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Investigating cognitive style differences in the perception of biological motion associated with visuospatial processing

Abstract *The purpose of the study was to compare the visuospatial decision-making error scores related to the perception of biological motion of individuals categorized as field dependent or field independent. A sample of 69 participants aged 18-27 years (M = 21.91, SD = 2.39) that included 33 males and 36 females completed the experiment. Cognitive style was assessed using the Group Embedded Figure Test. Perception of biological motion was evaluated using two different point-light stimuli developed from video images of a ballet dancer's performance of a correct and incorrect turn in the fifth position. The results showed that individuals classified as field independent made significantly fewer visuospatial processing errors. The findings are considered and discussed in relation to theoretical perspectives associated with both cognitive processing and cognitive style.*

Key words: *biological motion, cognitive style, visuospatial processing*

Introduction

Cognitive style can be considered as an important human characteristic that can affect the plethora of information processing heuristics necessary for problem-solving. It is a psychological dimension that highlights the consistencies and patterns of how an individual acquires and processes information (e.g., Ausburn & Ausburn, 1978; Blazhenkova & Kozhevnikov, 2010; Yoon, & D'Souza, 2009). The construct of cognitive style represents a specific approach to the processing of information by an individual regarding their environment across a range of levels from the perceptual to the metacognitive (Kozhevnikov, 2007). Choi and Sardar (2011) proposed that cognitive style can be linked to specific cognitive abilities, such as verbal abilities, visual imagery and spatial abilities, but highlighted that the nature of the associations remains unclear in the literature. Irrespective of this lack of clarity on the relationships they further suggested that "there is a general consensus that specific cognitive abilities, particularly spatial abilities, play key roles in cognitive styles" (p. 4). On this basis, the current study sought to examine differences in the visuospatial skills of individuals categorized according to their preferred cognitive style.

One of the most commonly acknowledged cognitive style theories is that of field dependence-independence (FDI) (Witkin & Goodenough, 1981). Witkin and colleagues focused on individual differences and distinguished two distinct cognitive styles: field dependent and field independent. At the basis of the styles is the developmentally conditioned process of psychological differentiation, which involves both the differentiation of perceptive and intellectual skills and self-differentiation (i.e., conceptualization of the body into a coherent entity) (Witkin, Goodenough, & Oltman, 1979). Within this framework, preference of the comprehensive view of the visual field (i.e., priority of the whole over components) denotes field dependence, whereas, differentiation, and concentrating on each component is a sign of field independence (Witkin, Oltman, Raskin & Karp, 1971). Alternative perspectives proposed to explain the field dependence-independence concept have focussed on the individual's differences associated with cognitive processing. The dependent style may "involve slow differentiation (selection) of a figure from the background and lingering of an entire context in short-term memory" (Bednarek & Orzechowski, 2008, p. 54). Those that are field dependent also attempt to preserve a figure – pattern during figure differentiation from the background. This

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can lead to slower processing of overall of perceptual data and transition between cognitive structures. Handal and Herrington (2004) also surmised that the field dependent style may require greater effort and time in the construction of meaningful information when the field lacks structure and few clues are obtainable. The field-independent style is proposed to utilise an active analytic way of perceiving data incorporating better differentiation of field fragments against the entire background, fast scanning of both the entire figure-ground background and criteria for field differentiation (Bednarek & Orzechowski, 2008). Variations in cognitive processing abilities between those that are field dependent and independent may serve as contributing factors in possible individual differences observed in other cognitive abilities (e.g., Guisande, Páramo, Tinajero, & Almeida, 2007).

The examination of differences in human cognitive functioning through the exploration of abilities such as spatial visualization (Halpern, 2000; Hyde, 2005) that involves using tasks associated with spatiotemporal ability (e.g., De Goede & Postma, 2008; Vuoksimaa, et al., 2010) constitutes an area of continuing research interest. Halpern (2000) defined this type of visual-spatial ability as cognitive processing involving "judgments about and responses to dynamic (i.e., moving) visual displays" (p. 101). Further consideration of the judgments that individuals make in this type of processing can be aligned with the area of perceptual decision making. A relevant definition of perceptual decision making was presented by Heekeren, Marrett and Ungerleider (2008) as "the act of choosing one option or course of action from a set of alternatives on the basis of available sensory evidence" (p. 467). Furthermore, perceptual decision making is influenced by factors such as attention, task difficulty, the previous experience of an event and its outcome.

