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시각적 기술 학습과 전이에 미치는 개인차의 효과

Individual Difference Effects on Perceptual Skill Learning and Transfer

노 윤 진*, 이 희 승**, 손 영 우*,**
(Yun Jin Rho), (Hee Seung Lee), (Young Woo Sohn)

요 약 본 연구에서는 순차적으로 자극이 제시되는 시각 구별 과제에서 개인차가 기술의 습득과 전이에 어떻게 영향을 미치는지 알아보았다. 여기서는 개인 차이를 세 가지 측면에서 측정하였는데 인지 양식의 차이, 작업 기억 용량의 수준, 그리고 의사 결정 방식의 차이를 가지고 개인 차이를 분류하였다. 시각 구별 과제에서는 크게 훈련 과정과 전이 과정으로 나누어 훈련 과정의 난이도가 전이 과정에서 어떠한 영향을 미치는지 알아보았는데, 특히 훈련 난이도는 인지 양식과 그리고 작업 기억 용량과의 상호 작용을 통하여 전이 과제에서의 정확도에 영향을 미친 것으로 나타났다. 본 연구에서 얻어진 결과는 시각 구별과 관련한 인터페이스를 디자인하는데 있어서 개인차를 고려하는 것이 필요함을 시사하였다.

주제어 개인차, 시각구별, 수행, 훈련, 전이

Abstracts This research examined the effects of individual differences on visual discrimination skill learning and its transfer to novel stimuli. Individual participants were categorized as having an analytic or holistic cognitive style, high or low working memory capacity, and high or low levels of rationality, experientiality, and adaptive decision-making styles. Participants received easy or difficult training for the serially presented discrimination task, and then transferred to novel discriminations. Training content interacted with cognitive style and working memory capacity to affect transfer accuracy performance, but individual differences in decision-making styles did not affect transfer performance. Results suggest individual differences should be taken into account when designing an interface for visual discrimination.

Keywords individual difference, visual discrimination, performance, training, transfer.

Introduction

Many job tasks involve visual discrimination. A visual discrimination task requires workers to compare a stimulus set and determine if the "test" stimulus is the same or different from the "standard" stimulus (Uttal, 1988). Some job tasks require workers to discriminate stimuli presented in parallel, in which both stimuli to be compared are present. This is true of karyotyping, in which cytogeneticists make visual discriminations between same and different chromosomes within a cellular sample (Brown, 2001). Alternatively, some job tasks require workers to search and discriminate stimuli serially, in which a discrimination response is made in the absence of the standard stimulus. Under these conditions, individuals make discriminations based on their memory of the standard stimulus. Monitoring system states (Gillan & Harrison, 1999) and chicken-sexing (Biederman & Shiffrar, 1987) are examples of jobs that require workers to make visual discriminations based on their memory of the standard stimulus.

In a parallel presentation context, research suggests that training techniques and cognitive style interact to influence visual discrimination strategies (Cooper, 1976; Doane,

* 연세대학교 인지과학 협동과정
yjpaino7@yonsei.ac.kr, 016-236-8220
** 연세대학교 심리학과

Alderson, Sohn, & Pellegrino, 1996; Doane, Sohn, & Schreiber, 1999; Eme & Marquer, 1998; Fisher & Tanner, 1992; Fisher & Young, 1987; Folk & Luce, 1987; Gillan & Harrison, 1999; Hogeboom & van Leeuwen, 1997; Job, Nicoletti, & Rumiati, 1982; Kramer, Pratt & Sohn, 2002; Pratt & Sohn, 2001). Whether the findings from these studies apply to serially presented stimuli is uncertain. Because many job tasks require workers to perform serial discriminations, the purpose of the present research is to determine how training content and individual difference variables effect skill acquisition and strategy development of serially presented stimuli.

Skill Acquisition

Fisher's optimal feature model of target search (Fisher & Tanner, 1992; Fisher & Young, 1987) has been used as a framework for discussing the acquisition of strategic visual discrimination skills. Originally developed to explain visual search, Fisher's model was revised by Doane et al. (1996) to include visual discriminations. According to Fisher's revised model, one learns, after repeated exposure, a sequence of features to compare between the "test" and the "standard" stimulus that minimizes the average number of comparisons required to make a discrimination. Training content (i.e., repeated exposure of the initial stimuli viewed) influences the type of strategy developed (Doane et al., 1996; 1999). The learned strategy is then transferred to novel situations and used to make future discriminations.

Feature-Integration theory (FIT; Treisman, 1980; Treisman & Gelade, 1980) and the Guided Search model (GS2; Wolfe, 1994) provide an explanation of how visual discrimination strategies vary depending on training content. Again, these theories explain visual search but can apply to visual discrimination tasks as well (see Uttal, 1988). A key issue of the FIT paradigm is the development of search functions, or how search time varies across increasing levels of stimulus complexity. According to FIT, when a test stimulus differs from the standard stimulus by a unique feature, the slope of the search function is flat, or close to zero. Flat search functions indicate holistic processing, in which the difference between the two stimuli are obvious and can be seen based on the global shape of the stimulus. Conversely, when the test stimulus differs from the standard stimulus by miniscule differences that cannot readily be seen based on overall shape, the search functions are steep, indicating the search proceeded point-by-point, or analytically.

The dichotomy proposed by FIT is acceptable for explaining *initial* exposures to stimuli; however, given practice, the steep slope that distinguishes the analytic strategy flattens. Given repeated exposure to stimulus sets, individuals learn to disregard certain features, or inhibit visual processing of those features, and focus only on relevant information that they have learned will determine a "same" or "different" response (Cave & Wolfe, 1990; Hoffman, 1978, 1979; Wolfe, 1994; Wolfe & Cave, 1989; Wolfe, Cave, & Franzel, 1989). The concentrated focus of specific features allows individuals to visually discriminate items more efficiently than those who develop a holistic strategy or maintain an unrefined analytic strategy (Doane et al., 1996).

