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An Empirical Investigation of the Relationships Among Cognitive Abilities, Cognitive Style, and Learning Preferences in Students Enrolled in Specialized Degree Courses at a Canadian College

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An Empirical Investigation of the Relationships Among Cognitive Abilities, Cognitive Style, and Learning Preferences in Students Enrolled in Specialized Degree Courses at a Canadian College

Abstract

Although specific cognitive abilities, cognitive style, and learning preferences are assumed to be inter-related, the empirical evidence supporting this assumption is mixed. Cognitive style refers to how individuals represent information, and learning preference refers to how individuals prefer the presentation of information (Mayer & Massa, 2003). Both cognitive style and learning preferences have been linked to specific cognitive abilities, such as verbal abilities, visual imagery and spatial abilities, though the nature of the inter-relationships remains tenuous in the literature. The present study addressed the roles of specific cognitive abilities in the relationship between learning preferences and the visualizer-verbalizer dimension of cognitive style, using a unique sample of students enrolled in specialized post-secondary programs. A battery of cognitive tests and questionnaires was administered. It was found that spatial abilities predicted visual cognitive style, which in turn, predicted visual learning preferences. Vocabulary knowledge predicted verbal cognitive style, but not verbal learning preferences. These results suggest that specific cognitive abilities predict visual-verbal cognitive styles, though the distinction between visual-verbal cognitive styles does not have clear associations with learning preferences.

Bien que l'on suppose que les habiletés cognitives, le style cognitif et les préférences en matière d'apprentissage soient interreliés, les preuves empiriques étayant cette supposition sont partagées. Le style cognitif renvoie à la façon dont les individus perçoivent l'information et les préférences en matière d'apprentissage concernent la présentation de l'information (Mayer & Massa, 2003). Les chercheurs ont établi un lien entre, d'une part, le style cognitif et les préférences d'apprentissage et, d'autre part, des capacités cognitives spécifiques comme les habiletés verbales, l'imagination visuelle et les capacités spatiales; quoique la nature des interrelations reste fragile dans les écrits. La présente étude a considéré le rôle des habiletés cognitives spécifiques dans la relation entre les préférences d'apprentissage et la dimension visualisation-verbalisation des styles cognitifs à partir d'un échantillon d'étudiants inscrits à des programmes postsecondaires spécialisés. Les chercheurs ont administré une batterie de tests cognitifs et de questionnaires. Ils ont découvert que les habiletés spatiales permettaient de prédire le style cognitif, qui à son tour, permettait de prédire les préférences d'apprentissage visuel. La connaissance du vocabulaire prédisait le style cognitif verbal, mais pas les préférences en matière d'apprentissage verbal. Ces résultats suggèrent que des habiletés spécifiques permettent de prédire les styles cognitifs verbaux et visuels, même s'il n'y a pas de lien clair entre les préférences d'apprentissage et la distinction entre ces styles.

Keywords

verbalizer-visualizer, cognitive abilities, cognitive style, learning preferences

Cover Page Footnote

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Individual differences associated with preferences for verbal or visual information form the foundation of one dimension of cognitive style, namely, the visualizer-verbalizer dimension. Cognitive style describes how individuals process and represent information (Mayer & Massa, 2003). It is popularly believed that visualizers prefer images to process and represent information whereas verbalizers prefer using words. Specific cognitive abilities, such as verbal abilities, visual imagery and spatial abilities are thought to play significant roles in the development of the visualizer-verbalizer dimension of cognitive style and learning preferences. The presumption that cognitive style and learning preferences are closely related frequently forms the basis of instructional practices across many different disciplines (e.g., Beheshti, 2009). Despite its intuitive appeal, however, empirical evidence validating the relationships among cognitive style, cognitive abilities and learning preferences remains contentious (Mayer, 2008; Sternberg, Grigorenko, & Zhang, 2008a). The present study sought to elucidate how learning preferences and one dimension of cognitive style, visualizer-verbalizer, are related, as well as explore the roles of specific cognitive abilities, using students enrolled in specialized post-secondary programs.

