감성과학, Vol. 7, No. 2, pp. 163-178. June 2004

Analysis of Cognitive Styles across Visual Discrimination Tasks

시각적 구별 과제를 통한 인지양식의 분석

Soo-Young Kim* · Shin-Woong Hwang** · Jee-Yun Cho* · Young-Woo Sohn*†

김수영* · 황신웅 · 조지연* · 손영우*†**

Department of Psychology, Yonsei University*
연세대학교 심리학과

Graduate Program in Cognitive Science, Yonsei University**
연세대학교 인지과학 협동과정

Abstract : The present study identified dimensions of cognitive styles that were concerned with individual differences in cognitive processes. The results provided support for Robertson's [36] theory of cognitive processes that are independent of task. An individual's first or initial cognitive strategy may be consistent across different tasks and therefore considered their style. However, an individual's cognitive style may change after interacting with the task during a number of trials, and lead to a strategy that is particular to the task.

Key words : visual discrimination, individual difference, cognitive style, cognitive strategy

요약 : 본 연구에서는 수행된 과제와 독립적인 인지과정에서의 개인차와 관계가 있는 인지양식의 차원들을 규명하였고 과제와는 독립적인 인지과정에 대한 Robertson(1985)의 이론을 지지하는 결과를 보여주었다. 각 개인의 초기 인지전략은 다른 과제를 수행해 가는 동안 계속해서 유지되는 것으로 관찰되었고 결국 그것이 그들의 인지양식으로 간주되었다. 그렇지만 개인들의 인지양식은 많은 수행을 거치면서 그 과제들과의 상호작용을 통해 변화하여 그 과제에 특정한 전략을 이끌어낼 수도 있다는 점을 시사하였다.

주제어 : 시각적 구별, 개인차, 인지양식, 인지전략

† 교신저자 : 손영우(연세대학교 심리학과)
E-mail : ysohn@yonsei.ac.kr
TEL : 02-2123-2444, 011-9133-5354
FAX : 02-365-4354

1. Introduction

Individuals exhibit significant differences in the information-processing strategies, or cognitive strategies, that they adopt while performing problem-solving and other decision-making activities[36]. Individual differences in cognitive strategies have been studied in areas such as engineering design[40], military training[23], graphical interface design[29], and spatial judgments[5,6, 16]. There are many different definitions for 'cognitive strategies' in the literature, however[1, 14]. Most tend to agree that cognitive strategies are conscious activities initiated by an individual to help them achieve a goal or complete a task. The cognitive strategy an individual uses to perform a task can have an impact on their performance of that task[30,33,38]. This impact may not only affect the time it takes them to complete the task, but also how accurately they perform it[10,25]. Particular types of cognitive strategies that have been studied include field.

Particular types of cognitive strategies that have been studied include field dependence-independence, conceptual systems approach, holistic and analytic strategy, convergent-divergent thinking, and reflective-impulsive thinking[36]. Among these types of cognitive strategies, holistic and analytic cognitive strategies have been studied extensively in the visual discrimination literature [17,19,21,24,26]. Some individuals take a big-picture, holistic approach when collecting information to solve a problem, while others take a more detailed, analytical approach to solving a problem[12,21,27]. Holistic and analytic cognitive strategies are of particular interest in visual discrimination tasks where individuals are asked to discriminate between disparate visual stimuli.

1.1 Cognitive Strategies for Visual Discrimination

Visual discrimination takes place when people look for differences in two or more figures. Different features of the figures being compared can require different information processing strategies[28]. Cooper[8] studied holistic and analytic strategies using a polygon visual discrimination task. In Cooper's study, participants were presented with random polygons and asked to determine whether those polygons were the same or different. Cooper proposed that the differences in the patterns of the reaction times of the participants reflected a difference in cognitive strategy. Cooper referred to the participants who did not show any change in reaction time as the similarity of the polygons increased as using a holistic strategy. Cooper referred to the second group of participants who did show a change in reaction time as the similarity of the polygons increased as using an analytic strategy. The author proposed the participants using an analytic strategy used a sequential comparison strategy, meaning they compared the polygon in memory point-by-point to the visual test polygon. As the similarity of the polygons increased, the point-by-point comparison process took longer to detect a difference.

Using another visual discrimination task, Job, Nicoletti, and Rumiati[26] manipulated task instruction in a geometric figures comparison task to induce holistic and analytic cognitive strategies. Participants were asked to compare 2 sets of geometric figures. Each set of figures were positioned one above the other, each of which consisted of three geometrical shapes inserted concentrically one inside another. The authors found that when participants were asked to indicate that the sets were 'same' only when the sets were identical and 'different' if they were equivalent or different, the participant used a holistic strategy. Participants had to examine all the dimensions of the stimulus and would mark different even if only one dimension differed which lead to a more holistic strategy. If the participants were asked to indicate the sets were 'same' if the sets were identical or equivalent and 'different' if the sets were different, the participants used an analytic strategy. Participants had to examine all the dimensions of the stimulus, and judge if enough of the dimensions of the stimulus were different enough to judge them diverse, leading them to a more analytic strategy.

