and increased responding to the distinctive feature. In the FN task, explicit feedback for incorrect responses increased responding to the common features and avoidance of the distinctive feature. However, fewer participants solved the FN task and participants in the FN condition solved the task with many more errors. When incorrect responses were not accompanied by explicit feedback, there were frequent failures to solve both the FP and FN tasks. Therefore, using explicit feedback with children in discrimination learning is beneficial.

Newman, Wolff, and Hearst (1980) conducted a series of experiments that demonstrated the FPE in college students. In the first experiment, a successive discrimination procedure was used. The stimuli consisted of index cards presented one at a time that contained four symbols each, with a triangle as the distinctive feature. Cards containing the triangle were “good” in FP discrimination, and cards not containing the triangle were “good” in FN discrimination. A clear FPE was found. In the second experiment, a simultaneous discrimination procedure was used, and the stimuli consisted of meaningless combinations of three letters (trigrams). Cards were presented one at a time, and each card had two trigrams on it. For half of the participants in each of the FP
and FN conditions, the feature was a vowel, and for the other half, the feature was a consonant. Therefore, in the FP condition, the stimulus displays that contained the letter “A” or “T” were correct, whereas, in the FN condition, the stimulus displays that did not contain the letter “A” or “T” were correct. It did not matter whether the feature was a consonant or a vowel, the FPE still occurred. When asked, participants reported that they focused on information in the positive trigram and ignored the information in the negative trigram. Therefore, a delayed feedback condition was added. The stimuli were the same as those used in the consonant group, but each card was removed from sight for five seconds before the experimenter provided feedback by stating whether the participants’ response was correct or incorrect. A FPE still occurred. In experiment three, the experimenters used a display that was similar to displays used in research with animals. The stimuli were trigrams, but either one or two letters in the trigram appeared on every trial. Participants first completed a simultaneous discrimination and then a successive discrimination. The simultaneous discrimination involved the same consonant-trigram discrimination as in experiment two, except that all the trigrams contained the letter “J” and the feature was “N.” One trigram appeared on each card and contained the letters “R” and “B” and a third letter that was either the feature (T) or one of the other 17 consonants. A FPE was obtained for both the simultaneous and successive discriminations. Newman et al. (1980, Experiment 6) used stimulus materials closer to everyday objects, such as line drawings of boats, houses, and locomotives. All stimulus materials remained the same except for the presence or absence of a distinctive feature, which was smoke rising from the chimney or smokestack on one of the pictures. In the FP condition, the presence of smoke indicated that a light would follow and the
absence of smoke indicated that the light would not follow. In the FN condition, the absence of smoke indicated that the light would follow and the presence of smoke indicated the light would not follow. Participants were asked to learn to predict when the light would follow the stimulus display. A poker chip was delivered for correct predictions about the occurrence and the nonoccurrence of light. A FPE still occurred. These experiments therefore demonstrate that the FPE occurs with humans in many different situations using different types of stimuli, reinforcers, and general procedures.

Richardson and Massel (1982) further examined the parameters of the FPE in adult humans. Their stimuli consisted of cards with trigrams on them, with the distinctive feature being the letter “A”. In the FP condition, the trigram that contained the letter “A” was “good” and the trigram that did not contain the letter “A” was “not good.” In the FN condition, the trigram that did not contain the letter “A” was “good” while the display that contained the letter “A” was “not good.” The experimenters found that the FP group produced the correct solution much faster than the FN group and had fewer incorrect trials than the FN group. In a second study, Richardson and Massel examined whether a FPE would occur when participants received both FP and FN trials randomly mixed. The same trigrams were used; however, the background color was blue on half of the cards and was orange on the rest of the cards, which indicated the FP and FN conditions, respectively. The distinctive feature on all cards was “A.” Therefore, when presented a blue card, the trigram containing the “A” was the correct response, and when presented the orange card, the trigram not containing the “A” was the correct response. There were no significant differences between the FP and FN condition, which indicates that a FPE was not found. This could be due to the use of the same distinctive features in the FP and
FN condition. Therefore, in experiment three, Richardson and Massel used two different distinctive features for the FP and FN conditions. The distinctive feature on the blue cards was an “A” but the distinctive feature on the orange cards was “E.” This time, a FPE was observed. These results suggest that the FPE can be observed with trials randomly mixed; however, separate distinctive features must be used for FP and FN conditions. This could be because it requires a new discrimination, not just the reversal of discriminations.

In summary, the FPE has been found in animals (Hearst, 1988; Jenkins & Sainsbury, 1970) and humans (Bitgood, Segrave, & Jenkins, 1976; Norton et al., 1971; Richardson & Massel, 1982). Many variables affect the size of the FPE including stimulus contact (Pace & McCoy, 1981), temporal parameters (Nallan, Pace, McCoy, & Zentall, 1979), compound stimuli arrangements (Reberg, 1978), the size of distinct and common features (Morris, 1977), and the effects of proximity (Sainsbury, 1971). Different types of stimuli, reinforcers, and procedures influence the size of the FPE in humans (Bitgood et al., 1976; Newman et al., 1980; Norton et al., 1971; Richardson & Massel, 1982). Nevertheless, the basic effect is quite robust and generalizes to many situations.

Theoretical Accounts for the FPE

Associative Processes

Jenkins and Sainsbury (1970) suggested that the FPE could be explained in terms of a search theory or a simultaneous discrimination theory. According to search theory, reinforcement increases the probability of search for the distinctive feature in the FP condition more than in the FN condition. Also, non-reinforcement decreases the
probability of search for the distinctive feature more so in the FN condition than the FP condition. The simultaneous discrimination theory is an associative theory, which suggests that any representation of an event, whether an external stimulus or action, can be associated with the representation of any other event, such as an external stimulus, the reinforcer, or the animal’s own actions (Mackintosh, 1997). In both FP and FN discrimination learning, associations are made between the outcome and the most predictive cue. In FP discrimination learning, the distinctive feature is more predictive of the outcome \[p(O) = 1.00\] than the common features \[p(O) = .50\]. This is because the distinctive feature appears on every correct or reinforced trial, whereas the common features appear on only half of the correct trials. In FN discrimination learning, the common features are more predictive of the outcome than the distinctive feature. However, successful discrimination in the FN condition requires learning a conditional discrimination; i.e., responding to these features only when the distinctive feature is absent (Jenkins & Sainsbury, 1970). Therefore, in FP discrimination, the animal must learn to choose the display that contains the distinctive feature, and in FN discrimination, the animal must learn to choose the display containing the common features if the distinctive feature is not present.

**Evidence for Associative Processes**

Studies with animals provide support for the associative theory. Animals localize their responses on the most predictive cues. For example, the peck location data of the pigeons in Jenkins and Sainsbury (1970) indicated that the animals in the feature positive condition pecked at the feature, and for the most part, animals in the FN condition avoided the distinctive feature and pecked at the common features. Jenkins and
Sainsbury designed another experiment in an attempt to find out which theory (search or simultaneous discrimination theory) best explained the FPE. The experimenters examined whether the distinct feature was avoided and attention was drawn to the common features in the FN condition. They found that the FP pigeons pecked directly at the feature, and FN pigeons pecked at the common features that were present in both FP and FN displays. These results cannot be explained by the search theory, which suggests that there are distinctive and common features, but the two types of features are not differentiated from each other at the onset of a trial. The search theory also suggests that the distinctive feature is not attended to in the FN condition. If the search theory could explain the results, the pigeons would have pecked at the common features even if the distinctive feature was present. However, the pigeons pecked at only the common features of the display even though the distinctive feature was sometimes paired with the common features. However, the simultaneous discrimination theory suggests that the distinctive and common features are available immediately. In the FP condition, the pigeons avoid the common features and peck at the distinctive feature, and in the FN condition, the pigeons peck at the common features and avoid the distinctive features. Therefore, the simultaneous discrimination theory, which is an associative theory, explains the FPE the best.

The other animal studies that were previously discussed can also be explained in terms of associative theory. For example, in FP discrimination, Pace and McCoy (1981) found that there was no significant difference between their experimental group that was required to peck both keys prior to the presentation of the operant key and their control group that was required to peck the key that provided reinforcement. However,
performance in FN discrimination was better for the experimental group than the control group. This suggests that the pigeons were not able to learn to peck the most predictive cue in FP (distinctive feature) and FN (common features) discrimination learning which eliminated the FPE. Nallan et al. (1979) found that FP pigeons learned faster when the trial duration was short regardless of the length of the ITI. A short trial duration would lead to pigeons’ receiving reinforcement quickly. Associative learning occurs much faster when reinforcement is given immediately after a response. Therefore, the shorter trial durations in the FP condition aid in the development of the FPE. Reberg (1978) found that discriminations were learned more rapidly in the FP condition than in the FN condition for both simultaneous and sequential compounds. When the rats were trained with the sequential compound and it signaled reinforcement, weak and unstable differential suppression occurred, and when the sequential compound did not signal reinforcement, the rats did not learn the discrimination. Since the trial duration was longer in the sequential discrimination condition than in the simultaneous discrimination condition, learning did not occur as quickly because reinforcement was not given right after the response. Morris (1977) found that the smaller the size of the feature relative to the common features, the slower FN learning occurred. According to associative theory, animals peck at the feature in FP discrimination and they peck at the common features in FN discrimination. Since the common features are large compared to the distinctive feature, the distinctive feature is even less salient. Thus responding continues even on displays containing the distinctive feature, decreasing FN learning and contributing to the FPE. Finally, Sainsbury (1971) found that pigeons in the distributed FN condition (the distinctive feature was not in close proximity to the common features of the display)
localized their responses on the common features of the display and did not learn the discrimination. Pigeons that received compact displays performed better on FN discrimination problems. Once again, going along with associative theory, it is possible that the pigeons performed better in FN discrimination with compact displays because the distinctive feature was more salient.

