Short Research Article

Eye Movement Patterns Characteristic of Cognitive Style

Wholistic Versus Analytic

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Abstract: Various tools have been designed to classify the wholistic/analytic cognitive style, based mostly on behavioral data that reveals little about how these processes function. The main goal of this study is to characterize patterns of eye movements (EM) that are typical of learners with tendencies toward wholistic/analytic styles. Forty students completed the E-CSA-W/A test, while their EM were simultaneously monitored. The results revealed that the overall response time of the wholist group was lower in both tasks. The differences in response time between the groups are interpreted as being influenced by impulsive/reflective styles. While the behavioral data provide us with the end result and quantitative differences between the groups, EM provide us with the qualitative information about the process that led to the response. The study showed that the wholist group is characterized by less fixations and transitions than the analytic group, which is interpreted as reflecting use of whole/partial strategy.

Keywords: eye movements, wholistic/analytic cognitive style, whole/partial strategies, E-CSA-WA

Introduction

Individual differences in the preferred way of thinking while employing learning strategies and processing information are known as *cognitive styles* (Riding & Rayner, 1998; Sternberg, 1988). The distinction between wholistic and analytic styles has been found to be an important element for both learning (Santos, Nguyen, Yu, Li, & Wilkinson, 2010) and cognitive, clinical, and social psychology (Förster & Higgins, 2005; Liberman, Trope, & Stephan, 2007).

Despite its impotency, the available tools for classifying the wholistic/analytic cognitive style provide only limited information about the final results, which enable classifying individuals according to their preferred cognitive styles. However, these tools lack the ability to provide adequate and objective information about the task solving process. Traditionally, "think-aloud" protocols have been the most useful and frequently used technique to understand cognitive processes and strategies used during learning (Mintzes, Wandersee, & Novak, 1999). However, this method often lacks objectivity and validity.

Since observing the visual field is not coincidental (Miellet, Vizioli, He, Zhou, & Caldara, 2013), tracking the scan path on a given task can provide important and unique insights into how individuals process information and on the nature of the strategy that they employ. For instance, some studies showed that wholist and analytic learners focus on different aspects of the visual field, making this a reflection of the selected whole/partial strategy (Chua, Boland, & Nisbett, 2005; Faiola & Macdorman, 2008; Miellet et al., 2013; Rayner, 1998). Nevertheless, these studies focus on a specific object (e.g., face recognition, reading, e-learning, etc.), while the current study focuses on the underlying mechanisms behind the apparent differences in cognitive processing styles and strategies.

We therefore suggest that tracking the participants' eye movements (EM) will make it possible to identify how different patterns of EM reflect the strategy that takes place, based on the cognitive style employed by the participant in real time. These patterns can provide a deeper understanding of how different strategies function in different types of tasks.

In addition, many studies (Huang, Hwang, & Chen, 2014; Mampadi, Chen, Ghinea, & Chen, 2011; Thomas & McKay, 2010) investigated the match/mismatch between the participant's preferred cognitive style and the methods required by a task. Tracking strategy patterns can tell us how different individuals deal with the match/mismatch conditions. This information can indicate whether one style is more flexible than the other one, if at all.

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The Wholistic/Analytic Cognitive Style

The wholistic/analytic style relates to the individual's tendency to organize and process information either as a whole (gestalt) or partial (step-by-step) structure, respectively (Pitta-Pantazi & Christou, 2009; Rezaei & Katz, 2004). Riding and Cheema (1991) proposed an integrative model with two independent dimensions: the visual-verbal dimension that reflects the way that individuals prefer to represent information while performing a given task; and the wholistic-analytic dimension that reflects the way that individuals organize and structure new information and comprehension of a given situation. However, despite Riding and Cheema's division of these styles into two independent dimensions, Riding and Sadler-Smith (1992) proposed integrating the two dimensions into a single one that they refer to as "unitary styles," which distinguishes between cognitive styles based on the type of information processing that takes place. Whereas wholist and visual learners process information globally, analytic and verbal learners process information locally. Additionally, there is a connection between the different hemisphere functions. As the common assumption is that, processing information as a whole or partial manner would be improved if done by the right or left hemisphere, respectively (for a review see Genovese, 2005).

Accordingly, most individuals have a habitual tendency to favor either the whole or partial processing mode when completing a task. Hence for the wholist learner, there is a risk that the distinction between different task details will be blurred. An analytic learner who separates the overall picture into its various components is liable to focus on one component at the expense of the remaining parts of the task or attribute exaggerated importance to a single component (Riding & Sadler-Smith, 1997). However, some individuals have neither wholistic nor analytic style preferences and are labeled "intermediate" (Riding & Cheema, 1991).

