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University of San Francisco

A REANALYSES OF INTERCORRELATIONAL MATRICES OF VISUAL AND VERBAL LEARNERS' ABILITIES, COGNITIVE STYLES, AND LEARNING PREFERENCES

A Dissertation Presented
to
The Faculty of the School of Education
Learning and Instruction Department

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

by
Jeanette M. Fox
May 2020

DISSERTATION ABSTRACT

In psychology and education, the visual-verbal conceptual distinction is a widely studied bipolar contrast, and this distinction has been the subject of much debate. There are two main issues: One is a construct-validity issue related to the extent that scores from a test measuring the visual- and verbal-conceptual distinction accurately reflect the construct being measured, and the second one is an issue related to the use of different data analysis methods that collect and analyze the data from the visual and verbal measurements.

To help resolve these issues, this study examined 21 individual intercorrelation matrices that were illustrative of the visual and verbal contrast in the learner-preference field. In this secondary data analysis, each of these 21 matrices were reexamined within and between domains using the methodology of a factor analysis. There were two research questions. First, when using a common factor analysis procedure, do studies measuring the visual-verbal learner-preference dichotomy consistently identify the visual and verbal constructs? Second, in studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

Overall, there were 73 total factors extracted; 17 of these were visual, verbal, or visual-verbal factors: six were visual factors defined independently, one was a verbal factor defined independently, and the other 10 were visual-verbal factors defined on the same factor. There was only one matrix with measures that identified a separate visual and verbal factor in the same matrix. It was concluded that the visual-verbal learner-

preference dichotomy was not consistently identified, and the extent to which the visual and a verbal factors correlate could not be addressed.

These findings neither provided empirical support for the visual- and verbal-conceptual distinction nor indicated there is evidence to support the visual-verbal learning-preference constructs. Moreover, the uniform data analyses in this study suggest that these findings are not the result of variation in factoring procedures. Rather than classifying students by their learning preference and applying one instructional method tailored to that preference, it may be more beneficial to present information to students with both words and pictures.

This dissertation, written under the direction of the candidate's dissertation committee and approved by the members of the committee, has been presented to and accepted by the Faculty of the School of Education in partial fulfillment of the requirements for the degree of Doctor of Education. The content and research methodologies presented in this work represent the work of the candidate alone.

Jeanette M. Fox	May 7, 2020
Candidate	Date

Dissertation Committee

Dr. Robert Burns	May 7, 2020
Chairperson	
Dr. Patricia L. Busk	May 7, 2020
Dr. Walter Gmelch	May 7, 2020

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CHAPTER I

RESEARCH PROBLEM

In psychology and education, the visual-verbal conceptual distinction is one of most widely studied bipolar contrasts of the 21st century (Pashler, McDaniel, Rohrer, & Bjork, 2009). This conceptualization hypothesizes that people process information visually or verbally and sometimes using both channels (Mayer, 2009). Educators often use this distinction to identify which method of instruction provides the best format to match the preferences of the learner. For a visual learner, it would mean emphasizing visual presentation of information such as printed text and pictures; for a verbal learner, it would mean emphasizing verbal presentation of information such as spoken words and sounds (Pashler et al., 2009).

Not only does the contrast between visual and verbal stimuli create a common dichotomy for instructional researchers, but also this contrast carries over into other areas as well: psychological measurement, working memory theories, and left-brain and right-brain conceptualizations. In psychological measurement, this distinction between visual and verbal abilities characterize two of the top three sets of ability measures in most current hierarchical theories of intelligence (Carroll, 1993; Cattell, 1971). For example, in Thurstone's (1938) model containing eight primary mental abilities, the visual and verbal distinction is referred to as visualizing ability and verbal comprehension ability. In Carroll's (1993) three-level model's second stratum that contains 8 to 10 broad abilities, the visual and verbal conceptual distinction is referred to as broad visual perception and broad auditory perception. In Gardner's (1993, 2006) theory of multiple intelligences that defines nine different types of intelligences, the visual and verbal conceptual distinction is referred to as spatial ability and linguistic ability.

In the field of memory, Baddeley's (1986) model of working memory uses the visual and verbal distinction to identify two of the model's subcomponents: one that represents visual information called the "visual-spatial sketchpad" and one that represents verbal information called the "phonological-loop" (Baddeley, 1986; Baddeley, Gathercole, & Papagno, 1998). Similarly, an example of the visual-verbal distinction is seen in research on the left brain-right brain hemispheres. In a study by Kraemer, Rosenberg, and Thompson-Schill (2009), for example, using the Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977), the higher an individual scored on the visualizer dimension, the more likely he or she was to activate the right side of the brain when presented with words that described visual features. In contrast, activity in a "left side" of the brain correlated with the verbalizer dimension during the picture-based condition involving language (Kraemer et al., 2009; Richardson, 1977). This study is consistent with other research on brain hemispheres (Ganis, Thompson, & Kosslyn, 2004; Howard et al., 1998; Ishai, Ungerleider, & Haxby, 2000; Mechelli, Price, Friston, & Ishai, 2004; Rich et al., 2006).

This dissertation focuses generally on the use of the visual-verbal distinction in the field of psychological measurement, where Mayer and Massa (2003) maintained there are three domains in which the visual-verbal distinction have been used: the measurement of abilities, the measurement of cognitive styles, and the measurement of learning preferences. Ability refers to general mental capability that involves reasoning, problem solving, planning, abstract thinking, complex idea comprehension, and learning from experience (Gottfredson, 1997). Cognitive style refers to a person's consistent mode of problem solving, thinking, perceiving, and remembering (Messick, 1976). Learning preference refers to the way each individual learner begins to concentrate on, process, absorb, and retain new and difficult material (Dunn, Dunn, & Price, 1989; Erginer, 2002).

Research in each of these three domains has been criticized in at least three areas: the inconsistent language used to characterize constructs, the evidence provided for construct validity, and the research methods and measures used for the constructs. Each of these problems is described below.

The language that researchers use to name these constructs in the three domains has been inconsistent. For instance, in the ability domain, substitute names include verbal-comprehension ability, visualizing ability, linguistic ability, spatial ability, crystallized intelligence, broad visual perception, broad auditory perception, spatial-visual ability, visual ability, or auditory ability. In the cognitive-style domain, labels include verbalizers, visualizers, listeners, scanners, and breadth of categorization. In the learning preference domain, extensive alternative names occur in the literature. Some common names used to identify visual-verbal conceptualization in these three domains are listed in Table 1 (p. 4).

Even with the long-term interest and research on the visual and verbal distinction in the three domains of ability, cognitive style, and learner preferences, there remains a construct validity issue (Coffield, Moseley, Hall, & Ecclestone, 2004; Curry, 1990; Snider, 1992; Stahl, 2002). Construct validity refers to the extent that scores from a test or scale accurately reflect the construct being measured. Researchers frequently do not define the visual and verbal constructs of abilities, cognitive style, and learning preferences consistently. In the literature, cognitive styles are sometimes confused with cognitive abilities or the two terms are used interchangeably. Other times, researchers apply the term learning style as a widespread classification to include cognitive styles, learning styles, learning preferences, or some combination (Evans, Cools, & Charlesworth, 2010; Plass, Chun, Mayer, & Leutner, 1998). Moreover, cognitive ability has been referenced by different names including spatial ability, general cognitive achievement, or simply as ability.

Table 1
Terms Used to Identify the Visual-Verbal Conceptual Distinction in the Domain of Abilities, Cognitive Styles, and Learning Preferences

Labels for Ability in Ability Domain	Labels for Cognitive Style in Cognitive Style Domain	Labels for Learning Preference in Learning Preference Domain
- Verbal Comprehension	- Verbalizers	- Learning Style or Cognitive Style
- Ability	- Visualizers	- Learning Modality
- Visualizing Ability	- Listeners	- Learning Strategies
- Linguistic Ability	- Scanners	- Ability for Auditory or Verbal or Visual Information
- Spatial Ability	- Breadth of Categorization	- Visual Perception or Verbal Perception or Perceptual-Preferences or Instructional Preference
- Crystallized Intelligence		- Auditory or Verbal or Visual Learning or Learner Information Processing Style
- Broad Visual Perception		- Imagery or Imagery (Dual Coding)
- Broad Auditory Perception		- Cognitive Personal Style
- Spatial-Visual Ability		- Viewing and Listening
- Visual Ability		- Wholist-Analytic and Verbal-Imager or Holist-Analytic and Verbaliser-Imager
- Auditory Ability		- Learning-Style Hypothesis or Meshing Hypothesis
		- Attribute-By-Treatment Interaction or Style-By-Treatment
		- Spatial-Visual Dichotomy

Complicating issues related to definitions are issues related to measurement: researchers use different data-analysis methods to collect and analyze the data from the measurements (Curry, 1990; Sternberg & Zhang, 2001). In each of these three domains, there are different measuring instruments and different ways of analyzing the data (Casey, Pezaris, Fineman, Pollock, Demers & Dearing, 2015; LeFevre et al., 2010; Zhang et al., 2014). Some of the data-analysis methods include correlational analyses, regression analyses, factor analyses, principal-component analyses, canonical-correlation analyses, analysis of variences (ANOVA), paired comparisons, or a combination of these measures. Each of these forms of analyses can vary in method of measurement (nominal, ordinal, interval, or ratio or rating scale applied) and can utilize different procedures to generate the scale items (e.g., Thurstone, Likert, or Guttman method) or index components. When analyzing multiple outcomes, some studies may examine each outcome separately, other studies may examine data by using a multivariate approach that models the different outcomes in a similar way as the separate models but that additionally takes into account the correlation between the outcomes. With each of these approaches, outcomes are interpreted somewhat differently and can result in varied or contrasting findings.

While researchers in these three domains of abilities, cognitive styles, and learner preferences all use the visual-verbal distinction, and all three experience the problems identified above, it is the field of learner preferences that has experienced the most problems, and this area of focus for this dissertation. The domain of learner preferences has a long history of researchers critiquing the research in this domain for language, construct validity, and other measurement issues (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973).

Purpose of the Study

Consequently, the purpose of this study was to reexamine the literature in the learner preference domain for evidence of construct validity. In particular, a search of the research literature on visual and auditory learner preferences was made. Those studies that measured visual and auditory preferences and reporting a correlation matrix were factor analyzed with a common factor analysis procedure to see if and to what extent the visual and auditory preference constructs could be identified across the studies. Two research questions guided the dissertation:

1. Using a common factor analysis procedure, do studies measuring the visual and the verbal learner-preference dichotomy consistently identify the visual and verbal constructs?

