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Individual Differences in Working Memory and Motor Performance:

A Cognitive Style Approach

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ABSTRACT

Previous research has showed that field independent participants show better performance in almost all tasks than field dependent participants. The present study designed to examine whether participants with different field dependence-independence cognitive style show differences in performance of tasks measuring working memory and accuracy. Forty three undergraduates were classified in 3 groups based on the total scores of the Group Embedded Figure Test (GEFT) (field dependent, neutral, and field independent). The results showed that field independent participants displayed better performance than neutral and field dependent participants on Spatial Span, Digit Span, and Dart throwing tasks. The findings indicated that higher score on the GEFT task demonstrate a better visuospatial ability (as component of working memory) in field independent which it may cause better performance in Spatial Span, Digit Span, and Dart throwing tasks.

Keywords: field dependence-independence, digit span, spatial span, accuracy

INTRODUCTION

Motor skills are gained in various ways due to individual differences on cognitive or learning styles. Thus, a perceiving of the relationship between individual differences in cognitive style and performance on motor tasks can enhance our understanding of the nature of those differences and contribute to the development of cognitive theory. In this study, the relationship between individual differences in field independent-dependent (FDI) (as different cognitive styles) and performance on a motor task measuring accuracy was investigated. Kozhevnikov (2007) suggested that cognitive styles represent heuristics that individuals use to process information about their environment. These heuristics can be identified at multiple levels of information processing, from perceptual to metacognitive, and they can be grouped according to the type of regulatory function they exert on processes ranging from automatic data encoding to conscious executive allocation of cognitive resources.

For more than half a century, scholars and educators have investigated the roles of styles of thinking and learning in human performance. Until recently, the field of styles was characterized by the conundrum that different styles are supposed to be not better or worse, but simply different. However, for many styles, this is not true. For example, field independence (FI) —a propensity for being able to orient oneself in space without regard to one's particular surroundings—is generally more adaptive than field dependence (FD) —the propensity to orient oneself in accord with the surroundings in which one finds oneself. In general, some styles are more adaptive than are others (Zhang & Sternberg, 2005). According to Peterson et al. (2005), differences on the cognitive style tests is independent from ability and personality. In contrast to many of the self-report learning style constructs, the FDI construct has an extensive history of research involving measurement using instruments that do not use self-report items and that tend to be more reliable when compared with many style oriented instruments. However, despite the view that ''the term 'cognitive style' has been used widely as a synonym for the FDI'', the measurement and application of the FDI has been plagued by the confusion about whether it is a cognitive style (Rittschof, 2008).

The terms FI and FD reflect a mode of information processing that is independent of the stimulus field or dependent on the stimulus field, respectively (Dooley & Harkins, 2009). The FI individuals are more individualistic, self or internal referencing, and tend to perceive information initially holistically or globally; therefore, the FI individuals are not influenced in their perception by the surrounding field, while the FD individuals are more socialistic, self or external referencing, and tend to perceive information separately or analytically. Therefore, the FD individuals are influenced in their perception by the surrounding field (Witkin et al., 1977). Results from the Zhang (2004) study indicated that the FDI construct represents an ability that requires visual disembedding rather than representing a broad cognitive style. Zhang (2004), based on definition of the thinking style construct by a general model of intellectual styles (Sternberg & Wagner, 1992), suggested that the FDI construct does not manifest any significant relationship to thinking style. Also, the FDI construct was related only to geometry—a subject matter that requires visual disembedding (Zhang, 2004).

Miyake et al. (2001) demonstrated that performance on the FDI tasks primarily reflects the operations of the visuospatial and executive components of working memory. The visuospatial is the component of working memory that allows you to temporarily hold and manipulate information about places. The central executive includes functions that they are responsible for the control and regulation of cognitive processes in general. These two components have been described in Baddeley's (1986, 1999) model of working memory. The aforementioned statements provide interesting discussion. Whether the FDI is a cognitive style or cognitive ability? In this case, there is inconsistent evidence. Thus, it seems necessary to conduct further research concerning the FDI. Thus, one goal of the present study was to investigate whether there are differences among groups of the FDI cognitive style in working memory and performance accuracy. Furthermore, we examined relationships between working memory and motor performance.