The Extended Cognitive Styles Analysis Test Wholistic/Analytic (E-CSA-WA) used in this study is an expansion by Peterson, Deary, and Austin (2003) of Riding's (1991) Cognitive Styles Analysis – Wholistic/Analytic (CSA-WA) test, and was designed to measure tendencies toward structuring information in a wholistic versus analytic manner.

The test has a strong theoretical basis and a significant body of empirical research that supports its construct validity (Dørum & Garland, 2011; Peterson & Deary, 2006; Peterson, Deary, & Austin, 2005; Pitta-Pantazi & Christou, 2009). Furthermore, the test has been validated and found reliable for differentiating between wholistic and analytic dimension styles (internal consistency r = .72; test retest reliability r = .55; Peterson et al., 2003). However, a significant shortcoming of this test should be noted, namely its inability to provide adequate information regarding the processes that the learner undergoes while solving a task (Peterson & Deary, 2006). These include fixations and the scan path that reflect how cognitive resources are invested in different areas. This information is critical for understanding the character of the strategy employed.

Using the CSA-WA test, Davies (2009) demonstrated that wholists prefer to process the entirety, while analytic individuals prefer to focus on details whenever possible by manipulating the multiple geometric forms that compose the complex stimuli in the CSA test. Therefore, the "wholist-analytic style" test was constructed based on the CSA test, wherein 20 stimuli were composed of three geometric figures (as in the CSA and the E-CSA-WA tests) and 20 stimuli were composed of five geometric forms. For wholist participants, response time (RT) remained similar for stimuli composed of three or five forms, whereas RT for analytic participants was slower for five-form stimuli. These results indicate that wholist learners were not affected by the number of figures that comprise the stimuli, most likely because they process the entire stimuli as single unit. The analytic learners, on the other hand, were influenced by the number of figures, as they process stimuli according to their components. Nevertheless, Davies reached this conclusion based on behavioral data of RT, which necessitated a manipulation of the original test. In the current study, monitoring EM enabled examination of the learning strategy employed by each group on the original test.

Therefore, the main objective of the current study will be to characterize various patterns of EM, as will be described below, as they reflect whole/partial strategies used during the E-CSA-WA test. These patterns can therefore shed light on the cognitive processes that typify different styles.

Monitoring Eye Movements

Monitoring EM during learning has become an accepted and valuable method in research, as it enables recording of cognitive activities as they occur and gathering information about the processes that the learner undergoes while solving a complex task. Therefore, it is a promising tool for understanding the process of cognitive style and learning strategies (Lai et al., 2013). Many researchers (Lai et al., 2013; Moeller, Fischer, Nuerk, & Willmes, 2009; Vakil, Lifshitz, Tzuriel, Weiss, & Arzuoan, 2011; Van Viersen, Slot, Kroesbergen, van't Noordende, & Leseman, 2013) have indicated that monitoring EM, to examine cognitive processing and learning strategies, can provide further qualitative information on the learning process. That in addition to standard behavioral measures (such as the number of correct answers and RT), which help understand the cognitive processes that lead to the problem's solution (Moeller et al., 2009; Vakil et al., 2011; Van Viersen et al., 2013).

Vakil et al. (2011) found that aside from the behavioral findings, EM measurements reveal a more fundamental difference between groups, based on the use of different strategies for solving perceptual and conceptual analogy tests, constructive matching and response elimination. In another study that examined global/local strategies for identifying faces of famous people, a significant connection was found between the strategy adopted and the location of the initial fixation on the face (Miellet, Caldara, & Schyns, 2011). Also, cultural differences between Westerners (who attend more to local objects) and East Asians (who attend more to global information) have been demonstrated through analysis of EM patterns during facial processing (Miellet, He, Zhou, Lao, & Caldara, 2012) and while processing naturalistic scenes (Chua et al., 2005). Finally, a study by Van Gog, Paas, van Merriënboer, and Witte (2005) revealed that analysis by means of eye monitoring yielded better results when identifying different forms of information processing while solving a problem in electronics.

Based on an assumption, that has yet to be tested by monitoring the individual EM, learners with wholistic/analytic cognitive styles sample the visual field differently, which lead them to employ diverse strategies that will be reflected by different types of EM while solving problems. Therefore, the primary objective of the present study will be to map the quantitative information gathered from analysis of EM of individuals with different styles while solving a task that match/mismatch their preferred style. Specifically, we attempt to identify different patterns of EM that are typical of wholistic/analytic information processing and construct a profile of cognitive styles according to these patterns. These objectives will be pursued simultaneously by monitoring EM while the participants take the E-CSA-WA test. This will enable matching the behavioral measures of the test with the measures derived from EM. Therefore, this study will address the following questions: (1) Can different strategies (whole/partial), which reflect how attention is attributed to different areas of the visual field, be characterized by different patterns of EM? (2) Does the task type influence the choice of strategy or does personal preferred style dictate the strategy used? (3) Which group (wholist or analytic), if any, is more efficient at solving a task that matches/mismatches their preferred style? (4) Which style, if any, is more efficient for seeking information, and is one style more flexible than the other?

