Three Facets of Visual and Verbal Learners: Cognitive Ability, Cognitive Style, and Learning Preference

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The authors examined the hypothesis that some people are verbal learners and some people are visual learners. They presented a battery of 14 cognitive measures related to the visualizer–verbalizer dimension to 95 college students and then conducted correlational and factor analyses. In a factor analysis, each measure loaded most heavily onto 1 of 4 factors: cognitive style (such as visual–verbal style questionnaires), learning preference (such as behavioral and rating instruments involving visual–verbal preferences in multimedia learning scenarios), spatial ability (such as visualization and spatial relations tests and verbal–spatial ability self-ratings), and general achievement (such as tests of verbal and mathematical achievement). Results have implications for how to conceptualize and measure individual differences in the visualizer–verbalizer dimension and cognitive style in general.

Some people are better at processing words and some people are better at processing pictures. This statement—deeply engrained in the folklore of educational practice—can be called the *visualizer–verbalizer hypothesis*. The visualizer–verbalizer hypothesis is particularly relevant to the design of multimedia training because multimedia training involves presenting words and pictures to learners, but our interest also goes beyond multimedia training scenarios to understanding the cognitive style construct in general. Research on cognitive style has had a somewhat stunted growth since the 1970s partly because of difficulties in conceptualizing and measuring the underlying construct of visual–verbal cognitive style (Cronbach, 2002; Jonassen & Grabowski, 1993; Sternberg & Zhang, 2001). However, the widespread development of multimedia training programs and new calls for exploring the concept of aptitude (Cronbach, 2002; Sternberg & Zhang, 2001) prompted us to reconsider the role of individual differences in visualizer–verbalizer cognitive style.

An important first step in research on individual differences in multimedia learning is to clarify the nature of the visualizer–verbalizer dimension and to establish economical ways of measuring it. A major obstacle in understanding visualizer–verbalizer individual differences concerns how to conceptualize and measure the visual–verbal dimension. In this research, we contribute to conceptualizing the visualizer–verbalizer dimension by testing whether it can be decomposed into three separable facets—cognitive ability (i.e., possessing low or high spatial ability), cognitive style (i.e., thinking with words or images), and learning preference (i.e., preferring instruction with text or graphics). Cognitive ability refers to things that people are capable of doing, cognitive style refers to the ways that people process and represent information, and learning preferences refer to the ways that people like information to be presented to them.

On the basis of reviews of the empirical literature, Riding (2001) concluded that one of the major dimensions of cognitive style is the visualizer–verbalizer dimension. Jonassen and Grabowski (1993) reported that the Verbalizer–Visualizer Questionnaire (VVQ) is "the primary instrument used" in research concerning the visualizer–verbalizer dimension (p. 193). However, in reviewing recent research on the visualizer–verbalizer dimension, Plass, Chun, Mayer, and Leutner (1998) concluded that the "the terms *cognitive style* and *learning style* are not used consistently in the literature" (p. 27), and Leutner and Plass (1998) demonstrated some of the shortcomings of the measurement instruments. Although some researchers refer to the visualizer–verbalizer dimension as a cognitive style (Riding, 2001), others refer to the visualizer–verbalizer dimension as a learning preference (Plass et al., 1998), and others have demonstrated that the visualizer–verbalizer dimension is correlated with verbal and spatial ability (Kirby, Moore, & Shofield, 1988). Clearly, there is a need to understand how to conceptualize and measure the key dimensions of cognitive style (Sternberg & Zhang, 2001).

In this research, we contribute to measuring the visualizer–verbalizer dimension by creating and validating behavioral measures of learning preference in authentic tasks and short self-report instruments for cognitive style and cognitive ability. In sum, our theoretical goal is to determine whether the visualizer–verbalizer dimension is unitary or multifaceted (for cognitive ability, cognitive style, and learning preference), and our practical goal is to produce valid and economical measures of style and ability as well as valid and behavioral measures of learning preference.

We restrict our search for cognitive style, learning preference, and cognitive ability to individual differences along the visualizer–verbalizer dimension within a multimedia learning environment. However, our overall goal is to understand the construct of cognitive style in general, including contexts that extend well beyond multimedia training. Spatial ability is recognized as a major type of cognitive ability (Carroll, 1993), the visualizer–verbalizer dimen-

sion (or verbal-imagery dimension) is recognized as a major type of cognitive style (Jonassen & Grabowski, 1993; Riding, 2001; Sternberg & Zhang, 2001), and the visualizer–verbalizer dimension fits the criterion of a learning preference (Jonassen & Grabowski, 1993; Sternberg & Zhang, 2001). Cognitive ability, cognitive style, and learning preference all fit Cronbach and Snow's (1977) classic definition of aptitude as a characteristic that promotes performance in a certain kind of environment. By focusing on the nature and measurement of individual differences within computer-based multimedia learning environments, our work is consistent with Snow's vision of aptitude as a property of "person-in-situation" (Cronbach, 2002, p. 42). In short, our aim is to understand the visualizer–verbalizer dimension within the context of multimedia learning environments and beyond.

Method

Participants

The participants were 95 college students recruited from the Psychology Pool at the University of California, Santa Barbara. All participants were students in an introductory psychology course, and their participation fulfilled a class requirement. The mean age was 18.88 years ($SD = 1.56$), the mean reported SAT Verbal score was 578 ($SD = 92$), the mean reported SAT Mathematics score was 599 ($SD = 87$), and women constituted 72% of the sample (i.e., there were 65 women and 30 men).