Hogeboom and van Leeuwen[24] used a jigsaw puzzle alignment task to identify holistic and analytic strategies. Participants were asked to identify if the facing edges of two pieces of a jigsaw would align properly. By manipulating the location of the non-fitting notches of the jigsaw puzzle pieces, reaction time could be used to identify the strategy. If reaction time increased as a function of the position of the non-fitting notch, an analytic strategy was identified. If reaction time did not increase as a function of the position of the non-fitting notch, a holistic strategy was identified.

Gillan and Harrison[18] used radar graph comparisons to identify holistic and analytic strategies. The authors displayed 4 radar graphs on a screen, each of which had 5 legs. The participant was asked to identify which of the radar graphs was different. The length of one of the legs on one of the radar graphs was different from the other radar graphs. An analytic strategy was identified if the coefficient of variation of reaction time for a participant increased as a function of the position of the different leg. A holistic strategy was identified if reaction time did not change as a function of the variation in reaction time of the different leg.

Holistic and analytic strategies were identified in all of these visual discrimination tasks. Using reaction time measures and manipulating the dimensions of the visual comparison tasks, the authors in each of these studies were able to identify differences in cognitive strategy between participants. The similarities in the findings between these studies lend confidence not only to the methodology in identifying individual differences in holistic and analytic strategies, but also to using these particular tasks in identifying these strategies.

Robertson[36] distinguished cognitive strategies from cognitive styles. Cognitive strategies are thought processes based on details of particular situations, and cognitive styles are overall thought processes that organize behavior across a wide variety of situations[36]. Robertson argued that dimensions of cognitive styles are concerned with individual differences in cognitive processes that are independent of the task being completed. The aspects of information processing an individual generally uses between tasks are referred to as cognitive styles. The types of processing an individual uses within particular tasks are referred to as cognitive strategies. The research question of this study is whether participants use similar holistic or analytic strategies persistently across tasks, indicating a cognitive style.

1.2 General Methodology

There are several methods for assessing a participant's cognitive strategy for visual discrimination. The three most commonly used are reaction time, verbal report and eye tracking. Classically, reaction time has been the most frequently used to identify visual discrimination cognitive strategy. This method is quantitative, but a change in reaction time as a function of complexity is not a direct measurement of whether participants use a point-by-point comparison[8].

A second method to assess strategy is verbal report. Many studies(e.g., [11,13,14,19,31]) have incorporated verbal report protocols to assess cognitive strategy. A common verbal reporting method utilized is what Gillan and Lewis[19] refer to as a 'think aloud' method. This method in general asks the individual to describe, step by step, what they are thinking while doing an example visual comparison. Example questions are, 'What are you thinking while you are performing this comparison?' and 'Do you look back and forth between the two polygons?' A criticism of this strategy is that verbal reporting of cognitive strategy while completing the task can cause an analysis of one's own strategy. This analytical process may lead to a more analytical cognitive strategy, therefore affecting the measurement of holistic cognitive strategies. Eme and Marquer[11], however, have found a high correlation between verbal report and reaction time measures of cognitive strategy.

A third method for assessing cognitive strategy in visual discrimination is eye tracking. Visual discrimination requires visual scanning of the objects. Eye movements can reveal aspects of cognitive processes, such as search strategy[32]. There are many theories regarding the connection of visual behavior and cognitive attention are connected[20]. Even though eye tracking is a popular tool for researching behavior, eye-tracking data can be extremely expensive and difficult to analyze[37]. Because of the inefficiency in eye-tracking methods and of the high correlation between verbal reports and reaction time, reaction time is used in this analysis of cognitive styles and strategies.

2. Present Research

The goal of the present research is to identify whether individuals use consistent holistic or analytic cognitive styles across visual discrimination tasks. Using Robertson's[36] definition, cognitive style is the information-processing method individuals use to complete any given task. As Bruner et al.[2] suggest, there are individual differences in the initial information-processing method people use to complete a task. For visual discrimination tasks, some individuals start out by using a holistic thought process, and others start out by using an analytic thought process. Do individuals utilize a consistent initial information-processing (cognitive) strategy to perform visual comparison tasks? If an individual uses the initial holistic or analytic strategy across visual comparison tasks that require either holistic or analytic strategies, then we can say they are using a holistic or analytic cognitive style.

To test this hypothesis, the polygon[8], geometric figures[26], jigsaw puzzle[24], and modified radar graph[18], visual discrimination tasks were used to see if individuals used the same cognitive style for completing all of these tasks. There were four blocks of comparisons, one block for each type of task. One block was the polygon comparisons, one was the geometric figure comparisons, one was the jigsaw puzzle comparisons, and one was the radar graph comparisons. Each participant performed all four tasks.

Participants' cognitive style was determined by analyzing slopes of the reaction times across the object manipulations in a similar fashion to Cooper[8], Job et al.[26], Hogeboom and van Leeuwen[24], and Gillan et al.[18]. We then correlated the slopes of each of the visual discrimination tasks. A significant correlation between the initial strategies that individuals use across the different visual comparison tasks would lend evidence to participants using the same initial strategy to visual discrimination tasks. This design was intended to provide evidence for Robertson's[36] and Bruner et al.'s[2] hypothesis that there are individual cognitive styles in approaching visual discrimination tasks in general.