METHOD

Participants

Participants were 46 male college students with either no, or very little, previous dart-throwing experience. Three participants were excluded from the study due to scores over three standard deviations from the mean. They were deleted from the data set, and all analyses were conducted with 43 participants. Their mean age was 19.74 years (SD = 1.14; range: 18-22 years).They were placed in three groups based on the total scores of their Group Embedded Figures Test (GEFT). Participants with a score of 13–18 were considered to be FI (n = 16, 37.2%); those with scores of 0–5 were considered FD (n = 14, 32.55%); and those with a score of 6–12 were considered neutral (NU) (n = 13, 30.23%). Participants had normal or corrected to normal vision. Each participant signed an informed consent prior to the testing.

Design

One- way ANOVA and correlation coefficients were performed for the following dependent variables: Dart-throwing accuracy, Spatial Span, and Digit Span. Also, SPSS version 16 software was used for statistical analysis. The significant differences level for all analyses was set at $p \leq 0.05$.

Materials

Dart accuracy. Dart-throwing accuracy was used as the motor performance measure for the study. The task was to throw darts into the center of a circular target, 1 m in diameter. In accordance with the World Darts Federation, the dartboard was positioned with its uppermost edge 1.73 m high from the floor, and all darts were thrown from the standard distance of 2.37 m from the dartboard. The experimenter spent 10 minutes with each participant to explain and demonstrate the basic technique of throwing darts. All participants were given the same general instructions regarding the task goal and the throwing position. The participants threw darts in 60 trials. The radial error score for each throw was calculated to assess accuracy. The radial error scores were calculated from the position of the dart in relation to the position of the target for each throw. This score was calculated using the X and Y coordinates of the target and the dart for each throw. Radial error = $\sqrt{}$(xd-xt)2 + (yd-yt)2 where d = dart and t = target (Hancock, Butler, & Fischman, 1995).

Digit Span. In this test, each participant would have to try to remember a sequence of numbers that would appear on the screen one after the other. When the participants heard a beep, they would type all of the numbers into the keyboard in the sequence in which they occurred. If the participant correctly remembers all of the numbers then the next list of numbers would be one number longer. If the participant made a mistake then the next list of numbers would be one number shorter. After three errors, the test was ended.

Spatial Span. In this test, each participant would have to try to remember a sequence of flashing boxes that would appear on the screen one after the other. When the participant heard a beep, he would click on the boxes in the same order in which they flashed. If the participant was correct, the next problem would have one more box in the sequence. If the participant made a mistake then the next sequence of boxes would be one shorter. After three errors, the test was ended.

The Group Embedded Figures Test (GEFT). The GEFT has been developed by Witkin, Raskin, and Oltman (1971). The GEFT classified individuals into three groups: FD, FI, and NU. The GEFT includes three parts. The first part was practice figures. Participants received the standardized instructions while practicing the first part. The second and third parts were test figures. The participant is required to locate a simple figure embedded within each complex figure. The second and third parts had 9 more difficult figures for each and were used to determine the CSs. Participants had 5 min to complete each part. The score was the total number of embedded figures correctly traced in both part 2 and 3 (scores range 1–18). Missing or omitting figures were scored as incorrect. Individuals scoring greater than the 12 were classified as FI, whereas those scoring less than the 6 were considered as FD, and those scoring between 6 until 12 were select as NU. According to this classification, FDs, FIs, and NUs were 14, 16, and 13 respectively.

Procedure

Participants in the study were asked to visit the laboratory and read and sign the consent form before taking part of the study. At the beginning of the session, completion of the GEFT, and the dart-throwing histories questionnaire took place. Upon completion of these questions 15 min were devoted to familiarizing each participant with the study's measures, and the procedure and scoring system for the tasks. The study's measures were performed individually. Initially, with the dominant hand, participants performed the dart throwing task. In this task, participants threw 60 darts from a 2.37 m distance. After the throw, the participant walked to the dartboard, measured the X, Y coordinates of the dart using the preprinted coordinate grid on the dartboard, and read aloud the X, Y position of the dart to the experimenter, who manually recorded these values into the computer. The participant then removed the dart from the board and returned to the same start location to prepare for the next trial. The radial error was calculated using the X and Y coordinates of the target and the dart for each throw. Radial error= $\sqrt{}$(xd-xt)2 + (yd-yt)2 where d = dart and t = target (Hancock, Butler, & Fischman, 1995).