One EM measure to be examined is *dwell time* (ms) – the total fixations and saccades in each Area of Interest (AOI), which has been found to indicate how information is processed and to correlate negatively with the efficiency of searching for relevant information. This measure therefore enables measuring how easy or difficult it was for the learner to complete a task (Schwonke, Berthold, & Renkel, 2009). A second measure is the *number of transitions* between areas of interest (right/left figure), which can indicate how learners direct their visual perception, which cognitive resources are invested in different areas, and the variety of strategies used (Schwonke et al., 2009).

Since the number of fixations correlates negatively with the ease/difficulty of a task (Schwonke et al., 2009), we expect the data to reveal fewer fixations when the task matches the respondent's preferred style, making dwell time shorter and indicating the relative ease of the task for that group. As Davies (2009) noted, adding geometric items affected the analytic learner who had to make more unit comparisons, while on the other hand, the wholist learner who grasps all stimuli as a single unit was not affected by the larger number of items. As analytic learners focus more on details and typically process information step-by-step, per unit (Kozhevnikov, Kosslyn, & Shephard, 2005), the assumption is that this group will display more transitions between areas of interest in order to compare all geometric items in both figures before reaching the correct answer. Wholists, on the other hand, tend to see the whole picture and are expected to require fewer transitions between areas of interest in order to scan the entire stimuli.

Methods

Participants

Eighty-six healthy students (57 females) with normal or corrected vision participated in this study. Nine participants who received poor calibration scores were excluded. The majority received course credits for their participation and others volunteered. Thirty-seven participants were eliminated from the analysis, after the E-CSA-WA test did not indicate either wholistic or analytic preferences, therefore the analysis was based on data obtained from 40 participants. Twenty-one (17 females) participants scored within a range of 0.75–0.97 (M = 0.88; SD = .057) and were therefore defined as wholist (aged 21–38 years; M = 29.67, SD = 3.73). Nineteen participants (12 females) scored within a range of 1.28–2.56 (M = 1.67; SD = .32) and were defined as analytic (aged 19–44 years; M = 30.53, SD = 6.83).

Apparatus

Eye movements were recorded by the SensoMotoric Instruments (SMI) RED-m remote eye-tracker that allows free head movements, with a sampling rate of 120 Hz and high accuracy of 0.5° (version 2.5 SMI, Berlin, Germany).

A 9-point calibration cycle at the beginning of the experiment provided a spatial resolution of 0.1°. A camera with an infrared source was placed in front of the laptop screen, below eye level, and approximately 60 cm away from the participant.

Stimuli were presented on a 15.6″ laptop screen, monitor driven at a refresh rate of 60 Hz and a resolution of 1,366 × 768 pixels (laptop screen and monitor: Fujitsu, Japan), using the E-prime 2.0 software (Psychology Software Tools, Inc., Pittsburgh, PA, USA), which controlled and recorded the temporal parameters of the stimulus display, and linked the timing of stimulus presentation with the computer that recorded EM.

Test

The E-CSA-WA[1] test was used in this study with its author's permission. The test is composed of 80 items. Forty items require global processing (the participant determines whether two geometric items are identical or not), and 40 require local processing (determining whether a simple geometric form exists within a complex geometric form). The task takes approximately 15 min to complete, and correct answers and RT in milliseconds are recoded.

To evaluate each participant's cognitive style, median RT on the global task is compared with median RT on the local task and each participant is given a wholistic-analytic style preference ratio which identifies their relative position on a wholistic-analytic style spectrum. Scores under .97 indicate a wholistic preference, and scores that are above 1.25 indicate an analytic preference. Scores between .97 and 1.25 suggest little style preference (Peterson, 2005).

Eye Movement Measures

All slides in the E-CSA-WA test contain two AOIs – figures on the right and left sides of the screen. EM measures recorded in this experiment were *dwell time* and *transitions* (the number of transitions from the left figure to the right figure, and vice versa), and were recorded using SMI BeGaze™ Eye Tracking Analysis Software. Figures 1 and 2 illustrate how a wholist learner produces EM patterns that differ from those of an analytic learner on global and local stimuli, respectively.