3. Method

3.1 Participants

Eighty undergraduate students between the ages of 18 and 27 years of age participated in the experiment. Each participant completed four different discrimination tasks. The order of presentation of these tasks was counterbalanced, and participants were randomly assigned to a task order.

3.2 Materials

The materials used in all of the experiments consisted of a polygon, a geometric figure, a jigsaw puzzle, and a radar graph discrimination task. The four visual discrimination tasks were presented to participants using PsyScope 1.2.5 on Macintosh G4's using 17-inch color monitors. Participants responded to the same-different tasks using specifically labeled keys on the keyboard. There was a 1500 ms pause between each trial.

During the polygon comparison task, participants were presented with polygon pairs taken from the Doane et al.[9] stimulus set(See Fig. 1). These polygons were random shapes of varying complexity that were drawn using a computer graphics program. The complexity of the polygons was manipulated by increasing the number of unique sides(6, 8, 12, 16 and 20 sides) that formed the polygon.

The polygon comparison pairs had six different levels of difficulty for each of the number of sides, as well as a same comparison (for details, see Doane et al. [9]). The comparisons were set so that there would be an equal number of same comparisons as there were different comparisons. In total, one block of comparisons would equal 30 different comparisons (5 levels of complexity by 6 levels of difficulty) and 30 same comparisons for a total of 60 comparisons. The Geometric figures comparison task drawn from Job et al. [26] consisted of two sets of geometric figures. Each set of geometric figures consisted of three

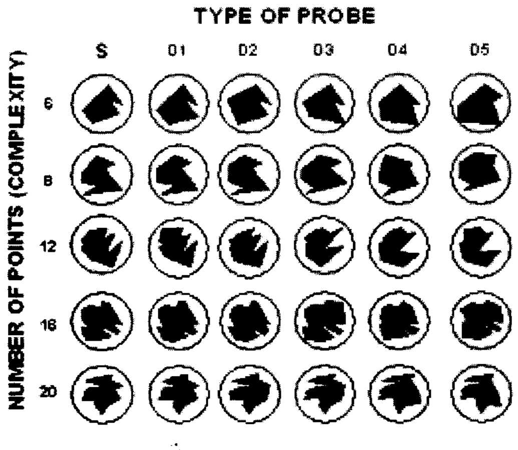


Fig. 1. Example Polygon Stimuli

geometric shapes concentrically placed inside each other (See Fig. 2). The sets consisted of either a triangle, a hexagon and a circle(Set A) or a square, a octagon or a circle(Set B). Each set was systematically varied so that all combination of shapes was included, or six configurations for each set. Each trial consisted of looking at two configurations of shapes on placed vertically on the computer screen, one drawn from either Set A or Set B on top and one drawn from Set A or Set B on bottom.

There were an equal number of same and different comparisons. Therefore, for each of the 12 configurations of Set A and Set B, there were

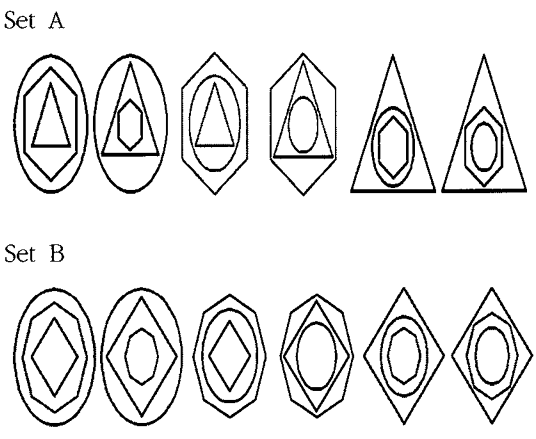


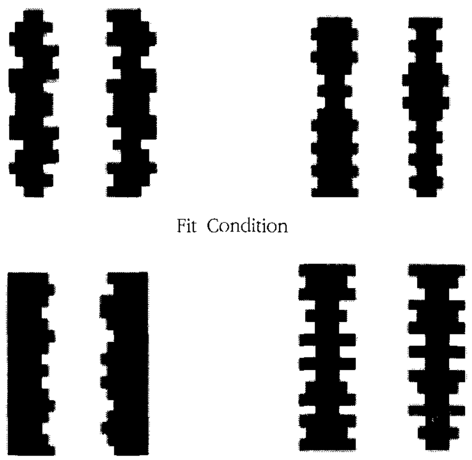
Fig. 2. Example Geometric Stimuli

11 same comparisons and 11 different comparisons, making a total of 264 comparisons. If the configuration on the top was exactly the same as the configuration on the bottom, the trial was considered 'same.' If the configuration on the top was from the same Set as the one on the bottom, then the trial was considered 'similar.' If the configuration on the top was from the opposite set as the one on the bottom, the configuration was considered 'different.'

The Jigsaw Puzzle comparison stimuli were drawn from the Hogeboom et al. [24] research. The stimuli were constructed to provide the maximum diversity in cognitive strategy participants might use. Each of the jigsaw comparisons consisted of a pair of black figures (See Fig. 3) in a white bounding box. Each of the two pieces within the box has 16 rectangular notches in its edges. The jigsaw puzzle condition was a 'fit' when the two pieces could be horizontally moved together and the facing edges would fit like a puzzle. A no fit condition was when one of the notches would not align.