The distinction between visualizers and verbalizers has a long but sketchy history in educational research (Kirby, Moore, & Schofield, 1988; Zhang & Sternberg, 2000). Proponents of the cognitive style movement suggest that individual differences in the way people process and represent information influence the effectiveness of instructional methods and overall learning in the classroom (Kirby et al., 1988). Research findings supporting this position are based primarily on self-report measures of cognitive style, which suggest that the visualizer-verbalizer dimension is related to learning preferences (e.g., Massa & Mayer, 2006; Plass, Chun, Mayer, & Leutner, 1998; Price, 2004; Riding & Watts, 1997). Massa and Mayer (2006), for instance, found that visualizers prefer using images for clarification, whereas verbalizers prefer text-based help to facilitate their comprehension. In other words, when required to choose between images versus text when clarification was needed, visualizers chose images and verbalizers chose text-based explanations. Recent research using Functional Magnetic Resonance Imaging (fMRI) provides corroborating evidence, suggesting that there is a neural basis underlying the distinction between visualizers and verbalizers (Kraemer, Rosenberg, & Thompson-Schill, 2009).

The relationship between learning and the visualizer-verbalizer dimension of cognitive style has direct implications on instructional practices. The theory of successful intelligence implies that instruction utilizing limited teaching methods assist only a small percentage of students, leaving the majority of students achieving below their true potential (Sternberg et al., 2008a). If this theoretical position is applied to the visualizer-verbalizer dimension of cognitive style, students who prefer to learn using words will be affected differentially by the same class, compared to their peers who prefer to learn using images. When problem-solving, for example, visualizers will be biased towards image-based instruction and solutions, whereas verbalizers will favour a lecture method in which verbal information is predominantly used. This is based on the presumption that instructional methods consistent with students' cognitive styles results in less need to engage in processing the information, which has received some empirical support (e.g., Riding & Watts, 1997; Thomas & McKay, 2010). In a recent fMRI study, for example, individuals who received information in their non-preferred modality were found to automatically convert it into their preferred modality, such that visualizers converted verbal information into visual representations, and verbalizers converted visual information into verbal representations (Kraemer et al., 2009). This conversion of new information into the preferred modality is presumed to aid processing and recall.

Despite the body of evidence supporting the consistency between cognitive style and instructional methods, some maintain that there are no significant differences in learning between visualizers and verbalizers, but rather, other factors, such as the students' level of prior knowledge, are more important than cognitive style (e.g., Mayer, 2008). It should be noted, however, that these results, for the most part, are based on undergraduate students enrolled in psychology classes and a large variation of cognitive styles. In contrast, individuals educated and working in specialized professional fields, such as visual arts, sciences and humanities, have been found to vary systematically in cognitive styles based on differing strengths in specific cognitive abilities, though very little is known about their corresponding learning preferences (Kozhevnikov, Blazhenkova, & Becker, 2010).

Irrespective of the contentious views on the relationship between differentiated instructional methods and cognitive style, there is a general consensus that specific cognitive abilities, particularly spatial abilities, play key roles in cognitive styles and learning preferences (Mayer, 2008; Sternberg, Grigorenko, & Zhang, 2008b). Clarifying the roles of specific cognitive abilities in learning preferences and cognitive styles will identify the origins of these individual differences. Understanding the origins of individual differences in learning, in turn, may inform how to provide necessary support to ensure that all individuals effectively learn. For example, if visualizers have weaker verbal abilities and verbalizers have weaker visual abilities, support may be provided in the necessary cognitive domains to facilitate learning. Recent research exploring the roles of specific cognitive abilities has revealed *two*, rather than one, types of visual learners, namely, spatial versus image-based visual styles (Kozhevnikov, Kosslyn, & Shepard, 2005). It has long been assumed that visual cognitive style is a unitary concept such that visual learners all use similar image-based representations to help learning, which may account for inconclusive research findings between cognitive style and learning preferences. Given the more precise conceptualization of visual cognitive style, definitive results of the relationship between visual styles and learning preferences may be revealed.