Additional support comes from studies with children. Sainsbury (1971) conducted a study with 4-year-old children using a simultaneous discrimination task. There were two symbols, which included a square and a triangle. One of these symbols served as the distinctive feature and the other symbol represented the common features of the display. A tape of nursery rhymes was played for 4 seconds after a correct response. The experimenter recorded the number and location of the responses. All the children in the FP condition learned the discrimination, but only one child in the FN condition learned the discrimination. Also, children in the FP condition pointed to the distinctive feature, while children in the FN condition localized responding on the common features regardless of which symbols served as the distinctive feature and common features. This suggests young children are using associative processes to learn the FP discrimination, but are unable to learn the conditional discrimination in the FN condition.

Sainsbury (1973) then conducted an experiment with three groups of four-, seven-, and nine-year-old children. The stimuli consisted of stimulus displays containing triangles and squares. For half of the participants, the triangle was the distinctive feature and the squares were the common features, and for the other half of the participants, a square was the distinctive feature and triangles were the common features. The learning criterion was set at 90% correct. In the four-year-old group, five of the six participants
met criterion in the FP condition, and none of the participants met criterion in the FN condition. In the seven-year-old group, all participants in the FP condition reached criterion while half of the FN participants met the criterion. In the nine-year-old group, all participants in the FP condition met criterion, and five of the six in the FN condition met criterion. When comparing this study to that of Sainsbury (1971), the performance of the four-year-old children in both studies was similar. The performance of the seven-year-old children in Sainsbury (1973) was also similar to that of the four-year-old children in both studies. The children were making associations involving the most predictive cues in both the FP and FN conditions. However, the seven-year-old children performed somewhat better on FN discrimination learning than the four-year-old children, and the nine-year-old children performed well on FN discrimination learning. These findings indicate that the older children may have used an additional process to learn the FN discrimination. This process may have been inductive reasoning as the ability to complete more complex tasks that require the use of inductive reasoning processes increases with age (Small, 1990). This suggests that older children's more effective inductive reasoning processes allowed them to perform successfully on FN discrimination learning. In contrast, the younger children had not yet developed the inductive reasoning processes needed to solve the more complex FN discrimination condition.

**Inductive Reasoning Processes**

According to Newman et al. (1980) and Levine (1966), inductive reasoning processes are important in human discrimination learning. Inductive reasoning involves forming a hypothesis, evaluating it, and revising the hypothesis when needed. People
form hypotheses about events through experience and use evidence they gather to test
and revise them. Inductive reasoning depends on the ability to integrate multiple
relations and inhibit irrelevant information (Viskontas, Morrison, Holyoak, Hummel, &
Knowlton, 2004). With FP and FN discrimination learning, humans use the most
predictive cue to generate or select a hypothesis based on the presence or absence of a
cue and can infer there is a correct rule (Newman, Wolff, & Hearst, 1980). More
specifically, participants generate hypotheses and keep or reject them based on the
feedback that is received (Levine, 1966). A correct response in FP discrimination
learning restricts the set of hypotheses participants are concerned with while an incorrect
response is used to test a hypothesis that was kept from a previous trial. However, in FN
discrimination learning, correct responses led participants to hypotheses that are wrong.
This is because an incorrect response can be used to discard a hypothesis retained from a
prior trial, but it does not help participants determine the correct hypothesis.

Evidence for Inductive Reasoning Processes

In the Sainsbury (1973) study, older children used the presence of the distinctive
feature as a cue for where not to respond. This shows that they were able to form a
general rule that could be applied to the learning condition. In addition, Bitgood et al.
(1976) provided verbal feedback, which could have prevented effective inductive
reasoning in both FP and FN discrimination learning. Therefore, the FPE occurred.

Also, findings that show humans can transfer their initial discriminations to new
problems support the idea that inductive reasoning occurs in human discrimination
learning. They can come up with a general rule that can be transferred to a new
discrimination. Newman et al. (1980, Experiment 4) conducted a study with college
students who received the same stimuli across discrimination conditions. The authors examined the frequency and location of key presses to measure discrimination learning and found that those who received an initial FP discrimination quickly learned a subsequent FN discrimination, but those who received an initial FN discrimination had much more difficulty with learning a FP transfer discrimination task. According to Newman et al., this was because in FP discrimination learning a general rule was formed that could be transferred to FN discrimination learning. However, when there was an initial FN discrimination, participants were less able to discover a rule or had difficulty transferring their rule to the transfer task.

In another study providing evidence for inductive reasoning in FP and FN discrimination learning, Nallan et al. (1981) replicated the Newman et al. (1980) procedure, with the exception that the stimuli used in the initial and transfer tasks were different and they used both consistent and inconsistent transfer. The measure of discrimination learning was the trial on which the participant articulated the correct rule. College students performed a FP or FN discrimination task using colors or symbols and then performed a FP or FN transfer task, such that if the participant had symbols in the initial task, they had colors in the transfer task and vice-versa. The type of transfer was also manipulated. In the consistent transfer condition, participants experienced FP discrimination problems in both the initial and transfer tasks or FN discrimination problems in both tasks. In the inconsistent transfer condition, participants completed FP discrimination learning in the initial task and FN discrimination learning in the transfer task or FN discrimination learning in the initial task and FP discrimination learning in the transfer task. At the end of the initial task, the participants were given the correct rule.
The procedure in Experiment 2 was identical to that in Experiment 1 except that the participants were not told whether their rules were right or wrong after the initial task. In both experiments, the FP groups learned significantly faster than the FN groups. Also, consistent transfer led to better performance on the transfer task than inconsistent transfer. Initial experience with FP or FN discrimination learning led to the development of a problem solving strategy or abstract rule that improved the same type of discrimination learning in the transfer task. This conclusion is strengthened because the use of different stimuli rules out the possibility of participants generalizing the rule in the initial task to the transfer task.

Lastly, Mutter et al. (2006) provided evidence for inductive reasoning in a study that examined the impact of age differences and working memory deficits on FP and FN discrimination learning. Working memory is defined as the temporary retention of items while processing information (Baddeley, 1992). A decline in working memory will affect the ability to manage multiple things at one time, and since inductive reasoning requires simultaneously manipulating, recoding, and reorganizing hypotheses in working memory (Cohen, 1981), a decline in working memory should adversely affect inductive reasoning processes in discrimination learning. Three groups of participants including older adults, younger adults, and working memory loaded younger adults participated in the study. The type of transfer (consistent versus inconsistent) was manipulated as in Nallan et al. (1981). The measure of discrimination learning was the number of trials it took participants to articulate a successful rule. The stimulus displays contained four symbols, with different symbols used in the initial and transfer tasks. They were arranged in left- and right-hand pairs in columns. One set of symbols consisted of a triangle, square, club,
and heart, with the triangle as the distinctive feature. Therefore, in FP discrimination learning, the pair of symbols containing the triangle was the correct response and the symbol pair not containing the triangle was incorrect. In FN discrimination learning, the symbol pair not containing the triangle was the correct response while the symbol pair containing the triangle was incorrect. The other set of symbols consisted of a spade, diamond, circle, and cross, with the spade as the distinctive feature. The FP and FN conditions were defined as above except with the presence or absence of the spade. The working memory loaded younger adults viewed a seven-digit number string prior to viewing the stimulus display, which they had to recall after making their selection.