The development of a refined analytic strategy is associated with difficult training. When individuals make multiple discriminations of highly similar stimuli, they refine their technique of visual search (Doane et al., 1996). The strategy developed during difficult training transfers to novel tasks and results in a transfer performance superior to those given easy training (Doane et al., 1996; Pratt & Sohn, 2001; Kramer, Pratt, & Sohn, 2002). The performance difference between difficult and easy training groups in transfer has been replicated using various levels of transfer difficulty, ranging from medium to difficult (Doane et al., 1996; Kramer, Pratt & Sohn, 2001). Whether these results can be replicated given serial presentation, rather than parallel presentation, is uncertain.

Individual Differences

While the results described above are typical, some individuals, who impose their cognitive style onto given tasks, react differently to training content. Cognitive style is defined as an overall thought process that organizes behavior in a similar pattern across a wide variety of situations (Robertson, 1985). When individuals have a strong inclination to use a cognitive style, they impose that style onto any given task and diverge from that style only if continuously unsuccessful (Bruner, Goodnow, & Austin, 1956). While cognitive styles have been conceptualized using many different approaches, analytic and holistic strategies have been extensively used to represent dichotomous styles in research related to visual discrimination (see review, Robertson, 1985). Analytic and holistic cognitive styles are defined by the slope of an individual's reaction time across increasing levels of complexity (Cooper, 1976), just as strategies are defined in the FIT model. What differentiates style from strategy is that a style is imposed on novel tasks regardless of stimuli; strategies, on the other hand, are stimulus-dependent.

By using a slope function to define cognitive style, we make the theoretical assumption that the analytic and holistic styles are opposite extremes on one unidimensional continuum. An individual's propensity to use one style would preclude use of the other. While this measure of cognitive style is reliable across various discrimination and visual search tasks (Pratt, 2002), participants have verbally reported using both analytic and holistic strategies in a single visual discrimination task (Eme & Marquer, 1998). Individuals who easily switch from one cognitive style to the other have been called "adaptive decision makers" (Nygren & White, 2002). To study the adaptive decision-making style, individual differences must be examined as orthogonal constructs, in which individuals could score high or low on both individual difference measures.

The cognitive-experiential self-theory (CEST; Epstein, 1994) captures two decision-making styles, rational and experiential, as orthogonal personality characteristics that contribute to behavior. The rational system is "conscious, relatively slow, (and) analytical" and the experiential system is "rapid, automatic, (and) holistic" (p. 972, Pacini & Epstein, 1999). An individual who scores high in both rationality and experientiality is considered to be an adaptive decision maker, easily switching strategies depending on the task context (Nygren & White, 2002). Individuals low in decision making adaptability score high in one style and low in the other, resulting in a large difference score between the two. CEST has been used to study decision-making under various probability tasks (Nygren & White, 2002; Pacini & Epstein, 1999), but the present research investigates how CEST relates visual discrimination strategies.

Given parallel presentation, the visual discrimination strategy an individual develops affects future performance on similar tasks (Doane et al., 1996; 1999; Kramer, Pratt & Sohn, 2002; Pratt & Sohn, 2001). Strategy development is influenced by the interaction between cognitive style and training (Kramer, Pratt & Sohn, 2002; Pratt & Sohn, 2001). Individuals with an analytic cognitive style perform well on novel comparisons regardless of training, while individuals with a holistic cognitive style perform poorly unless given difficult training. Whether this interaction occurs given serial presentation of visual discriminations is uncertain.

Also questionable is whether individual differences in decision-making style interact with training to affect transfer performance. Decision-making style, as conceptualized here, is a self-report measure and addresses a global style of thinking while cognitive style is operationalized with a behavioral measure that is domain specific to visual discrimination tasks. Cognitive style and decision-making styles are expected to relate. Individuals who report being rational should behave with an analytic style and individuals who report being experiential should behave with a holistic style. Whether individuals who report being experiential perform poorly on a transfer task if given easy training is uncertain.

The present research theorizes cognitive style and decision-making style do not relate to cognitive ability (operationally defined as WM capacity). Some measures of style, such as the embedded figures test (Witkin, 1950), incorporate accuracy into the measure of style, thus incorporating ability into the measure and not the method of search. Unlike previous measures of style, the present research uses a behavioral measure of style (quantifying a visual search pattern) and a self-report measure of style (qualifying a personal preference) to avoid differences in ability and instead focus on differences in process.

Although WM capacity is not expected to relate to cognitive style or decision-making style, it is expected to play a role in discrimination performance of serially presented stimuli. Given parallel presentation, strategy selection can compensate for low WM capacity, meaning an individual can look back and forth between the standard and the test stimulus to make a discrimination. However, given serial presentation of visual discriminations, individuals with low WM capacity will be at a disadvantage compared to individuals with high WM capacity in making visual discriminations, thus performing with less accuracy.

Research Objectives

The objective of the present research is threefold: explore the effects of serial presentation of visual discriminations, investigate the relationship between cognitive style, decision-making style, and WM capacity, and determine if the aforementioned variables interact with training content to affect transferability of visual discrimination skills.

Serial and parallel presentation of visual discriminations will be compared to determine if individuals utilize a different strategy depending on presentation type. Although not statistically tested, Krueger (1983) found that when discriminating a series of English letters, participants verbally reported using an analytic or holistic strategy depending on the presentation style. Participants reported looking point-by-point between the stimuli if given parallel presentation (i.e., analytic style), and memorizing the overall shape of the letter series if discriminating serial presented stimuli (i.e., holistic style).

While these strategies are effective for some participants, individuals with a propensity to use a cognitive style are predicted to utilize their preferred strategy regardless of presentation style. Participants who have high or low slope scores given parallel presentation are expected to have high or low slope scores, respectively, for serial presentations. Similarly, participants who have high or low slope scores for the discrimination task are expected to self-report having high or low levels of rationality, respectively. WM capacity is not expected to relate to cognitive style or decision-making style, but should lead to decrements in transfer performance. Transfer performance is expected to be poor for holistic and experiential groups if given easy training, but not if given difficult training.