Materials

The materials consisted of 14 measures, which are summarized in Table 1. For each measure, Table 1 indicates the number of items (1–80), the type of instrument (such as questionnaire, timed test, or on-line behavior), and the source (i.e., seven measures were adapted from existing instruments, as indicated by citations, and seven measures were created as original material for this study and are presented in the Appendix). In addition, Table 1 provides a brief description of the task and scoring procedure for each measure.

Measures 1–3 were intended to assess general cognitive achievement (or general cognitive ability), namely, verbal and mathematical achievement. Self-reported scores on the SAT Verbal and SAT Mathematics (Measures 1 and 2, respectively) were solicited on a sheet entitled the "Participant Questionnaire." The Vocabulary Test (Measure 3) consisted of 18 items adapted from the Vocabulary scale of the Armed Services Vocational Aptitude Battery (ASVAB) as selected from a test preparation book (Barron's Educational Series, 2001).

Measures 4–6 were intended to assess a specific cognitive ability, namely, spatial ability. Measure 4 was a 3-min version of the Card Rotations Test (i.e., Part 1 of S-1) from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, & Harman, 1976), Measure 5 was a 3-min version of the Paper Folding Test (i.e., Part 1 of VZ-2) from the Kit of Factor-Referenced Cognitive Tests (Ekstrom et al., 1976), and Measure 6 was a two-item Verbal–Spatial Ability Rating that was original (see the Appendix).

Measures 7–10 were intended to assess cognitive style, namely, visualizer–verbalizer style. The VVQ, listed as Measure 7, assesses the degree to which people use verbal or visual modes of thinking and consists of 15 statements. Although the VVQ asks for a true–false response, we altered the format to a 7-point Likert-type scale, ranging from 1 (*strongly agree*) to 7 (*strongly disagree*). In creating the VVQ, Richardson (1977) extracted 15 items from Paivio's (1971) Individual Differences Questionnaire. The VVQ is probably the most commonly used measure of verbal–visual cognitive style, despite criticisms that the VVQ lacks construct

validity (Edwards & Wilkins, 1981) and does not have high levels of internal consistency (Boswell & Pickett, 1991; Sullivan & Macklin, 1986).

The Santa Barbara Learning Style Questionnaire—Measure 8—is an original six-item questionnaire intended to tap the same factor as the VVQ but with fewer questions (see the Appendix). The Cognitive Styles Analysis, listed as Measure 9, contains a Verbal-Imager subtest that is based on patterns of response times to categorizing statements based on imagery or conceptual features (Riding, 1991). For example, test takers see a statement on the computer screen in which they are asked if two items are the same type (i.e., belong to same category) or if two items are the same color and are asked to press the BLUE key if the statement is right or the RED key if the statement is wrong. Relatively faster response time to statements based on imagery features (such as the statement about color) indicates visualizer style, and relatively faster response times to statements based on conceptual features (such as the statement about type) indicates verbalizer style. Although the Cognitive Styles Analysis is a behavioral measure that has been used in numerous studies (Riding, 2001), the measures are not derived from an authentic multimedia learning situation. The Verbal–Visual Learning Style Rating—Measure 10—is an original one-item rating task, intended to tap the visualizer–verbalizer style dimension in a single question (see the Appendix).

Measures 11–14 were original instruments intended to assess learning preference in the context of authentic multimedia training tasks. The Learning Scenario Questionnaire (Measure 11) asked about preferences in five learning situations based on brief text descriptions (see the Appendix). Although this questionnaire does not require participation in actual learning tasks, it does require preference choices based on brief descriptions of authentic learning situations (as do some of the items on the VVQ). Thus, the Learning Scenario Questionnaire can be considered to be on the borderline between cognitive style and learning preference. The Multimedia Learning Preference Test is a behavioral measure of learning style in an authentic multimedia learning task and was inspired by Leutner and Plass's (1998) Visualizer/Verbalizer Behavior Observation Scale (VV-BOS). The Multimedia Learning Preference Test consists of five text frames explaining the process of lightning formation; each frame has two help buttons—one that offers an annotated graphic (i.e., pictorial help) and one that offers a glossary that defines selected terms (i.e., verbal help). In some cases, the information presented in corresponding pictorial and verbal help frames was not the same, although both types of help were intended to guide the learner's understanding of the explanation. For each of the five frames, the learner is given 1 point for selecting visual help first—yielding a score of 0 to 5 on the Choice Scale (Measure 12). In addition, the program asks the learner to rate which type of help was most useful on each frame, and the learner is given 1 point each time visual help is rated as most useful—yielding a score of 0 to 5 on the Preference Scale (Measure 13). The Multimedia Learning Preference Questionnaire (Measure 14) is a paper version of the Multimedia Learning Performance Test and is presented in the Appendix.

The apparatus consisted of five Sony Vaio laptop computers (for administering the Cognitive Styles Analysis and the Multimedia Learning Preference Test).