In the initial task in Mutter et al. (2006), there was a FPE with each group’s performance better on the FP discrimination task than on the FN discrimination task. Also, younger participants articulated the rule faster than older and working memory-loaded younger adults for both FP and FN discrimination learning. The similar performance of older participants and memory-loaded younger participants suggests that impaired working memory capacity due to either age or concurrent working memory load in younger adults led to performance decline for both FP and FN discriminations. In the transfer task, younger participants articulated the FN rule as quickly as the FP rule, and older and working memory loaded younger adults articulated the FN rule more slowly than the FP rule. Also, there were no group differences in the articulation of the FP rule, but older and working memory loaded younger adults took longer to articulate the FN rule than younger adults. Therefore, the FPE disappeared for the young adults and stayed for the older and working memory loaded younger adults suggesting that the associative and inductive reasoning processes are working satisfactorily in FP discrimination.
learning but are less efficient in FN discrimination learning. According to Mutter et al. (2006), inductive reasoning processes are involved in both FP and FN discrimination learning. However, because inductive reasoning processes are not as efficient in FN discrimination learning as they are in FP discrimination learning, inductive reasoning in FN discrimination learning places greater demands on working memory resources. Older adults and working memory loaded younger adults have impaired working memory, so they cannot effectively accomplish inductive reasoning in FN discrimination learning. A closer look at the transfer results provides evidence for inductive reasoning. Consistent transfer provided a benefit in both FP and FN discrimination tasks for younger adults. Inconsistent transfer resulted in differences in performance. Initial FP discrimination provided a benefit for FN transfer discrimination in younger adults, while initial FN discrimination provided no benefit in learning a transfer FP discrimination. This finding replicates the finding of Newman et al. (1980, Experiment 4). Consistent transfer for FP discrimination learning benefited older adults and working memory loaded younger adults, but inconsistent transfer of FP discrimination learning to FN discrimination learning did not. Also, both consistent and inconsistent transfer provided no benefits for older adults and working memory loaded younger adults who started with an initial FN discrimination. They were unable to learn either FP or FN discrimination in the transfer task.

**Evidence for Age Differences in Inductive Reasoning**

The findings by Mutter et al. (2006) suggest that inductive reasoning processes are needed in FP and FN discrimination learning and that due to working memory decline, older adults are less effective at using these processes in discrimination learning.
This is especially true for FN discrimination learning. Numerous other studies also show that older adults have impaired inductive reasoning abilities and that this may be due to age-related declines in working memory capacity (Rhodes, 2004; Hartman, Bolton, & Fehnel, 2001; Babcock, 1994; Salthouse & Prill, 1987; Quereshi & Smith, 1998). These studies have used a variety of inductive reasoning tasks including concept learning and series completion.

Concept Learning

According to Kellogg (1982), both automatic frequency processing and controlled hypothesis testing are involved in concept learning. Automatic processing of the frequency of exemplar features occurs unconsciously and unintentionally and is therefore not dependent upon working memory and attentional capacities. Controlled hypothesis testing occurs when people devote conscious effort to sampling, testing, and storing their hypotheses in working memory. To examine age differences in these processes, Kellogg (1983) compared fifth graders, college students, and older adults on a concept identification task in which they could both compile feature frequency information and test hypotheses. College students performed much better in estimating feature frequencies, in selecting the right hypotheses, and in accurately recalling sampled hypotheses than fifth graders and older adults. Estimation of feature frequencies and hypothesis testing was similar for fifth graders and older adults. These findings suggest that acquiring frequency information may not be automatic and more importantly, that fifth graders and older adults are less able to use inductive reasoning processes.

Inductive reasoning is also important in category learning on the Wisconsin Card Sorting Task (WCST). Rhodes (2004) conducted two meta-analyses examining age
differences on this task. The first meta-analysis looked at the number of categories achieved while the second one looked at the number of perseverative errors made. Perseverative errors occur when participants sort according to a category that was formerly correct but is no longer in effect. Results indicated that there were age-related changes on both measures. The experimenters suggested that these age differences could be the result of a decline in working memory, since they both involve a failure to keep in mind information about previous sorts while processing information for the next sort.

A study by Hartman et al. (2001) examined the role of cognitive inflexibility and reduced working memory capacity in the age-related declines on the WCST. Cognitive inflexibility refers to difficulty inhibiting inappropriate responses (Hasher & Zacks, 1988). Perseverative errors indicate the presence of cognitive inflexibility, and these errors along with the number of categories achieved were examined. Each error was classified as occurring under high or low memory demands, depending on whether the previous sort contained enough information to select the correct rule. If it did, it was considered low memory demand, and if not, it was considered high memory demand. Older adults completed fewer categories and made more errors than younger adults. Errors were more frequent during high demand conditions, indicating a significant deficit in working memory. Also, older adults perseverated on sorting principles other than the one most recently reinforced, which is inconsistent with the inflexibility hypothesis. Hartman et al. suggested that reduced working memory capacity produces a decrement in the ability to update contents of working memory and labeled this phenomenon the updating hypothesis. They further examined the updating hypothesis by creating a modified version of the WCST that provided a better opportunity for encoding and
recalling information about the completed sorts by giving cues for the outcome of the most recent sort. The cues consisted of cardboard arrows labeled “yes” and “no” and were placed above the most recent sort at the same time oral feedback was given. The arrows remained in place until the next card was sorted and were then placed appropriately above the newly sorted card. These cues improved performance for both younger and older adults, but more so for the older adults. The age differences were largely eliminated. This suggests that a decline in updating working memory could be responsible for the age differences on this test.

**Series Completion**

Age differences are also seen in series completion tasks. In a series completion task, the goal is to select an item that continues the sequence of objects, such as letter or number series. In solving these problems, participants must determine how the elements are related to one another and how the relational pattern is parsed into repeated units, which requires inductive reasoning processes. Salthouse and Prill (1987) conducted a study with younger and older adults to determine why increased age is associated with poorer performance on these letter and number problems. There were three types of series completion problems that differed in relational complexity. Participants also completed a test measuring working memory capacity, along with the letter and number series problems. They found that younger adults’ performance was better than older adults’ performance on all of the tests. Older adults were especially impaired when relations were complex or when different problems involved alternative organizational patterns, possibly due to a decline in working memory capacity. The letter and numbers series correlations with the working memory test were lower than expected; however, it was
suggested that this might be due to the reliability of the measures. A second experiment was conducted. Two different versions of the number series were given, which included simultaneous and successive presentations of the stimuli. This allowed the experimenters to study the time participants studied the elements in the series and the time it took participants to hit the key to go to the next presentation of stimuli. They did not look at the correlations with the working memory measure in this study. Once again, younger adults performed better than older adults. Participants did better when the stimuli were presented simultaneously rather than successively. Older adults were slower than younger adults, solution times increased with greater complexity, and the age difference increased with greater complexity.

Quereshi and Smith (1998) also examined inductive reasoning abilities in older adults using letter and number series. One group completed the letter series and then the number series problems and the other group completed the tasks in the reverse order. The order in which the tasks were completed did not have a significant effect on successful completion, but the number series problems were solved better than the letter series problems. According to Quereshi and Smith, successful performance on the letter series problems requires an extra step of translating the letter of the alphabet into its numerical equivalent, which may have exceeded the working memory capacity of older adults.

Babcock (1994) conducted a more comprehensive study of age differences in series completion using Raven's Advanced Progressive Matrices (APM) Test. In this task, matrices are presented in a 3 X 3 form with the last cell blank, and participants must generate a rule that satisfies the rows and columns of the matrix. Babcock proposed four
processes that are important for successful completion of the task, including
decomposition of figures into elements, rule discovery, the application of the rules to a
new row or column, and the coordination of the rules. Two different tests were
administered for each of the four processes, which included Hidden Figures and Hidden
Patterns (Ekstrom, French, Harman, & Dermen, 1976), the Figure Classification Test and
Letter Sets (Ekstrom et al., 1976), Geometric Transformation and Pattern Transformation
Tasks, and the Calendar Test and Following Directions Test (Ekstrom et al., 1976),
respectively, for a total of eight tests altogether. Confirmatory factor analysis was used to
examine whether or not the two measures for each of the processes were more highly
related to each other than to the measures of the other processes thought to be important
for successful performance on the APM. The hypothesized processes measure separate
processes if the two measures of a process are more highly related to each other than to the
measures of the other processes. The tasks chosen to measure rule application and
rule coordination were highly related, which indicated that the measures represented like
factors. There was a weak relationship between the tasks thought to measure rule
discovery, which the authors concluded may have been caused by the different nature of
the tasks, so one of them was replaced. The ability to decompose elements into figures
was taken out because it did not measure a separate process. Babcock then conducted a
second study to determine the amount of age-related variance on the APM that could be
accounted for by age-related variance on the three hypothesized components. The author
also included tests of working memory, since working memory is thought to contribute to
the age-related differences on the APM. Older adults performed more slowly and less
accurately than younger adults on the APM. Rule discovery, the application of the rules
to a new row or column, and the coordination of the rules accounted for variance in APM beyond that accounted for by working memory. However, working memory accounted for all but a nonsignificant amount of age-related variance on rule discovery and rule coordination processes. Therefore, working memory is a very important process for successful performance on the APM.