The complexity of the placement of the notches on the facing edges was varied in a course grain dimension and a fine grain dimension. In the course grain dimension, there were three conditions. In the small-symmetry condition, the facing edges were divided into four sections were the upper half of each section was symmetrical to the lower half. In the large-symmetry condition the whole upper half was symmetrical to the lower half of the facing edge. In the no-symmetry condition there was no symmetry at all.

The fine grain dimension had three conditions as well. In the iteration condition, notches were omitted at uneven positions. In the random condition, notches were placed randomly. In the irregular condition, no two neighboring notch positions could be identical. The non-facing edges were also altered. In the straight condition, the non-facing edges were straight, in the symmetry-creating condition, the non-facing edges were mirrors of each other, and in the symmetry-destroying condition the non-facing edges were duplicates of their respective facing edge.



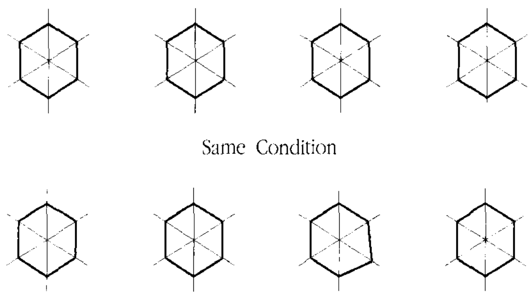
Fit Condition

No-Fit Condition

Fig. 3. Example Jigsaw Puzzle Stimuli

All combinations of coarse grain, fine grain, and rear edge complexity were used, making 27 different combinations. An equal number of fit and no fit conditions were created, with the non-fitting notch placed randomly along the facing edge. Therefore, 54 different jigsaw puzzle combinations were used, and were presented to the participant three times each, making a total of 162 trials.

The Radar Graph comparisons consisted of four graphs placed vertically along the computer screen, similar to Gillan et al. [18]. Leg and Outline star graph condition. The radar graphs (See Fig. 4) consisted of a center point with a number of lines emanating from the center point (each line is classically used to represent a variable in a graph). Points toward the ends of the legs were connected by lines, creating an outline in the shape of a radar(the outline is classically used to represent system state of a group of variables). In each trial, one of the four graphs would have one of its outline connection points increased. The increase was either 7%, 10%, or 15% change in the distance from the center point. The lower the percent change in distance from the center point, the more difficult it was to identify the radar graph as different from the others. The number of legs was also varied, from four legs to eight legs. A total of 450 trials varied with the distance from the enter, the number of legs, and the position of the different graph.



Same Condition

Different Condition

Fig. 4. Example Radar Graph Stimuli

3.3 Procedure

Participants were first verbally instructed that they would be making comparisons of figures on a computer screen, shown which keys to use for their responses, and asked to respond as quickly and as accurately as possible. Then, they received specific instructions from the computer, a few practice trials, and breaks in between blocks of trials. In each of the four different tasks, the participants were given three practice trials with immediate feedback telling them the correct answer. Then the participants responded to all of the trials for each of the comparison tasks. Between each task type, the participants were allowed to take breaks.

4. Results

We analyzed the reaction time for each of the task types to identify the style that participants used to compare the shapes on the screen. In general, analytic strategies were defined by increased reaction times as the complexity of comparisons increased. Holistic strategies were defined in general by little to no change in the reaction time as the complexity of the comparisons increased.

For all tasks, reaction times less than 500ms and greater than 10,000ms were removed from analysis. With the remaining data means and standard deviations were calculated for each participant. The reaction time for each trial was then given a z score. z scores less then -4.0 and greater than +4.0 were removed from analysis as well. Overall accuracy was also calculated for each participant. If a participant's accuracy was under 80%, they were removed from analysis.

4.1 Polygon Style

The reaction times to the polygon comparisons were first screened. Across the 80 participants, there were 14,400 comparisons. There was no difference, $F(2, 112)=.604$, $p>.05$, between the first, second and third sets of polygon comparisons for correct same-judgment accuracies, so the first block of same-judgment accuracies was used to calculate style for comparing polygons.

Slope was calculated based on the responses to 'same' comparisons as a function of complexity. For the remaining 57 participants, the mean reaction time slope was 179.04, the median was 151.42 and the standard deviation was 205.16. A median split was used to identify holistic and analytic participants. Slopes above 151.42 were considered analytic and slopes below 151.42 were considered holistic. This resulted in 29 Holistic participants and 28 Analytic participants.

Figure 5 shows the slope of same-comparison reaction times over the increase in complexity of the polygons. Even though an arbitrary median split was chosen to group participants into holistic and analytic initial styles, the graph clearly shows a difference between the two groups. Participants using an analytic style take more time to make the comparison as the number of sides of the polygons increases. This increase seems fairly systematic. The more sides the polygon has, the longer it takes analytic participants to indicate whether the polygons are same, indicating a point-by-point comparison style.