Additionally, an important element of perceptual processing originally discussed by Johansson (1973) is the capability of people to visually recognize the motion patterns of humans. Johansson labeled this process 'biological motion', and demonstrated the phenomenon by attaching illuminated dots to the joints of a walking person in a darkened room and filmed their motor movements. Individuals operating in the role as perceivers could then be shown an animation of the "point light walker" and asked to identify the image. Researchers examining perception of biological motion have used this methodology to highlight variations in an individual's cognitive abilities to determine characteristics such as directions of motion (Bertenthal & Pinto, 1994), the type of motor action (Dittrich, 1993; Vanrie & Verfaillie, 2004), and styles of movement (Pollick, Fidopiastis, & Braden, 2001).

Choi and Sardar (2011) proposed that spatial abilities may predispose individuals towards developing a particular cognitive style. Individuals with well-developed spatial abilities tend to prefer processing and representing information visually, leading to the development of a visual cognitive style. The study involving 60 undergraduate students found a small significant correlation between preference for the visual cognitive style and their performance of a well known spatial skills measures, the mental rotations task. Madar and Hassim (2011) investigated the relationship between visual spatial ability as assessed by the Spatial Visual Ability Test (SVAT) and field dependent-independent cognitive style preference and achievement in a multimedia task. A comparison of pre and post test scores in a course work graphic animation test involving a sample of 138 first year polytechnic students highlighted that individuals who were classified as field independent and high in spatial visualization ability achieved greatest improvement in test scores over the course.

Currently, only limited cognitive style preference studies could be found that have focused on comparing skills in the visuospatial domain using the perception of biological motion as the discriminating variable. Lee (2011) used a biological motion recognition task to differentiate between groups of individuals classified as field dependent or field independent. Results clearly highlighted that the field independent group correctly identified biological movements in a shorter time. Additional research in this specific cognitive processing domain could further clarify the role that the cognitive style of field dependence-independence plays in an individual's capacity to recognise the human movements represented via biological motion.

Aims and Purpose

The main purpose of the present study was to examine possible cognitive style differences in visuospatial processing assessed using a task incorporating the perception of biological motion. The specific task involved the discrimination of point-light images generated using specific ballet movements. It was hypothesized that that those who field independent would make fewer errors in determining similarities or differences between the point light stimuli pair. This is because those that are field independent are better able to cognitively construct whole images from the parts they process within their visual field of view. Contrasting differences in the perception of biological motion between individuals classified as field independent or field dependent, may provide additional information that assists in clarifying the association between cognitive style preference and the visuospatial processing on which it is reliant. Furthermore, this study may contribute to a clearer understanding of the processes that individuals use to decode spatiotemporal information associated with perception of biological motion.

Method

Participants

The convenience sample comprised 69 citizens of Estonia drawn from a university student cohort ranging in age from 18-27 years (*M* = 21.91, *SD* = 2.39). The participant group included 33 males (*M* = 21.76, *SD* = 2.33) and 36 females (*M* = 22.06, *SD* = 2.46). All participants had normal or corrected-to-normal visual acuity, reported they had no experience in ballet, and were aware that the specific aim of the investigation was in relation to the examination of a specific cognitive processing skill. Approval to recruit participants and collect data was given by the Tallinn University ethics committee.

Measures

Cognitive style was assessed in the present study using the Group Embedded Figure Test (GEFT) designed by Oltman, Raskin, & Witkin, (2003). The GEFT measures ability to encode a spatial pattern and recognize it in a complex figure. In this test, participants are given a sheet showing several simple 2-D geometric figures. On each trial they are shown a complex 2-D figure, and their task is to locate the simple figure within the complex figure and to trace it in pencil. There are three sections of the test: an initial practice section with 7 items, lasting 2 min, and two sections with 9 items each, for which participants are allotted 5 min apiece. The number of correct figures located is taken as the score of GEFT which indicates the position of the individual in the field independence-field dependence cognitive style continuum, where 18 is the maximum score and 0 is the minimum score. A higher score in the range of 10 – 18 indicates a stronger inclination towards the field-independent cognitive style whilst a lower score in the range of 0 – 9 indicates a stronger inclination towards the field-dependent cognitive style. These scoring classifications were used as the basis for grouping participants into the two cognitive style categories in the current study. The reliability and validity of the test instrument has been proven by a number of studies and reported coefficients in the order of 0.82 – 0.90 were detailed in the GEFT manual (Witkin et al., 1971).

Apparatus and stimuli

Spatial visualization was evaluated using point-light stimuli representing the performance of the ballet dancer. Images were generated using the ELITE Biomech 2002 optic-electronic apparatus (BTS – Bioengineering Technology and Systems, Italy). The system includes six cameras that have an infrared illuminator and contacts, reflecting markers covered with aluminum powder that are attached to the participant's body, and analysis software. The markers were seen on the screen as white dots on a black board. It is possible to show the sensitivity to biological motion by increasing/decreasing the number of illuminated joints (Neri, Morrone & Burr, 1998). In the current study, we attached 20 markers to the ballet dancer's body by using the Davis body model (Karpova et al., 2005). All stimuli were presented to participants on a portable laptop using the ELITE Biomech 2002 software to present the stimuli.