Procedure

Participants were tested in groups of 1 to 5 per session. Participants were seated at desks in individual cubicles that blocked visual contact with other participants. First, the experimenter explained that the participants would be asked to complete a series of tasks. Then, the tasks were administered in the following order: SAT Verbal, SAT Mathematics, Verbal–Spatial Ability Rating, and Verbal–Visual Learning Style Rating (which were all part of a single sheet entitled "Participant Questionnaire"), Santa Barbara Learning Style Questionnaire, Learning Scenario Questionnaire, Card Rotations Test, Paper Folding Test, Vocabulary Test, Verbalizer–Visualizer Questionnaire, Multimedia Learning Preference Test (Choice Scale and

Table 1
Fourteen Individual-Difference Measures

Number and measure	Number of items	Type	Source	Task	Score
Cognitive ability measures					
1. SAT Mathematics	1	Questionnaire	Educational Testing Service	Write SAT Math score on questionnaire.	Self-reported score from Mathematics scale of the SAT (200–800).
2. SAT Verbal	1	Questionnaire	Educational Testing Service	Write SAT Verbal score on questionnaire	Self-reported score from Verbal scale of the SAT (200–800).
3. Vocabulary Test	18	Timed test	Adapted from Baron's Educational Series (2001)	Given a target word such as *gritty,* select a synonym from a list of 5 words.	Number correct minus one fifth number incorrect in 3 min (0–18).
Spatial ability measures					
4. Card Rotations Test	80	Timed test	Ekstrom et al. (1976)	Determine whether a shape is a rotated image of a target shape.	Number correct minus number incorrect in 3 min (0–80).
5. Paper Folding Test	10	Timed test	Ekstrom et al. (1976)	Imagine folding a sheet of paper, punching holes, and opening it. Select pattern from 5 choices.	Number correct minus one fifth number incorrect in 3 min (0–10).
6. Verbal–Spatial Ability Rating	2	Questionnaire	Original	Rate level of spatial ability on 5-point scale and verbal ability on 5-point scale.	Self-rating of spatial ability minus self-rating of verbal ability (−4 to +4).
Cognitive style measures					
7. Verbalizer–Visualizer Questionnaire (VVQ)	15	Questionnaire	Richardson (1977)	Rate agreement with statements about verbal and visual modes of thinking on 7-point scale. (Original VVQ had true–false format rather than 7-point scale.)	Weight of provisual ratings minus weight of proverbal ratings (−45 to +45). 3 = *strongly agree–disagree,* 2 = *moderately agree–disagree,* 1 = *slightly agree–disagree.*
8. Santa Barbara Learning Style Questionnaire	6	Questionnaire	Original	Rate agreement with statements about verbal and visual modes of learning on 7-point scale.	Weight of provisual ratings minus weight of proverbal ratings (−18 to +18). 3 = *strongly agree–disagree,* 2 = *moderately agree–disagree,* 1 = *slightly agree–disagree.*
9. Cognitive Styles Analysis	40	Computer-based behavior	Riding (1991)	Respond to whether on-screen statements about visual and verbal features are true or false.	On the basis of pattern of response times, program assigns score.
10. Verbal–Visual Learning Style Rating	1	Questionnaire	Original	Rate preference for visual versus verbal learning on 7-point scale.	Weight of rating with "strongly more visual than verbal" counted as +3 and "strongly more verbal than visual" counted as −3 (−3 to +3).
Learning preference measures					
11. Learning Scenario Questionnaire	5	Questionnaire	Original	Choose preferred mode of learning for descriptions of 5 learning tasks.	Number of tasks on which visual mode is preferred (0–5).
12. Multimedia Learning Preference Test—Choice	5	Computer-based behavior	Original	Choose visual or verbal help in a 5-frame on-line multimedia lesson.	Number of frames in which visual help was chosen first (0–5).
13. Multimedia Learning Preference Test—Rating	5	Computer-based behavior	Original	Rate preference for visual or verbal help in a 5-frame on-line multimedia lesson.	Number of frames in which visual help was rated higher (0–5).
14. Multimedia Learning Preference Questionnaire	5	Questionnaire	Original	Rate preference for visual or verbal help in a 5-frame paper-based multimedia lesson.	Number of frames in which visual help was rated higher (0–5).

Preference Scale), Cognitive Style Analysis, Multimedia Learning Preference Questionnaire. The tests were administered in an order that was intended to minimize carryover effects and provide variety. The Paper Folding Test, the Card Rotations Test, and the Vocabulary Test each had 3-min time limits; all other instruments did not have time limits so participants progressed through the tasks at their own pace. The Cognitive Style Analysis and Multimedia Learning Preference Test were administered on Sony Vaio laptop computers. The paper-based instruments where either untitled or had generic titles such as "Learning Questionnaire." On completion of the tasks, each participant was thanked and debriefed. Throughout the project, the rights of the participants were protected, and applicable human subjects guidelines were followed. The entire session lasted between 30 and 45 min.

Results

The major goal of this study was to determine the relationships among measures tapping general achievement, spatial ability, cognitive style, and learning style.

Descriptive Statistics

Table 2 lists the mean score, standard deviation, and sample size for each of the 14 measures.