2. In studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

Significance of the Study

Findings from this study are important for several reasons. First, as far as my literature review could tell, no one has completed this kind of reanalysis before. Second, this study should provide important information on the measurements used and factors identified in the learner preference field, the biggest area of contention for learner preference literature. Third, factor analysis is one of the most common methods for establishing construct validity as it is able to identify measures that correlate among themselves and simultaneously separate from other measures. Furthermore, applying a common factor analysis procedure to the identified correlation matrices will eliminate the variability of methodology used to establish the construct validity of learner preferences. Fourth, it is anticipated that the use of measures from studies from more than a single domain will aide factor identification as it is often easier in factor analysis to identify constructs when measures for multiple constructs are being factored. Finally, visual and auditory learners is the basic dichotomy among teachers and teacher educators advocating student learning styles, yet the evidence for such learner preferences is still highly debated. This study may shed light on this debate.

Theoretical Framework

The theoretical framework and model that underpins this study is one proposed by Mayer and Massa (2003). Results of both Mayer and Massa's 2003 and Massa and Mayer's 2006 studies supported that there are three ways of distinguishing verbal and visual learners, that is by individual differences in ability, cognitive style, and learning preference. This dissertation applied an adapted version of this model. An illustration of this model is shown in Figure 1.

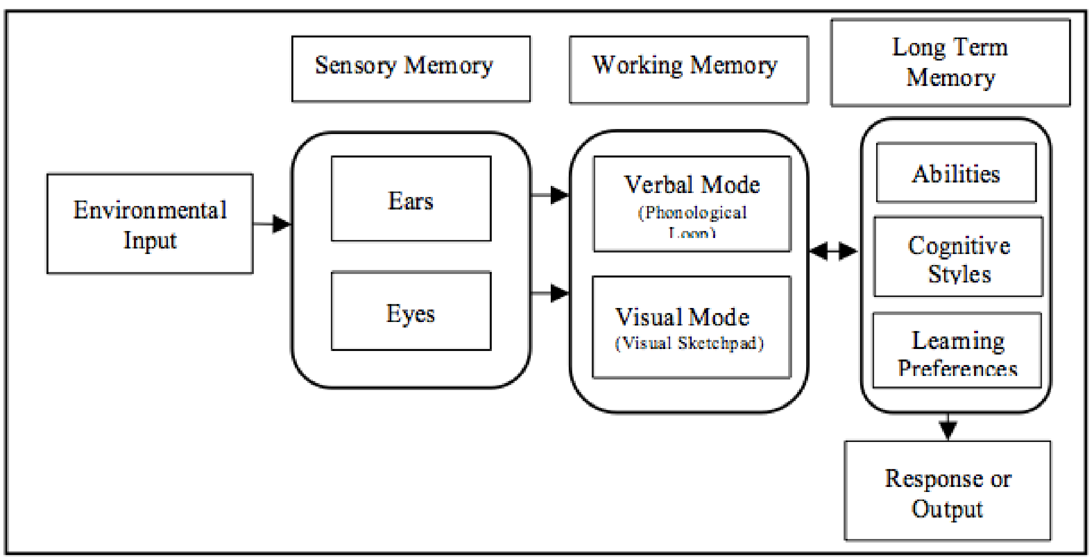

Figure 1. Adapted version of Mayer and Massa (2003) visual-verbal conceptual distinction.

The model represented in Figure 1 is a basic visual-verbal model that examines if the hypothesized domains of abilities, cognitive styles, and learning preferences have evidence of construct validity. The model contains three memory stores: sensory memory, working memory, and long-term memory. Each memory store of this diagram is represented by a rounded rectangular box. The first store of sensory memory is where environmental stimulus or input enters a learner's eyes and ears as symbolized by the rightward arrow. Sensory memory holds this information temporarily. Verbal information received from the ears is held as printed text, and visual information or images received from the eyes is held as visual images. Using a sensory-modalities approach emphasizes the format of the stimulus-as-presented in working memory of auditory or visual (Mayer, 2009) that is central to the research of this dissertation.

The second store of working memory maintains the visual- or the verbal-sensory information. In this store, knowledge is held and manipulated temporarily and most conscious learning takes place. Integrating Sweller's (2011) assumption of cognitive load, this model recognizes working memory's limited capacity of holding images or sounds in the visual or the auditory channel of working memory (Baddeley, 1992; Chandler & Sweller, 1991). Input received from the ears is transmitted to the verbal mode of working memory, also referred to as the phonological loop that holds knowledge constructed as verbal images. Input received from the eyes is transmitted to the visual mode of working memory, also referred to as the visual sketchpad that holds knowledge constructed as pictorial information. This flow of input is indicated in the figure with the two corresponding arrows from sensory memory to working memory.

The third memory store represents long-term memory and depicts the learner's storehouse of prior knowledge. This memory store is where temporary images or sounds from working memory are integrated with prior knowledge from long-term memory. Unlike working memory, long-term memory can hold large amounts of knowledge over long periods of time, but in order to think actively about material in long-term memory it must be brought into working memory. The learner builds internal connections among selected words to create a verbal model and among pictures to create a pictorial model and then builds external connections between the verbal and pictorial models and with prior knowledge (Mayer, 2009). This interactive relationship between long-term memory and working memory is indicated in the diagram with a left-right, double arrow.

Most importantly, long-term memory is where the visual and verbal conceptual distinction of abilities, cognitive styles, and learning preferences are processed which, in turn, evokes a response or output. This visual representation of memory processes substantiates visual and verbal distinctions that is the basis for the theory of this research. Moreover, this theory connects with the factor-analysis research of this study by examining if studies using measures of the visual and verbal distinction in domains of abilities, cognitive styles, and learning preferences group into their respective verbal and visual clusters of output when statistical analyzed with a factor analysis procedure.

Background and Need for the Research

A common practice among teachers is to classify students by their learning preference or style (Dekker, Lee, Howard-Jones, & Jolles, 2012; Pashler et al., 2009; Rogowsky, Calhoun, & Tallal, 2015). As an example, in the field of learning-styles research by Dekker et al. (2012) indicated that 95% of teachers in Great Britain, the Netherlands, Turkey, Greece, and China believe that students learn better when they receive information in their preferred learning style. In another study, Newton (2015) found that 89% of the research papers in ERIC and PubMed research databases with dates ranging from 2013 to 2015 implicitly or directly endorsed the use of learning styles in higher education. Although teachers use learning preferences, research suggests that there is not much evidence to support them as constructs.

Because practitioners routinely use the visual-verbal conceptual distinction and may not be using it correctly, it is important to promote improved understanding of the strengths and weaknesses of measures relating to this distinction in educational practice. Pashler et al. (2009) stated, “If education is to be transformed into an evidence-based field, it is important not only to identify teaching techniques that have experimental support but also to identify widely held beliefs that affect the choices made by educational practitioners that lack empirical support” (p. 117). Without knowledge of models’ strengths and limitations, methods inadvertently could increase rates of failure and inequality in schools through mislabeling and discriminating (Coffield et al., 2004; Curry, 1990; Kavale & Forness, 1987; Pashler et al., 2009).

There is an educational need for this study because the findings can provide empirical evidence to guide educational practitioners when deciding whether their students will or will not benefit from receiving instruction in a style that coincides with their visual or verbal preference. Rogowsky, Caloun, and Tallal (2015) defined the educational need as it relates to learning-style applications, “Educators and professional development leaders spend considerable time and resources assessing their students’ learning style and developing instruction to specifically match a student’s preferred learning styles” (p. 77).

U.S. educators have come to believe that optimal learning can occur when individuals are taught in their preferred learning style. Although the concept of helping a student’s poor performance by teaching in a mode that coincides with his or her preferred style of learning holds an attractive appeal, it needs to be substantiated. Rogowsky et al. (2015) described associated issues:

> Contrary to current educational beliefs and practices, educators may . . . be doing a disservice to auditory learners by continually accommodating their auditory learning style preference by providing them instruction that coincides with their auditory learning style, rather than focusing on strengthening their visual word skills. . . . Most testing, from state standardized education assessments to college admission tests, is presented in a written word format only. Thus, it is important to give students as much experience with written material as possible to help them build these skills, regardless of their preferred learning style. (p. 77)

Several learning-preference and cognitive-style reviews have attempted to organize the various types of styles into groups (Coffield, Moseley, Hall, & Ecclestone, 2004; Curry, 1983; Grigerenko & Sternberg, 1995; Rayner & Riding, 1997; Kozhevnikov, 2007). The review by Coffield et al. (2004) demonstrates the extensiveness and variety of style models. It identified 71 different types of styles in practice and grouped these into five categories based on the styles' overarching themes.

Although the use of cognitive and learning styles continues to increase in popularity among the academic community, research findings vary considerably. In some studies, researchers found positive support, and in other studies, researchers found no support or negative support for accommodating students' visual or verbal preference. For example, Claxton and Murrell (1987) and Garcia-Otero and Teddlie (1992) found that accommodating a student's visual and verbal learning style empowered the learners and promoted greater academic success. Hill (1976), Kennedy, Fisher, and Ennis (1991), and Halpern (1998) found that focusing on the preferred learning style helped the students develop transferrable, critical-thinking skills whereas Dunn and Griggs's (2003) findings suggest improved student attitudes. Fine (2002) and Oberer (1999, 2003) described positive behavior manifestation in students. Mangino (2004) found that when students are taught in their preferred learning style it "enhanced other aspects of life, such as discipline choice, profession as adults, school and program selection, educational attainment level, study habits, and attitudes" (p. 22).

In contrast, there are many studies where the researchers found little support or negative support for accommodating students' visual or verbal preference. For example, Pashler et al. (2009) found limited empirical evidence to validate that providing instruction in an individual's preferred learning style improves learning. Massa and Mayer (2006) found that students reported their preference for verbal or visual information, but the preference was only weakly related to their actual abilities when objectively measured. Other researchers found no relationship between a learning style and the actual learning of items when presented visually or verbally (Constantinidou & Baker, 2002). Clark (1982) found that often when a learner said he or she preferred a particular way of learning, he or she typically did not learn better or even performed worse when it was used. Often it appears there is a difference between the way someone prefers to learn and that which actually leads to effective and efficient learning (Kirschner, 2017).

Although research findings on the visual-verbal conceptual distinction vary considerably, numerous experts claim that there are problems with construct validity, particularly with studies that examine cognitive styles and learning preferences (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973), teachers continue to use these measures to design instruction and make learning decisions about students (Dandy & Bendersky, 2014; Dekker et al., 2012). Therefore, it is imperative to cross-analyze the way abilities, cognitive styles, and learning preferences are assessed to ensure construct validity of the tests or scales used to measure these constructs accurately measure them. Tests that measure intelligence or measures of ability such as those defining the visual and verbal conceptual distinction can either be used to design and implement interventions that help students reach their potential more effectively or can be used to segregate and label people (Wasserman, 2012).