Method

Participants

Eighty-four undergraduates voluntarily participated in the present research for course credit. Fifty-five of the participants were female and twenty-nine were male. Three participants dropped out of the experiment early, so their data were removed, for a total of N=81.

Materials

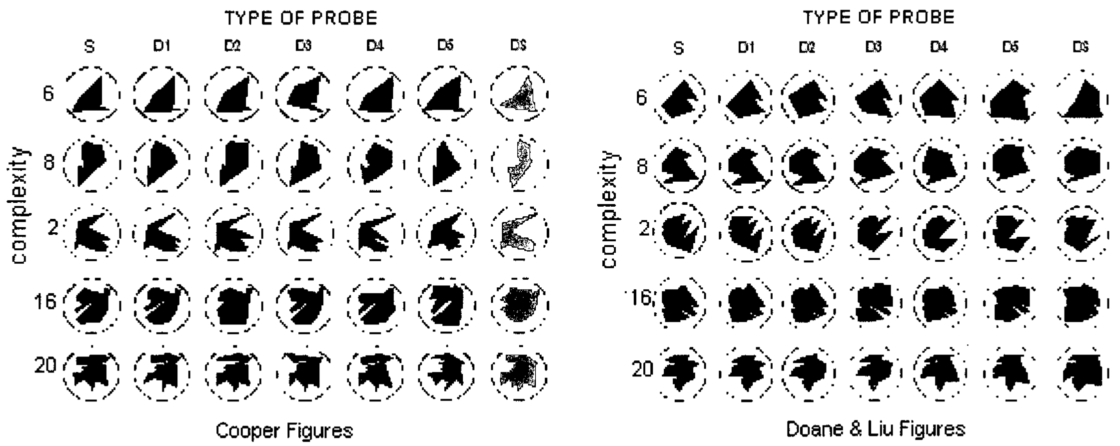
Individual Difference Measures. Participants were screened for three individual differences measures: decision-making style, cognitive style, and WM capacity. Decision-making style was surveyed using a paper-based questionnaire, with all questionnaire items on a 5-point scale ranging from 1 (definitely not true of myself) to 5 (definitely true of myself). The cognitive style and WM capacity tasks were presented to participants using Psycope 1.2.5 on a 17-inch monitors.

Decision-making style. Decision-making style was measured using the Rational-Experiential Inventory (REI; Pacini & Epstein, 1999). The REI measures rational and experiential decision-making styles and includes subscales of self-reported ability and self-reported engagement within each style. The REI consists of 40 items; with 10 items per subscale. Rational Ability refers to reports of high level of ability to think logically and analytically (e.g., "I have no problem thinking things through carefully"); Rational Engagement refers to reliance on and enjoyment of thinking in an analytical, logical manner (e.g., "I enjoy thinking in abstract terms"); Experiential Ability refers to reports of a high level of ability with respect to one's intuitive impressions and feelings (e.g., "When it comes to trusting people, I can usually rely on my gut feelings"); Experiential Engagement refers to a reliance on and enjoyment of feelings and intuitions in making decisions (e.g., I like to rely on my intuitive impressions"). Overall Rationality and Experiential scales were obtained by summing the appropriate ability and engagement subscales.

WM capacity. Participants were presented five English capital letters (J, L, R, P, F) and their mirror images one at a time, each appearing in different orientations on the computer screen. The letters were 6° wide and 7° tall, given a 45cm distance between the computer screen and the participants' eyes. Each letter was presented for 2,200 ms and appeared in the center of the computer screen in one of seven possible orientations in 45° increments, excluding the upright orientation. The letter appeared in a series of two, three, four, and five letter sequences.

The task was to remember the orientation of each letter in the correct order, while saying aloud whether each letter was normal or mirror-imaged as quickly and accurately as possible. An experimenter recorded responses. Following each letter sequence, a new window appeared and participants were asked to recall, in the correct sequence, the orientation for each letter. Using the computer mouse, participants indicated where the top of each letter appeared by clicking the mouse in one of eight buttons that represented each possible orientation (for more detail, see Shah & Miyake, 1996).

Cognitive style. Individual differences in cognitive style



(Fig. 1) Stimulus sets used for the present research

were assessed using methods described by Pratt and Sohn (2001). Participants visually discriminated two parallel-aligned polygons as being same or different. Polygons, taken from the Cooper (1976) stimulus set, were random shapes varying in complexity and similarity (see Figure 1). Complexity was defined by the number of points (6, 8, 12, 16, 20) that connected the shape of each polygon. The more complex polygons contained more points. Five polygons served as standards (i.e., See S column in Figure 1), each of which was paired with itself or one of six mismatches (D1-D6). The mismatches varied in the degree of similarity to the standard, with D1 being the most similar and D6 being the most dissimilar. The polygons were 6° wide and 7° tall and separated by 3.5° of visual angle.

Cognitive style was measured, using the same materials as described above with two exceptions. The polygons were taken from the Doane et al. (1996) stimulus set and all trials consisted of two polygons viewed sequentially rather than in parallel. The first polygon displayed within a trial was the standard. Participants pressed the space bar of the computer keyboard to remove the standard polygon and view the test polygon. The participant pressed the "s" or the "l" key to indicate whether the test polygon was the same or different from the standard polygon. After pressing the corresponding key, 1500 ms passed and the next trial began. Time spent viewing the standard polygon, time spent viewing the test polygon, and discrimination accuracy was recorded.

Visual Discrimination Task. The visual discrimination task was similar to the serially presented polygon comparison task used to measure cognitive style. The Doane (1996) stimulus set was used for the training session and the Cooper (1976) stimulus set was used for the transfer session (see Figure 1). For the training session, participants randomly assigned to the difficult training condition discriminated only the most similar polygons (S vs. S, D1, D2) and participants randomly assigned to the easy training condition discriminated only the most dissimilar polygons (S vs. S, D5, D6). For the transfer session, participants discriminated polygons of medium difficulty (S vs. S, D3, D4).