Correlational Analysis

Table 3 is a correlation matrix showing the Pearson product–moment correlation for all possible pairings of the 14 measures. The three measures of general achievement (1, 2, and 3) correlated highly with each other, the three measures of spatial ability (4, 5, and 6) correlated highly with one another, three of the four measures of cognitive style (7, 8, and 10) correlated highly with one another, and the four measures of learning preference (11, 12, 13, and 14) correlated highly with one another. The Santa Barbara Learning Styles Questionnaire (Measure 8), the Verbal–Visual Learning Style Rating (Measure 10), and the Learning Scenario Questionnaire (Measure 11) each correlated significantly with

Table 2
Descriptive Statistics for Analyzed Measures

Measure	M	SD	Analyzed N
1. SAT Verbal	578.00	91.71	80
2. SAT Mathematics	599.25	87.20	80
3. Vocabulary	8.69	3.06	95
4. Card Rotations	50.94	19.54	95
5. Paper Folding	6.26	2.44	95
6. Verbal–Spatial Ability Rating	−0.01	0.81	95
7. Verbalizer–Visualizer Questionnaire	10.54	9.38	95
8. Santa Barbara Learning Style Questionnaire	3.58	5.07	95
9. Cognitive Styles Analysis	0.11	0.78	95
10. Verbal–Visual Learning Style Rating	0.88	1.34	95
11. Learning Scenario Questionnaire	3.82	1.05	95
12. Multimedia Learning Preference Test—Choice	2.08	1.75	95
13. Multimedia Learning Preference Test—Rating	2.82	1.74	95
14. Multimedia Learning Preference Questionnaire	2.00	6.43	95

Table 3
Correlation Matrix for Fourteen Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. SAT Mathematics	—													
2. SAT Verbal	.63**	—												
3. Vocabulary Test	.30**	.47**	—											
4. Card Rotations Test	.13	.08	.16	—										
5. Paper Folding Test	.14	.07	.18*	.52**	—									
6. Verbal–Spatial Ability Rating	.10	−.22*	−.08	.23*	.37**	—								
7. Verbalizer–Visualizer Questionnaire	−.13	−.27**	−.21*	−.02	.10	.24**	—							
8. Santa Barbara Learning Style Questionnaire	.11	−.06	−.10	.08	.24*	.26**	.46**	—						
9. Cognitive Styles Analysis	.00	−.08	−.02	.09	−.00	.00	.02	.19*	—					
10. Verbal–Visual Learning Style Rating	.10	−.14	−.11	−.01	.20*	.31**	.40**	.74**	.14	—				
11. Learning Scenario Questionnaire	−.01	−.02	−.11	.02	.24**	.21*	.27**	.44**	.17	.44**	—			
12. Multimedia Learning Preference Test—Choice	.11	.13	−.04	.02	.13	.08	.15	.31**	.21*	.36**	.30**	—		
13. Multimedia Learning Preference Test—Rating	.17	.15	−.07	.04	.00	−.04	.21*	.48**	.07	.39**	.25**	.48**	—	
14. Multimedia Learning Preference Questionnaire	.00	.02	−.07	−.08	.07	.10	.28**	.43**	.09	.37**	.29**	.42**	.59**	—

* $p < .05$.   ** $p < .01$.

many of the measures of learning preference, cognitive style, and spatial ability. The Cognitive Styles Analysis (Measure 9) had low correlations overall and did not correlate significantly with any other measure except one.

Factor Analysis

An exploratory factor analysis using maximum likelihood extraction and varimax rotation revealed four factors with eigenvalues greater than 1. In the case of missing data (i.e., for 15 participants who did not report SAT scores), the factor analysis was based on pairwise deletion rather than subjectwise deletion. The four-factor solution explained 49.83% of the total variance. Table 4 shows the factor loadings for each of the 14 measures. For each measure, the highest factor loading above .300 is indicated in bold.

We labeled the four factors as *cognitive style*, *learning preference*, *general achievement*, and *spatial ability*. Four measures loaded most strongly on the first factor, which we labeled as *cognitive style*: 10, 8, 11, and 7. Three measures loaded most strongly on the second factor, which we labeled as *general achievement*: 2, 1, and 3. General achievement could also be labeled as *general ability* because the underlying tests were likely to tap both general cognitive achievement and general cognitive ability.

Three measures loaded most strongly on the third factor, which we labeled as *learning preference*: 13, 14, and 12. Three measures loaded most heavily on the fourth factor, which we labeled as *spatial ability*: 5, 4, and 6. Spatial ability is a specific type of cognitive ability, so we also refer to this factor as cognitive ability. The Cognitive Styles Analysis did not load strongly on any of the factors; the Cognitive Styles Analysis had its strongest loading of .175 on the first factor (cognitive style). The results of our study do not offer a validation of the Cognitive Styles Analysis as a test of visual–verbal cognitive style.

Internal Consistency

Cronbach's alpha coefficients were computed to evaluate the internal consistency of the questionnaires (Measures 7, 8, 11, and

14). Acceptable Cronbach's alphas were found for the Verbalizer–Visualizer Questionnaire (.71), the Santa Barbara Learning Style Questionnaire (.76), and the Multimedia Learning Preference Questionnaire (.80). The Learning Scenario Questionnaire had a low alpha coefficient of .38. Similar levels of reliability have been reported for the Verbalizer–Visualizer Questionnaire (Jonassen & Grabowski, 1993; Richardson, 1977); the other three questionnaires are original and therefore have not previously been tested.