Research Questions

There were two research questions posed for this study:

1. Using a common factor analysis procedure, do studies measuring the visual and the verbal learner-preference dichotomy consistently identify the visual and verbal constructs?
2. In studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

Definition of Terms

The following terms and definitions are applied in this study.

Ability or cognitive ability: Ability refers to general mental capability that involves reasoning, problem solving, planning, abstract thinking, complex idea comprehension, and learning from experience (Gottfredson, 1997). In the literature, it is measured by achievement scores such as a Standard Achievement Test (SAT) Verbal test, SAT Mathematics test, Card Rotations test (Ekstrom, French, & Harman, 1976), or Paper Folding test (Ekstrom et al., 1976).

Cognitive style: Cognitive style refers to a person's consistent mode of problem solving, thinking, perceiving, and remembering (Messick, 1976). It is measured in the literature with tests such as Cognitive-Styles Analysis (Riding, 2001) and the Santa Barbara Learning Style Questionnaire.

Domain(s): The visual and verbal conceptual distinction in this research are analyzed by three domain groupings. They are as follows:

- Single-Domain studies are those where the researcher analyzed the visual and verbal construct with a single domain of either abilities, cognitive styles, or learning preferences

- Two-Domain studies are those where the researcher analyzed the visual and verbal constructs with two domains either of abilities and cognitive style or of abilities and learning preferences.

- Three-Domain studies are those where the researcher analyzed the visual and verbal constructs with all three domains of abilities, cognitive styles, and learning preferences.

Field-independence versus field-dependence: Field-independence and field-dependence are types of cognitive-style measures that examine the manner in which a person approaches the environment, such as a person's primary method of processing, remembering, and thinking (Kogan, 1971). A field independent person tends to differentiate objects or figures from his or her embedded background or contexts in an analytical fashion; a field-dependent person tends to experience objects or figures as part of their backgrounds or contexts in a global fashion (Federico & Landis, 1979) and is identified with the Field Dependent-Independence model (Witkin, 1962).Various tests are used to measure field-independence and field-dependence behavior such as the Rod and Frame test, the Body Adjustment Test, the Hidden Figures Test, and the Group Embedded Figures Test (Witkin et al., 1973).

Learning preferences: Learning preference refers to "the way each individual learner begins to concentrate on, process, absorb, and retain new and difficult material" (Dunn et al., 1995, p. 353). For example, someone with a visual preference would prefer information presented visually, someone with an auditory preference would prefer information presented verbally or auditorily (Howard-Jones, 2014). Learning preferences are measured with a test such as the Learning Scenario Questionnaire (Mayer & Massa, 2003) or the VARK Questionnaire (Fleming & Mills, 1992).

Multiple-Intelligence: Gardner's Multiple Intelligences theory (1993) led to the development of 10 different types of intelligences including linguistic, logic-mathematical, musical, spatial, body or kinesthetic, interpersonal, intrapersonal, naturalistic, existential, and pedagogical. This multifaceted theory of human intelligence posits that everyone has at least varying degrees of different intelligences (Hajhashemi, Caltabiano, Anderson, & Tabibzadeh, 2018).

Visual and verbal learner: The visual or verbal learner refers to the way people process information either visually using printed or spoken text or verbally by hearing or by pictorial format, or with both channels. This concept hypothesizes instructional relevance for learning styles by identifying which method of instruction provides the best format to match the preferences of the learner. For a visual learner, it would mean emphasizing visual presentation of information; for a verbal learner, it would mean emphasizing verbal presentation of information (Pashler et al., 2009).

Summary

Chapter one provided an overview of the research problem, the purpose of the study, the significance of the study, the theoretical framework that underpins the study, the background and need for the research, and definition of terms. Chapter II provided a review of the literature and research related to this study. Chapter III provided the methodology used in this research. The results are reported in chapter IV; and the analyses, limitations, discussion, and implications are reported in chapter V.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study was to investigate if there is empirical support for the visual and verbal conceptual distinction as it relates to domains of abilities, cognitive styles, and learning preferences. This was accomplished by performing a factor analytic secondary analysis of 24 intercorrelation matrices from three domain sources. This chapter provides a review of the literature and is grouped into three sections: studies that examined a single domain, studies that examined two domains and studies that examined three domains of abilities, cognitive styles, and learning preferences.

The inclusion and exclusion criteria used for the 24 total matrices from 21 studies with that met the search criteria to be included in this research are defined in the methodology of chapter III. In the sources of sample data and characteristics of the sample section of chapter III, the detailed characteristics of the studies used in this research and the method of obtaining these sources of sample data are specified. This research focused on two basic questions:

1. Using a common factor-analysis procedure, do studies measuring the visual-verbal learner-preference dichotomy consistently identify the visual and verbal constructs?
2. In studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

In this review, ability refers to general mental capability that involves reasoning, problem solving, planning, abstract thinking, complex idea comprehension, and learning from experience (Gottfredson, 1997). In the cognitive-style group, the term cognitive style refers to a person's typical mode of perceiving, thinking, remembering and problem solving (Messick, 1970, 1984). Worth noting, however, is that the language researchers apply to identify cognitive styles has been somewhat varied. Some researchers use the term cognitive style as a synonym for learning style as though the two terms can be used interchangeably (Evans, Cools, & Charlesworth, 2010; Plass, Chun, Mayer, & Leutner, 1998). As a matter of fact, perhaps because cognitive style and learning style constructs share similarities in name and defining characteristics, in recent years the two literatures appear to have merged into a common "styles" literature (Kozhehnikov, 2007; Rayner & Riding, 1997). Historically, however, learning styles have always been conceptualized differently than cognitive styles. Therefore, they will be kept separate in this literature review because that is how most of the research represents cognitive styles.

Many researchers have attempted to categorize systematically the various types of styles (Allinson & Hayes, 1996; Grigorenko & Sternberg, 1995; Hermann, 1996; Rayner & Riding, 1997; Riding & Cheema, 1991; Sternberg & Grigorenko, 1997). Messick's review (1970, 1976) is one of the most extensive and was the one applied in this study. In his taxonomy the visual-verbal distinction is classified as a sensory modality of visual and auditory modes.

The term learning preference has been defined in many ways, but definitions primarily vary according to whether learning style is thought to be relatively fixed or more malleable to environmental demand. Rita and Kenneth Dunn completed some of the most prolific research on learning style preferences. The Dunns' model proposes that learning preferences also known as learning styles refer to the way in which each individual learner begins to concentrate on, process, absorb, and retain new and difficult material (Dunn, Dunn, & Price, 1989). Several literature reviews have categorized learning styles (Cassidy, 2004; Coffield, Moseley, Hall, & Ecclestone, 2004; Curry, 1983). One of the most extensive reviews is that performed by Coffield, Moseley, Hall, and Ecclestone (2004). Coffield et al. (2004) identified 71 different learning style theories in practice and organized these into five families. From this taxonomy the visual-verbal conceptual distinction is classified as a biologically-based type.

This chapter includes the research that was found in studies examining a single domain, Group A; studies examining two domains, Group B; and studies examining all three domains, Group C. Studies in Group A consist of three different types: those that examine a single domain of abilities, those examining a single domain of cognitive styles, and those examining a single domain of learning preferences. Studies in Group B consist of two types: those that examine the two domains of abilities and cognitive style and those that examine the two domains of abilities and learning preferences. Group C consists of one type of studies, those that examine all three domains. Each study in its respective group is summarized including the purpose of the study, research questions it attempted to answer, methodology used, and the findings.

Studies Grouped by Domain(s) Examined

There was three different groups of studies examined including studies examining a single domain, studies examining two domains, and studies examining three domains.

Studies examining a single domain

There were eleven total studies that analyzed a single domain. Two of these studies were ability studies that examined the single domain of abilities including Buktenica (1969) and Casey et al. (2015). Another four studies were cognitive-style studies that examined the singlehid domain of cognitive style including two studies that were experiments performed by Blazhenkova, Becker, and Kozhevnikov (2011) Experiment 1 and Experiment 2. The other studies were Hajhashemi et al. (2018), and Sozcu (2014). The remaining five studies were learning preference studies, all of which examined the single domain of leaning preferences including Andrusyszyn, Cragg, and Humbert (2001); Leite, Svinicki, and Shi (2010); Vahid Baghban (2012); Wintergerst, DeCapua, and Itzen (2001); and Yang and Kim (2011). The defining characteristics of the nine studies using a single domain can be found in Table 2.

Table 2

Summary of Studies Examining One Domain, Group A

Domain Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Buktenica (1969)	
Ability	140 Elementary-grade students	Correlational analysis	Twenty-one total measures were administered, seven measures for each of the three years. Six of the 21 measures were visual-verbal constructs: The six visual-verbal constructs were • Three Berry-Buktenica Visual–Motor-Integration tests (Buktenica, 1969) measuring visual ability • Three Wepman Auditory Discrimination Tests measuring verbal ability The remaining 15 tests were other ability measures: • Three were Tests of Nonverbal Auditory Discrimination • Three were tests of intelligence measured with the Science Research Associates Primary Mental Abilities Test for IQ • Three were test of reading ability measured with Reading Total or MAT Total • Six were tests of word or spelling ability measured with three Word Knowledge tests and three Word Discrimination tests

Table 2 continues

Table 2 Continued

Domain Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Casey et al. (2015)	
Ability	127 participants originally, but 79 participated in both first- and fifth-grade studies Elementary-grade students	Correlational analysis & Regression analysis	Nine total measures applied, four were visual-verbal ability constructs: One visual-verbal measure was verbal ability • 1st Grade Peabody Picture Vocabulary Test-Fourth Edition Three visual-verbal measures were spatial ability: • 1st Grade Block Design subtest of Wechsler Intelligence Scale for Children –Fourth Edition • 1st Grade Two-Dimensional Mental transformation Task • 1st Grade Three-Dimensional Mental Rotation task Remaining five tests were other measures • 1st Grade Addition ability test • 1st Grade Subtraction ability test • Household income level • Mother's years of education Mother's spatial skills
		Blazhenkova, Becker, and Kozhevnikov (2011) Experiment 1	
Cognitive style	222 Elementary-grade to high-school students	Correlational analysis & Principal component factor analysis	Eight total measures were examined, all were visual-verbal ability constructs: Three were visual-object ability constructs • Vividness of Visual Imagery Questionnaire • Degraded Pictures Test • The Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object Three were visual–spatial ability constructs • Mental Rotation Test • Paper Folding Test • C-OSIVQ spatial Three were verbal ability constructs • Arranging Word Test • C-OSIVQ verbal
		Blazhenkova, Becker, and Kozhevnikov (2011) Experiment 2	
Cognitive style	**269** Elementary-grade to high-school students	Correlational analysis	Eight total measures were examined, all were visual-verbal ability measures and were the same measures as those examined in Experiment 1: • Three visual-object ability constructs • Three visual–spatial ability constructs • Two verbal ability constructs
		Hajhashemi et al. (2018)	
Cognitive style	111 Undergraduate students	Correlational analysis Principal component analysis Mann- Whitney U test analysis	Thirteen total measures were examined, two of these were visual-verbal cognitive style measures of Multiple Intelligence (MI): Two visual-verbal cognitive style measures were: • Verbal Linguistic MI cognitive style • Visual MI cognitive style Remaining 11 tests were other MI measures: Overall MI, Intrapersonal, Bodily Kinesthetic, Musical Rhythmic, Interpersonal, Naturalist, Logical Mathematical, Existential, Learning Experience, Motivation, and Age