Procedure

Participants were tested individually in a quiet room and were given a brief explanation about the equipment. In order to achieve optimal results, information about cognitive style in general and the nature of the test were explained after the test was completed. After signing a written informed consent form, participants sat on a chair with their head approximately 60 cm from the laptop screen, and were instructed to place their fingers on the answer keys on the keyboard where the letter "*L*" was marked "Yes" and "*A*" was marked "No." They were instructed to fix their gaze on the screen for the entire duration of the test. For the global task, the learner was instructed to determine whether two geometric items are identical or not. In the local task, the learner was instructed to determine whether a simple geometric form exists within a complex geometric form. Furthermore, participants were instructed to respond as accurately as possible and at their own pace.

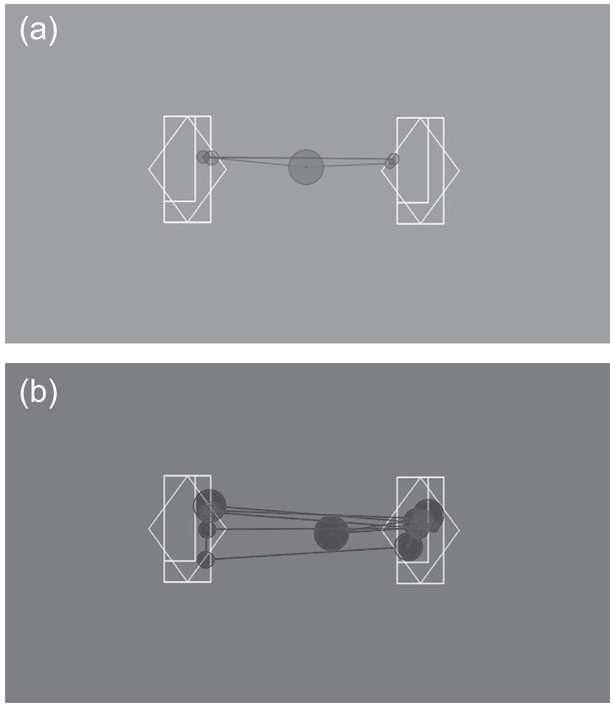

Figure 1. Differences in eye movement patterns of a wholist learner (a) and an analytic learner (b) using the same stimuli on the global task.

When the participant was ready, a standard 9-point calibration spatial cycle of EM was positioned to begin the experiment, while each point appeared for 10 ms and the participant was instructed to follow it with their eyes. Initially, the participant's demographic details are recorded (participant number, age, gender, and field of education). Instructions on the E-CSA-WA test are part of the program and are designed to be carried out with minimal intervention by the researcher and were thus presented before each trial. Participants received feedback on their accuracy, and eye movements were recorded simultaneously.

[1] Minor modifications were made in order to obtain accurate eye movement patterns: All captions were removed from the slides.

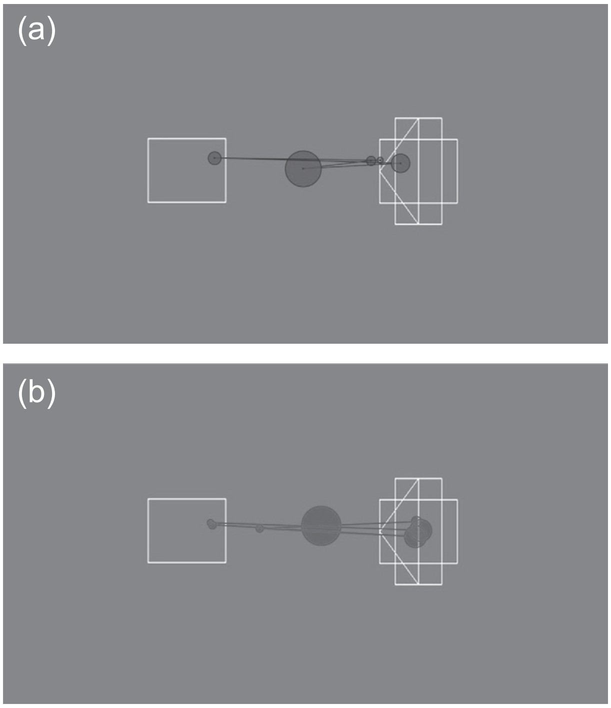

Figure 2. Differences in eye movement patterns of a wholist learner (a) and an analytic learner (b) using the same stimuli on the local task.

Results

The analysis included both behavioral data (number of correct answers and RT) and EM data (dwell time and number of transitions). All raw data can be found online (ESM 1).

Behavioral Measures

Correct Answers

As recommended by Peterson (2005), participants with a 30% error rate or higher should be excluded, as this may indicate that they pressed the answer keys randomly or that they pressed them too quickly to be accurate. Since none of the participants reached a 30% error rate on the global section (error range 0–15%) or on the local section (error range 0–27%), none were excluded. In addition, an independent *t*-test was conducted in order to analyze the mean of incorrect answers made by the two groups (wholists vs. analytics). The groups did not differ significantly on the overall number of incorrect answers, $t(38) = 1.45$, $p = .15$, $d = .46$.