Procedure

Participants began the experiment by participating in the WM capacity task, the parallel cognitive style task, and the serial cognitive style task. The three tasks were counter-balanced to remove any potential order effects. For the WM capacity task, participants were verbally instructed to say aloud whether a letter was reversed (the mirror image) or correct and to recall the orientation of each letter in the correct sequence. Participants were then asked to read specific instructions on the computer screen. Following the instructions, the experimenter and the participant performed five practice trials together with accuracy feedback provided. The participant then performed the WM capacity task, and the experimenter recorded the participant's verbal judgments. For the cognitive style tasks, participants were provided verbal instructions, and then asked to read specific instructions on the computer screen. Following the instructions, participants performed three practice trials with accuracy feedback before beginning the task. Both cognitive style tasks consisted of three blocks of 60 trials for a total of 180 trials.

Following the individual difference tasks, participants were randomly assigned to either the difficult or easy training condition. Again, participants received verbal instructions, were asked to read specific instructions on the computer screen, and performed three practice trials with feedback. Participants discriminated a total of 192 trials, which were divided into four blocks of 48 trials. Each block was separated by an optional rest period. The transfer session followed the training session. Participants were provided verbal and written instructions, three practice trials, and then began the discrimination trials. The transfer session mirrored the training session, consisting of 192 trials divided into four blocks of 48 trials. Each block was separated by a rest period.

After the discrimination task was complete, participants were asked to fill out a REI questionnaire. The participant was debriefed after finishing the survey. The entire experiment lasted approximately 90 minutes.

Results

All participants were required to meet an 80% cutoff accuracy score on all the visual discrimination tasks to be included in the data analysis. Twenty-five participants scored below 80%, so their data were removed. The following data analysis is based on a sample of 56 participants unless otherwise specified.

Individual Difference Measures

Gender Differences. Gender differences have been associated with differences in spatial ability (Murphy & Lorenz, 2001) and self-report measures of the REI (Pacini & Epstein, 1999). An independent samples t test was performed to determine if man and woman participants performed differently on the four individual difference measures. No differences were found with the exception of the experiential scale of the REI. Females reported higher levels of experiential thinking, $t(55) = 2.61$, $p < .05$; and reported higher experiential ability, $t(55) = 2.47$, $p < .05$. Gender differences were partialed out of the analyses involving the REI as recommended by Pacini & Epstein (1999) by using the covariates.

Decision-making Style. Rationality significantly correlated with its subscales and experientiality correlated with its subscales. None of the rationality measures correlated with experientiality or its subscales, indicating the two styles are orthogonal. The possible minimum and maximum scores were 20 and 100 for each scale. Participant's scores for the experiential scale ranged from 50 to 85. The mean was 71.69, the median 71, and the standard deviation was 6.44. For the rational scale, scores ranged from 49 to 89. The mean was 68.32, the median 70, and the standard deviation was 8.6. Using a median split, the ten highest scores and the ten lowest scores within each scale were used for further analysis. Subscales of the rational and experiential scales were examined using the same method. To determine which participants had an adaptive decision-making style, the rational and experiential scales were summed and then divided by their difference score.

Participant's scores ranged from 5.54 to 150. The mean was 35.76, the median 19.28, and the standard deviation was 41.51. Using a median split, the ten highest scores (adaptive decision making style) and the ten lowest scores (nonadaptive decision making style) within each scale were used for further analysis. The group's performance on the visual discrimination task was observed across the training and transfer tasks.

WM capacity. WM span was scored using methods described by Shah and Miyake (1996). A participant's span score was defined as the highest set size for which all the orientations were recalled in the correct order, for at least three of the five sets. If the participant's recall was accurate on two of the five sets at the next set size, half a point was added to the score. If a participant correctly recalled less than three of the five sets at a particular level but was able to recall two or more sets at a higher level (this case was rare, n = 9), the average of the lower and the upper limits was used as the span score. The possible maximum and minimum scores for the spatial span measures were 5.0 and 1.0 (in cases in which only one or no set was correctly recalled at the two-item level) respectively.

The mean span score was 2.37, the median was 2.0, and the standard deviation was .95. Participants with scores higher than 2.0 were categorized as having high memory span and participants with scores lower than 2.0 were categorized as having low memory span. The top ten high memory span scores and the top ten low memory span scorers were used for further analysis.

Cognitive Style. For comparisons made in parallel, only one reaction time score was recorded per trial, but for comparisons made serially, two reaction time scores were recorded. The first reaction time score represents the process of encoding, the second reaction time score represents encoding and the decision process. Because the first reaction time score captures the activities within the parallel session, only the second reaction score was plotted as a function of polygon complexity to determine individual difference slope scores. For parallel presentation, the mean slope score was 22.54, the median slope score was 19.08 and the standard deviation was 17.65. For serial presentation, the mean slope score was 29.09, the median slope score was 20.0, and the standard deviation was 49.09.

A paired samples t test was performed to determine if individual slope scores were significantly different for parallel and serial presentation styles. Individual parallel slope scores were not significantly different from serial slope scores, $t(55) = -1.075$, $p > .05$; indicating participants used a similar strategy given parallel or serial presentation. Participants were identified as holistic and analytic using a median split of the serially presented slope scores. The top ten holistic (flattest slope) and the top ten analytic (steepest slope) participants were used for further analysis.

Partialed Correlations. Slope scores taken from parallel-presented polygons significantly correlated with slope scores taken from the serially presented polygon task, $r = .370$; $r = .344$ (gender partialed out). While significant, the relationship between parallel and serial slope scores was not very strong, indicating that, while individuals apply their cognitive styles across tasks, contextual factors, such as presentation type, have an impact on strategy choice as well.

No relationship was found between WM capacity and all other individual difference measures, indicating that individual differences in cognitive styles are distinct methods of discriminating, and not related to or influenced by cognitive ability. Surprisingly, no relationship was found between self-reported decision-making style and cognitive style. The behavioral process of making a visual discrimination appears to be different from the cognitive process an individual reports using to make hypothetical decisions. Alternatively, individuals may not be good judges of their style, meaning they report acting one way when in reality they behave another way.