Table 2 continues

Table 2 Continued

Domain Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Sozcu (2014)	
Cognitive style	157 College and Undergraduate students	Correlational analysis Independent samples t-test ANOVA	Ten total measures were examined; two of which were visual-verbal cognitive style constructs: • Prefer reading materials (printed texts) in e-learning • Levels of field dependence-independence (FDI)as measured by the Group Embedded Figures Test (GEFT) Remaining eight measures were other tests: • E-learning techniques • Attitudes about e-learning instruction • Attending distance-learning programs before • Locations for accessing distance education programs • Knowledge levels about e-learning and distance education • Assessment in e-learning instruction • Knowledge about e-learning instructional Learner interface design features
		Andrusyszyn et al. (2001)	
Learning Preferences	125 University students	Correlational analysis Paired comparisons ANOVA	Twelve total test measures examined, two of which were visual-verbal measures: One visual-verbal measure was a visual construct • Prefer to learn by observing One visual-verbal measure was a verbal construct • Prefer learning by reading Remaining 10 measures were other preference tests including Prefer to Learn New Things on my Own Rather than with Others, Prefer to Learn in Groups Having 15 of Less People, Prefer to Learn in Larger Groups of 16 or More, Prefer to Learn by Considering the Big Picture versus by Focusing on the Details, Prefer to Learn by Having a Learning Plan Set for me versus by Setting my Own Learning Plan, Prefer to Learn by Focusing on Theoretical Concepts versus by Focusing on Concrete Examples, Prefer Learning by Hearing, Prefer to Learn by Discussing, Prefer to Learn by Doing, and Prefer to Learn by Reflecting.
		Leite, Svinicki, and Shi (2010)	
Learning Preferences	14,211 Students of all ages	Correlational analysis Multitrait–multimethod confirmatory factor analysis	Four total measures were examined from Fleming's (2001)Visual-Aural-Read-Kinesthetic learning-style-inventory instrument, two of which were visual-verbal constructs: • Visual • Aural The remaining two tests were other measures: • Read/write • Kinesthetic
		Vahid Baghban (2012)	
Learning Preferences	120 College students	Correlational analysis ANOVA Factor analysis with varimax rotation	Nine total measures were examined, two of which were visual-verbal measures: • Visual, • Auditory Remaining seven were other measures • Kinetic, Memory, Cognitive, Compensation, Metacognitive, Affective, and Social

Table 2 continues

Table 2 Continued

Domain Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Wintergerst, DeCapua, and Itzen (2001)	
Learning Preferences	100 participants University students	Correlational analysis Exploratory factor analysis with both a varimax and an oblimin rotation	Ten total factor measures were examined, two of them were visual-verbal factors: • Factor 3 consisting of two visual items (Q12 and Q10) • Factor 4 consisting of three auditory items (Q7, Q1, and Q20) Remaining eight factors were other measures: Factor1, Factor 2, Factor 5, Factor 6, Factor 7, Factor 8, Factor 9, Factor 10
		Yang and Kim (2011)	
Learning Preferences	(Set 1 had 100 Chinese students and Set 2 had 104 South Korean students as participants High-school students	Correlational analysis Regression analysis ANOVA	Five measures were examined for each of the students in two different countries; four of these were visual-verbal measures: • Two VV measures were visual constructs • Two VV measures were auditory constructs Remaining 8 measures were other measures: • Two were kinesthetic measures • Two Ideal L2 Self measures • Two Motivated L2 behavior measures

Studies examining a single domain of ability

The two studies examining the single domain of abilities were Buktenica (1969) and Casey et al. (2015). The Buktenica (1969) study used a correlational analysis to investigate if reading achievement could be predicted from first through third grade with performance on group administered, nonverbal auditory and visual perceptual tests administered in the first grade by following a sample of 140 elementary-grade students over a 3-year period. All children included in the sample scored within the "average" range of IQ scores and were instructed with the same reading program. Participants took a reading achievement test in first grade and at the end of third grade.

During their first year of school, the students as a group received a battery of auditory perceptual, visual perceptual, intelligence, reading, and spelling achievement tests. In the second year of school, participating students as a group were administered the auditory and visual perceptual tests. In the second year, the tests were repeated. In the third year, the participating children as a group were administered the auditory and visual perceptual tests, as well as the reading achievement tests at the end of the third grade. A total of 21 measures were administered: seven measures for each of the 3 years.

Six of the 21 measures were visual-verbal ability constructs and included three visual perceptual tests measured with Berry-Buktenica Visual-Motor Integration test (VMIa, VMIb, VMIc; Buktenica, 1969) that is a test of ability to copy an image and to identify identical image, and three auditory perceptual tests measured with the Wepman Auditory Discrimination Test (WADTa, WADTb, WADTc; Wepman, 1964) that is a verbal test of reading ability used to differentiate vowel and consonant sounds. The remaining 15 tests were other ability measures and included three tests of Nonverbal Auditory Discrimination Ability (NVADTa, NVADTb, NVADTc; Buktenica, 1969) that is a test measuring ability to differentiating pitch rhythm duration and timing, three tests of intelligence measured with Science Research Associates Primary Mental Abilities Test for IQ (IQa, IQb, IQc; Thurstone & Thurstone, 1953), three tests of reading skill measured with Reading Total or MAT Total (MATa, MATb, MATc; Metropolitan Achievement Test), and six tests of spelling ability measured with three Word Knowledge tests (WKnowa, WKnowb, WKnowc; Metropolitan Achievement Test) and three Word Discrimination tests (WordDisa, WordDisb ,WordDisc; Metropolitan Achievement Test).

These measures typically were rated by students' scores on ability test to differentiate sounds, complete letter sequences, identify a correct match, perform mental rotation, or draw an image. Measures included timed tests, selecting correct or incorrect response, or completing pencil-and-paper tests. Buktenica's (1969) correlational matrix demonstrates all possible correlations for pairings of the 21 measures (Appendix A).

The correlational analysis was used to examine relationships. Results of this analysis revealed that correlations between the verbal-visual constructs of Visual–Motor Integration test and the Wepman Auditory Discrimination Test and the achievement variables remained at the same level when administered in first, second, and third grades. Similar relationships were observed with the Test of Nonverbal Auditory Discrimination. Although the researchers hypothesized that the relationship between perceptual variables and reading would tend to decrease from first through third grade. In fact, there was a tendency for the Wepman test, which is verbal in nature, to increase in its relationship with achievement from first through the third grade. Moreover, results of correlations between tests of nonverbal auditory and visual perception and reading achievement remained high and rather constant over the 3-year period. The highest correlation between predictors and achievement variables was obtained with the Test of Nonverbal Auditory Discrimination. This test proved the best predictor of reading ability, but all perceptual tests were more effective than IQ measures. Buktenica (1969) concluded that by using group-administered, nonverbal auditory and visual perception tests, it is possible to identify children's potential in reading achievement at the beginning of first grade.

The second ability study that analyzed a single domain of abilities was Casey et al. (2015). This study was a longitudinal analysis that examined first-grade spatial skills compared with arithmetic and verbal skills as predictors of two different types of fifth-grade mathematics reasoning: mathematics reasoning-spatial and mathematics reasoning analytical. Originally the study had 127 first-grade girls as participants, but of those only 79 participated in both first- and fifth-grade studies.

There were nine total measures, four of which were visual-verbal ability constructs including one visual-verbal measure of verbal skill as measured with the First Grade Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn & Dunn, 2003), three visual-verbal measures testing spatial performance with the First Grade Block Design subtest of the Wechsler Intelligence Scale for Children –Fourth Edition (WISC-IV; Wechsler, 2003), the First Grade Two Dimensional Mental transformation Task (Levine et al., 1999), and the First Grade Three-Dimensional Mental Rotation task (Casey et al., 2008). The remaining five tests were either other measures including test of first-grade addition ability, first-grade subtraction ability, the social economic status based on household income level, the mothers' years of education, and the mothers' spatial ability skills.

Measures of this study were rated by participants' response to two- or three-dimensional mental-rotation tasks, multiple-choice questions, or self-reported responses but also included responses to telephone interviews, standardized test scores, and individual classroom assessments or tests. These measures were analyzed with a correlation analysis and a path analysis to answer three research questions: Is there is a direct relationship between the first-grade spatial composite score and two different types of fifth-grade mathematics reasoning: mathematics reasoning-spatial and mathematics reasoning analytical? Is the first-grade arithmetic composite score is significantly related to fifth-grade mathematics reasoning-analytical, and related to fifth-grade mathematics reasoning-spatial? Is the first-grade verbal score predicts fifth-grade spatial and analytical mathematics reasoning scores? Casey et al. (2015) correlational matrix contains all possible correlations for pairings of the nine measures (Appendix B).

Results of the correlational analysis supported the first research question: there was a direct relationship between the first-grade spatial composite score and both fifth-grade mathematics reasoning-spatial and fifth-grade mathematics reasoning analytical. In effect, first-grade spatial skills proved the strongest predictors of both types of fifth-grade mathematics reasoning. The findings indicated some support for the second research question: the first-grade arithmetic composite score was statistically significantly related to and statistically significantly predicted fifth-grade mathematics reasoning-analytical, but was only marginally related to fifth-grade mathematics reasoning-spatial. The findings did not support the third research question: no direct relationship was found between the first-grade verbal score and fifth-grade spatial and analytical mathematics reasoning scores. Moreover, the first-grade verbal score was not directly related to and did not directly predict fifth-grade spatial and analytical mathematics reasoning scores. Instead, there were statistically significant indirect effects between this language measure and the fifth-grade outcomes. An indirect pathway connected them through first-grade spatial skills. The estimated path model accounted for approximately half the variance in mathematics reasoning. Thus, the researchers concluded that spatial skills, assessed by first grade, already function as key, long-term predictors of analytical as well as spatial mathematics-reasoning skills as late as fifth grade.