Sex Differences Analysis

Sex differences in spatial and verbal ability have been the focus of much research and discussion (Halpern, 2000). Although our study was not designed mainly to assess sex differences, we compared the mean scores of men and women on each of the 14 measures using two-tailed t tests. In our sample, there were no significant sex differences on any of the measures of cognitive style or learning preference. On tests of spatial ability, men ($M = 58.4$, $SD = 15.8$) scored significantly higher than women ($M = 47.5$, $SD = 20.2$) on the Card Rotations Test, $t(93) = 2.618$, $p = .010$; men ($M = 7.0$, $SD = 2.5$) scored significantly higher than women ($M = 5.9$, $SD = 2.4$) on the Paper Folding Test, $t(93) = 2.125$, $p = .036$; and men ($M = 0.2$, $SD = 0.8$) scored marginally higher than women ($M = -0.1$, $SD = 0.8$) on the Verbal–Spatial Ability Rating, $t(93) = 1.750$, $p = .084$. On tests of general ability, men ($M = 611$, $SD = 70$) reported significantly higher scores than women ($M = 562$, $SD = 97$) on the SAT Verbal scale, $t(78) = 2.304$, $p = .024$; men ($M = 643$, $SD = 87$) reported significantly higher scores than women ($M = 578$, $SD = 80$) on the SAT Mathematics scale, $t(78) = 3.277$, $p = .002$; and men ($M = 9.5$, $SD = 3.1$) scored marginally higher than women ($M = 8.3$, $SD = 3.0$) on the Vocabulary Test, $t(93) = 1.885$, $p = .063$. The sex differences on tests of spatial ability and on the SAT in our sample are somewhat consistent with previous findings (Halpern, 2000; Zwick, 2002). The pattern of finding of sex differences with tests of spatial ability, but not with measures of cognitive style or learning preference, provides further support for making distinctions among these three facets of visual and verbal learners.

Table 4
Factor Loadings for Fourteen Measures

| Measure | Factor | | | |
	1: Cognitive style	2: General achievement	3: Learning preference	4: Spatial ability
10. Verbal–Visual Learning Style Rating	**.831**	−.037	.241	.036
8. Santa Barbara Learning Style Questionnaire	**.780**	.035	.335	.093
11. Learning Scenario Questionnaire	**.494**	.048	.159	.105
7. Verbalizer–Visualizer Questionnaire	**.483**	−.208	.135	.028
2. SAT Verbal	−.165	**.976**	.124	−.059
1. SAT Mathematics	.060	**.644**	.128	.081
3. Vocabulary Test	−.135	**.479**	−.066	.157
13. Multimedia Learning Preference Test—Rating	.191	.059	**.979**	−.022
14. Multimedia Learning Preference Questionnaire	.327	.001	**.541**	−.034
12. Multimedia Learning Preference Test—Choice	.293	.131	**.425**	.029
5. Paper Folding Test	.237	.159	−.039	**.744**
4. Card Rotations Test	−.047	.109	.061	**.694**
6. Verbal–Spatial Ability Rating	.379	−.128	−.097	**.399**
9. Cognitive Styles Analysis	.175	−.054	.039	.025

Note. For each measure, the highest factor loading above .300 is indicated in bold.

Discussion

An important first step in adapting multimedia training to the needs of visual and verbal learners is to determine how to conceptualize and measure individual differences in the visual–verbal dimension. We explore how to conceptualize the visual–verbal dimension in the *Theoretical Implications* section and how to measure the visual–verbal dimension in the *Practical Implications* section.

Theoretical Implications

What does our research contribute to understanding the visualizer–verbalizer hypothesis? Overall, these results are consistent with the differentiation of three ways of distinguishing verbal versus visual learners—on the basis of spatial ability (e.g., high vs. low spatial ability), on the basis of cognitive style (e.g., visual vs. verbal style), and on the basis of learning preference (e.g., visual vs. verbal preference within multimedia learning situations). Our results are consistent with the idea that the visualizer–verbalizer dimension is multifaceted, including individual differences in ability, style, and preference. These three facets are summarized in Table 5.

The factor analysis revealed four clear factors: cognitive style (or learning style), learning preference, cognitive ability (or spatial ability), and general achievement. Each of the measures of general achievement—SAT Verbal, SAT Mathematics, and Vocabulary Test—loaded on the same factor; each of the three measures of spatial ability—Paper Folding, Card Rotations, and Verbal–Spatial Ability Rating—loaded on the same factor; three of the four measures of cognitive style—Verbalizer–Visualizer Questionnaire, Santa Barbara Learning Style Questionnaire, and Verbal–Visual Learning Style Rating—loaded on the same factor; and three of the four measures of learning preference—Multimedia Learning Preference Test Choice Scale, Multimedia Learning Preference Rating Scale, and Multimedia Learning Preference Questionnaire—loaded on the same factor.

The Learning Scenario Questionnaire, which we originally designed as a measure of learning preference, loaded most heavily on the cognitive style factor. Learning preference measures loading on the learning preference factor all involved choices within the context of an authentic multimedia lesson, whereas the Learning Scenario Questionnaire provided only general descriptions of choices—such as learning about an atom from a "paragraph describing each part" or a "labeled diagram showing each part." Presumably, the more general descriptions of the Learning Scenario Questionnaire tapped the same cognitive style factor as other questions with general statements. We conclude that learning

preference refers to choices made within the context of authentic multimedia learning tasks, whereas cognitive style refers to ratings of more general questions.