The holistic participants, on the other hand, show little to no increase in reaction time as they are comparing polygons with more and more sides. Holistic participants are not affected by the number of sides of the polygon and are therefore using a strategy that includes the polygon as a whole as opposed to it being constructed of a number of sides. There is an increase in reaction

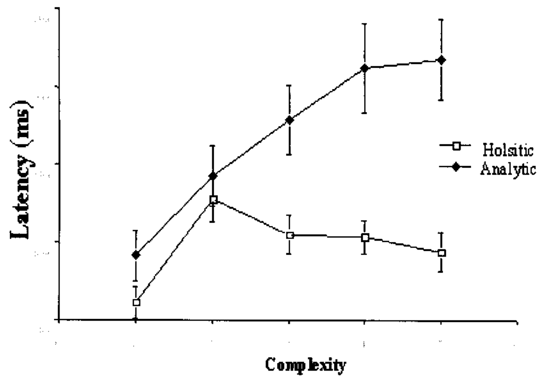


Fig. 5. Polygon comparison mean reaction time as a function of complexity for holistic and analytic participants.

time for the holistic participants going from complexity 1 to 2, but the subsequent increases in complexity show no increase or decrease. This may be due to the participants who are classified as holistic, but are not as holistic as others, might be including some analytic, point-by-point strategy in the lower complexity comparisons.

4.2 Geometric Figure Style

The reaction times for the geometric figures comparisons were then screened. Across the 80 participants, there were 21,120 comparisons. There was a significantly different reaction time across the 'same', 'different', and 'similar' comparison types, F(2, 67)=339.078, p<.05.

Slope was calculated across the conditions for 'same' comparisons, 'different' comparisons and 'similar' comparisons. All but three participants had average reaction times for 'similar' comparisons that were longer than the average reaction time for 'different' comparisons. Nine participants had 'different' comparison average reaction times that were faster than 'same' comparison average reaction times. For the remaining 69 participants, the mean reaction time slope was 538.04, the median was 530.61 and the standard deviation was 226.85. A median split was used to identify holistic and analytic participants. Slopes above 530.61 were considered analytic and slopes below 530.61 were considered holistic. This resulted in 34 Holistic participants and 35 Analytic participants.

As suggested by Figure 6, there was a significant Response Type ('same', 'different', 'similar') effect, F(2, 134)=339.078, p<.05 on reaction time, a significant Initial Style between-subjects effect, F(1, 67)=892.409, p<.05, and a significant Response Type by Initial Style interaction, F(2, 134)=42.718, p<.05. For accuracy, there was a significant effect of response type, F(2, 134)=61.341, p<.05, but no significant between-subjects effect of Initial Style.

Geometric Figures comparisons also needed to be screened for trials that were completed too quickly or too slowly. According to Job et al. [26], if a template matching strategy, in other words a holistic strategy, was used then the response time to the stimulus should not be related to the number of dimensions on which

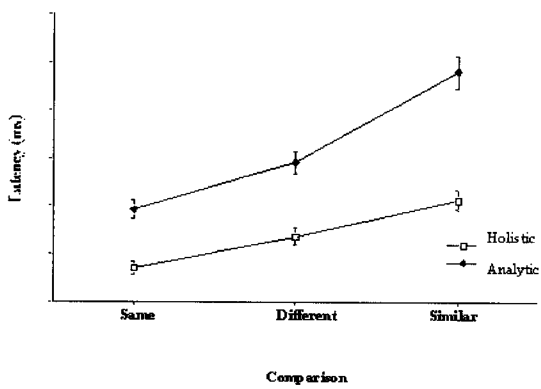


Fig. 6. Geometric figure comparison mean reaction time as a function of comparison type for holistic and analytic participants

the configurations in the stimulus differ. This means a holistic strategy for holistic comparisons would theoretically show no differences between the reaction times for same and different responses. Over all of the participants, there was a statistically significant increase in reaction time from 'same' comparisons, to 'different' comparison, to 'similar' comparisons. According to Job[26], this task then mediated an analytic strategy.

Looking at the flattest and steepest slopes of the participants completing the geometric figures task shows that even those with flattest slopes show a significant increase in reaction time from 'same' to 'different' and from 'different' to 'similar' comparisons. There are, however, differences between those participants who were categorized as holistic and those who were categorized analytic. Even though this task induced a more analytic strategy, some participants were somewhat more holistic in their style. The statistically significant Response Type by Initial Style interaction revealed evidence for this.

4.3 Jigsaw Puzzle Style

The reaction times for the jigsaw puzzles comparisons were then screened. Across the 80 participants, there were 12,960 comparisons. Slope was calculated using a Spearman rank correlation coefficient ρ (r_s) statistic, where reaction time were correlated with difference position for each individual. Participants with ρ values over the critical value of 0.564 for significance at the .10 level were considered analytic, and those that were insignificant were considered holistic. This resulted in 26 Holistic participants and 17 Analytic participants.