Studies examining a single domain of cognitive style

In the group of 11 studies that examined a single domain, there were four studies that examined the single domain of cognitive styles including Blazhenkova et al. (2011) Experiment 1 and Experiment 2, Hajhashemi et al. (2018) and Sozcu (2014). The first two studies that examined one domain of cognitive styles included two experiments conducted by Blazhenkova et al. (2011) Experiment 1 and Experiment 2. In both of these experiments Blazhenkova et al. (2011) sought to validate a new questionnaire called the Children's Object–Spatial Imagery and Verbal Questionnaire (C-OSIVQ) on two different sample groups. The C-OSIVQ Questionnaire is a children's version of the original, adult questionnaire called the Object–Spatial Imagery and Verbal Questionnaire (OSIVQ; Blazhenkova & Kozhevnikov, 2009). The C-OSIVQ, also referred to hereafter as the Children's Version was designed to assess cognitive styles in younger populations (8–17 years old) compared with the original OSIVQ, referred to hereafter as the Adult Version designed to access cognitive styles in adult populations (18-42 years old).

In Experiment 1, Blazhenkova, Becker, and Kozhevnikov (2011) used a correlational analysis and a principal component analysis to test the Children's Version of the new questionnaire on a sample of 222 elementary-grade to high-school students. Eight total measures were examined, all of which were visual-verbal ability measures including three tests of visual-object ability constructs measured with the Vividness of Visual Imagery Questionnaire, the Degraded Pictures Test, and the Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object; three tests of visual–spatial ability constructs measured with the Mental Rotation Test, the Paper Folding Test, and the C-OSIVQ spatial; and two measures of verbal-ability constructs measured with the Arranging Word Test and the C-OSIVQ verbal. These measures were typically rated by participants' response to either a self-reported questionnaires, Likert questions, mental-rotation tasks, or categorizing exercises. The correlational matrix of Blazhenkova, Becker, and Kozhevnikov's (2011) Experiment 1 demonstrates all possible correlations for pairings of the 20 measures (Appendix C).

First the predictive validity of the Children's Version was tested by correlating scores on the object, spatial, and verbal scales with performance on two of the three visual–object measures of Vividness of Visual Imagery Questionnaire and Degraded Pictures Test and with two of the three visual–spatial measures of Mental Rotation Test, the Paper Folding Test, and one of the two verbal assessment measures of Arranging Word Test. Scores on the object scale correlated with performance on visual–object tasks, scores on the spatial scale correlated with performance on visual–spatial tasks, and scores on the verbal scale correlated with performance on verbal tasks. Overall findings of the correlational analysis indicated support for the predictive ability of the new Children's Version of the questionnaire.

Following the correlation analysis in Experiment 1, Blazhenkova, Becker, and Kozhevnikov (2011) performed a principal component analysis on the same sample. Findings of this second analysis revealed three major clusters of highly intercorrelated variables factors called factors: object, spatial, and verbal factors. In this analysis, items designed to assess object cognitive style had a strong positive relationship "loaded positively" onto the first factor, but spatial and verbal items did not. Items assessing spatial cognitive style loaded positively onto the second factor, while object and verbal items either did not load or loaded negatively on this factor. Items designed to assess verbal cognitive style loaded positively on the third factor, whereas most of the items designed to assess object or spatial imagery preference either did not load or loaded negatively on this factor. The researchers concluded that the distribution of scores for the Children's Version of this questionnaire and the relationships between the scales were nearly identical to the distribution of scores obtained from the Adult Version (Blazhenkova & Kozhevnikov, 2009).

In Experiment 2, Blazhenkova, Becker, and Kozhevnikov (2011) used a different correlational analysis to revalidate the Children's Version of the questionnaire (C-OSIVQ) on another sample of 269 participants. The participants were elementary-grade to high-school students from the same sample pool as those used in Experiment 1 but also included 47 additional children from other elementary, middle, and high schools. All participants completed the same eight visual-verbal ability tests as those used in Experiment 1 including three tests of visual-object ability constructs measured with the Vividness of Visual Imagery Questionnaire, the Degraded Pictures Test, and the Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object; three tests of visual–spatial ability constructs measured with the Mental Rotation Test, the Paper Folding Test, and the C-OSIVQ spatial; and two measures of verbal-ability constructs measured with the Arranging Word Test and the C-OSIVQ verbal. See the correlational matrix of Experiment 2 (Appendix D).

The findings of the correlation analysis in Experiment 2 were consistent with those of Experiment 1. Scores on the object scale tended to correlate with performance on the two visual–object tasks, scores on the spatial scale correlated with performance on the two visual–spatial tasks, and scores on the verbal scale correlated with performance on the verbal task. Moreover, the verbal scale was correlated with object measures.

Overall, in Experiment 1 and Experiment 2, scores on the object scale of the C-OSIVQ correlated with performance on visual-object ability measure of Vividness of Visual Imagery Questionnaire but not significantly for the visual-object ability of

Degraded Pictures Test. Scores on the spatial scale of the C-OSIVQ correlated with performance on visual–spatial tasks, and scores on the verbal scale of the C-OSIVQ correlated with performance on verbal tasks. The researchers concluded that based on overall findings of the experiments that the Children's Version of this questionnaire demonstrated high internal reliability and predictive validity and proved to be a valid instrument for extended ages.

In the Hajhashemi et al. (2018) study, the researchers use a correlational analysis, a principal component analysis, and a Mann-Whitney U test analysis to investigate the interrelationships between learners' different intelligences in relation to online video experiences, age, gender, and mode of learning on a group of 111 university students. Thirteen total measures were examined, two of which were visual-verbal cognitive-style measures: Verbal Linguistic MI and Visual MI. The remaining 11 tests were other MI measures of Overall MI, Intrapersonal, Bodily Kinesthetic, Musical Rhythmic, Interpersonal, Naturalist, Logical Mathematical, Existential, Learning Experience, Motivation, and Age.

Two survey instruments were used in this study, the McKenzie Multiple Intelligences Inventory (1984) and the Online Video Experience Inventory. Both of these instruments were administered online and were rated on a Likert-scale of 1 to 5. The McKenzie Multiple Intelligences Inventory investigated the Multiple Intelligence (MI) profile scores of participants. Results of this survey indicated that as a group, respondents were overall lower in Existential intelligence and higher on Intrapersonal intelligence. Bodily-Kinesthetic and Musical-Rhythmic intelligences were other highly developed intelligences of students. The MI profiles of respondents by age categories of pre-adulthood, early-adulthood, and middle-adulthood, revealed similar findings. All three groups of students were again lower in Existential intelligence, and students in pre-adulthood category and middle-adulthood group were higher on Intrapersonal intelligence. The Early-adulthood respondents were higher on Bodily-Kinesthetic intelligence.

The principal components analysis used a varimax orthogonal rotation method, and the analysis was applied to assess the construct validity of Online Video Experience Inventory instrument. This analysis converted the correlated variables into sets of linearly uncorrelated variables called components and investigated the number of components. Components were calculated using all of the variance of the variables. Results of Cattell's (1966) Scree Test, a line segment graph showing the fraction of total variance in the data as explained or represented by each principal component, revealed a clear break after the second component. Therefore, the researchers decided to retain these two distinct components for further investigation and labeled them "Motivation" and "Learning Experience" components. Hajhashemi et al. (2018) correlational matrix demonstrates all possible correlations for pairings of the 13 measures (Appendix E).

Once the principal component analysis results established components for the Online Video Experience Inventory instrument (OVEI), these components were then used to calculate correlations with students' MI scores and age. For this purpose, the score of the nine MI subscales initially were added together to obtain an overall MI score for participants. The overall MI score was correlated with MI subscales, Age and the two components from the OVEI called Motivation and Learning Experience. The correlation coefficient values indicated a negligible statistically significant relationship between the two subscales of Learning Experience Inventory and age of the participants. The relationship between the two variables of Learning Experience and Motivation, Learning Experience and MI scores and Learning Experience and bodily-kinesthetic and visual-spatial intelligences also had moderate correlations. Overall multiple intelligences was statistically significantly positively correlated with learning experience but not with student motivation. The final analysis was a Mann-Whitney U tests between the two genders and MI subscales. This test revealed a statistically significant difference between gender and Logical-Mathematical and Intrapersonal intelligences.

In the Sozcu (2014) study, a correlation analysis, an independent-sample *t* test, and an Analysis of Variances (ANOVA) test were used to examine relationships between cognitive styles of Field Dependent learners' attitudes toward e-learning, distance education, and other variables in learning and instructional behavior as learners experience e-learning, assessment in e-learning and competencies in Learner Interface Design within an e-learning environment on a group of 157 college freshman-undergraduate students. The researchers posed four research questions. What are the relationships between distance education learners' cognitive style of Field Dependent learners and their (a) experience or background with having e-learning program, (b) attitudes in e-learning instruction, (c) preference of testing instructional processes, and (d) their attitudes, preferences, and perceptions with Learner Interface Design features in using e-learning instruction?

Ten total measures were examined, two of which were visual-verbal cognitive-style tests: Preferred Reading Materials for printed texts in e-learning and Levels of Field Dependence-Independence as measured by the Group Embedded Figures Test. The remaining eight measures were general tests relating to e-learning including e-learning techniques, attitudes about e-learning instruction, prior distance-learning programs attended, locations for accessing distance education programs, skill level for e-learning and distance education, assessment in e-learning instruction, knowledge of e-learning instructional, and learner interface design features.

The Attitude About Distant Learning survey used to assess students' preference toward e-learning instruction with distance education was based on a 5-point Likert scale was used, and a Group Embedded Figures Test, a perceptual test that requires the person to locate a previously seen figure within a larger complex figure was used to identify participants' cognitive-style levels as Field Independent, Field Neutral, or Field Dependent (Dwyer & Moore, 1991, 1992, 1994; Ipek, 1995, 2011). Based on the survey responses, six tables provided the demographic information such as gender, age, and educational level or provided items of the survey test questions with frequency, percentage, mean, and standard deviations. The survey responses indicated that 29.3% of participants had experience or background with having e-learning program, 40.4% of the participants' attitudes in e-learning instruction was moderate. In response to preference of testing instructional processes, 43.9% of participants were happy to take distant education. Sozcu (2014) correlational matrix is displayed in Appendix F.

The correlational analysis revealed there were some statistically meaningful relationships between the variables. For example, correlation coefficients indicated how much attitudes were related to former knowledge for e-learning and learner interface design (LID) features (r=.39, and r=.47). Overall findings indicated that technological, motivational, and instructional-learning variables in Learner Interface Design for e-learning instruction were correlated with students' learning outcomes, attitudes, perceptions, and preferences in Learner Interface Design and attitudes toward e-learning instruction. Students' cognitive style of field dependence was correlated with their attitudes and preferences for students' roles in e-learning for distance education. The researchers concluded that although there were not high-level correlations between cognitive styles of Field Dependence and Learner Interface Design variables, and between Field Independent learners' preferred e-learning technologies and learner interface design characteristics.