The emergence of learning preference as a distinct factor from cognitive style is a particularly interesting outcome of our study. The learning preference factor is consistent with Snow's situative view of aptitude in which the "concept of aptitude in the person's head should be replaced by aptitude as a property of person-in-situation" (Cronbach, 2002, p. 41). Unlike questionnaires about cognitive style, which focus on aptitude as a property of the learner's mind, behavioral measures of learning preference in authentic tasks focus on aptitude as a property of the learner's interaction with a particular learning situation.

The Cognitive Styles Analysis—which we originally listed as a measure of cognitive style—did not load on any of the factors and did not correlate significantly with any other measure. We conclude that we were unable to validate the Verbal–Visual scale of the Cognitive Styles Analysis as a measure of cognitive style or learning preference. In short, we are not able to specify what the Cognitive Styles Analysis measures, but it does not seem to measure what other instrument designers think of as cognitive style or learning preference. In contrast, Riding and Watts (1997) found that verbalizers (based on the Cognitive Styles Analysis) tended to prefer verbal methods of instruction, whereas visualizers (based on the Cognitive Styles Analysis) tended to prefer pictorial methods of instruction in a classroom learning task. Further research is needed concerning the validity of the Verbal–Visual scale of the Cognitive Styles Analysis. Although we found relations among our measures based on linear correlations, it is possible that there are also interactive effects in which relations among measures may depend on other factors such as the sex of the learner. Sensitivity to possible interactive effects is particularly important in interpreting research in which students with different levels of cognitive style learn under different instructional conditions.

Practical Implications

First, we found that one or two self-ratings can yield effective and economical measures of spatial ability and learning style. For example, the Verbal–Spatial Ability Rating—in which people rate their spatial and verbal abilities on 5-point scales—loaded on the same factor as timed spatial tests (i.e., the Paper Folding Test and the Card Rotations Test) and correlated strongly with them. Similarly, the Verbal–Visual Learning Style Rating—in which people

Table 5
Three Facets of the Visualizer–Verbalizer Dimension

Facet	Types of learners	Definition
Cognitive ability	High spatial ability	High proficiency in creating, holding, and manipulating spatial representations.
	Low spatial ability	Low proficiency in creating, holding, and manipulating spatial representations.
Cognitive style	Visualizer	Uses visual modes of thinking.
	Verbalizer	Uses verbal modes of thinking.
Learning preference	Visual learner	Prefers instruction involving pictures.
	Verbal learner	Prefers instruction involving words.

simply rate the degree to which they are more verbal or more visual learners on a 7-point scale—loaded on the same factor as traditional multi-item questionnaires (i.e., Verbalizer–Visualizer Questionnaire and Santa Barbara Learning Style Questionnaire) and correlated strongly with them. In some cases, a simple self-rating of spatial ability or of learning style can be an effective substitute for longer, more time-consuming instruments.

Second, we found encouraging evidence for the usefulness of behavioral measures for assessing people's learning preferences for multimedia training. The Multimedia Learning Preference Test yielded measures that correlated with one another and with paper-based measures of preference (i.e., Multimedia Learning Preference Questionnaire) and which loaded on a factor tapping learning preference. The Multimedia Learning Preference Test serves to extend the pioneering work of Leutner and Plass (1998) on developing behavioral measures of learner's choices in authentic learning situations. Like Leutner and Plass, we found that an important aspect of our behavioral measure of learning preference is the use of an authentic learning scenario–such as a multimedia lesson on lightning formation in which learners could choose help information in the form of graphics or text. Although we had success in developing a behavioral measure of learning preference that correlated with questionnaire measures, the Cognitive Styles Analysis did not prove to yield a behavioral measure of cognitive style that correlated with questionnaire measures.

Third, measures of visual–verbal preference within the context of an authentic learning scenario—such as a multimedia lesson on lightning formation—represent a separate factor that is distinct from general measures of verbal–visual cognitive style—such as the Verbalizer–Visualizer Questionnaire. The factor analysis revealed that choices made within the context of an authentic learning scenario (as measured by the Multimedia Learning Preference Test Choice Scale, Multimedia Learning Preference Test Rating Scale, and Multimedia Learning Preference Questionnaire) tap a different factor (which we call learning preference) than do general questionnaires about whether people are visual or verbal learners (such as the Verbalizer–Visualizer Questionnaire, the Santa Barbara Learning Styles Questionnaire, and the Verbal–Visual Learning Style Rating).

Future Directions

An important next step is to determine how these measures of individual differences along the visualizer–verbalizer dimension relate to multimedia learning. In particular, we recommend studies in which measures of ability, style, and preference are correlated with measures of learning outcome (such as transfer test scores based on a multimedia lesson) and with measures of learning process (such as the choice of visual vs. verbal help during training). The ultimate goal of subsequent research should be to revisit the classic issue of Attribute $\times$ Treatment interactions concerning visual versus verbal learners (as the attribute) and pictorially based versus text-based instruction (as the treatment). The present results provide an important first step by helping to clarify the multifaceted nature of the visualizer–verbalizer dimension as consisting of ability, style, and preference subfactors and by suggesting straightforward methods of measuring each subfactor. Finally, the most striking outcome of our study is the identification of a verbal–visual learning preference (as measured by

behavioral tests in authentic multimedia tasks) as distinct from a verbal–visual cognitive style (as measured by responses to more general questions). The Multimedia Learning Preference Test (i.e., a computer-based instrument) and the Multimedia Learning Preference Questionnaire (i.e., a paper-based instrument) now join Leutner and Plass's (1998) VV-BOS as prototypes for measuring aptitude as a property of learners-within-learning situations. The situational nature of these instruments is a defining difference between measures of cognitive style and measures of learning preference. Future research is needed to determine the respective roles of these factors in multimedia learning.