For the Jigsaw Puzzle task, Spearman's ρ was used as a measure of whether there was an increase in response time due to a point-by-point comparison along the edge of the jigsaw puzzle, as was suggested by Hogeboom et al. [24]. This was a fascinating way to calculate initial style since, upon informal verbal report, some of the participants reported analyzing the jigsaw puzzles from the bottom to the top, while others reported analyzing the puzzles top to bottom. Using the absolute value of the Spearman's ρ correlation between the position of the different notch and the reaction time allowed for an analytic participant to start their search from the bottom to the top, or from the top to the bottom, and still be categorized as analytic. The structure of the task induced a strategy of up and down scanning since the jigsaw puzzles themselves were tall and skinny and the participants was asked to compare the insides of the jigsaw puzzles. Looking at Figure 7, the holistic participants showed a relatively flat slope, while

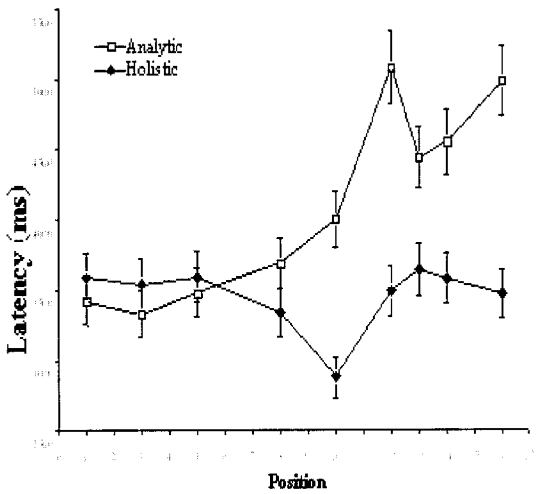


Fig. 7. Jigsaw puzzle discrimination mean reaction time as a function of notch position for holistic and analytic participants.

the analytic participants showed an increasing slope of reaction time over notch position. Therefore, most of the analytic participants used a top to bottom point-by-point search strategy. It does seem clear that both groups of people grouped the top quarter of the puzzle together, since the reaction times of points 1, 3, and 5 do not differ from each other or between the two styles. As the different notch moved further down the puzzle, however, the differences between the way participants responded to the task started to appear. Analytic participants took longer to scan for and detect different notches, whereas holistic participants showed no increase in reaction time the further down the different notch landed.

4.4 Radar Graph Style

The reaction times for the radar graph comparisons were then screened. Across the 80 participants, there were 36,000 comparisons. Slope was calculated based on the responses to 'same' comparisons as a function of number of sides of the radar graphs. For the remaining 57 participants, the mean reaction time slope was 119.34, the median was 119.37 and the standard deviation was 95.24. A median split was used to identify holistic and analytic participants. Slopes above 119.37 were considered analytic and slopes below 119.37 were considered holistic. This resulted in 29 Holistic participants and 28 Analytic participants.

The method for assessing the style of visual discriminations of radar graphs is the same as that used for polygon comparisons. Slopes were calculated only for those trials where the radar graphs were the same. For those trials, slopes of reaction time as a function of the number of sides of the radar graph was calculated. If participants took more time to compare radar graphs with more sides than those graphs with fewer sides, this would indicate an analytic, point-by-point comparison strategy. If they did not take more time to make the comparisons as the number of sides increases, it means that they were using more of a holistic strategy and not analyzing the individual points of the graphs into account. As can be seen in Figure 8, the holistic participants showed no significant increase in reaction time as the number of sides increased, whereas the analytic participants showed a significant increase.

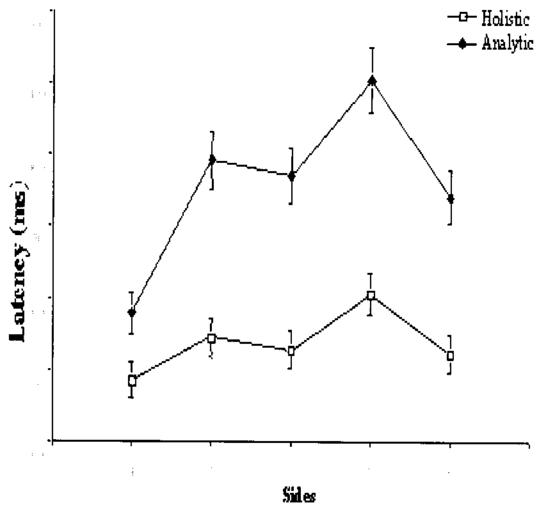


Fig. 8. Radar graph discrimination mean reaction time as a function of the number of sides for holistic and analytic participants.

4.5 Correlation of Measures of Initial Style

A correlation analysis was used to test the relationships of the style measurements of the different tasks. To improve pair-wise linearity and to reduce the skewness of the polygon comparison slopes and the radar comparison slopes, a log transformation was used for both measures in the correlation analysis.

Since a bi-modal distribution of measures of style is expected, a Spearman's r_s correlation coefficient was used. As suggested by Table 1, the Radar Graph slopes were most significantly correlated with polygon slopes.

Table 1. Correlation of style measurements of initial style for the four task types

Measure of Style	Polygon Slope	Geometric Slope	Jigsaw p	Radar Slope
1. Polygon Slope	-			
2. Geometric Slope	.356 p = .088 N = 24	-		
3. Jigsaw p	.216 p =.311 N = 24	.176 p =.370 N = 28	-	
4. Radar Slope	.590 p =.003 N = 23	.352 p =.072 N = 27	.296 p =.134 N = 27	-

5. Discussion

Using a common measurement analysis, looking at the correlation between the measures of holistic and analytic style as measured by four different tasks provides a test of concurrent validity for these measures. The most ideal situation would have been to look at a multi-trait multi-method matrix as identified by Campbell and Fiske[3] to tease out trait variance from method variance. The present study only deals with trait variance, and method variance was not manipulated. The correlation matrix of the measures of style seemed to be the most appropriate method to identify use of a similar style across tasks.