The spatial span and digit span tests were performed with a 17-inch color monitor of a LG computer. In the digit span test, each participant would have to try to remember a sequence of numbers that would appear on the screen one after the other. If the participant correctly remember all of the numbers then the next list of numbers would be one number longer. If the participant made a mistake then the next list of numbers would be one number shorter. After three errors, the test was ended. In the spatial span test each participant would have to try to remember a sequence of flashing boxes that appeared on the screen one after the other. If the participant was correct, the next problem would have one more box in the sequence. If participant made a mistake then the next sequence of boxes would be one shorter. After three errors, the test was ended. The experimenter registered the test scores.

RESULTS

Dart Accuracy

The one-way ANOVA revealed a significant main effect for dart-throwing accuracy F (2, 40) = 4.08, p <.05. Pair-wise multiple comparisons showed that the FIs (M = 9.27, SD = 2.47) were significantly more accurate than the FDs (M = 11.17, SD = 1.61). There wasn't a significant difference between two groups of FD and NU (M = 10.78, SD = 1.42), and no significant differences between the FIs and NUs.

Spatial Span

Considering Spatial Span, differences were significant [F (2, 40) = 9.67, p <. 05]. While FIs (M = 6.38, SD = .81) and FDs (M = 5.07, SD = .73) were significantly different (p < 0.01), FDs and NUs (M = 5.85, SD = 1.00) were different marginally, p < .05.

Digit Span

In relation to Digit Span, two significant differences were obtained [F (2, 40) = 11.60, p <. 05)]. The first was between the FIs (M = 7.31, SD = 1.14) and FDs (M = 5.64, SD = .93). The second was between FDs and NUs (M = 6.54, SD = .66). The first difference was at p < .05, whereas the second difference was marginal (p < .05). FIs and NUs statistically weren't different (p > .05).

Correlation

In order to investigate relationships between FDI scores with Spatial Span scores and Digit Span scores, the bivariate correlations were computed. Zero-order correlations indicated statistically significant relationships between dart-throwing accuracy and Spatial Span at the 0.05 level (r = .35), whereas dart-throwing accuracy and Digit Span was unrelated (r = .27, p > .05).

DISCUSSION

This study investigated the impacts of the FDI CSs on motor performance and working memory. In the accuracy task where performers made a series of dart throws, the FIs were significantly more accurate than the FDs. The FIs and NUs did not significantly differ in accuracy. Moreover, the NUs and FDs were not significantly different. Regarding to working memory, the FIs had better performance than the FDs in Spatial Span and Digit Span. There is a marginally significant difference between the NUs and FDs. Furthermore, the FIs weren't different than NUs. Also, considering working memory and performance, Spatial Span and motor performance was associated, but there wasn't a significant relationship between motor performance and Digit Span.

In the present study, the accuracy task was a closed-motor task. Athletes in a closed – motor task performed the learned routines in a consistent environment (e.g., gymnastics, diving, swimming, or high jump). Therefore, with regards to the relationship between the FDI and accuracy, the FI individuals as compared to the FDs seemingly benefit in closed skills and this is in accordance with previous studies (Cano & Marquez's, 1995; Chu, 1988; Guillot & Collet, 2004; Liu, 2003; McLeod, 1985). Kane (1972), cited by Liu et al. (2008), argued that the FI could be an advantage for athletes in closed-skill sports, which have a higher requirement in using internal (body) information. The FI are those who have the tendency to use internal frames, including body information such as kinesthetic feedback and proprioceptive awareness, for their information processing (Liu et al., 2008). It seems reasonable that the FI individuals tend to be more likely to choose sports with a preponderance of closed skills than the FD individuals (Liu, 2003).

On the other hand, the relationship between the FDI and Spatial Span, also association between Spatial Span scores and motor performance scores, show that the FI individuals have other abilities which lead to more accuracy. McLeod (1986) estimated the inter-trait correlation between the FD and spatial ability to be indistinguishable from one. Based on this the work, Sternberg (1997) concluded, ‘‘the FI is tantamount to spatial ability.’’ This finding corresponds with learners’ need to maintain shapes spatially in memory during perceptual dis-embedding tasks (Rittschof, 2008). Thus, based on previous studies (Dassonville et al., 2006; Miyake et al., 2001; Walter & Dassonville, 2007), visuospatial sketchpad and the central executive functioning as crucial components of the FDI subsystem described in Baddeley’s (1986, 1999) model of working memory can be other causes of more accuracy in tasks that participants performed in present study. The present findings may have some limitations. First, we investigated males in an age-specific range. Thus, future research needs to demonstrate that the present findings can be generalized to females and to other age-groups, as researches have pointed out that the FDI may show gender-specific relationships (Amador-Campos & Kirchner-Nebot, 1999).

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