The purpose of the present study was to explore the inter-relationships among learning preferences, cognitive style, and specific cognitive abilities, namely spatial abilities, imagery, and verbal abilities. The unique contribution of the present study lies predominantly in the composition of the sample. The majority of research findings have been based on undergraduate psychology samples (e.g., Mayer & Massa, 2003), and there is limited evidence that the reported findings can be extrapolated outside this narrowly defined population. This is significant, given that a number of recent studies have demonstrated that professionals in specialized fields in sciences and arts show distinct relationships between cognitive abilities and cognitive styles (e.g., Blajenkova, Kozhevnikov & Motes, 2006; Kozhevnikov et al., 2005). There is, however, a paucity of work focusing on the learning preferences of these individuals with highly specialized abilities. To further expand upon these findings, participants used in the present study were all enrolled in specialized degree-level programs at a post-secondary institution. This unique sample will test the external validity of the reported relationships among the visualizer-verbalizer dimension of cognitive style, learning preferences and the role of specific cognitive abilities.

Method

Participants

Sixty students enrolled in degree-level general education courses at Humber Institute of Technology and Advanced Learning (ITAL) volunteered to participate in the study. Five incomplete questionnaires were discarded, resulting in a final sample of 55, consisting of 20 males (M = 21.60 years, SD = 4.88) and 35 females (M = 21.89 years, SD = 4.91). All participants were entered in a draw to win one of four $50 gift certificates from the campus bookstore. All participants signed consent forms, informed that they could withdraw without consequence at any time, and assured of confidentiality and anonymity. The programs in which participants were enrolled at Humber ITAL are as follows: Creative Advertising (n=10), Criminal Justice (n=15), Industrial Design (n = 11), Interior Design (n=4), Fashion Management (n=2), Music (n=1), Nursing (n=12).

Materials and Procedure

The study was conducted in the 2010 winter term by the authors after research ethics approval was granted. A battery of cognitive tasks and questionnaires were administered in the order described below.

Specific cognitive abilities. General verbal abilities and object imagery were assessed by the Vocabulary Test and Snowy Pictures, two tests from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Dermen, 1976). The Vocabulary Test consisted of 18 target words in which a synonym from 4 options for each target word was chosen. The total time for the test was four minutes. Snowy Pictures consisted of 12 items, completed in three minutes. The number of correct responses comprised the score for each of the tests. Two measures of spatial abilities were administered, Waterline task and Mental Rotations. The Waterline task was a measure of spatial perception consisting of drawings of 12 bottles tilted to varying degrees on a horizontal stand and tilted stand (Choi, McKillop, Ward, & L'Hirondelle, 2006). Participants were given three minutes to complete the task with instructions to indicate how the top of the water bottle would look in each bottle if it were half filled with water. The mean angle of deviation from the horizontal line comprised the score. A second spatial measure, Vandenberg and Kuse's (1978) adaptation of Shepard and Metzler's (1971) three-dimensional mental rotation task, was used. The task consisted of 24 target items, each containing four options that included two rotated versions of the target item. Participants were required to identify which two of the four options were the rotated targets. Participants were given 10 minutes to complete the task. The difference between the correct and incorrect responses comprised the overall score.

Cognitive style and learning preferences. A 20-item revised version of the Verbalizer-Visualizer Questionnaire was used to assess cognitive style, consisting of 10 items each for verbal factors and visual factors (Kirby et al., 1988). A five-point Likert scale, ranging from strongly disagree to strongly agree, was used. Two averaged scores were calculated: one for verbal cognitive style and one for visual cognitive style. The Multimedia Learning Preference Questionnaire was also administered (Mayer & Massa, 2003). This five-item questionnaire presented learning scenarios in which participants chose their preferences for visual or verbal help to comprehend the scenarios. The score comprised the number of scenarios in which visual help was preferred.

Lastly, a short demographic questionnaire was completed.

Results

To assess the inter-relationships among specific cognitive abilities, and verbal and visual cognitive style, two-tailed Pearson correlation coefficients were calculated (see Table 1).