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(Appendix follows)

Appendix

Original Measures

Verbal–Spatial Ability Rating (VSAR, Version 1.0)

Please rate your verbal ability (check one):
— Very high
— Somewhat high
— Average
— Somewhat low
— Very low

Please rate your spatial ability (check one):
— Very high
— Somewhat high
— Average
— Somewhat low
— Very low

Santa Barbara Learning Style Questionnaire (SBCSQ, Version 1.0)

Please place a check mark indicating your level of agreement or disagreement.

I prefer to learn visually.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

I prefer to learn verbally.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

I am a visual learner.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

I am a verbal learner.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

I am good at learning from labeled pictures, illustrations, graphs, maps, and animations.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

I am good at learning from printed text.

○	○	○	○	○	○	○
Strongly agree	Moderately agree	Slightly agree	Neither agree or disagree	Slightly disagree	Moderately disagree	Strongly disagree

Verbal-Visual Learning Style Rating (VVLSR, Version 1.0)

In a learning situation sometimes information is presented verbally (e.g., with printed or spoken words) and sometimes information is presented visually (e.g., with labeled illustrations, graphs, or narrated animations). Please place a check mark indicating your learning preference.

◯	◯	◯	◯	◯	◯	◯
Strongly more verbal than visual	Moderately more verbal than visual	Slightly more verbal than visual	Equally verbal and and visual	Slightly more visual than verbal	Moderately more visual than verbal	Strongly more visual than verbal

Learning Scenario Questionnaire (LSQ, Version 1.0)

1. Which format do you prefer in learning a scientific description of an atom?
   ◯ a paragraph describing each part
   ◯ a labeled diagram showing each part

2. Which format do you prefer in learning a scientific explanation of how a bicycle tire pump works?

   ◯ an essay describing what happens when you pull up on the handle and when you push down on the handle
   ◯ a series of labeled diagrams showing the status of each part of the pump when you pull up on the handle and when you push down on the handle

3. Which format do you prefer for following directions for how to get somewhere on a new college campus?
   ◯ verbal directions including when to turn left and when to turn right in getting from the starting point to the stopping point
   ◯ a map showing the roads and buildings along with a line from the starting point to the stopping point

4. Which format do you prefer for following instructions for how to set the time on a stopwatch?

   ◯ a list of steps in words
   ◯ a labeled diagram showing the steps

5. Which format do you prefer for describing the mathematics test scores for 6th grade boys and girls for the last 5 years?

   ◯ a list of the scores for boys in one sentence and a list of the scores for girls in another sentence
   ◯ a line graph with one line showing the scores for boys and another line showing the scores for girls

(Appendix continues)

Name: _____

Help Screen Questionnaire

Multimedia Learning Preference Questionnaire
Please read this text:

> Cool, moist air moves over a warmer surface and becomes heated. Warmed moist air near the earth's surface rises rapidly. As the air in this updraft cools, <u>water vapor</u> condenses into <u>water droplets</u> and forms a cloud. The cloud's top extends above the <u>freezing level</u>. At this altitude, the air temperature is well below freezing so the upper portion of the cloud is composed of tiny <u>ice crystals</u>.

Suppose you need help on understanding the text.
You can click on one icon and get this: Or, you can click on another icon for this:

Help Screen 1

> **"water vapor"** MEANS moisture in air that is in gas form such as in rising air before it condenses into a cloud
> **"water drops"** MEANS moisture in air that is in liquid form such as in the part of a cloud below the freezing level
> **"ice crystals"** MEANS moisture in air that is in solid form such as in the part of a cloud above the freezing level
> **"freezing level"** MEANS at some point above the surface of the earth there is an imaginary line in the sky so that above the line water in a cloud will freeze into ice crystals and below the line water in a cloud will stay as water droplets

Help Screen 2
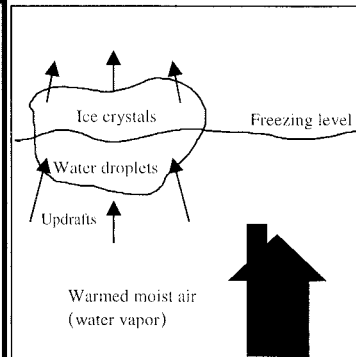
1. Warm moist air rises, water vapor condenses and forms a cloud.

Which of the two help screens do you prefer?

○	○	○	○	○	○	○
Strongly prefer 1	Moderately prefer 1	Slightly prefer 1	Equally like 1 and 2	Slightly prefer 2	Moderately prefer 2	Strongly prefer 2

Please read this text:

> Eventually, the water droplets and ice crystals become too large to be suspended by the updrafts. As raindrops and ice crystals fall through the cloud, they drag some of the air in cloud downward, producing downdrafts. When downdrafts strike the ground, they spread out in all directions, producing the gusts of cool wind people feel just before the start of the rain.
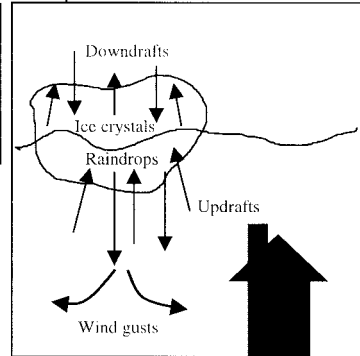
Suppose you need help on understanding the text.
You can click on one icon and get this: Or, you can click on another icon for this:

Help Screen 1   Help Screen 2

> **"updraft"** MEANS that a body of air is moving upward because it is warmer than the surrounding air
> **"downdraft"** MEANS that a body of air is moving downward because it is cooler than the surrounding air

2. Raindrops and ice crystals drag air downward.

Which of the two help screens do you prefer?