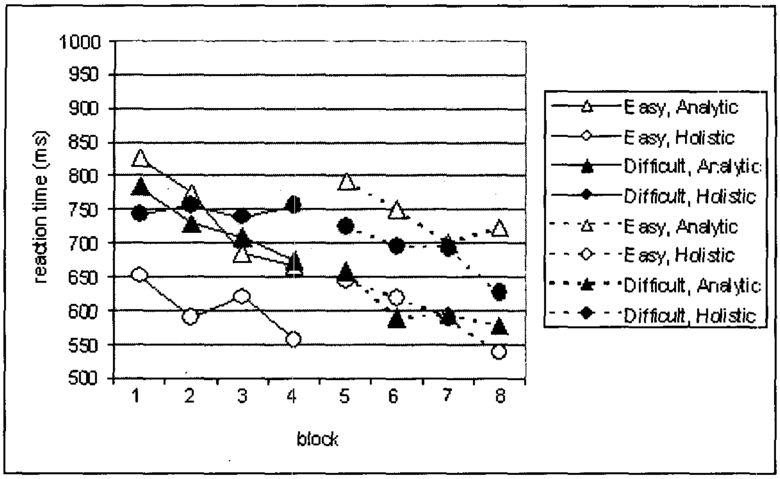
Training and Transfer Task

The effects of training on the individual difference variables were examined using reaction time and accuracy scores of the training and transfer sessions. Responses to same-discrimination trials and different-discrimination trials were examined separately. Each participant's mean accuracy score and median reaction time score for each stimulus set was determined for each block. To examine participants' strategy development, slope scores were assessed for each block using reaction time scores as a function of increasing polygon complexity level. Results are explained for each individual difference variable.

Cognitive Style. Each training condition contained ten analytic and ten holistic participants, for a total of $n = 40$. Analytic and holistic group performance was assessed across the training and transfer sessions.

Reaction time. In (Figure 2), the same-judgment reaction time means are shown across the training and transfer sessions for holistic and analytic participants within the easy and difficult training conditions. The easy trained holistic group appears to spend the least amount of time making a same judgment compared to all other groups during the training session. During the transfer session, however, both the easy trained holistic group and the difficult trained analytic group appear to spend less time making same judgments compared to the easy trained analytic group and the difficult trained holistic group.

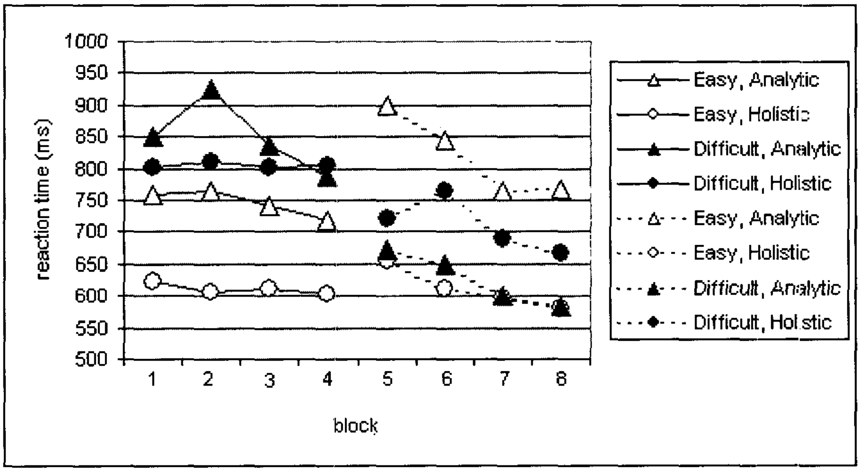
An ANOVA was performed using training condition (easy, difficult) and cognitive style (analytic, holistic) as between measures and session (training, transfer) and block (4 within each session) as within measures. This analysis was done to determine if there was a significant interaction between training condition and cognitive style. The interaction between training condition and cognitive style was significant, $F(1, 36) = 4.32$, $MSE = 722000.00$, $p < .05$. This relationship was examined again, using only the reaction times from the four transfer blocks, and the same relationship occurred, $F(1, 36) = 5.21$, $MSE = 503329.23$, $p < .05$. Participants classified as holistic spent more time making same judgments during the transfer session if they were given difficult training. Participants classified as analytic spent more time making same judgments during the transfer session if



(Fig. 2) Reaction time scores for same comparisons across the training and transfer sessions for individuals with analytic and holistic cognitive styles within the easy and difficult training conditions.

they were given easy training.

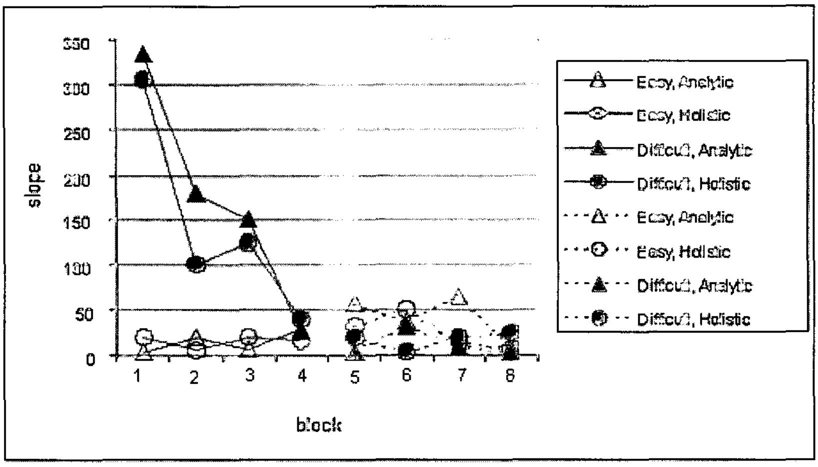
(Figure 3) shows the different-judgment reaction time means for holistic and analytic participants within the easy and difficult training conditions across the training and transfer sessions. Reaction time scores for different judgments



(Fig. 3) Reaction time scores for different comparisons across the training and transfer sessions for individuals with analytic and holistic cognitive styles within the easy and difficult training conditions.

appear to be very similar to reaction time scores for same judgments. Although the results of the different-discriminations appear similar to the results of the same-discriminations, the interaction between cognitive style and training condition was not significant. A second ANOVA was performed, this time using only the four transfer blocks as within measures. Training condition and cognitive style significantly interacted, $F(1, 34) = 8.22$, $MSE = 98967.11$, $p < .01$. The results for the four transfer blocks were similar to the reaction time scores for same judgments.