Response Time

Mixed Analysis of Variance was conducted in order to analyze the effect of Group (wholists/analytics) and Task type (global/local). The former is a between-subjects factor and the latter is a within-subjects factor. The dependent measure was the RT (in ms).

On average, it took longer for the analytic group to respond compared to the wholist group, $F(1, 38) = 72.58$, $p < .001$, $\eta^2 = .66$. It took longer for both groups to respond on the global task than on the local task, $F(1, 38) = 77.09$, $p < .001$, $\eta^2 = .67$. These two main effects should be interpreted cautiously because of the significant interaction between them, $F(1, 38) = 105.19$, $p < .001$, $\eta^2 = .74$. It is due to the fact that the analytic group's RT was significantly longer on the global task than on the local one, whereas the wholist group RT did not differ by the task type (see Figure 3a).

Eye Movement Measures

Two primary dependent measures of EM were analyzed separately: dwell time and number of transitions. In order to analyze the differences between the groups on the dependent measures, analyses were performed separately for each task (global/local), in order to check the differences between respondents with a distinct tendency to a certain style on a task that either coincides or conflicts with their preferred style. Beforehand, in order to analyze measures beyond the type of task, the task types were compared.

Comparison of the Global and Local Tasks

Comparison took place between the left figure in the global task and the complex figure on the right in the local tasks, which are similar in complexity and therefore comparable. Mixed Analysis of Variance was conducted in order to analyze the differences between groups (wholists/analytics) on task type (global/local), the former being a between-subjects factor and the latter a within-subjects factor. Dwell time (in ms) and number of transitions were the dependent measures.

Dwell Time

On average the analytic group spent more time on AOIs than the wholist group, $F(1, 38) = 68.25$, $p < .001$, $\eta^2 = .64$. Dwell time on the global task was longer than on the local task, $F(1, 38) = 36.19$, $p < .001$, $\eta^2 = .49$. These main effects should be interpreted cautiously because of the significant interaction between them, $F(1, 38) = 12.19$, $p = .001$, $\eta^2 = .24$. This is due to the fact that the analytic group spent more time on the global task than on the local one, while performance in the wholist group did not differ per task type (see Figure 3b).

Number of Transitions

Overall, the groups did not differ significantly on the average number of transitions from one AOI to another, $F(1, 38) = 0.80$, $p = .38$, $\eta^2 = .02$. More transitions were made on the global task than on the local task,