Table 1
Intercorrelations Among Specific Cognitive Abilities and Cognitive Style

Cognitive Task	1	2	3	4	5	6
1. Vocabulary Task	--	.01	-.35**	.41**	.42**	.24
2. Snowy Pictures	--	--	-.16	.21	.08	.14
3. Waterline Task[a]	--	--	--	-.44**	.19	-.10
4. Mental Rotations Task	--	--	--	--	.16	.29*
5. Verbal Cognitive Style	--	--	--	--	--	.13
6. Visual Cognitive Style	--	--	--	--	--	--

*$p < .05$. **$p < .01$.
Note. [a] higher scores denote poorer performance

Verbal cognitive style was positively correlated with vocabulary. Visual cognitive style was positively correlated with mental rotations. There were no other statistically significant correlations with either one of the cognitive style variables. There were, however, correlations among the vocabulary and the two spatial measures, mental rotations and waterline tasks. In order to assess the unique contribution of each of the specific cognitive abilities on the two types of cognitive style variables, two separate step-wise regression analyses were performed using verbal cognitive style and visual cognitive style as dependent variables. As predicted, vocabulary was the sole predictor for verbal cognitive style and mental rotations was the sole predictor for visual cognitive style (see Table 2).

Table 2
Predictors of Verbal and Visual Cognitive Styles

	Predictor	*B*	*SE B*	*F*	ΔR^2
Verbal Cognitive Style[a]					
	Constant	2.71	.18		
	Vocabulary	.06	.02	11.10**	.17
Visual Cognitive Style[b]					
	Constant	3.64	.01		
	Mental Rotations	.01	.004	4.76	.082

*p < .05. **p < .01.
[a] Variables not entered into the equation include Waterline Task, Mental Rotation, Snowy Pictures.
[b] Variables not entered into the equation include Vocabulary, Waterline Task, Snowy Pictures.

A step-wise regression analysis using learning preference as a dependent variable, and the two cognitive style variables and specific cognitive abilities as factors was performed to assess how much of the total variability was accounted for by each factor. Results revealed that visual cognitive style was the sole predictor of learning preference (see Table 3). No other factors accounted for statistically significant amount of the total variability.

Table 3
Predictors of Learning Preferences

Predictor	*B*	*SE B*	*F*	ΔR^2
Constant	-1.88	2.06		
Visual Cognitive Style[a]	1.23	.54	5.23*	.09

*p < .05.
[a] Variables not entered into the equation include Verbal Cognitive Style, Vocabulary, Mental Rotations, Waterline Task, Snowy Pictures.

Discussion

The present study found support for associations between specific cognitive abilities and cognitive style. Mental rotation abilities, a specific type of spatial ability, was the sole predictor of visual cognitive style, such that those with better developed mental rotation abilities tended to self-identify as visualizers. Congruently, higher vocabulary scores predicted verbal cognitive style; students with more developed vocabulary abilities were more likely to identify themselves as verbalizers. Partial support was found for the consistency between learning preferences and the visual-verbalizer dimension of cognitive style. Self-identified visualizers preferred to learn using aids that used images. Interestingly, self-identified verbalizers did not prefer the use of verbally-biased aids.

The results suggest that specific cognitive abilities play significant roles in predicting the visualizer-verbalizer dimension of cognitive style, supporting previous findings (Kozhevnikov et al., 2005; Kozhevnikov et al., 2010). Specific cognitive abilities, such as spatial abilities and vocabulary, may predispose individuals to specific interests that bias them towards developing a particular cognitive style. Those with well-developed spatial abilities may be more inclined to process and represent information visually, leading to the development of a visual cognitive style. This conjecture is supported by the positive relationship between mental rotations and visual cognitive style. There were, however, no associations between visual cognitive style and the waterline task, another measure of spatial abilities. It may be that the waterline task is not as sensitive as mental rotations as a measure of spatial abilities (Voyer, Voyer, & Bryden, 1995). The mental rotation task used in the present study is considered to be the gold standard for assessing spatial abilities in humans (Driscoll, Hamilton, Yeo, Brooks, & Sutherland, 2005). It further should be noted that visual imagery did not predict visual cognitive style. In our particular sample, those with strong mental rotations abilities, but not necessarily strong visual imagery, reported a visual cognitive style. This may be due to the nature of our sample, such that there were a number of students enrolled in the industrial design program in which spatial skills play a particularly significant role (Cross, 1986). Performance on the vocabulary test predicted verbal cognitive style in the present study, lending further support that specific cognitive abilities bias individuals towards a particular cognitive style. Individuals who have well-developed vocabulary are more inclined to process and represent information verbally, developing a stronger verbal cognitive style. It is interesting to note that those with weaker vocabulary abilities were not inclined to develop a visual cognitive style, inferring that the development of cognitive style is based on the strength of specific cognitive abilities rather than compensatory for weaker cognitive abilities. Specifically, weak vocabulary does not appear to lead to a visual cognitive style, nor does weak mental rotations abilities lead to a verbal cognitive style, given the lack of correlation between less developed vocabulary and visual cognitive style.