Studies examining a single domain of learning preference

In the group of 11 studies that examined a single domain, the five studies that examined a single domain of learning preferences were Andrusyszyn, Cragg, and Humbert (2001); Leite, Svinicki, and Shi (2010); Vahid Baghban (2012); Wintergerst, DeCapua, and Itzen (2001); and Yang and Kim (2011). In the first learning preference study analyzing a single domain of learning preferences, Andrusyszyn et al. (2001) used a correlational analysis, paired comparisons, and an ANOVA to investigate how learning styles correlate with achievement by examining relationships among various distance-delivery methods, preferred learning style, content, and achievement for primary-care nurse-practitioner students. Participants originally consisted of 125 university students enrolled in one or all five courses of the Primary Health Care Nurse Practitioners (PHCNP) program, but the final sample had 86 participants. The researchers used a correlational design with bipolar and paired comparisons to examine constructs of relationships among learning preference, choices among various distance-delivery methods, and academic achievement.

Twelve total test measures were examined, two of which were visual-verbal measures: one visual-verbal measure was a visual construct of Prefer to Learn by Observing and the other one was a verbal construct measure of Prefer Learning by Hearing. The remaining 10 measures were other preference measures including Prefer to Learn New Things on my Own Rather Than With Others, Prefer to Learn in Groups Having 15 or Less People, Prefer to Learn in Larger Groups of 16 or More, Prefer to Learn by Considering the Big Picture versus by Focusing on the Details, Prefer to Learn by Having a Learning Plan Set for Me versus by Setting My Own Learning Plan, Prefer to Learn by Focusing on Theoretical Concepts versus by Focusing on Concrete Examples, Prefer Learning by Reading, Prefer to Learn by Discussing, Prefer to Learn by Doing, and Prefer to Learn by Reflecting. These measures were scored by a 5-point-rating scale questionnaire developed by the researcher.

Each of the bipolar learning-preference items was evaluated on a 5-point scale. A series of two-tailed *t* tests were conducted to compare the observed mean rating for these bipolar items against an "expected" mean rating. Paired comparison items were used to obtain additional measures of learning preferences involving two or more constructs. Estimates of preferred learning group style were investigated using paired comparisons between three possible preferences. Finally, correlations were examined between the 12 learning preference items.

Andrusyszyn et al.'s (2001) correlational matrix demonstrates all possible correlations for pairings of the 12 measures (Appendix G). Participants rated each of seven delivery methods according to how desirable they perceived each method for a specific program content area. Students made choices based on how they preferred to learn relative to on a combination of life circumstances. A repeated measures ANOVA was calculated on the mean ratings for each content area with preferences for distance methods. A correlation matrix analyzed relations between learning preference items and choice of distance method collapsed across content areas. Several positive associations were found: The most preferred method was print-based material, and the least preferred method was audiotape. The most suited method for content included video teleconferencing for counseling, political action, and transcultural issues; and videotape for physical assessment.

In the second study analyzing a single domain of learning preferences, Leite et al. (2010) was one of the two studies from the learning-preference group that evaluated the reliability and validity of an existing learning-style instrument. Specifically, this study examined the Visual-Aural-Read-Kinesthetic (VARK) learning-style-inventory instrument (Fleming 2001; Fleming & Mills, 1992), an instrument that examines the four sensory modalities used for obtaining information. The researchers used a correlational analysis and a multitrait–multimethod confirmatory factor analysis to investigate whether the scores of the VARK learning style inventory support the four-factor structure of the scale hypothesized by its researcher. Two research questions were asked: Does the four-factor hypothesized structure of the VARK scale adequately explain the relationships between the observed scores on the VARK items? Can adequate reliability estimates be obtained for the VARK scores?

Participants included 14,211 US students of all ages who had taken the VARK learning-style-inventory test for the first time. Scores of measures to evaluate the dimensionality of the VARK's four measures of Visual, Aural, Read-Write, and

Kinesthetic were obtained from an online test consisting of 16 multiple-choice questions. Because the VARK is viewed as a questionnaire composed of 16 testlets of 4 dichotomous items each (Leite, Svinicki, & Shi, 2010), the correlations between items caused by their grouping in the same testlet are a type of method effect, and a MTMM-CFA can be used to model method effects as the researchers have done in this study.

Four total measures were examined, two of which were visual-verbal constructs of Visual and Aura. The remaining two tests were other measures of Read-Write, and Kinesthetic. All measures were derived from Fleming's Visual-Aural-Read-Kinesthetic learning-style-inventory instrument (2001). Moreover, the researchers applied Campbell and Fiske's (1959) four multitrait–multimethod confirmatory factor analysis models consisting of four types of methods: the Correlated-Trait-Correlated-Method, the Correlated-Traits-Correlated-Uniqueness, the Correlated-Trait-Uncorrelated-Methods, and the Correlated-Traits-Correlated Methods-Minus-One. Leite, Svinicki, and Shi's (2010) correlational matrix demonstrates all possible correlations for pairings of the four measures (Appendix H).

Results of the study showed preliminary support for the validity of the VARK scores. Of the four measures examined, the Correlated-Trait-Correlated-Method model had the best fit to the VARK scores. The researchers also investigated that a four-factor Correlated-Trait-Correlated-Uniqueness model fits the observed data and that there were adequate reliability estimates of the scores of the VARK (Fleming 2001; Fleming & Mills, 1992).

In the next study, analyzing a single domain of learning preferences, Vahid Baghban (2012) who examined nine total measures, two of which were visual-verbal constructs of Visual and Auditory. The remaining seven were other measures including Kinetic, Memory, Cognitive, Compensation, Metacognitive, Affective, and Social. This study's research was performed on 120 female Iranian college students studying English. The original sample consisted of 200 students but was reduced when unqualified participants were removed. Several instruments of measure were employed, including Michigan State University English Language Exam, Learning Styles Inventory (LSI) Reid's (1984) questionnaire, the Strategy Inventory for Language Learning (SILL) – which is also referred to as the Language Learning Style (LLS) questionnaire.

The researcher used three analyses, a one-way ANOVA, a correlation analysis, and a factor analysis to examine whether any significant correlational relationship existed between Iranian learners' learning style preferences in learning a language using visual, auditory, and kinetic learning as proposed by Reid (1984) and the preferred strategies used by the learners for specific language-learning strategies based on Oxford (1990) which included memory, cognitive, compensation, metacognitive, affective, and social). The one-way ANOVA (ANOVALLIS by SIL) was conducted to investigate the effect of styles on strategy uses. The correlation analysis was used to analyze the nine measures and a factor analysis applying a varimax rotation method was used to investigate the underlying constructs of the components of LSI and LLS questionnaires. Measures of these analyses included the Michigan State University Exam, the Learning Styles Inventory questionnaire which evaluated preference for studying in options of either a group, an individual, or in a visual, auditory, and tactile-kinesthetic situation, and the Language Learning Strategies questionnaire to evaluate strategy for learning such as memory strategy, cognitive strategy, comprehension strategy, meta-comprehensive strategy, affective strategy, and social strategy. Vahid Baghban's (2012) correlational matrix demonstrates all possible correlations for pairings of the nine measures (Appendix I).

Results of the ANOVA analysis revealed that learners who scored higher on the Strategy Inventory for Language Learning (SILL) test performed better on the Language Learning Strategies (LLS). Results of this analysis also indicated that cognitive, metacognitive, and most of all affective strategies related to emotions showed a significant correlation with the auditory style of learning. Findings of the correlational analysis indicated that metacognitive and most of all memory and social strategies showed a significant correlation with the kinesthetic style. Visual learning style did not show any correlation with the other factors. Similar to the results of the correlational analysis, loadings on the factor analysis revealed four sections of the Language Learning Strategies (social, compensation, metacognitive, and memory) as loading on the first factor together with the kinesthetic section of the Learning Styles Inventory. The affective and the cognitive sections of the Language Learning Strategies (LLS) together with the auditory section of the Learning Styles Inventory (LSI) loaded on the second factor.

Findings of the factor analysis also revealed that except for the first four factors that belonged to the Language Learning Strategies (LLS), the other factors belonged to Learning Styles Inventory (LSI) and Michigan State University English Language Exam and did have stable underlying constructs. This distribution transpired because four sections of the language learning strategies loaded on the first factor, including social, compensatory, metacognitive and memory, whereas affective and cognitive loaded on the second factor, and three sections of the learning styles loaded on three different factors. That is, kinesthetic on the first, auditory on the second, and the visual on the third factors. Factor analysis outcomes revealed that cognitive, metacognitive, and most of the affective strategies related to emotion indicated a strong correlation with the auditory style of learning. Moreover, metacognitive and most memory and social strategies indicated a strong correlation with the kinesthetic style. Visual learning style did not show any correlation with the other factors.

In the fourth study analyzing a single domain of learning styles, the Wintergerst, DeCapua, and Itzen (2001) study was another study that evaluated the reliability and validity of an existing learning-style instrument, examining Reid's (1984) Perceptual Learning Style Preference Questionnaire (PLSPQ). The researchers used a correlational analysis and an exploratory factor analysis with both a varimax and an oblimin rotation method to examine 100 English-as-a-Second-Language (ESL) university students and the relationship that exists between the learning styles identified in the PLSPQ and the language background of these participants. Reid's (1984) six learning style scales consist of visual-scale items, auditory-scale items, kinesthetic-scale items, tactile-scale items, group-scale items, and individual-scale items.

In this study, the item–total correlations were examined for the items in all scales. Correlations for items in the Kinesthetic and Group scales were within acceptable ranges (.30 or greater). Although the Individual scale had a good overall reliability (.75), the item-total correlation for Q27 (.28) was lower. Analyses indicated that if this item were deleted from the scale, the scale alpha would improve to .78. In the Visual scale, Q6 was found to have a low item–total correlation (.0022) and further analyses indicated that if this item were deleted, the scale reliability would reach more acceptable levels (.63). Similarly, Q11 in the Tactile scale was found to have a low item–total correlation (.20). Deletion of this item would increase the reliability of this scale to .62. Four (Q7, Q9, Q17, and Q20) of the five items in the Auditory scale were found to have item-total correlations lower than 0.30. Further analysis revealed that a maximum alpha of .56 could be obtained by deleting Q9 and Q17.

The validity of the hypothesized factor structure of the PLSPQ was examined through 10 factor measures with an exploratory factor analysis using the SPSS software Version 8.0 for Windows. In the rotated factor matrix of Reid’s survey there were ten factors, two of which were visual-verbal factors: Factor 3 which consisted of two visual items (Q12 and Q10) and Factor 4 which consisted of three auditory items (Q7, Q1, and Q20). The remaining eight factors were other measures included Factor 1, 2, 5, 6, 7, 8, 9, and 10.