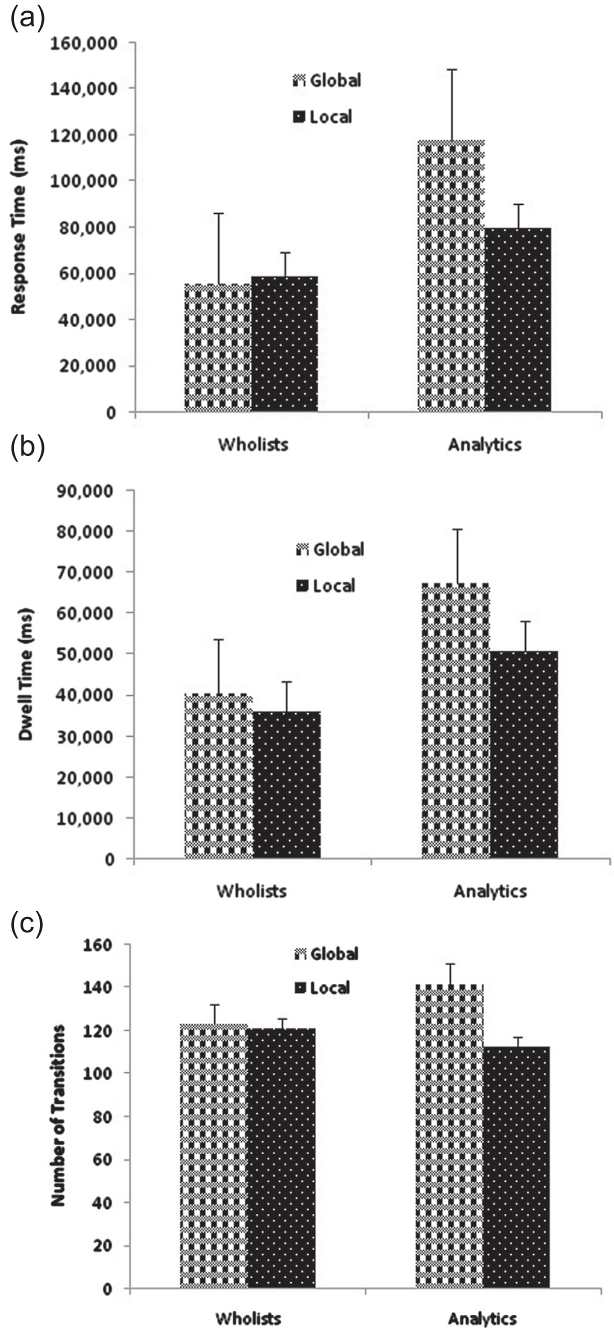

Figure 3. (a) Average response time on slides and standard errors for the global and local tasks by the wholist and analytic groups. (b) Average dwell time on slides and standard errors for the wholist and analytic groups, a comparison between the global task (left figure) and the local task (right-complex figure). (c) Average number of transitions from one figure to another and standard errors for the wholist and analytic groups, a comparison between the global (left figure) and local (right-complex figure) tasks.

$F(1, 38) = 25.08$, $p < .001$, $\eta^2 = .40$. These main effects should be interpreted cautiously because of the significant interaction between them, $F(1, 38) = 20.19$, $p < .001$, $\eta^2 = .35$. That interaction is due to the fact that the analytic

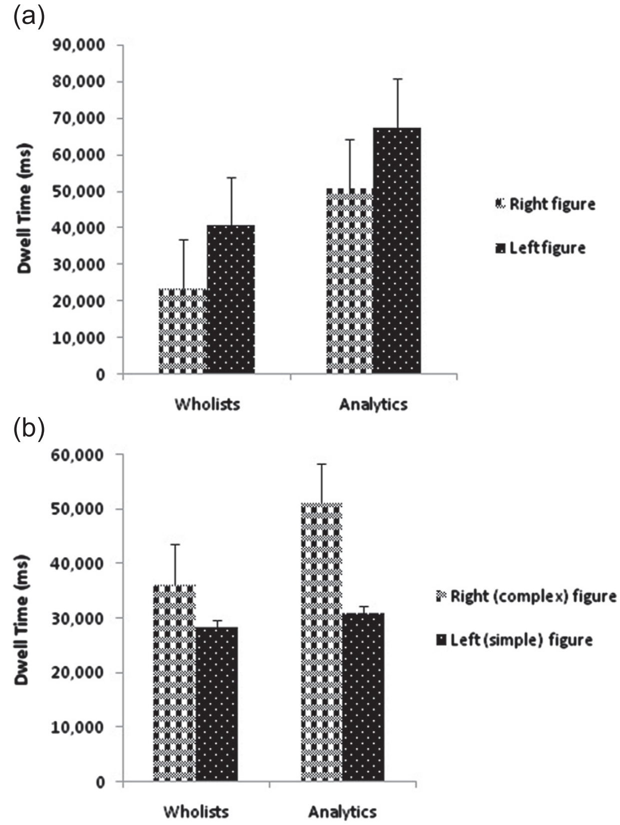

Figure 4. (a) Average dwell time and standard errors for the right and left figures for the wholist and analytic groups on the global task. (b) Average dwell time and standard errors for the right (complex) and left (simple) figures for the wholist and analytic groups on the local task.

group made more transitions in the global task than in the local one, while the number of transitions in the wholist group was similar for both task types (see Figure 3c).

Global Task

Mixed Analysis of Variance was conducted in order to analyze the differences between groups (wholists/analytics) for the different figures (right/left). The former is a between-subjects factor and the latter, a within-subjects factor. Dwell time (in ms) was the dependent measure. Additionally, in order to analyze the differences between the number of transitions in the wholist and analytic groups, an independent *t*-test was conducted.

Dwell Time

On average the analytic group dwelled longer on AOIs than the wholist group, $F(1, 38) = 113.78$, $p < .001$, $\eta^2 = .75$. Dwell time was longer on the left figure than on the right one, $F(1, 38) = 198.24$, $p < .001$, $\eta^2 = .84$. The interaction between the AOIs and groups did not reach significance, $F(1, 38) = .04$, $p = .84$, $\eta^2 = .001$, indicating that there was a similar increase in dwell time on both the left and right figures for both groups (see Figure 4a).

Number of Transitions

A *t*-test revealed significant differences between the groups, $t(38) = -2.69$, $p = .01$, $d = .84$. On average, the number of transitions from one figure to another in the analytic group ($M = 141.79$, $SD = 26.71$) was higher than in the wholist group ($M = 122.95$, $SD = 16.98$).