○	○	○	○	○	○	○
Strongly prefer 1	Moderately prefer 1	Slightly prefer 1	Equally like 1 and 2	Slightly prefer 2	Moderately prefer 2	Strongly prefer 2

(Appendix continues)

Please read this text:

> Within the cloud, the rising and falling air currents cause <u>electrical charges</u> to build. The charge results from the collision of the cloud's rising water droplets against heavier, falling pieces of ice. The <u>negatively-charged particles</u> fall to the bottom of the cloud and most of the <u>positively-charged particles</u> rise to the top.

Suppose you need help on understanding the text.
You can click on one icon and get this: Or, you can click on another icon for this:

"electrical charge" MEANS the
negatively-charged particles and
positively-charged particles in material
have been separated
"negatively-charged particle" MEANS a
part of the material in clouds that has a
negative electrical charge, which
normally is attracted to positively-
charged particles
"positively-charged particle" MEANS a
part of the material in clouds that has a
positive electrical charge, which
normally is attracted to negatively-
charged particles
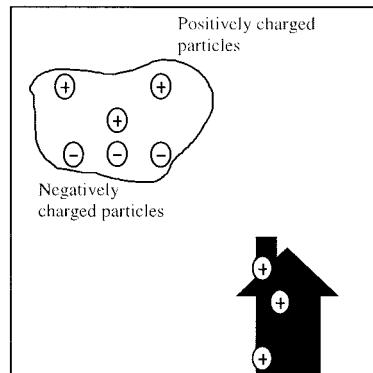
3. Negatively charged particles fall to
the bottom of the cloud.

Which of the two help screens do you prefer?

| ○	○	○	○	○	○	○
Strongly prefer 1	Moderately prefer 1	Slightly prefer 1	Equally like 1 and 2	Slightly prefer 2	Moderately prefer 2	Strongly prefer 2

Please read this text:

A <u>stepped leader of negative charges</u> moves downward in a series of zig-zag steps. It nears
the ground. A <u>positively charged leader</u> travels upward from such objects as trees
and buildings. The two leaders generally meet about 165 feet above the ground. Negatively-
charged particles then rush from the cloud to the ground along the path created by the
leaders. It is not very bright.

Suppose you need help on understanding the text.
You can click on one icon and get this: Or, you can click on another icon for this:

"stepped leader of negative charges"
   MEANS that negatively-charged
   particles from the bottom of the cloud
   move downward toward the positively-
   charged particles in objects on the earth's
   surface
"positively charged leader" MEANS that
   positively-charged particles from objects
   on the earth's surface move upward
   toward the stepped leader of negative
   charges

Stepped leader of
negative charges

Zig zag steps

Positively
charged leader
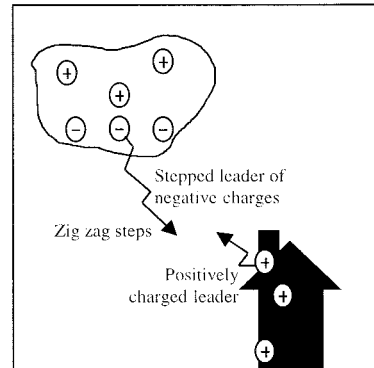
4. Two leaders meet, negatively
charged particles rush from the cloud
to the ground.

Which of the two help screens do you prefer?

○	○	○	○	○	○	○
Strongly prefer 1	Moderately prefer 1	Slightly prefer 1	Equally like 1 and 2	Slightly prefer 2	Moderately prefer 2	Strongly prefer 2

(Appendix continues)

Please read this text:

> As the <u>leader stroke</u> nears the ground, it induces an opposite charge, so positively charged particles from the ground rush upward along the same path. This upward motion of current is the <u>return stroke</u>. It produces the bright light that people notice as a flash of lighting.

Suppose you need help on understanding the text.
You can click on one icon and get this: Or, you can click on another icon for this:

> **"leader stroke"** MEANS that negatively-charged particles travel all the way from the cloud to the ground
> **"return stroke"** MEANS that positively-charged particles travel all the way from the ground to the cloud
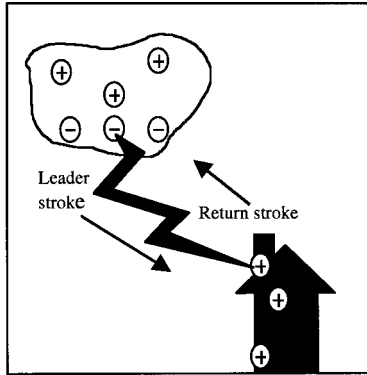
5. Positively charged particles from the ground rush upward along the same path.

Which of the two help screens do you prefer?

○	○	○	○	○	○	○
Strongly prefer 1	Moderately prefer 1	Slightly prefer 1	Equally like 1 and 2	Slightly prefer 2	Moderately prefer 2	Strongly prefer 2