**Current Research**

Both associative and inductive reasoning processes seem to be important components of FP and FN discrimination learning. Associative learning identifies the most predictive cue. In FP discrimination learning, the most predictive cue is the distinctive feature. In FN discrimination learning, the most predictive cues are the common features. Associative learning is more difficult in FN learning than in FP learning, because the common features are reinforced only when the distinctive feature is absent. Since the common features are present on reinforced and non-reinforced trials, FN discriminations are more difficult to learn. Inductive reasoning involves producing hypotheses about potential cues and assessing them with regard to the feedback that is received. Inductive reasoning is more efficient in FP discrimination learning than in FN discrimination learning. This is due to the fact that in FN discrimination learning, correct responses led participants to hypotheses that are wrong.

Age-related declines in working memory could have a negative impact on both associative learning and inductive reasoning processes in FP and FN discrimination learning. Research has shown, for example, that working memory decline affects older adults' associative learning (Salthouse, 1994). Based on the finding that older adults and working memory loaded younger adults were slower at both initial FP and FN
discrimination learning, but with additional experience, they improved at FP but not FN discrimination learning, Mutter et al. (2006) concluded that age-related working memory decline primarily affected older adults' ability to perform the more difficult inductive reasoning processes required in FN discrimination learning. However, the Mutter et al. (2006) procedure did not allow them to isolate the associative and inductive reasoning processes involved in FP and FN learning because they only asked participants to state the rule when they thought they knew it.

The current study investigated how associative and inductive reasoning processes developed over trials in FP and FN discrimination. Younger and older adults were tested using a procedure similar to that used by Mutter et al. (2006), but participants were also asked to verbalize the rule they were considering at the beginning of each trial. Tracking associative and inductive reasoning processes was possible with this procedure because it could be determined when participants forgot and retained their responses and how, if ever, they articulated the correct FP and FN rules. Participants received either consistent transfer, where the same type of learning occurred in the initial and transfer tasks (FP-FP; FN-FN) or inconsistent transfer, where one type of learning occurred in the initial task and a different type of learning occurred in the transfer task (FP-FN; FN-FP). This transfer procedure showed whether younger and older participants learned a general rule in initial discrimination that they could transfer to new stimuli in the transfer discrimination task. This would further indicate the use of inductive reasoning. As in the Mutter et al. (2006) study, it was generally expected that age differences would be smaller in FP discrimination than in FN discrimination, especially in the transfer task.
On each trial, the stimulus display was linked to the participant's response. For the associative processes, a participant's response was categorized as a forgotten response if he or she gave an incorrect response for a given stimulus pair after having previously seen that stimulus pair. The proportion of the total number of forgotten responses to the total number of opportunities to forget was calculated for each of the three pair of symbols containing the distinctive feature. The overall proportion of forgotten responses was obtained by calculating the average of the three proportions. Participants were also required to state their best hypothesis for the rule on every trial. By examining the younger and older participant’s rules, it was possible to see whether aging led to greater difficulty discovering FP and FN rules as well as whether aging made it difficult to transfer these rules to a new discrimination task.

Offenbach (1974) conducted a study examining hypothesis testing and cue selection strategies in children, young adults, and older adults using a discrimination-learning task in which he examined how participants changed their hypotheses based on the feedback they received. Using a procedure similar to Offenbach’s, participants’ hypotheses were categorized as irrelevant or relevant cue shifts, perseverations, or confirmation tests. An irrelevant cue shift occurred when a participant changed his or her hypothesis so that it brought the participant away from the exact rule. For example, if on a previous trial, the participant stated, “When the heart and square are together,” and received “incorrect feedback,” and then changed the rule to “when the heart and the square are diagonal,” that would be an irrelevant cue shift, because the participant is not getting closer to the rule. A relevant cue shift occurred when a participant changed his or her hypothesis so that it brought the participant closer to the exact rule. For example, if
on a previous trial, the participant stated that the rule was “when the square and triangle are diagonal,” and received “incorrect feedback,” and then changed the rule to “the square and the triangle together,” that would be a relevant cue shift, because the participant was closer to the exact rule. The proportion of irrelevant cue shifts was obtained by calculating the total number of irrelevant cue shifts before the rule was articulated divided by the total number of cue shifts before the rule was articulated (relevant plus irrelevant). A confirmation test occurred when the participant repeated a hypothesis from a previous trial after having received “correct feedback,” and a perseveration occurred when the participant repeated a hypothesis from the previous trial after having received “incorrect feedback.” The proportion of perseverations was obtained by calculating the total number of perseverations before the exact rule divided by the total number of times the same hypothesis was repeated before the exact rule (confirmation tests plus perseverations).

In the initial task, it was expected that older adults would have more forgotten responses than younger adults in both discrimination conditions. The proportion of forgotten responses should be greater in inconsistent transfer than in consistent transfer for both types of discrimination. As for the reasoning processes, it was expected that older adults would have a greater proportion of irrelevant cue shifts and perseverations than younger adults in both discrimination conditions. These proportions of irrelevant cue shifts and perseverations should be greater in inconsistent transfer than in consistent transfer for both discrimination conditions.

In the transfer task, older adults should have more forgotten responses than younger adults in both discrimination conditions. The proportion of forgotten responses
should be greater in inconsistent transfer than in consistent transfer for both
discrimination conditions. As for the inductive reasoning processes, older adults should
have a greater proportion of irrelevant cue shifts and perseverations than younger adults
in both discrimination conditions. The proportion of irrelevant cue shifts and
perseverations should be greater in inconsistent than consistent transfer for both
discriminations.
CHAPTER 3

Method

Participants

Thirty-two older adults (12 males and 20 females; age, $M = 72.28$, $SD = 6.33$; years of education, $M = 14.47$, $SD = 2.21$) and thirty-two younger adults (15 males and 17 females; age, $M = 19.56$, $SD = 1.66$; years of education, $M = 13.13$, $SD = 1.36$) participated in this experiment. Older adults were recruited from Warren County, KY via mail-outs and advertisements and were paid a small monetary stipend for their participation. Younger adults were recruited from lower level psychology classes at Western Kentucky University and received course credit for their participation. Participants reported all medications they were taking or diseases they may have had that may affect cognitive functioning. Those who were taking medications known to affect cognitive functioning or who suffered from neurological or psychological diseases were excluded from the study. All participants were in good health for their age group.

Design

A 2 (Group: Younger vs. Older) x 2 (Initial Task: FP vs. FN) x 2 (Transfer Task: FP vs. FN) mixed factorial design was used. All participants completed both an initial and a transfer discrimination-learning task. For the initial task, half of the participants in each age group were randomly assigned to the FP condition and the other half to the FN condition. For the transfer task, half of the participants in each of these conditions were further divided into the FP condition and the other half to the FN condition. Therefore, the participants either completed the FP condition in the initial and transfer task, FP in the initial task and FN in the transfer task, FN in the initial and FP in the transfer task, or FN
in both the initial and transfer task. There were eight participants in each of the final groups. The measure of discrimination learning was the number of trials it took participants to articulate the simple rule. Participants also verbalized the rule they were using on every trial.

Materials

Two sets of stimulus displays containing four symbols were used in this experiment. They were arranged in left- and right-hand columns. Set 1 contained a triangle, square, club, and a heart, with the triangle designated as the distinctive feature. Set 2 contained a spade, diamond, circle, and cross, with the spade designated as the distinctive feature. In the FP condition, the stimulus display containing the distinctive feature was correct, and the stimulus display not containing the distinctive feature was incorrect. In the FN condition, the stimulus display containing the distinctive feature was incorrect while the stimulus display not containing the distinctive feature was correct. Twenty-four displays were created so that each symbol pair appeared equally often in the top and bottom positions of the left and right columns. Two, three-block series of 72 trials were created by presenting the 24 displays in each set in three different random orders. One set of symbols was used in the initial task and the other set was used in the transfer task.

A tape-recorder was used to record all participants' verbalizations of their hypotheses. The experimenter had a data sheet to keep track of which trial the participants were on when verbalizing their hypotheses.
Procedure

Preliminary Procedures. Testing was done in the Cognition Laboratory. Participants were tested individually in one session lasting approximately two hours. Some tasks were completed on a Macintosh computer and some using a pencil and paper. Younger and older participants were tested using the same procedure.

FPE Task. Participants viewed a series of 72 stimulus displays containing the symbol pairs. At the beginning of the experiment, participants were told that there was a rule that determined which symbol pair was correct and that their goal was to discover the rule. Also, they were told that they were to state their best guess of the rule before each trial. The tape-recorder was turned on, and the experimenter stated the number assigned to that particular participant. Prior to viewing the first stimulus display, participants stated their initial guess of the rule. After the participants stated their current guess about the rule, the experimenter pressed a key to show the stimulus display. The display appeared for five seconds, and participants made a response by choosing the “V” key to select the left set of symbols or the “M” key to select the right pair of symbols. Immediate feedback was given by a prerecorded voice stating, “That is correct” or “That is incorrect.” Then, the next trial began. Starting with the second trial, a “?” appeared at the beginning of each trial to indicate that participants should state their current guess of the rule used to determine correct and incorrect pairs. Participants were told to complete all 72 trials of the initial and transfer tasks. It was explained to them that the experimenter could not tell them if their rule was correct, but that they should test it on the remaining trials. Half of the participants received the first set in the initial task and
the second set in the transfer task, and the other half of the participants received the two
sets in the reverse order.