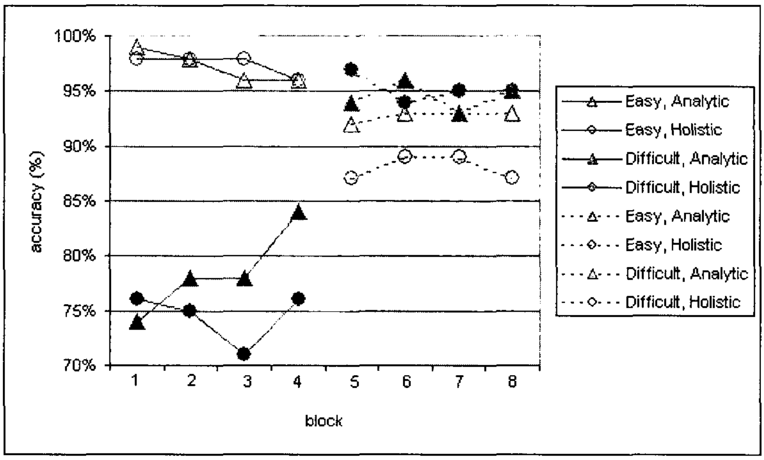
Reaction time scores were converted into slope scores using reaction time as a function of polygon complexity. (Figure 4) shows the mean slope score for analytic and holistic groups



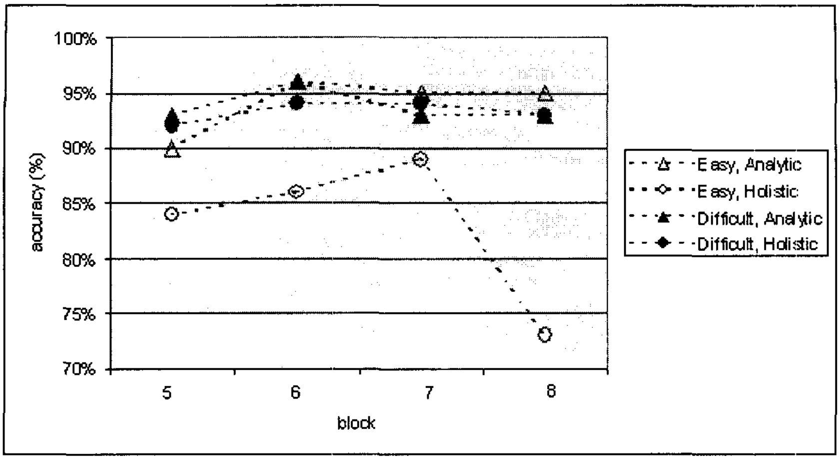
(Fig. 4) Slope scores across the training and transfer sessions for individuals with analytic and holistic cognitive styles within the easy and difficult training conditions.

within each training condition across the training and transfer sessions. During the training session, slope scores appear to vary based on training condition, or the difficulty level of the discriminations. Individual differences in cognitive style do not appear to play a role in strategy selection, $F(1, 36)$ = 18.93, MSE = 2140335.57, p < .001. In the transfer session, it appears as though individuals are using the same strategy, although individuals given easy training appear to have higher slope scores than individuals given difficult training.

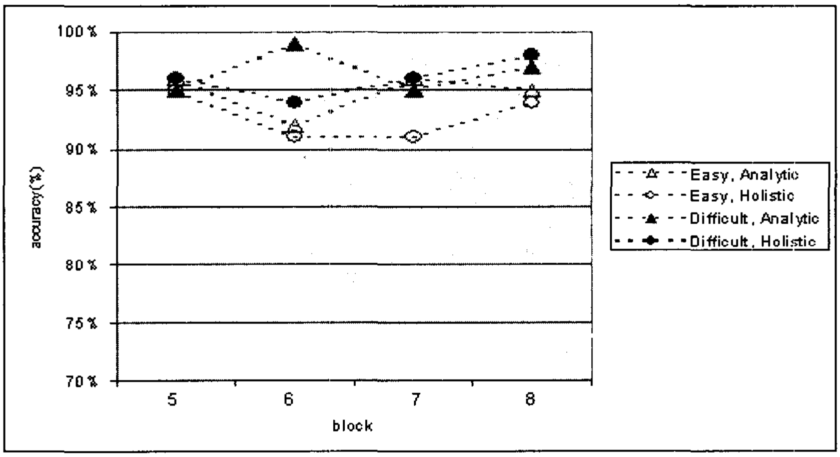
Accuracy. (Figure 5) shows the accuracy means of different-discrimination judgments across the training and transfer sessions. In the training session, participants who received easy training clearly perform with greater accuracy than individuals given difficult training. Participants given difficult training show an increase in accuracy, indicating learning given practice, while the easy trained groups show a slight decrease in performance, although still performing significantly better than the difficult group. In the transfer session, all participants appear to perform equally well, with the exception of the easy-trained holistic group, who



(Fig. 5) Accuracy scores for different comparisons across the training and transfer sessions for individuals with analytic and holistic cognitive styles within the easy and difficult training conditions.



(A)



(B)

(Fig. 6) Accuracy scores for different comparisons across the transfer session for individuals with analytic and holistic cognitive styles within the easy and difficult training conditions (A.) for individuals with low WM capacity and (B) for individuals with high WM capacity.

performed with less accuracy. As the graph indicates, a significant four-way interaction between session, block, training condition, and cognitive style was shown, $F(3, 108) = 4.57$, $MSE = .011$, $p < .005$.