Local Task

Dwell Time

On average the analytic group dwelled longer on AOIs than the wholist group, $F(1, 38) = 20.16$, $p < .001$, $\eta^2 = .35$. Dwell time on the right AOI was longer than on the left AOI, $F(1, 38) = 59.87$, $p < .001$, $\eta^2 = .61$. These main effects should be interpreted cautiously because of the significant interaction between them, $F(1, 38) = 11.16$, $p = .002$, $\eta^2 = .23$. This significant interaction is due to the fact that the analytic group dwelled longer on the right (complex) figure than did the wholist group. On the other hand, no differences were found for dwell time on the left (simple) figure (see Figure 4b).

Number of Transitions

A *t*-test revealed that the differences between the groups did not reach significance, $t(38) = 1.41$, $p = .16$, $d = .45$. Overall, the wholist group ($M = 121.38$, $SD = 21.29$) did not differ significantly from the analytic group ($M = 112.84$, $SD = 16.44$) on the average number of transitions from the right (complex) figure to the left (simple) one, and vice versa.

Discussion

As described in the Introduction, many researchers emphasize the importance of investigating the individual's cognitive style, *inter alia* to improve their learning ability and achievements (Peterson, Rayner, & Armstrong, 2009). This study presents our efforts to monitor the participants' EM in order to understand the underlying processes that individuals with different cognitive styles undergo while solving a task, by means of characterizing various patterns of EM (based on cognitive rather than behavioral data) that are typical of learners with a distinct tendency toward wholistic or analytic styles.

Behavioral Aspect

As hypothesized, the two groups made very few errors on the E-CSA-WA test. In terms of RT, as can be seen in Figure 3a, although the analytic learners answered more quickly on the local task than on the global one and were therefore defined as "analytic," their overall performance was slower than the wholists on both tasks.

The faster performance in the wholist group compared to the analytic group on both tasks can be explained based on the assumption that the analytic learner is typically more reflective while wholist learners tend to react more impulsively (Kozhevnikov, 2007; Rozencwajg & Corroyer, 2005). According to Kagan, Rosman, Day, Albert, and Phillips (1964), reflective learners emphasize accuracy over speed of response, while impulsive learners place greater emphasis on speed of response and less on accuracy. Therefore, reflective learners will generally display a high level of accuracy and a relatively longer RT than impulsive learners. In fact, analytic learners took longer to respond on both parts of the test compared to the wholists, but in terms of accuracy there were no differences between groups, apparently because of the relative simplicity of the test.

The impact of reflective style on RT in the analytic group might be related to the instructions given for the E-CSA-WA test, as participants were asked to answer as accurately as possible without any time constraints, in order to prevent impulsive reactions. It appears that the analytic learners who are typically more reflective in their responses may have been influenced by these instructions, resulting in longer RT than the wholists. These findings coincide with earlier studies that showed that when an instruction was added to the CSA test emphasizing the importance of speed in addition to accuracy (Rezaei & Katz, 2004), the influence of reflective style was reduced.

As noted, the behavioral measures made it possible to divide the participants into two groups based on their preferred cognitive style. Similarly, the measures indicated that reflective style may have influenced the analytic participants' RT. Nevertheless, we cannot infer the style of learning from these measures *per se* or reveal the underlying cognitive processes that the learner experiences while solving the test. The EM measurements shed light on this point and others.

Eye Movements

Since RT measures are a function of the dwell time measures, the analysis indicated a similar direction. As can be seen in Figure 3b, the average dwell time for the analytic group was greater than for the wholist group on both tasks. In terms of the manner of learning, one of the important findings that arose from this study was the different patterns of EM that were revealed. This may be ascribed to two learning strategies: whole (gestalt) or partial (step-by-step) strategies that are directly linked to wholistic and analytic cognitive styles (Rezaei & Katz, 2004), respectively.

Global Task

Our assumption was fully confirmed, as significant differences were found between the two groups. As can be seen in Figure 4a, on the global task that was better suited to the wholist participants' preferred style of learning, this group performed more efficiently and had to process less information than the analytic participants. As a result, their dwell time and number of transitions were relatively low compared to the analytic group.

The significant differences found in the number of transitions performed by the wholist group compared to the analytic group attest to the fact that the groups did indeed adopt different strategies to solve the task. It may be concluded that the wholists processed the information as a whole, and therefore required less transitions between the different figures. However, the analytic participants processed the details of each stimulus, therefore performing more transitions between the figures in order to completely scan all of their components. This may indicate that processing information as a whole will require fewer transitions than partial processing. Another aspect that should be studied further is that wholist style might reflect better visual memory, therefore less transitions are made by the wholist learner (for further reading see Kozhevnikov, Hegarty, & Mayer, 2002). These findings are consistent with Davies (2009), who demonstrated that wholists prefer to process the entirety, while analytic individuals prefer to focus on details if possible. Nevertheless, this conclusion was based on behavioral data of RT, which necessitated performing a manipulation on the original test. In the current study, use of EM monitoring enabled examination of the strategy employed by each group on the original test. Hence, it appears that the longer RT of the analytic group compared to the wholist group on the global task can be attributed to use of a strategy that is not suited to the task type, and not to use of a strategy that does not suit the participant's preferred style.