Use of Verbal Protocols. There has been much controversy over the use of verbal
protocols. Concurrent verbalization techniques that have been used previously include
thinking aloud and talking aloud. Thinking aloud involves saying exactly what you are
thinking while solving problems and talking aloud involves saying out loud what you are
saying silently to yourself (Ericsson & Simon, 1984). Retrospective reports have also
been used and consist of verbalization after the task is completed.

Some researchers (e.g., Wilson & Schooler, 1991) think that concurrent
verbalization has an adverse effect on task performance while other researchers (e.g.,
Fleck & Weisberg, 2004) believe that it does not affect performance. There are many
variables associated with verbalization that can affect task performance. The instructions
that are used to elicit verbalization can significantly influence performance, and it is very
important that the experimenter avoids excessive prompting for verbalizations. Also, if
participants are asked to explain their thoughts out loud as if they are explaining them to
the experimenter, then one can expect a detrimental effect on performance (Wilson &
Schooler, 1991; Schooler, Ohlsson, & Brooks, 1993). However, thinking aloud and
talking aloud procedures alone are not detrimental to task performance (Ericsson &
Simon, 1984). In a study conducted by Fleck and Weisberg (2004), participants were
instructed to solve insight problems while thinking aloud or not thinking aloud. There
was a verbal and a nonverbal condition. The experimenters were interested in comparing
solution rates, solving times, and the types of solutions made to determine if verbalization
adversely affected problem solving. Fleck and Weisberg found that participants’ performance was not adversely affected by verbalization.

In the current study, participants were asked to state their hypotheses on each trial. Verbalizing the rule in this study was thus a type of concurrent verbalization. Because participants were not explaining their thoughts, and there was no excessive probing for their verbalizations, verbalization should not have interfered with their normal thought processes.

Cognitive Measures. After the experimental task, participants completed measures of cognitive abilities including working memory executive functioning [i.e., WCST (Berg, 1948; Grant & Berg, 1948) and Reading Span (Salthouse & Babcock, 1991)], working memory storage capacity [WAIS Backward Digit Span (Wechsler, 1997)], processing speed [WAIS-III Digit Symbol Coding (Wechsler, 1997)], associative memory [WAIS-III Digit Symbol Incidental Learning (Wechsler, 1997)], associative learning [Conditional Associative Learning (CAL) (e.g., Levine, Stuss, & Milberg, 1997)], and verbal knowledge [Mill Hill Vocabulary]. These tests confirmed that these samples of older and younger adults match other researcher’s samples of younger and older adults. Older adults’ performance on the Reading Span and Digit Symbol Coding and Incidental learning tasks was poorer than younger adults, whereas their vocabulary scores were much higher than younger adults. The means and standard deviations of all the cognitive measures are shown in Table 1.
Table 1

*Mean Scores and Standard Deviations of Younger and Older Adults on Cognitive Measures*

<table>
<thead>
<tr>
<th>Task</th>
<th>Group</th>
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<tr>
<td></td>
<td>Younger</td>
<td>Older</td>
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<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
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<td>Digit Symbol Incidental Learning *</td>
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<td>16.69</td>
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<tr>
<td>Reading Span *</td>
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<td>.91</td>
<td>2.03</td>
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<tr>
<td>Mill Hill Vocabulary *</td>
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<td>5.20</td>
<td>38.09</td>
</tr>
<tr>
<td>Standard Progressive Matrices *</td>
<td>49.25</td>
<td>5.41</td>
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<td>WCST</td>
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<tr>
<td>Perseverative Errors *</td>
<td>6.84</td>
<td>3.34</td>
<td>9.56</td>
</tr>
<tr>
<td>Number of Categories *</td>
<td>3.84</td>
<td>1.35</td>
<td>3.00</td>
</tr>
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<td>Backward Digit Span</td>
<td>7.06</td>
<td>2.03</td>
<td>7.13</td>
</tr>
<tr>
<td>Conditional Associative Learning (CAL)</td>
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<td></td>
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<tr>
<td>Successful Response</td>
<td>6.78</td>
<td>2.39</td>
<td>7.13</td>
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<tr>
<td>Retained Response*</td>
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<td>12.62</td>
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<td>4.50</td>
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<td>Discrimination Failure*</td>
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<td>Perseveration*</td>
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<tr>
<td>Unsuccessful Guess*</td>
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<td>3.07</td>
<td>7.63</td>
</tr>
</tbody>
</table>

* ANOVA, $p < .05$
CHAPTER 4

Results

All analyses were performed after excluding participants who fell two or more standard deviations above or below the mean on the initial discrimination-learning task. This resulted in the replacement of two older adults and four younger adults.

General Discrimination

The first set of analyses was performed on the number of trials it took participants to articulate the exact rule in the initial and transfer discrimination tasks. The exact rule in FP discrimination would be “when the triangle is present,” whereas the exact rule in FN discrimination would be “when the triangle is absent.” The means and standard deviations for the general discrimination in the initial and transfer tasks are shown in Table 2.

Initial Discrimination Task. Sixteen younger and nine older participants articulated the rule in the FP condition, whereas only eight younger and five older participants articulated the rule in the FN condition. This suggests that a FPE was present.

The mean trials to articulation for each group in the initial task are shown in Figure 1. A 2 (Group: Younger vs. Older) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance (ANOVA) on the number of trials to articulation of the exact rule revealed a main effect of group, $F(1, 60) = 20.51, MSe = 421.77, p = .00, \eta^2 = .26$, showing that older adults’ performance was relatively poor on both FP and FN discrimination. There was also a main effect of discrimination condition, $F(1, 60) =
44.02, \( p = .00, \eta^2 = .42 \), but a group by discrimination condition interaction, \( F(1, 60) = 3.94, p = .05, \eta^2 = .06 \), indicated that the FPE was greater for younger than older adults.

To explore age differences for each discrimination condition, analyses of the effect of group for FP and for FN discrimination were conducted. Older adults took a greater number of trials to articulate the exact rule in FP discrimination than young adults, \( F(1, 30) = 18.82, MSe = 475.27, p = .00, \eta^2 = .38 \). Older adults also took marginally more trials to articulate the rule in FN discrimination than younger adults, \( F(1, 30) = 3.71, MSe = 368.26, p = .06, \eta^2 = .11 \). Age differences were greater in FP discrimination due to younger adults' very good performance in FP discrimination learning. However, age differences were smaller for FN discrimination learning.

Figure 1. Mean trials to articulation and standard errors for younger and older adults in the initial discrimination task.
Table 2

Mean Trials to Articulation and Standard Deviations for the Initial and Transfer Tasks

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial Task</th>
<th>Transfer Task</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Inconsistent</td>
<td>Consistent</td>
<td>Inconsistent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FP</td>
<td>SD</td>
<td>FP</td>
<td>SD</td>
<td>FN</td>
</tr>
<tr>
<td>Younger</td>
<td>9.19 8.00</td>
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<td>36.75 31.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Older</td>
<td>42.63 29.77</td>
<td>38.63 31.77</td>
<td>46.50 28.85</td>
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<tr>
<td>FN</td>
<td>53.44 24.88</td>
<td>36.88 31.20</td>
<td>33.88 31.74</td>
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<tr>
<td>Older</td>
<td>66.50 10.85</td>
<td>41.13 29.62</td>
<td>72.00 .00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. FP and FN indicate which transfer task was completed.

Transfer Discrimination Task. For consistent FP discrimination, eight younger and five older participants articulated the exact rule, whereas for consistent FN discrimination, five younger and five older participants articulated the exact rule. For inconsistent FP discrimination, five younger and four older participants articulated the exact rule, whereas for inconsistent FN discrimination, five younger and no older participants articulated the exact rule. This suggests that the FPE was, once again, present and that consistent transfer led to better performance than inconsistent transfer.

The mean trials to articulation for each group in the transfer task are shown in Figure 2. A 2 (Group: Younger vs. Older) x 2 (Transfer Type: FP vs. FN) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance was conducted on
the number of trials to the articulation of the exact rule. There were main effects of group, $F(1, 56) = 10.95$, $MSe = 711.43$, $p = .00$, $\eta^2 = .16$, transfer type, $F(1, 56) = 6.89$, $p = .01$, $\eta^2 = .11$, and discrimination condition, $F(1, 56) = 4.98$, $p = .03$, $\eta^2 = .08$. Transfer type did not interact with discrimination condition, $F(1, 56) = .29$, $p = .60$, $\eta^2 = .01$. Group did not interact with transfer type, $F(1, 56) = .08$, $p = .78$, $\eta^2 = .00$, or discrimination condition, $F(1, 56) = .02$, $p = .90$, $\eta^2 = .00$; however, there was a three-way interaction among group, transfer type, and discrimination condition, $F(1, 56) = 5.10$, $p = .03$, $\eta^2 = .08$.