Several of the measures of style were highly correlated with each other. From a statistical significance perspective, the most interesting correlation was between the polygon slope measure and the radar graph slope measure. The correlation of .590 indicates that approximately 35% of the variance of one slope is accounted for by the variance of the other slope. The correlation was positive, so the correlation must indicate a strong relationship between the measures of holistic or analytic styles in making comparisons. Another way of looking at this relationship is that participants were using a consistent style across the two tasks. Participants who used a point-by-point style of comparisons for polygon comparisons also tended to use a point-by-point style of comparisons for radar graphs. Participants who used a method of looking at the pairs of polygons on the screen as a whole also tended to scan for differences among radar graphs holistically.

The correlations between Geometric Figures slope and the Radar Graph(r_s= .356) as well as the Polygon (r_s= .352) comparison tasks were marginally significant. These relationships are marginal, but considering the differences in the exact method used to identify style used in each task might account for much of the error variance, the correlations provide some support for the concept of a general style of visual discrimination.

Both the Radar Graph and the Polygon task used 'same' comparisons along a varying dimension of complexity to measure style, whereas the geometric figure task used the difference across 'same', 'similar' and 'different' comparisons. Since the analytic participants were biased towards responding that the figures were different, as well as were more sensitive to differences between the two sets of geometric figures, means that analytic participants used more of a detailed strategy in their comparisons. They looked at each set of figures, decided what they contained and compared them back and forth to see if both sets of figures contained the same shapes. It may not go as far as to indicate a point-by-point style comparison as strongly as the Radar Graph and Polygon comparisons do, however.

Therefore, the Geometric Figures measure of style indicates a holistic and analytic style, but the difference in the method these styles are measured by may be a signal of the differences within holistic and analytic styles themselves. The geometric Figures comparisons required participants to look at several different figures and to decide if the overall shapes included in the set of figures was the similar, as opposed to looking at one figure type and comparing it with another single figure. There was no complexity change of one figure, there were whole figures being changed in these comparisons. This added error variance may have caused the correlations between Geometric Figures and the other two tasks' slopes to be strong, but not significant.

The correlation between the Jigsaw Puzzle comparisons and the other three tasks were low (below r=.3, or 9% variance). Of course sample size takes into account much of the significance of those correlations, but the Jigsaw Puzzle task was much more complex in the dynamics of the manipulations of the puzzles, and therefore the different styles one could use in comparing them. The design of the jigsaw puzzles themselves took into account the cognitive inducing properties of the task in their design. Some comparisons used big chunks of notches in the Jigsaw puzzle to show a difference, where as other used small chunks of notches. These differences, regardless of the position of those changes, can affect the style one uses in comparing the puzzles. This effect on style would not be picked up by a measure of linear relationship between the position of notch change and the reaction time of comparison.

A more detailed analysis of style within Jigsaw Puzzle comparisons is needed. For example, the facing edge complexity manipulation may have made a notch change in the lower part of a puzzle more distinctive even for analytic participants, therefore reducing the time it takes for them to scan for this difference in this particular condition, and therefore reducing the difference between holistic and analytic participants due to task structure.

The task structure of both the Geometric Figures and Jigsaw Puzzle comparison tasks induced higher levels of discrimination between same and different polygons for analytic participants than they did for holistic participants. There were no differences between holistic and analytic participants in discrimination of the Radar Graph and the Polygon comparisons. The Geometric Figures and Jigsaw puzzle comparisons may have taken a higher level of detail to perform analytically than the Radar Graphs and Polygons. This may result in a difference in the measures of the style people used across these tasks, therefore reducing the strength in the correlations between the measures of style for these tasks.

Finally, relatively few participants achieved 80% accuracy in completing all four tasks, so the sample size for the correlations was lower than expected. Future research could increase this sample size. The present results, however, show a very strong picture of the similarity in initial style that participants use across these visual discrimination tasks. The correlations between the measures of style between these tasks lend evidence to the concept that people approach new tasks using a similar cognitive style, even if that style changes as the task progresses. The results of this study support Robertson's [36] theory that there is a difference between cognitive style and strategy.

References

[1] Amirkhiabani, G., & Hendry, G. D. (1994). Cognitive strategies. Perceptual & Motor Skills, 78(2), 491-500.

[2] Bruner, J. S., Goodnow, J. J., & Austin, G. A. (1956). A study of thinking. New York: John Wiley & Sons.

[3] Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin, 56, 81-105.

[4] Christoffersen, K., Hunter, C. N., & Vicente, K. J. (1996). A longitudinal study of the effects of ecological interface design on skill acquisition. Human Factors, 38(33), 523-541.

[5] Clear, S.-J. (1978). Sex differences in spatial ability: A critique. International Journal of Behavioral Development, 1(3), 241-246.

[6] Cochran, K. F., & Wheatley, G. H. (1989). Ability and sex-related differences in cognitive strategies on spatial tasks. Journal of General Psychology, 116(1), 43-55.

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

[8] Cooper, L. A. (1982). Strategies for Visual Comparison and Representation: Individual Differences. In R. J. Sternberg(Ed.), Advances in the Psychology of Human Intelligence (Vol. 1, pp. 77-124). Hillsdale, NJ: Lawrence Erlbaum Associates.