Procedure

The point-light stimuli were created from video of ballet dancers in motion. The major movements in ballet involve dancers using standardized foot and arm placements: first, second, third, fourth, and fifth positions. The fifth position is the toe-to-heel position. It involves the movement of both feet while the dancer maintains a 180° vertical-angle with the left foot forward. The heel of one foot lines up with the toe of another foot. In this version of the pirouette, the head moves first during rotation, one arm in the first position, and contralateral arm (same as the support leg) is in the second position (See Figure 1).

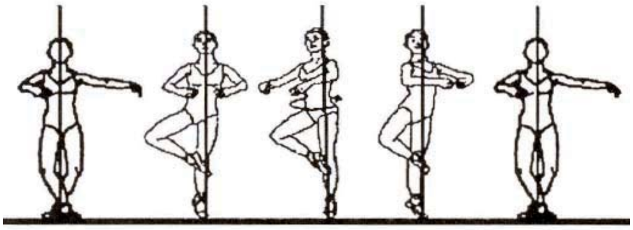

Figure 1. Example of the correct ballet movement used for the point-light stimulus

For this study, point-light images of a ballet dancer performing a correct turn (balanced) and an incorrect turn (off balance) from the fifth position were used as the basis of the visuospatial processing task stimuli (See Figure 2). Within the experimental stimuli the characteristic of the image that differentiated if the turn was correct or incorrect was whether the balance line of the dancer during the movement was in a direct 180º vertical position (Stimulus 1) or off to the left or right side by 15 to 20 degrees (Stimulus 2) (See Figure 3). Participants were presented 20 pairs of the stimuli that were either similar or contrasting versions of the stimuli. Each pair had the combination of stimuli presented in a random order equally represented from the following possibilities (i.e., stimulus 1/stimulus 1; stimulus 1/stimulus 2; stimulus 2/stimulus 1; stimulus 2/stimulus 2), with interstimulus intervals that were constant (5000 ms). Participants were then asked whether the second stimulus of the pair was the same or different from the first stimulus of the pair. Right and wrong answers were registered according to whether the participant did or did not correctly recognize a difference or similarity within the pair of stimuli. The experimental task was completed on two occasions separated by a 2 day interval depending on participant availability. The tasks were completed in relaxed conditions in a quiet room. Participants completed the GEFT immediately prior to completion of the visuospatial processing task. SPSS version 17 was used for the data analysis.

Figure 2. Example of Point Light Stimulus Images

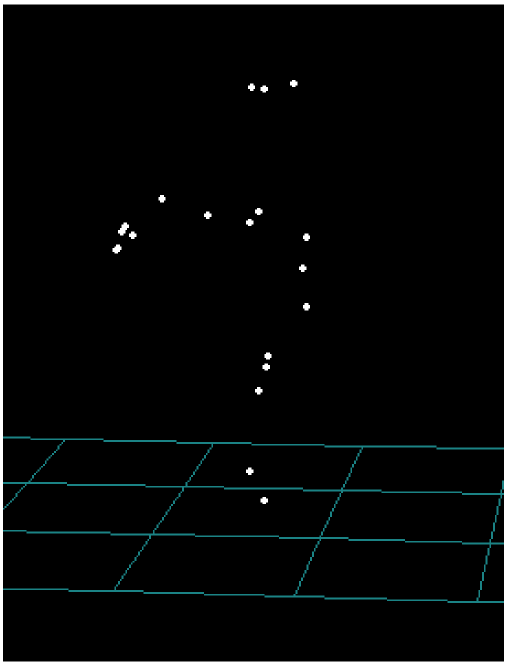

Figure 3. Example of Screen Shot of the Point Light Stimulus Image Task

Results

The visuospatial error scores for the point-light stimuli test for the field dependent (FD) and field independent (FI) groups are presented in Table 1. The descriptive analysis details for the error score at occasion 1, occasion 2, and the difference score between occasions are presented in Table 1.

Table 1 Means and standard deviations of decision-making errors in biological motion perception for FD, FI, and total participants.