![Figure 2. Mean trials to articulation and standard errors for younger and older adults in consistent (left panel) and inconsistent (right panel) transfer tasks.](image)

To explore this three-way interaction, analyses of the effect of group and transfer type were conducted for each discrimination condition. For FP discrimination, there was a main effect of group, $F(1, 28) = 5.94$, $MSe = 708.41$, $p = .02$, $\eta^2 = .17$, and transfer type, $F(1, 28) = 5.01$, $p = .03$, $\eta^2 = .15$. However, there was no interaction between
group and transfer type, \( F(1, 28) = 1.96, p = .17, \eta^2 = .07 \). Young adults articulated the FP rule more quickly than older adults and both groups articulated the rule more quickly with consistent than inconsistent transfer. For FN discrimination, younger adults articulated the FN rule more quickly than older adults, \( F(1, 28) = 5.02, MSe = 714.45, p = .03, \eta^2 = .15 \). Although, there was no difference between consistent and inconsistent transfer, \( F(1, 28) = 2.17, p = .15, \eta^2 = .07 \), there was a marginally significant interaction between group and transfer type, \( F(1, 28) = 3.21, p = .08, \eta^2 = .10 \). This was due to the fact that differences in trials to articulate the FN rule for the two groups were larger for inconsistent transfer than for consistent transfer.

**Associative Processes**

The overall proportion of forgotten responses until the rule was articulated in the initial and transfer tasks was obtained for each participant. For each trial, the stimulus display was linked to the participants’ response. A participant’s response was categorized as a forgotten response if he or she gave an incorrect response for a given stimulus pair after having previously seen that stimulus pair. The total forgotten responses were obtained for each of the three pairs of symbols containing the distinctive feature (i.e., triangle and square, triangle and heart, triangle and club). The proportion of forgotten responses to the total number of opportunities to forget was then calculated for each pair of symbols. These three proportions were averaged together to get an overall proportion of forgotten responses. The means and standard deviations for the proportion of forgotten responses in the initial and transfer tasks are shown in Table 3.

**Initial Task.** A 2 (Group: Younger vs. Older) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance (ANOVA) was performed on the arcsin-
transformed overall proportion of forgotten responses. This analysis revealed a main
effect of group, \( F(1, 60) = 25.91, MSe = .18, p = .00, \eta^2 = .30 \), showing that older adults
had more forgotten responses than younger adults. There was also a main effect of
discrimination condition, \( F(1, 60) = 9.08, p = .00, \eta^2 = .13 \), which indicated that there
were more forgotten responses in the FN condition than in the FP condition. There was a
marginal group by discrimination condition interaction, \( F(1, 60) = 2.21, p = .14, \eta^2 = .04 \), which indicated that the proportion of forgotten responses in FP and FN
discrimination was different for younger and older adults.

Table 3

*Mean Proportions of Forgotten Responses and Standard Deviations for the Initial and Transfer Task*

<table>
<thead>
<tr>
<th>Group</th>
<th>Consistent</th>
<th>Inconsistent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial Task</td>
<td>Transfer Task</td>
</tr>
<tr>
<td></td>
<td>Consistent</td>
<td>Inconsistent</td>
</tr>
<tr>
<td></td>
<td>FP</td>
<td>SD</td>
</tr>
<tr>
<td>Younger</td>
<td>.03</td>
<td>.04</td>
</tr>
<tr>
<td>Older</td>
<td>.24</td>
<td>.20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>FN</th>
<th>SD</th>
<th>FN-FN</th>
<th>SD</th>
<th>FP-FN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td>.15</td>
<td>.14</td>
<td>.09</td>
<td>.07</td>
<td>.12</td>
<td>.16</td>
</tr>
<tr>
<td>Older</td>
<td>.29</td>
<td>.16</td>
<td>.17</td>
<td>.24</td>
<td>.37</td>
<td>.21</td>
</tr>
</tbody>
</table>

*Note. FP and FN indicate which transfer task was completed.*

To determine whether age differences in forgotten responses were related to the
age differences observed in general discrimination, comparisons of the effect of age
within each discrimination condition were conducted for the proportion of forgotten responses. Older adults had a greater proportion of forgotten responses than younger adults for FP discrimination, $F(1, 30) = 21.86, MSe = .17, p = .00, \eta^2 = .42$, and for FN discrimination learning, $F(1, 30) = 6.43, MSe = .18, p = .02, \eta^2 = .18$. These results show that older adults' memory for their prior responses is worse than younger adults' memory in both discrimination conditions.

Transfer Task. A 2 (Group: Younger vs. Older) x 2 (Transfer Type: FP vs. FN) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance was conducted for the arcsin-transformed proportion of forgotten responses. A main effect of group, $F(1, 56) = 22.78, MSe = .27, p = .00, \eta^2 = .29$, indicated that older adults had more forgotten responses overall than younger adults, and a main effect of transfer type, $F(1, 56) = 8.55, p = .01, \eta^2 = .13$, indicated that participants had a greater number of forgotten responses for inconsistent transfer than consistent transfer. The overall number of forgotten responses was similar for FP and FN discrimination, $F(1, 56) = .70, p = .41, \eta^2 = .01$, and transfer type did not interact with discrimination condition, $F(1, 56) = .64, p = .43, \eta^2 = .01$. In addition, group did not interact with transfer type, $F(1, 56) = .12, p = .73, \eta^2 = .00$, or discrimination condition, $F(1, 56) = .84, p = .37, \eta^2 = .02$, and there was no three-way interaction among group, transfer type, and discrimination condition, $F(1, 56) = .89, p = .35, \eta^2 = .02$.

To determine whether age differences in forgotten responses were related to the age differences observed in general discrimination, comparisons of the effect of age and transfer type within each discrimination condition were conducted for the proportion of forgotten responses. For FP discrimination learning, there was a main effect of group, $F$
(1, 28) = 18.32, MSe = .24, p = .00, $\eta^2 = .40$. There was no main effect of transfer type, $F(1, 28) = 2.56, MSe = .24, p = .12, \eta^2 = .08$, and no interaction between group and transfer type, $F(1, 28) = .20, MSe = .24, p = .66, \eta^2 = .01$. For FN discrimination learning, there was a main effect of group, $F(1, 28) = 6.67, MSe = .30, p = .02, \eta^2 = .19$, and a main effect of transfer type, $F(1, 28) = 6.19, p = .02, \eta^2 = .18$. There was no interaction between group and transfer type, $F(1, 28) = .75, p = .40, \eta^2 = .03$. Thus, older adults had a greater proportion of forgotten responses than younger adults in both discrimination conditions. In FP discrimination learning, the proportion of forgotten responses was similar for consistent and inconsistent transfer, whereas in FN discrimination learning, the proportion of forgotten responses was greater for inconsistent than in consistent transfer.

**Inductive Reasoning**

To obtain measures of inductive reasoning, all of the participants' hypotheses prior to the articulation of the exact rule were coded as either an irrelevant or relevant cue shift, a perseveration, or a confirmation test. An irrelevant cue shift occurred when a participant changed his or her hypothesis so that it brought the participant away from the exact rule. For example, if on a previous trial, the participant stated, "When the heart and square are together," and received "incorrect feedback," and then changed the rule to "when the heart and the square are diagonal," that would be an irrelevant cue shift, because the participant was not getting closer to the rule. A relevant cue shift occurred when a participant changed his or her hypothesis so that it brought the participant closer to the exact rule. For example, if on a previous trial, the participant stated that the rule was "when the square and triangle are diagonal," and received "incorrect feedback," and
then changed the hypothesis to "the square and the triangle together," that would be a relevant cue shift, because the participant was closer to the exact rule. The proportion of irrelevant cue shifts was obtained by calculating the total number of irrelevant cue shifts divided by the total number of cue shifts (relevant plus irrelevant). A confirmation test occurred when the participant repeated a hypothesis from a previous trial after having received "correct feedback," and a perseveration occurred when the participant repeated a hypothesis from the previous trial after having received "incorrect feedback." The proportion of perseverations was obtained by calculating the total number of perseverations divided by the total number of times the hypothesis was repeated (confirmation tests plus perseverations). The means and standard deviations of the proportions of irrelevant cue shifts and perseverations are shown in Table 4 and Table 5, respectively, for the initial and transfer tasks.