WM Capacity. Participants with high and low WM capacity were compared across the training and transfer sessions. WM capacity did not interact with training conditions to affect reaction time or accuracy performance across the training and transfer sessions. However, individual differences in cognitive style appeared to interact with WM capacity across the session blocks. (Figure 6) presents the means for individuals with (A) low WM capacity and (B) high WM capacity across the four transfer blocks. Easy trained holistic participants categorized as having low WM capacity appear to perform with less accuracy in the transfer session than all other groups.

An ANOVA was performed using training condition (easy, difficult), cognitive style (analytic, holistic), and memory span ability (high and low) as between measures and the four transfer session blocks as within measures. Two three-way interactions occurred between block, cognitive style, and memory span, $F(1, 63) = 3.491$, $MSE = .006$, $p < .01$; and between the block, training condition, and memory span, $F(1, 63) = 3.77$, $MSE = .007$, $p < .01$.

Cognitive-Experiential Self-Theory. Surprisingly, survey responses from the REI, which was designed to capture rationality, experientiality, and adaptive decision-making styles, did not interact with training conditions to affect reaction time or accuracy performance across the training and transfer sessions. Further analysis was done using only the subscales of engagement, which captures participant's preference to use rational or experiential thinking. The engagement subscale did not interact with training conditions, nor did it interact with individual differences in cognitive style to effect transfer performance. The subscales of ability were investigated as well, but no significant results were found.

Discussion

The present research was undertaken for three main purposes. The first was to compare the effects of presentation style on visual discrimination performance. The second was to examine the relationships between individual difference variables as they relate to parallel and serially presented visual discriminations. Third, we were interested in examining the effects of training on serially presented visual discriminations and whether certain individual difference variables affect transfer performance.

Discrimination Presentation

Contrary to Krueger's (1983) findings, individuals used a similar strategy to discriminate parallel and serially presented stimulus sets. Use of the same strategy across different tasks reaffirms the theoretical assumption of unidimensionality and is consistent with the characterization of cognitive style. Because cognitive style is pervasive across tasks, it should be taken into account when designing job tasks involving visual discrimination.

It is important to note that the relationship between cognitive style and presentation style, while significant, was not very strong. External factors, such as information display characteristics, are speculated to have an influence on strategy selection. For example, an individual's point-by-point comparison of a stimulus set (e.g., an analytic cognitive strategy) would slightly differ depending on whether the standard stimulus was present or absent during the discrimination decision process. In addition to individual differences in cognitive style, display characteristics, such as presentation style (Krueger, 1983), stimulus size (Payne, Bettman, & Johnson, 1993), stimulus complexity (Kramer, Pratt & Sohn, 2002), and information layout (Wickens & Campo, 1996) influence a user's visual search and discrimination strategy and subsequent skill. When designing an information display, the above factors should be taken into account based on the results of the present research.

Individual Difference Variables

None of the individual difference variables significantly correlated with each other. The "global measures" of rationality and experientiality were expected to correlate with the "domain specific measures" of cognitive style. However, neither scale, nor its corresponding subscales, related to cognitive style. Based on the results of the present research, it is speculated that the visual discrimination task, while capable of expressing holistic and analytic processing, did not express rational and experiential characteristics because the polygon discrimination task did not create a conflict between a participant's "heart and head". According to Pacini and Epstein (1999), rationality and experientiality are expressed when an individual must choose between being analytical or intuitive. Perhaps participants' cognitive style would have related to their decision-making style if the discrimination task had consequences attached to discrimination responses. Given an applied task, such as monitoring a nuclear power plant's system state or discriminating between enemy and ally targets, individuals are speculated to use a discrimination strategy predictive of their decision-making style. Such task conditions would create adequate conflict between the analytic and intuitive systems, altering a participant's discrimination response process.

Transfer Performance

Training content appears to have the greatest impact on participants' ability to successfully transfer their discrimination skills. Difficult training eliminates differences in transfer performance for individuals who vary in cognitive style and WM capacity. It is speculated that the strategy developed during difficult training allows individuals to discriminate stimuli with greater accuracy and greater speed than individuals given easy training. Using the guided search theory (Wolf, Cave, & Franzel, 1989) as a framework, individuals learn what features constitute a same or different response during difficult training. Rather than processing and remembering the entire stimulus, individuals focus only on the features critical to discrimination.

The abbreviated strategy developed during difficult training is crucial for individuals with a holistic cognitive style and low WM capacity. Encoding the standard stimulus takes greater effort for individuals with low WM capacity compared to individuals with high WM capacity; and as a consequence, individuals with low WM capacity have a greater probability of experiencing fatigue (e.g., Suess & Schmudek, 2000). The strategy developed during difficult training allows the individual with low WM capacity to reduce the amount of encoding, which in turn, reduces the amount of fatigue experienced during the transfer session. Ultimately, training with difficult discriminations allows all participants, regardless of individual differences in style or ability, to discriminate with greater accuracy and speed while experiencing less cognitive fatigue during a novel discrimination task.

Future Research

The present research adds to the body of knowledge associated with individual differences in visual strategies. As computer automation increases, interface designers must be cognizant of individual differences in information processing and how to manipulate and wield an individual's visual search and discrimination strategy to suit the goals of the interface. While the present research offers valuable information, addition research in this area is necessary to fully understand the process of visual search and discrimination.

To gain more insight on strategy development and implementation, future research should assign the basic principles of the present research to an applied work task. Given a real world task, discrimination judgments carry consequences and hold meaning or value to the individual making the judgments. Understanding how individuals respond to consequential discriminations in a real working environment would contribute to this line of research. Visual discriminations made under conditions of high workload, or underload, over an expansive amount of time, should be investigated. The results of such research would improve the interface design for military personnel, air traffic controllers, and other jobs related to visual discrimination.

References

Biederman, I., & Shiffrar, M. (1987). Sexing day-old chicks: A case study and expert systems analysis of a difficult perceptual-learning task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13* (4), 640-645.

Brown, J. D. (2001). Spatial ability as a predictor of karyotyping ability. *The Journal of the Association of Genetic Technologists, 27*(4), 135- 139.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). *A Study of Thinking*. Oxford, England: John Wiley and Sons.