[9] Doane, S. M., Alderton, 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(5), 1218-1248.

[10] 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.

[11] 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.

[12] Epstein, S., Pacini, R., Denes Raj, V., & Heier, H. (1996). Individual differences in intuitive-experiential and analytical-rational thinking styles. Journal of Personality and Social Psychology, 71(2), 390-405.

[13] Ericcson, K. A., & Simon, H. A. (1993). Protocol Analysis: Verbal reports as data (Revised ed.). Cambridge, MA: MIT Press.

[14] Evans, J. S. B. (1990). Verbal reports of cognitive strategies: A note on Marquer and

Pereira. Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 42(1-A), 169-170.

[15] Fienberg, S. E. (1979). Graphical Methods in Statistics. The American Statistician, 33(4), 165-178.

[16] Fischer, S. C., Hickey, D. T., Pellegrino, J. W., & Law, D. J. (1994). Strategic processing in dynamic spatial reasoning tasks. Learning & Individual Differences, 61, 65-105.

[17] Fisher, D. L., & Tanner, N. S. (1992). Optimal symbol set selection: A semiautomated procedure. Human Factors, 34(1), 79-95.

[18] Gillan, D. J., & Harrison, C. (1999). A Componential Model of Human Interaction with Graphs IV: Holistic and Analytical Perception of Star Graphs. Paper presented at the Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting, Albuquerque, NM.

[19] Gillan, D. J., & Lewis, R. (1994). A componential model of human interaction with graphs: I. Linear regression modeling. Human Factors, 36(3), 419-440.

[20] Gullberg, M., & Holmqvist, K. (1999). Keeping an eye on gestures: Visual perception of gestures in face-to-face communication. Pragmatics and Cognition, 7(1), 35-63.

[21] Hammond, K. R., Hamm, R. M., Grassia, J., & Pearson, T. (1987). Direct comparison of the efficacy of intuitive and analytical cognition in expert judgment. IEEE Transactions on Systems, Man, and Cybernetics, 17(5), 753-770.

[22] Henry, G. T. (1993). Using graphical displays for evaluation data. Evaluation Review, 17(1), 60-78.

[23] Hogan, J., Arneson, S., & Salas, E. (1987). Individual differences in military training environments: Four areas of research. US Naval Training Systems Center Technical Reports(87-003).

[24] 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.

[25] Hupet, M., Citta, M., & Costermans, J. (1984). Ordinal position effects on speed-accuracy trade-off in absolute judgment, Psychologica Belgica. 24(2), 137-146.

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

[27] Kosslyn, S. M. (1989). Understanding charts and graphs. Applied Cognitive Psychology, 3(3), 185-225.

[28] Lightfoot, N., & Shiffrin, R. M. (1993, November). On the unitization of novel, complex visual stimuli. Paper presented at the 34th Annual Meeting of the Psychonomic Society, Washington, DC.

[29] Lohse, G. L. (1997). The role of working memory on graphical information processing. Behaviour and Information Technology, 16(6), 297-308.

[30] Mugny, G., & Doise, W. (1978). Socio-cognitive conflict and structure of individual and collective performances. European Journal of Social Psychology, 8(2), 181-192.

[31] Nowicki, J. R., & Coury, B. G. (1993). Individual Differences in Processing Strategy for a Bargraph Display. Paper presented at the Human Factors 37th Annual Meeting, Santa Monica, CA.

[32] O'Regan, J. K., & Levy-Schoen, A.(Eds.). (1987). Eye movements: From physiology to cognition.

[33] Piesbergen, C. (1986). Induzierte kognitive Strategien und Uebungseffektbei Mehrfachaufgaben: Induced cognitive strategies and the effect of practice on multiple-task performance. Zeitschrift fuer Experimentelle und Angewandte Psychologie, 33(3), 475-488.

[34] Pratt, J. H., & Sohn, Y. W. (2000, September 13, 2000). Individual difference effects on the acquisition and transfer of strategic processing skill. Paper presented at the University of Connecticut Psychology Graduate Student Poster Session, Storrs, CT.

[35] Pratt, J. H., & Sohn, Y. W. (2001). Individual Difference Effects on Training and Transfer of Visual Processing Strategy. Paper presented at the Human Factors and Ergonomics Society 45th Annual Meeting, Minneapolis, MN.

[36] Robertson, I. T. (1985). Human information-processing strategies and style. Behaviour and Information Technology, 4(1), 19-29.

[37] Salvucci, D. D., & Anderson, J. R. (2001). Automated eye-movement protocol analysis. Human Computer Interaction, 16(1), 39-86.

[38] Shore, B. M., & Carey, S. M. (1984). Verbal ability and spatial task. Perceptual & Motor Skills, 59(1), 255-259.

[39] Vicente, K. J., & Williges, R. C. (1988). Accommodating individual differences in searching a hierarchical file system. International Journal of Man Machine Studies, 29(6), 647-668.

[40] von der Weth, R., & Frankenberger, E. (1995). Strategies, competence and style-Problem solving in engineering design. Learning & Instruction, 5(4), 357-383.

[41] Wilkinson, L. (1988). SYGRAPH. Evanston, IL: SYSTAT, Inc.