**Initial Task.** A 2 (Group: Younger vs. Older) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance (ANOVA) was performed on the arcsin-transformed proportion for both irrelevant cue shifts and perseverations. For the proportion of irrelevant cue shifts, this analysis revealed a main effect of group, $F(1, 60) = 5.73, MSe = .68, p = .02, \eta^2 = .09$, indicating that older adults had proportionally more irrelevant cue shifts than younger adults. However, there was no main effect of discrimination condition, $F(1, 60) = .15, p = .70, \eta^2 = .00$, but there was a marginal interaction between group and discrimination condition, $F(1, 60) = 2.66, p = .11, \eta^2 = .04$, indicating that the proportion of irrelevant cue shifts in the FP and FN conditions was different for younger and older adults.
To determine whether the differences in discrimination conditions for the proportion of irrelevant cue shifts were similar to the differences in discrimination learning, analyses of age differences in each discrimination condition were conducted for the proportion of irrelevant cue shifts. In FP discrimination, older adults made a greater proportion of irrelevant cue shifts than younger adults, $F(1, 30) = 6.38, MSe = .87, p = .02, \eta^2 = .18$, whereas in FN discrimination, older and younger adults made similar proportions of irrelevant cue shifts, $F(1, 30) = .40, MSe = .20, p = .53, \eta^2 = .01$.

Table 4

<table>
<thead>
<tr>
<th>Mean Proportion of Irrelevant Cue Shifts and Standard Deviations for the Initial and Transfer Task</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Task</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Group</strong></td>
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<tr>
<td>Older</td>
</tr>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td>Younger</td>
</tr>
<tr>
<td>Older</td>
</tr>
</tbody>
</table>

*Note.* FP and FN indicate which transfer task was completed.

For the proportion of perseverations, there was a main effect of group, $F(1, 60) = 5.10, MSe = .70, p = .03, \eta^2 = .08$, which indicated that older adults' proportion of
perseverations was greater than younger adults. There was no main effect of discrimination condition, $F(1, 60) = .44, p = .51, \eta^2 = .01$, and group did not interact with discrimination condition, $F(1, 60) = 1.14, p = .29, \eta^2 = .02$, indicating that the proportion of perseverations in FP and FN discrimination was similar for younger and older adults.

Table 5

*Mean Proportion of Perseverations and Standard Deviations for the Initial and Transfer Tasks*

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial Task</th>
<th>Transfer Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consistent</td>
<td>Inconsistent</td>
</tr>
<tr>
<td></td>
<td>FP $SD$</td>
<td>FP-FP $SD$</td>
</tr>
<tr>
<td>Younger</td>
<td>.13 .34</td>
<td>.13 .35</td>
</tr>
<tr>
<td>Older</td>
<td>.34 .35</td>
<td>.28 .22</td>
</tr>
<tr>
<td></td>
<td>FN $SD$</td>
<td>FN-FN $SD$</td>
</tr>
<tr>
<td>Younger</td>
<td>.10 .14</td>
<td>.00 .00</td>
</tr>
<tr>
<td>Older</td>
<td>.18 .20</td>
<td>.16 .35</td>
</tr>
</tbody>
</table>

*Note.* FP and FN indicate which transfer task was completed.

To determine whether age differences in perseverations were related to the age differences observed in general discrimination, comparisons of the effect of age within each discrimination condition were conducted for the proportion of perseverations. Older adults had a marginally greater proportion of perseverations than younger adults in FP
discrimination learning, $F(1, 30) = 3.42, MSe = 1.13, p = .07, \eta^2 = .10$. However, older and younger adults had similar proportions of perseverations in FN discrimination learning, $F(1, 30) = 1.84, MSe = .50, p = .19, \eta^2 = .06$. Older adults repeat their hypotheses after incorrect feedback more often than younger adults in FP discrimination learning, whereas older and younger adults repeat their hypotheses after incorrect feedback in a similar manner in FN discrimination learning.

Thus, older adults made more irrelevant cue shifts and marginally more perseverations than younger adults in FP discrimination learning. However, older and younger adults made a similar proportion of irrelevant cue shifts and perseverations in FN discrimination. These results are similar to the results found for the discrimination learning task.

**Transfer Task.** A 2 (Group: Younger vs. Older) x 2 (Transfer Type: FP vs. FN) x 2 (Discrimination Condition: FP vs. FN) factorial analysis of variance (ANOVA) was performed on arcsin-transformed proportions of both irrelevant cue shifts and perseverations. For the proportion of irrelevant cue shifts, this analysis revealed an effect of group, $F(1, 56) = 15.41, MSe = .73, p = .00, \eta^2 = .22$. The effect of transfer type was not significant, $F(1, 56) = 3.20, p = .08, \eta^2 = .05$, and transfer type did not interact with group, $F(1, 56) = 1.50, p = .23, \eta^2 = .03$, indicating that the proportion of irrelevant cue shifts was similar in consistent and inconsistent transfer for younger and older adults. In addition, transfer type did not interact with discrimination condition, $F(1, 56) = 1.16, p = .29, \eta^2 = .02$, indicating that the proportion of irrelevant cue shifts for consistent and inconsistent transfer was similar and did not vary in FP and FN discrimination conditions. There was no main effect of discrimination condition, $F(1, 56) = .51, p = .48, \eta^2 = .01$;
however, there was a group by discrimination condition interaction, \( F(1, 56) = 10.20, MSe = .73, p = .00, \eta^2 = .15 \), indicating that the proportion of irrelevant cue shifts in FP and FN discrimination varied for younger and older adults. There was no three-way interaction among group, transfer type, and discrimination condition, \( F(1, 56) = .58, p = .45, \eta^2 = .01 \).

To explore age differences in each discrimination condition, analyses of the effect of group and transfer type for each discrimination condition were conducted. Older adults had a greater proportion of irrelevant cue shifts for FP discrimination than younger adults, \( F(1, 28) = 30.22, MSe = .62, p = .00, \eta^2 = .52 \). There were no differences in the number of irrelevant cue shifts for consistent and inconsistent transfer, \( F(1, 28) = .30, p = .59, \eta^2 = .01 \), and group and transfer type did not interact, \( F(1, 28) = .13, p = .72, \eta^2 = .00 \). Older and younger adults had a similar proportion of irrelevant cue shifts for FN discrimination, \( F(1, 28) = .23, MSe = .85, p = .64, \eta^2 = .01 \). There was a marginal effect of transfer type, \( F(1, 28) = 3.54, p = .07, \eta^2 = .11 \), and group did not interact with transfer type, \( F(1, 28) = 1.70, p = .20, \eta^2 = .06 \). Therefore, overall older adults made a greater proportion of irrelevant cue shifts in FP but not FN discrimination learning. There were no differences in the number of irrelevant cue shifts for consistent and inconsistent transfer in FP discrimination and a marginal difference in FN discrimination learning.

For the proportion of perseverations, there was a main effect of group, \( F(1, 56) = 12.37, MSe = .55, p = .00, \eta^2 = .18 \), indicating that older adults had a greater proportion of perseverations compared to younger adults. There was no main effect of transfer type, \( F(1, 56) = .08, p = .78, \eta^2 = .00 \), or discrimination condition, \( F(1, 56) = 1.37, p = .25, \eta^2 = .00 \).
Transfer type did not interact with discrimination condition, \( F(1, 56) = 1.02, p = .32, \eta^2 = .02 \), indicating that the proportion of perseverations in FP and FN discrimination did not vary in consistent and inconsistent transfer. Group did not interact with transfer type, \( F(1, 56) = .32, p = .58, \eta^2 = .01 \), or discrimination condition, \( F(1, 56) = .01, p = .94, \eta^2 = .00 \), and there was no three-way interaction among group, transfer type, and discrimination condition, \( F(1, 56) = .00, p = .99, \eta^2 = .00 \).

To explore age differences in FP and FN discrimination learning, analyses of the effect of group and transfer type for each of these discrimination conditions were conducted for the proportion of perseverations. Older adults had a greater proportion of perseverations for FP discrimination than younger adults, \( F(1, 28) = 5.62, MSe = .63, p = .03, \eta^2 = .17 \). There were no differences in the number of perseverations for consistent and inconsistent transfer in FP discrimination, \( F(1, 28) = .23, p = .64, \eta^2 = .01 \), and group and transfer type did not interact, \( F(1, 28) = .13, p = .72, \eta^2 = .01 \). Older adults also had a greater proportion of perseverations than younger adults in FN discrimination learning, \( F(1, 28) = 6.96, MSe = .47, p = .01, \eta^2 = .20 \). However, there were no differences in the number of perseverations for consistent and inconsistent transfer, \( F(1, 28) = .99, p = .33, \eta^2 = .03 \), and group and transfer type did not interact, \( F(1, 28) = .19, p = .67, \eta^2 = .01 \). Therefore, older adults made a greater proportion of perseverations than younger adults in both discrimination conditions, and there were no differences in the number of perseverations for consistent and inconsistent transfer in both discrimination conditions.
CHAPTER 5
Discussion

Initial Task

It was expected that older adults would have more difficulty with the initial
discrimination learning task than younger adults. Consistent with what was expected in
the initial task, older adults took a greater number of trials to articulate the rule than
younger adults showing that discrimination learning is more difficult for older adults than
for younger adults. The FPE was expected to be greater for older adults than for younger
adults. However, the FPE was greater in younger than older adults because younger
adults performed very well on FP compared to FN discrimination learning, whereas the
older adults performed relatively poorly in both discrimination conditions. Thus,
younger adults had a selective decline in learning cue-nonoccurrence information,
whereas older adults showed an overall decline in discrimination learning. These
findings are consistent with Mutter et al. (2006) in that in the initial task, both younger
and older adults showed the FPE. However, in the present study, the greatest age
differences were in FP discrimination learning, whereas in the Mutter et al. (2006) study,
there were age differences in both FP and in FN discrimination learning.