The first factor consisted of five Group items. The second factor consisted of four Individual items and two Visual items. The third factor was made up of two items, Item Q12 and Q10 (Visual items referring to reading instructions). Factor 4 consisted of three auditory items (Q7, Q1, and Q20). Factors 5 to 9 consisted of items from different learning style scales that were not always found to be conceptually compatible. For example, Factor 10 included only one item, Q19, and Q6 did not load on any factor. Wintergerst, DeCapua, and Itzen’s (2001) correlational matrix demonstrates all possible correlations for pairings of the nine measures (Appendix J).

Results of the factor analysis’ varimax and oblimin rotations were reviewed. Results of the interfactor correlation matrix revealed only four correlations of .25 or greater suggesting that a varimax rotation would appropriately represent the underlying factor structure. The 30 items in the survey did not clearly load on Reid’s six hypothesized learning styles as expected. Results indicated that specific survey items did not necessarily group into factors conceptually compatible with Reid's learning style model.

In the fifth study analyzing a single domain of learning preferences, Yang and Kim (2011) used a correlational analysis, regression analysis, and ANOVA to explore relationships among perceptual learning styles, Ideal-Second-Language-Learning (L2) self, and Motivated L2 behavior of 330 high-school students from four countries: China (*n*=100), Japan (*n*=70), South Korea (*n*=104), and Sweden (*n*=56). The study sought to answer three research questions: Which of the three perceptual learning styles of visual, auditory, and kinesthetic is most closely related to the learners’ Ideal L2 self? From the perspective of the L2 Motivational self-system, are there any differences among the four participating countries? To what extent can the Motivated L2 behavior of learners in the four countries be explained by their perceptual learning styles, imagination, and Ideal L2 self?

Twenty total measures were examined, eight of these were visual-verbal measures including four visual constructs and four auditory constructs. The remaining 12 measures were other measures of four kinesthetic measures, four Ideal L2 Self measures, and four Motivated L2 behavior measures. This study used a modified and expanded version of Kim's (2009) Perceptual Learning Style and L2 Motivation Questionnaire. The questionnaire contains questions relating to perceptual learning styles, such as the preferred perceptual channel when studying and questions relating to imagination ability relative to L2 learning and to the learners' Ideal L2 self, such as how students perceive themselves and to perceived degree of motivated L2 behavior, such as how committed they are to study English.

To evaluate the study's constructs of perceptual learning style and Second Language Learning (L2), the researchers performed a series of statistical tests. These tests included a descriptive analysis to collect basic information on each country's perceptual learning styles and motivated behavior, a correlation analysis to identify statistically significant relationships between the three subtypes of learning styles and other motivational constructs, an ANOVA with the Scheffé test to investigate statistically significant differences in the Ideal L2 self and Motivated L2 behavior among the four countries, and a stepwise regression analysis was used to identify the predictors of the students' Motivated L2 behavior. To evaluate which of the three perceptual learning styles most closely related to the learner's Ideal L2 self, the results of correlations between the variables revealed that the visual learning style was statistically significantly related to the Ideal L2 self and Motivated L2 behavior for all four countries. To evaluate differences among the four participating countries based on perspective of the L2 Motivational self-system, results of the ANOVA indicated that although the Chinese students were more likely to show Motivated L2 behavior than the other students, Chinese students showed statistically significant lower levels of the Ideal L2 self than the Swedish students. Yang and Kim's (2011) correlational matrix demonstrates all possible correlations for pairings of the 20 measures (Appendix K).

The researchers performed the correctional analysis and a sidewise regression analysis to investigate the extent that learners' Motivated L2 behavior in the four countries was explained by their perceptual learning styles, imagination, and Ideal L2 self. The correlation matrix contained five measures for each of the four countries: visual, auditory, kinesthetic, Ideal L2 self, and Motivated L2 behavior. Measures were questionnaires relating to perceptual learning styles, such as the preferred perceptual channel when studying and questions relating to imagination ability relative to L2 learning and to the learners' Ideal L2 self as to how students perceive themselves and to perceived degree of Motivated L2 behavior as to how committed they are to study English.

Results of the correlation analysis indicated that the learners' perceptual learning styles of visual, auditory, and kinesthetic styles were significantly correlated with the other two constructs of Ideal L2 self and Motivated L2 behavior. In contrast, the results of the stepwise regression indicated that none of three perceptual learning styles were meaningful predictors of Motivated L2 behavior. Instead, only ideal L2 self was found to be meaningful predictor of their Motivated L2 behavior, and, the ideal L2 self was the most powerful predictor of motivated L2 behavior for the Swedish students.

Studies Examining Two Domains

There are two types of studies examined in the two-domain group: studies of the two domains of abilities and cognitive styles; and studies of the two domains of abilities and learning preferences.

Studies examining the two domains of abilities and cognitive styles

The six total studies that examined two domains consisted of two types of pairings. One pairing was studies that examined the two domains of abilities and cognitive styles, and included three studies: Federico and Landis (1979), Federico and

Landis (1984), and Nah and Lane (1990). The second pairing was studies that examined the two domains of abilities and learning preferences and included three studies: Danisman and Erginer (2017), Haciomeroglu (2015), and Rogowsky et al. (2015). The defining characteristics of the six studies using a two domain, Group B, can be found in Table 3.

Table 3
Summary of Studies Examining Two Domains, Group B

Domains Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Federico and Landis (1979)	
Abilities and Cognitive Styles	207 participants College-age students	Correlational analysis and a Stepwise discriminant analysis	Twenty-four total measures were examined, two were visual-verbal measures: • One visual-verbal measure was a cognitive ability measures of verbal comprehension • The other visual-verbal measure was a cognitive aptitude measure of space perception Remaining 22 tests were other measures • Six of which were cognitive style measures of field-independence or field-dependence, conceptualizing style, reflectiveness-impulsivity, tolerance of ambiguity, category width, and cognitive complexity • Five of which were cognitive ability measures of general reasoning, associational fluency, logical reasoning, induction, and ideational fluency • Eleven were cognitive aptitude measures of general information, numerical operations, attention to detail, word knowledge, arithmetic reasoning, mathematics knowledge, electronics information, mechanical comprehension, general science, shop information, and automotive information

Table 3 continues

Table 3 Continued

Domains Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Federico and Landis (1984)	
Abilities and Cognitive Styles	201 participants College-age students	Correlational analysis, Canonical analyses, and Principal-factor analysis with a varimax rotation	The same 24 total measures were examined as in Federico and Landis (1979), two of these were visual-verbal constructs: • One visual-verbal measures was a cognitive ability construct of verbal comprehension • One visual-verbal measure was a cognitive aptitude construct of space perception Remaining 22 tests were other measures • Six of which were cognitive style measures of field-independence or field-dependence, conceptualizing style, reflectiveness-impulsivity, tolerance of ambiguity, category width, and cognitive complexity • Five of which were cognitive ability measures of general reasoning, associational fluency, logical reasoning, induction, and ideational fluency • Eleven were cognitive aptitude tests of general information, numerical operations, attention to detail, word knowledge, arithmetic reasoning, mathematics knowledge, electronics information, mechanical comprehension, general science, shop information, and automotive information.
		Nah and Lane (1990)	
Abilities and Cognitive Styles	390 participants High-school students	Correlational analysis, Canonical correlation analysis, and Regression analysis	Twelve total measures were examined, five of which were visual-verbal cognitive style or ability constructs: Three were visual-verbal measures of spatial ability • Group Embedded Figures test • Analytic ability to identify simple figures hidden in complex field • Spatial ability to identify geometric shapes and mentally rotate objects Two were visual-verbal measures of visual ability • Discrimination ability to visualize important elements of a task • Categorization ability to choose verbal sentences from verbally stated problems Remaining seven tests were other measures including • Sequential Processing ability, Memory ability, Korean language, Mathematics, English, Social Studies, and Science
		Danisman and Erginer (2017)	
Ability and learning preference	97 participants Elementary-school students	Correlational analysis and Regression analysis	Six total measures were examined, three were visual-verbal measures: One visual-verbal measure was • Spatial Ability Test (SAT) Two visual-verbal measures were Test on Learning Styles (TLS) • Visual • Auditory Remaining three tests were other measures of Mathematical Reasoning Test (MET), Kinesthetic, and Reading

Table 3 continues

Table 3 Continued

Domains Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Haciomeroglu (2015)	
Ability and learning preference	150 participants High-school students	Correlational analysis, factor analysis, and regression analysis	Twelve total measures were examined, seven were visual-verbal measures: Four of the visual-verbal measures were spatial constructs • Cube Comparisons Test • Card Rotations test • Form Board Test • Paper Folding Test Three of the visual-verbal measures were visual constructs • Visual preference for graphic calculus tasks • Visual preference for algebraic calculus task • Visual preference for algebra tasks on the Mathematical Processing Instrument The remaining five tests were other measures of Advanced Placement Calculus exam score, mathematical performance on graphic calculus tasks, mathematical performance on algebraic calculus tasks, Nonsense Syllogisms Test, and Diagramming Relationships Test
		Rogowsky, Calhoun, and Tallal (2015)	
Ability and learning preference	121 participants College students	Correlational analysis, ANOVA analysis, and regression equation	Six total measures were examined, three of which were visual-verbal: • BE Auditory learning style • BE Visual learning style • Difference between BE Auditory and Visual learning styles Remaining three tests were other measures of Listening and Reading aptitude, and Difference between Listening and Reading aptitude

The three studies that examined the two domains of ability and cognitive styles were Federico and Landis (1979), Federico and Landis (1984), and Nah and Lane (1990). The Federico and Landis (1979) sought to identify cognitive characteristics that differentiate successful from unsuccessful graduates by trying to investigate if students who did not graduate and graduates significantly differed on scores of cognitive styles, or on scores of cognitive abilities or on scores of cognitive aptitudes. The sample consisted of 207 high school through college age Navy preparatory-school trainee students who had completed the Basic Electricity and Electronics training school. Of this group, 172 were graduates and 35 were students who did not graduate.

Twenty-four total measures were examined, two of which were visual-verbal measures: one a cognitive ability measures of verbal comprehension and the other one a cognitive aptitude measure of space perception. The remaining 22 tests were other measures: six of which were cognitive-style measures of field-independence versus field-dependence, conceptualizing style, reflectiveness-impulsivity, tolerance of ambiguity, category width, and cognitive complexity; five of which were cognitive ability measures of general reasoning, associational fluency, logical reasoning, induction, and ideational fluency; and eleven of which were cognitive aptitude tests including general information, numerical operations, attention to detail, word knowledge, arithmetic reasoning, mathematics knowledge, electronics information, mechanical comprehension, general science, shop information, and automotive information.