Local Task

As can be seen in Figure 4b, the findings refute the assumption that the average dwell time for the analytic group will be lower than for the wholist group, though the number of transitions will be higher. Nevertheless, the assumption that analytic learners process information reflectively could explain the length of dwell time, since processing information reflectively is more time consuming. Davies and Graff (2006) argued that the reflective tendency influences the scale of the CSA test, primarily because the global task always appears first, thus causing an imbalance in presentation of the tasks. The E-CSA-WA test maintains this imbalance, and therefore it is necessary to examine the obtained behavioral and EM measurements by dividing the E-CSA-WA test into two sections. The first section will include the original CSA test developed by Riding, which appears first and is therefore more likely to be influenced by the reflective style; and the second will contain Peterson's test that always appears second and is thus less subject to the reflective style, as the participants have already become familiar with the nature of the test.

Despite the differences in dwell time between the groups, no significant differences were found between the groups in the average number of transitions. This finding coincides with the argument presented by Davies (2009) regarding the asymmetry in the CSA test that was carried over to the E-CSA-WA test, whereby the global task may be solved using the two strategies, that is, focusing on details and observing the whole, whereas the local task can be solved only by means of focusing on details. Hence, no differences were found in the number of transitions used by the different groups, which shows that both groups used the same, apparently partial, strategy to reach the solution. Therefore, it seems that the wholists "adopted," or were forced to adopt, a partial strategy in order to solve the local task, and the analytics again used the partial strategy that suits their cognitive style. As a result, although the wholists adopted the local pattern of partial processing that does not naturally suit their cognitive style, their tendency toward impulsive reactions had a greater influence on the dwell time than did the data processing strategy that does not coincide with their preferred style.

Based on the above, it appears that the global task enables expression of different strategies. It follows that the wholists were tested for their ability to adopt a strategy for the task, whereas the analytics were tested for the efficiency of their partial strategies in different tasks. The resulting question is whether the asymmetry of the test caused the wholists to adjust their strategy to the task, or would they have employed the same strategy even if the situation had allowed otherwise? In order to deal with this problem, we suggest using Navon's figures (1977), in which the global stimulus is comprised of local stimuli, and whole processing is required for the global stimulus and local processing for the local stimuli. If we were to find that wholists are capable of adjusting strategies to suit the task, we could conclude that their cognitive style is more flexible.

Visual Attention

An additional interesting finding that arose from this study is how the learner's attention is drawn to different stimuli in the different tasks. In the global task, both groups dwelled longer on the left figure than on the right figure. This finding may be explained by studies that show that right-to-left readers focus more on the left region, whereas left-to-right readers focus more on the right (Pollatsek, Bolozky, Well, & Rayner, 1981). As noted, the participants in this experiment were native Hebrew readers (right to left), and they did in fact, perform as expected. This finding must be tested in populations that read from left to right, using the same task used here, in order to determine whether the longer dwelling time will shift to the figure on the right. In the local task, on the other hand, the primary focus was on the right (complex) figure. Apparently, since the left figure is composed of a single form, it requires less processing. Therefore, although the participants in this study were right-to-left readers, the figural characteristics of the stimuli appeared to have a stronger impact on referral of visual attention (Antes, 1974).

Conclusions

On the theoretical level, this study reveals a qualitative difference between analytic and wholist groups that goes well beyond the behavioral and quantitative differences found in different studies over the years, some of which necessitated manipulations on the original tests. It appears that monitoring EM enables assembling a cognitive profile that characterizes different strategies adopted by each group while performing the test. One of the conclusions drawn is that the EM measurements coincided with the analytic learner's tendency to focus on details during the learning process, as indicated by more transitions between the AOIs. On the other hand, wholist learners who grasp all stimuli as gestalts displayed fewer transitions. Therefore, these differences are interpreted as a reflection of partial (step-by-step) and whole (gestalt) processing, respectively.

From the practical aspect, wholists seem to learn more efficiently. Therefore it may be important to endow global learning patterns while teaching even high school students. However, more research is required on this issue.

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Electronic Supplementary Materials

The electronic supplementary material is available with the online version of the article at http://dx.doi.org/10.1027/1618-3169/a000323

ESM 1. Raw data (Excel).
Raw data of the Experiment.

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