In discrimination learning, associative processes are required to localize the most
predictive cues, whereas inductive reasoning processes are required to generate and test
hypotheses about those cues (Hearst, 1984; Levine, 1966). Younger adults discovered the
rule more quickly than older adults in FP discrimination learning. This suggests that the
younger adults had less difficulty isolating the most predictive cue and/or generating and
testing hypotheses in the initial FP condition than older adults. Older adults had
difficulty with these processes even in this easier discrimination condition. However, both younger and older adults had difficulty with FN discrimination suggesting that even the younger adults had problems isolating the most predictive cue (s) and/or testing hypotheses in this discrimination condition.

One of the main goals of this study was to examine whether the age differences in associative processes for FP and FN discrimination learning could explain age differences in discrimination learning. Successful discrimination learning begins with acquiring associations between the most predictive cue and the outcome. Consistent with what was expected for the initial task, younger adults learned the FP and FN rules more quickly than the older adults because it was easier for them to remember their responses and acquire the association between the symbol pairs and the outcome. They could then isolate the most predictive cue quickly in FP discrimination learning. However, associative processes did not completely account for young adults’ FN discrimination learning because there was only a marginal age difference in discrimination learning while there was a large difference in the number of forgotten responses.

Older adults had a higher overall proportion of forgotten responses than younger adults in both FP and FN discrimination learning. One reason they articulated the rule more slowly than younger adults in both discrimination tasks could have been because they did not remember the responses they made from trial to trial. The older adults’ difficulty remembering their responses suggests that they had trouble acquiring the association between the symbol pairs and the outcome. As a result, they could not isolate the most predictive cue (s) very well in either discrimination condition. Thus, age-related decline in associative processes (see also Naveh-Benjamin, 2000; Naveh-Benjamin,
Hussain, Guez, and Bar-On; Experiment 1, 2003) has a negative effect on discrimination learning.

Another goal of this study was to investigate whether age differences in reasoning processes for FP and FN discrimination learning could account for age differences in discrimination learning. When a participant makes an irrelevant cue shift, this means that he or she is focusing on a part of the stimulus display that is unrelated to the exact rule. Perseverations are hypotheses that are repeated after getting incorrect feedback. Irrelevant cue shifts and perseverations are detrimental to hypothesis testing because they cause the participant to take longer and possibly never articulate the exact rule.

Consistent with what was predicted, in the initial FP task older adults made a greater number of irrelevant cue shifts and perseverations than younger adults suggesting that their inductive reasoning processes were less efficient than those of younger adults. It is therefore possible that it took older adults so much longer to articulate the exact rule in FP discrimination learning not only because their associative memory was poorer, but also because they had deficits in hypothesis testing. This finding is consistent with Offenbach (1974) who found that older adults make more irrelevant cue shifts than younger adults in discrimination learning. It is also consistent with studies of concept learning (Rhodes, 2004; Hartman et al, 2001) and series completion (Babcock, 1994; Querseshi & Smith, 1998; Salthouse & Prill, 1987) that provide evidence for age differences in inductive reasoning.

In initial FN discrimination learning, younger and older adults made similar numbers of irrelevant cue shifts and perseverations. This result shows that younger adults' reasoning abilities were not very good in FN discrimination learning. This could
be the reason that younger adults’ FN discrimination learning was not that much better than older adults even though they could remember their responses to make the association between the symbol pair and the outcome.

**Transfer Task**

In the transfer task, older adults articulated the rule less quickly in FP discrimination learning than younger adults. Consistent with this finding, older adults once again had a greater proportion of forgotten responses in FP discrimination than younger adults. This again suggests that they took longer than younger adults to articulate the exact rule because they did not remember the associations between the symbol pairs and the outcome and could not isolate the most predictive cue(s) as well as younger adults. As expected, older adults also made a greater number of irrelevant cue shifts and perseverations than younger adults in FP discrimination learning providing additional support for less effective hypothesis testing strategies than younger adults. Therefore, older adults took longer to articulate the rule than younger adults in FP discrimination learning, because of deficits in both associative and inductive reasoning processes.

Both groups had more difficulty in inconsistent than in consistent transfer. It was predicted that the proportion of forgotten responses would be greater in inconsistent than consistent transfer for FP discrimination learning. The proportion of forgotten responses was marginally higher in inconsistent than consistent transfer for FP discrimination. It was expected that the number of irrelevant cue shifts and perseverations would be greater in inconsistent than in consistent transfer. However, these numbers were similar in inconsistent and consistent transfer for FP discrimination learning. These findings
suggest that transferring to the same task provided some benefit for FP transfer
discrimination learning perhaps by allowing participants to use the same strategy for
associative learning they acquired in the initial task. However, the finding that
participants' hypothesis testing strategies were similar in FP discrimination learning,
regardless of whether they transferred to the same or a different task, suggests that
transferring to the same task did not provide any extra benefit over transferring to a
different task for FP discrimination learning perhaps because participants were not using
the same reasoning strategy that they acquired in the initial task.

Older adults articulated the rule less quickly in FN discrimination learning than
younger adults, and they had a greater proportion of forgotten responses in FN
discrimination learning than younger adults. This suggests once again, that they took
longer than younger adults to articulate the rule because they could not remember the
association between the symbol pairs and the outcome well enough to isolate the most
predictive cue. In FN discrimination learning, it was predicted that older adults would
have a greater number of irrelevant cue shifts and perseverations than younger adults.
Older and younger adults had similar numbers of irrelevant cue shifts, but younger adults
did have fewer perseverations than older adults. These findings suggest that younger
adults used somewhat better inductive reasoning skills in the transfer task, and this could
be why younger adults articulated the rule more quickly than older adults.

Both groups articulated the rule no more quickly in consistent than in inconsistent
transfer for FN discrimination learning. Consistent with what was predicted, there was a
greater proportion of forgotten responses in inconsistent transfer than in consistent
transfer for FN discrimination learning. This finding suggests that all participants had
more difficulty associating the symbol pairs with the outcome when they transferred to a new discrimination task than when they transferred to the same task. In addition, it was predicted that there would be a greater number of irrelevant cue shifts in inconsistent than in consistent transfer because the inductive reasoning processes would be less efficient in inconsistent than consistent transfer. However, this difference was only marginal. In addition, the number of perseverations was similar in consistent and inconsistent transfer. This finding suggests that participants’ hypothesis testing strategies were similar in FN discrimination learning regardless of whether they transferred to the same or a different task.

**Limitations**

Although the results of this study add to the literature on FP and FN discrimination learning, there are some limitations that must be addressed. Previous research suggests that inductive reasoning processes should be more difficult in FN than FP discrimination learning (Newman et al., 1980; Mutter et al., 2006). In this study overall differences in inductive reasoning measures for FP and FN discrimination learning were minimal. It is possible that the measures chosen were not particularly good at capturing the inductive reasoning processes involved in discrimination learning. In future research, it would be interesting to use different measures of inductive reasoning such as discrimination failures, which occur when a participant states a hypothesis that he has used before, but not on the previous trial. In addition, the current study had a small sample size and there were many effects that were large, but failed to reach the $p \leq .05$ criterion. Increasing the sample size would provide a better understanding of what is really happening with regards to associative and inductive reasoning processes in
discrimination learning. Finally, younger adults performed extremely well in FP discrimination, which has not been found in previous studies (Mutter et al., 2006). This ceiling effect for the young adults allowed little variation in the associative and inductive reasoning measures.

Summary

In the initial discrimination learning, older adults seem to have difficulty with both FP and FN discrimination learning due to deficits in both associative and inductive reasoning processes. Younger adults do very well in FP discrimination learning but have more difficulty in FN than in FP discrimination learning. This seems to be related to difficulties with inductive reasoning. In the transfer task, older adults continued to have difficulty in both FP and FN discrimination learning suggesting that their associative and inductive reasoning processes did not improve. Younger adults' difficulties with inductive reasoning processes in the initial FN discrimination learning task did decrease in the transfer task, suggesting that they were able to apply what they learned in the initial task to the transfer task.
References


Hartman, M., Bolton, E., & Fehnel, S. E. (2001). Accounting for age differences on
the Wisconsin Card Sorting Test: Decreased working memory, not inflexibility. Psychology and Aging, 16(3), 385-399.


Neuropsychology, 11, 367-381.