The pattern of our results examining the relationships between cognitive abilities and cognitive style contribute to the literature by providing further support for the notion of cognitive style. While some have questioned the visual-verbal cognitive style distinction (Mayer, 2008), others maintain that the visual-verbal distinction in cognitive style is a valid one (Kraemer et al., 2009). Our results are consistent with the growing number of empirical studies that suggest that individual differences in visual-verbal cognitive style are valid and emanate from specific cognitive abilities. Future studies focusing on the emergence of cognitive abilities and cognitive style may provide further insight into the relative development of cognitive style and abilities, and how they interact with learning preferences.

From the standpoint of the purpose of the present study, the most critical finding is the relationships among cognitive styles and learning preferences. Although there is some emerging evidence to suggest that there are differences in cognitive styles and cognitive abilities among professionals and students in differing fields such as science versus humanities (e.g., Blajenkova et al., 2006; Kozhevnikov et al., 2005), there is scant evidence supporting the notion that learning preferences are predicted directly by visual-verbal cognitive style. Existing empirical support for the relationships between cognitive styles and learning preferences are mixed. Although it has been suggested that cognitive styles act as heuristics that bias individuals to process information using a particular modality, such that they act as regulators of information coming from the environment (Kozhevnikov, 2007), empirical support for this presumption was required to test its validity. Individuals whose cognitive styles are more verbal in nature show greater inclination towards processing and representing information verbally, whereas those with visual cognitive styles are more inclined to process and represent information visually. This idea was partially supported by the regression analysis demonstrating that visual cognitive style accounted for a significant amount of variability in visually-biased learning preferences. It should be noted that visual cognitive style solely predicted visually-biased learning preferences, and specific cognitive abilities did not account for any more variability. In other words, mental rotation abilities predicted visual cognitive style, which, in turn, predicted visual learning preferences; mental rotation abilities did not directly predict visual learning preferences. The relationship between verbal cognitive style and learning preferences failed to emerge in our sample. This implies that verbal cognitive style does not necessarily predict specific types of learning preferences.

Taken together, these results suggest that specific cognitive abilities, namely, mental rotations and vocabulary, predicts visual and verbal cognitive style, respectively. Visual cognitive style, in turn, predicts visual learning preferences. The analogous relationship between verbal cognitive style and verbal learning preferences did not emerge. It is plausible that specific cognitive abilities bias individuals to develop visual or verbal cognitive styles, which then may influence learning preferences, particularly in the case of visual cognitive style.

In addition to contributing to the literature, the present findings have direct implications on instructional practices at the tertiary level. Our findings that mental rotation abilities predicted visual cognitive style, which then predicted visual learning preferences, implies that instructional methods emphasizing spatial relations will result in practices that are consistent with the students' learning preferences. It may be that in specialized groups of students in which specific cognitive abilities play a key role, differentiated instruction may be beneficial. Based on the present findings, instructional methods utilizing images with spatial elements would coincide with students' learning preferences, which is presumed to facilitate learning (Kraemer et al., 2009). Students with a visual cognitive style would have representations that are visual-spatial in nature, most likely have well-developed mental rotation abilities and prefer learning visually. Instructional practices such as presentation of information using three-dimensional charts and designs, concept maps and idea webs to illustrate complex relationships, would be consistent with students' visual cognitive style and learning preferences.

The relationship between verbal cognitive style and verbal learning preferences failed to emerge. Students with verbal cognitive styles are more likely to have well-developed verbal abilities, but no strong learning preferences. This implies that verbal cognitive styles may be less tied to a specific modality of learning, such that it is amenable to different types of learning preferences. More general, in addition to verbally-based, instructional methods would be consistent with verbal cognitive styles. Overall, the results of the present study provides empirical support for the relationships among specific cognitive abilities, cognitive style and learning preferences, contributing to the existing literature, as well as support for evidence-based instructional practices.

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