Variable	Mean Total (n = 69)	SD	Mean FI (n = 37)	SD	Mean FD (n = 32)	SD
Errors occasion 1	3.65	1.67	3.05	1.65	4.34	1.43
Errors occasion 2	3.57	1.66	3.14	1.67	4.06	1.50
Errors difference score	0.09	2.34	-0.08	2.44	-0.28	2.25

A repeated measures Multivariate Analysis of Variance (MANOVA) was conducted to evaluate differences between the FD and FI groups in relation to test occasion. A significant difference was found between the FD and FI groups in decision-making errors, $F(1,67) = 19.131$, $p < .001$. The effect size was small, $\eta\rho^2 = .022$. The within subjects analysis indicated no significant difference across test occasions, $F(1,67) = 0.34$, $p = .124$. No significant difference was found, $t(67) = 0.64$, $p = .53$. The pattern of change as shown in Figure 2 indicated that the FD individuals made fewer errors across test occasions whereas the FI individuals demonstrated a very small increase in errors made. Overall, the results clearly highlight that the FI group made less errors than the FD group at each test occasion.

Discussion

The aim of this study was to compare the decision-making error scores of individuals categorized as field dependent or field independent in relation to their skill to discriminate between variations in a point-light stimuli representation of a ballet dancer's correct and incorrect turn in the fifth position. The point-light stimulus format for exemplifying biological motion served as the basis of the task used to compare the visuospatial processing skills of the participants. Results clearly supported the research hypothesis and revealed that individuals who were classified as field independent made significantly fewer errors at each test occasion.

The current findings showed that performance on the point-light discrimination task could be differentiated on the basis of preferred cognitive style. Previous studies regarding cognitive style preferences and performance on comparable visuospatial tasks such as a spatial visual ability measure (Madar & Hashim, 2011) and mental rotations test (Choi & Sardar, 2011) revealed differences between groups categorized according to their preferred cognitive style. However, only very limited prior research could be found that utilized the point-light stimulus approach as a type of visuospatial processing task to discriminate between the individuals grouped according to their preferred cognitive style (e.g., Lee, 2011).

Cognitive style theory describes how an individual acquires knowledge and processes information (Witkin et al. 1977). The various styles relate to the thinking behaviors which individuals apply habitually when solving problems, and affect the way in which information is obtained, sorted, and utilized (Birch & Hayward, 1994). More specific consideration of recent interpretations of field dependence theory (e.g., Bednarek & Orzechowski, 2008, Guisande et al., 2007) has highlighted how patterns of individual cognitive processing associated with either a field dependent or field independent preference are observable within the present results. The greater number of errors made by participants classified as field dependent demonstrates the difficulty that they may have experienced in identifying the correct movement of the point light image of the dot pattern from the blank black background. Alternatively, Bednarek and Orzechowski (2008) proposed those who were field independent are more analytic in their processing, scan images faster, and are capable of differentiating fragments to construct a whole image. Lower error scores reported for the field independent group infers that the biological motion task utilized in the present investigation is aligned to this type of cognitive processing. Individuals who were field independent were better at assessing the pattern positioning of the signal dots within the point light display and perhaps constructed clearer mental images of the pair of movements.

Furthermore, the present results are supportive of previous cognitive style and cognitive processing findings summarized by Kozhevnikov (2007), who reported that object visualizers encode and process images holistically, as a single perceptual unit, and spatial visualizers generate and process images analytically, part by part. Field dependent individuals could be classified as object visualizers, whereas, field independent individuals are classified as spatial visualizers. Each individual grouped according to these processing preferences, under the same experimental conditions, may have been engaging in the biological motion task differently, thus, leading to the variations in accuracy outcome. Furthermore, Witkin (1967) proposed that cognitive styles are consistent over time. In the current investigation, the field independent group made fewer errors at each test occasion, that were separated by a two day interval.

A major limitation of the current study was the use of a small sample. This was due to a secondary aim of the investigation being the finalization of the adaptation of the biological motion methodology to substantiate its use as an alternative procedure for evaluating visuospatial skills within future research. Therefore, within this phase of the investigation a larger sample of participants from a broad range of ages was not sourced.

Consideration of both the current findings and the limited previous related research highlights that additional investigations are required to clarify the strength and pattern of cognitive style differences related to the discrimination of human movements measured by perceptual decision-making. Future research should also be undertaken that involves a reciprocal experiment with field-dependent/independent participants grouped according to their expert or novice status in relation to the specific biological motion task (e.g., ballet dancers, non-dancers). In relation to the experimental task, further evaluation is required to determine whether outcomes associated with the perception of biological motion have a practical application in settings associated with motor skill development such as in sport, physical education, or dance. Moreover, continued evaluation of biological motion as a measure of visuospatial ability should incorporate neuropsychological apparatus to determine whether the mirror-neuron system serves as an indicator of the cognitive activity associated with biological motion processing. In summary, it was concluded that differences in cognitive style appear to constitute characteristics that affect the perception of biological motion when considered in terms of visuospatial processing.

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