Cave, K. R., & Wolfe, J. M. (1990). Modeling the role of parallel processing in visual search. *Cognitive Psychology, 22*, 225-271.

Cooper, L. A. (1976). Individual differences in visual comparison processes. *Perception and Psychophysics, 19*(5), 433-444.

Doane, S. M., Alderson, D. L., Sohn, Y. W., & Pellegrino, J. W. (1996). Acquisition and transfer of skilled performance: Are visual discrimination skills stimulus specific? *Journal of Experimental Psychology: Human Perception and Performance, 22*, 1218-1248.

Doane, S. M., Sohn, Y. W., & Schreiber, B. (1999). The role of processing strategies in the acquisition and transfer of a cognitive skill. *Journal of Experimental Psychology: Human Perception and Performance, 25*(5), 1390-1410.

Eme, P. E., & Marquer, J. (1998). Quantitative and qualitative individual differences in visual comparison processing: Are strategies only analytic or holistic? *Personality and Individual Differences. 25*(3) 459-475.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist, 49*, 709-724.

Fisher, D. L., & Tanner, N. S. (1992). Optimal symbol set selection: A semiautomated procedure. *Human Factors, 34*, 79-95.

Fisher, D. L., & Young, G. (1987). Perceptual learning: Theory and applications. In *Proceedings of the 31st Annual Meeting of the Human Factors Society* (pp. 1049-1053). Santa Monica, CA: The Human Factors Society.

Folk, M. D., & Luce, R. D. (1987). Effects of stimulus complexity on mental rotation rate of polygons. *Journal of Experimental Psychology: Human Perception and Performance*, 13, 395-404.

Gillan, D. J., & Harrison, C. (1999). A Componential Model of Human Interaction with Graphs IV: Holistic and Analytic Perception of Star Graphs. In *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting*, Albuquerque, NM: Human Factors and Ergonomic Society.

Hitch, G. J., Towse, J. N., & Hutton, U. (2001). What limits children's working memory span? Theoretical accounts and applications for scholastic development. *Journal of Experimental Psychology: General, 130*, 184-198.

Hoffman, J. E. (1978). Search through a sequentially presented visual display. *Perception and Psychophysics, 23*, 1-11.

Hoffman, J. E. (1979). A two-stage model of visual search. *Perception and Psychophysics, 25*, 319-327.

Hogeboom, M., & van Leeuwen, C. (1997). Visual search strategy and perceptual organization covary with individual preference and structural complexity. *Acta Psychologica, 95*(2), 141-164.

Job, R., Nicoletti, R., & Rumiati, R. (1982). The effects of task requirements on the processing of complex stimuli. *Acta Psychologica, 51*(2), 105-114.

Kramer E. A., Pratt J. H., & Sohn, Y. W. (2002). Task Context and Individual Difference Effects on Skill Acquisition of Visual Processing Strategy. In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*, Baltimore, MD: Human Factors and Ergonomic Society.

Krueger, L. E. (1983). Probing proctor's priming principle: The effect of simultaneous and sequential presentation on same-different judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition,. 9*(3), 511-523.

Murphy, E., & Lorenz, B. (2001). Is Spatial Visualization Ability a Stronger Predictor of Performance for Males than for Females on Computer-Based Tasks? In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*, Minneapolis, MN: Human Factors and Ergonomic Society.

Nygren, T. E., & White, R. J. (2002). Assessing Individual Differences in Decision Making Styles: Analytical vs. Intuitive. In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*, Baltimore, MD: Human Factors and Ergonomic Society.

Pacini, R., & Epstein, S. (1999). The relation of rational and experimental information processing styles to personality, basis beliefs, and the ratio-bias phenomenon. *Journal of Personality and Social Psychology*, 76, 972-987.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). The use of multiple strategies in judgment and choice. In N. J. Castellan, *Individual and Group Decision Making*. Erlbaum: Hillsdale, NJ. 19-39.

Pratt, J. H. (2002). Development of Cognitive Styles and Strategies in the Visual Discrimination of Computer displayed Graphics: Task Characteristics, Training and Design. Dissertation Abstracts, University of Connecticut.

Pratt, J. H., & Sohn, Y. W. (2001). Individual Difference Effects on Training and Transfer of Visual Processing Strategy. In *Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting*, Minneapolis, MN: Human Factors and Ergonomic Society.

Robertson, I. T. (1985). Human Information-Processing Strategies and Style. *Behaviour and Information Technology*, 4(1) 19-29.

Shah, P., & Miyake, A. (1996). The separability of working memory resources for spatial thinking and language processing: An individual differences approach. *Journal of Experimental Psychology*: General, 125, 4-27.

Suess, H. M., & Schmudek, F. (2000). Fatigue and practice effects during cognitive tasks lasting several hours. *Zeitschrift fuer Experimentelle Psychologie, 47*(3) 162-179.

Treisman, A. M. (1980). Features and Objects: The 14th Bartlett Memorial Lecture. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology. 40*(2) 201-237.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*. 12(1) 97-136.

Wickens, C. D., & Campo, M. C. (1996). Information Processing. In G. Salvendy (Ed.), *Handbook of Human Factors and Ergonomics* (pp. 89-129). New York: John Wiley & Sons, Inc.

Witkin, H. A. (1950). Individual differences in ease of perception of embedded figures. *Journal of Personality,* *19*, 1-15.

Wolfe, J. M. (1994). Guided search 2.1: A revised model of guided search. *Psychonomic Bulletin and Review, 1*, 202-238.

Wolfe, J. M., & Cave, K. R. (1989). Deploying visual attention: The guided search model. In T. Troscianko and A. Blake (Eds.), *AI and the Eye*, Chichester, UK: Wiley and Sons.

Wolfe, J. M, Cave, K. R., & Franzel, S. L. (1989). Guided Search: An alternative to the Feature Integration model for visual search. *Journal of Experimental Psychology: Human Perception and Performance, 15*, 419-433.

Uttal, W. R. (1988). *On Seeing Forms*. Hillsdale, NJ: Erlbaum Associates.

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