Before trainees began the Basic Electricity and Electronics training school, they were administered six tests of cognitive styles and six tests of cognitive abilities. The 12 measures of cognitive aptitude were obtained from the Armed Service Vocational Aptitude Battery subtests. These measures were analyzed with a stepwise discriminant analysis and a correlation analysis. The measures were scored with timed tests, multiple choice questions, sorting exercises, true or false statements, agree or disagree, estimating values, verbal ability, arithmetic problems, and mental rotations exercises but also included scoring measures for items related to electronics specific or science questions. The correlational matrix of Federico and Landis' (1979) demonstrates all possible correlations for pairings of the 24 measures (Appendix L).

Findings of seven stepwise discriminant analyses revealed that except for field-independence, cognitive-style measures appeared to be generally independent of the others. Ability and aptitude measures appeared to be related. Relations of the correlational analysis indicated that Basic Electricity and Electronics graduates significantly differ in certain cognitive characteristics. Scores of the cognitive-style measures revealed that graduates tended to have field-independent processing styles or have narrow conceptualization styles, that is, they were more analytical and inclined to distinguish objects or figures from their contexts in a differentiated manner. In contrast, the Basic Electricity and Electronics training school students who did not graduate were more field-dependent, having a more global processing style and being inclined to perceive objects or figures embedded in their contexts in an undifferentiated manner. Scores of ability measures revealed that graduates performed better in verbal comprehension, ideational fluency, as well as in general and inductive reasoning than those who did not graduate. Scores of aptitudes measures revealed that graduates performed better than those who did not graduate in quantitative, technical, verbal, or general aptitudes than those who did not graduate. Moreover, graduates performed better on tests measuring skills in numerical operations, arithmetic reasoning, mathematical knowledge, electrical knowledge, mechanical comprehension, and general science.

In the second study using two domains, Federico and Landis (1984) and administered the same 24 test measures as those in their former, 1979 study to another sample group of 201 high school through college-age Navy recruits to investigate whether cognitive styles, abilities, and aptitudes provide complementary or redundant information. Two of the 24 measures examined visual-verbal constructs: one was a cognitive ability measure of verbal comprehension and the other one was a cognitive aptitude measure of space perception. The remaining 22 tests were other measures: six of which were cognitive-style measures of field-independence or field-dependence, conceptualizing style, reflectiveness-impulsivity, tolerance of ambiguity, category width, and cognitive complexity; five of which were cognitive ability measures of general reasoning, associational fluency, logical reasoning, induction, and ideational fluency; and eleven of which were cognitive aptitude tests of general information, numerical operations, attention to detail, word knowledge, arithmetic reasoning, mathematics knowledge, electronics information, mechanical comprehension, general science, shop information, and automotive information. The Federico and Landis's (1984) correlational matrix is found in Appendix M.

Relationships among all cognitive attributes and between sets of styles and abilities as well as styles and aptitudes were computed with a correlational analysis, two canonical analyses, and a principal factor analysis with varimax rotation. Results of the correlational analysis for measures of cognitive styles, abilities, and aptitudes revealed that all cognitive styles except reflection-impulsivity were significantly related to abilities or aptitudes. These small but statistically significant correlations revealed that many of the cognitive styles are associated with abilities and aptitudes that are involved in general problem solving. Moreover, Field independence had higher correlations with abilities and aptitudes than any other cognitive style.

Using the percentage of variance to investigate the amount of variance that factors explained in the principal-factor analysis, the researchers extracted three significant factors which underlie most of the variability of cognitive characteristics: technical aptitude, verbal ability, and general problem solving. Findings of the varimax solution suggested that some styles were related to aspects of general problem solving. For example, cognitive-style measures of field independence and reflection-impulsivity substantially contributed to the general problem-solving factor but not the technical aptitude or verbal ability factor of the varimax solution. The other members of this problem-solving component were inductive ability and mathematics aptitude. Overall findings of the various analyses established: (a) the relative dependence of most cognitive styles with abilities and aptitudes inherent to general problem solving and (b) the relative independence of some cognitive styles from technical aptitude and verbal ability dimensions.

The third study in the cognitive-style group that examined two domains was Nah and Lane (1990). The researchers administered a multidimensional measure of cognitive style as well as achievement tests measuring academic areas of Korean language, mathematics, English, social studies, and science to a sample of 390 ninth-grade Korean students. The researchers used a correlational analysis, a canonical-correlation analysis, and a regression analysis to examine 12 total measures. Five of the total measures were visual-verbal cognitive style or ability constructs. These included three tests of spatial ability: Group Embedded Figures test, Analytic Skill test to evaluate ability identify figures hidden in complex field, and Spatial Skill test to evaluate ability to identify geometric shapes and mentally rotate objects; one measure a test of visual ability, the Discrimination Skill test used to evaluate ability to visualize important elements of a task; and one test of verbal ability, the Categorization Skill to evaluate ability to choose verbal sentences from verbally stated problems. The remaining seven tests were other ability measures including Sequential Processing Skill, Memory Skill, Korean Language, Mathematics, English, Social Studies, and Science.

Several instruments were used to obtain the 12 measures. Initially the Learning Style Profile (LSP) by National Association of Secondary School Principals was used to measure the preference characteristics of individual learning styles by examining four higher order factors: cognitive styles, perceptual responses, study preferences, and instructional preferences. Second, the Group Embedded Figures Test developed by Oltman, Raskin, and Witkin (1971) where individuals taking the test are asked to locate a small, previously viewed figure in a larger, more complex picture. Third, a Kyohaksa achievement test (November 1988 version) was administered to obtain achievement scores of participants' proficiency in Korean and English languages, social studies, and science. The correlational matrix of Nah and Lane (1990) demonstrates all possible correlations for pairings of the 12 measures (Appendix N).

To investigate if the field dependent or field independent, analytic, and spatial styles were statistically significantly related with the academic achievement, a canonical correlation analysis examined relations between the set of cognitive scales to the set of achievement scales. Results of the analysis revealed a statistically significant relationship between cognitive style and achievement. Three analytic-type cognitive scales loaded heavily in the relationship; three relevant patterns were seen in the correlations. First, the examination of both the standardized canonical coefficients and the canonical variate-variables correlations implicated that among the cognitive scales, only the Group Embedded Figures measure, the analytic skill measure, and spatial skill measure were moderately intercorrelated, and these three measures accounted for the composition of the cognitive variate. The cognitive variate is primarily a combination of three measures. Moreover, results indicated a pattern of moderate correlations among the achievement variables and the Group Embedded Figures, analytic skill, and spatial skill. Finally, the researchers found that the five achievement scales that defined the nature of the achievement variate had substantial overlap. The achievement scales were all highly intercorrelated.

To investigate if multidimensional measures of cognitive styles were statistically significantly related to or predict performance in academic areas of Korean language, mathematics, English, social studies, and science, the relationships were examined with a multiple-regression analysis. Due to the high correlations among achievement scales, the researchers used the highest correlation with the achievement variate. The results of the multiple regression analysis noted that 37% of the variance in Korean language is common to the cognitive scales. After analytic ability, spatial ability, and the Group Embedded Figures were entered into the equation, the remaining four cognitive skills failed to add statistically significantly to the prediction of the Korean language scores. The three cognitive styles of field dependent or independent, analytic, spatial explained most of the variance in the achievement scores of Korean language, mathematics, English, social studies, and science, respectively. The researchers concluded that Field Independent students perform significantly better in mathematics, sciences, and engineering. The Field Dependent or Independent, analytic, and spatial styles appear highly related with academic achievement.

Studies examining the two domains of abilities and learning preferences

The three studies examining two domains of ability and learning preferences and are summarized in Appendix B. The three studies that examined the two domains of ability and learning preferences included Danisman and Erginer (2017); Haciomeroglu

(2015); and Rogowsky, Calhoun, and Tallal (2015). The Danisman and Erginer (2017) who investigated 97 fifth graders' mathematical reasoning and spatial ability to identify the predictive power of learning styles on mathematical learning profiles. The researchers used a correlational analysis and a regression analysis to investigate how scores for learning styles correlate with scores for mathematical learning profiles and to what extent scores for learning styles predict scores for mathematical learning profiles.

Six total measures were examined, three of these were visual-verbal measures including one dependent variable of Spatial Ability Test, and two independent variables of Test on Learning Styles with both a visual and an auditory test. The remaining three tests were other measures of Mathematical Reasoning Test (MET), Kinesthetic, and Reading. Data were collected using three instruments: Erginer's (2002) Test on Learning Styles, Danişman's (2011) Mathematical Reasoning Test, and Danişman's Spatial Ability Test (2011). Statistical analyses were carried out using SPSS. Measures were scored with test of recall, memory retention, and multiple-choice questions. The correlational matrix of Danisman and Erginer (2017) demonstrates all possible correlations for pairings of the six measures (Appendix O).

The correlations between mathematical learning profiles and learning styles were identified, and the predictive power of the learning styles on the mathematical learning profiles was calculated using a multiple linear regression analysis. First the researchers examined the combined view of the students' scores for learning styles and mathematical learning profiles, and then they examined correlations between these same scores and the correlation coefficients among the main variables of the study. Findings of the combined view on a plane indicated that the highest mean score was spatial ability followed by visual learning, reasoning, kinesthetic learning, reading-learning, and auditory learning. Results suggested that students were predominantly visual and kinesthetic learners rather than auditory.

In turn, findings of correlations between the students' scores for learning styles and mathematical learning profiles and the correlation coefficients among the main variables of the study indicated that there was a moderate, positive, and significant correlation between scores for mathematical reasoning and spatial ability. The determination coefficient suggested that the scores for mathematical reasoning and spatial ability accounted for 18% of the variance. The highest bivariate correlation was between visual learning and reading learning. There was not any significant correlation between reading learning, and spatial ability or between auditory learning and reasoning.

Following the correlation analysis, the researchers used a multiple-regression analysis to examine the extent that scores for learning styles predict scores for mathematical learning profiles. According to the standardized regression coefficient, the predictive variables that influenced spatial ability were defined in order of importance as visual, kinesthetic, combined, reading, and auditory learning. According to the results of the test of statistical significance for regression coefficients, only visual learning was a significant predictor of mathematical reasoning. Danisman and Erginer (2017) concluded that learning styles do affect mathematical reasoning and spatial ability.

The Haciomeroglu (2015) study investigated if calculus tasks could be used to investigate preferences for visual or analytic processing, and if the resulting preferences could be used to examine relationship to calculus performance, to spatial, and to verbal-logical reasoning ability on 150 high-school students. Three analyses were applied a correlational analysis, exploratory factor analysis, and multiple regressions. The correlational analysis examined 12 total measures, seven of which were visual-verbal measures: four of the visual-verbal measures were spatial constructs including Ekstrom, French, and Harman's (1976) Cube Comparisons Test (CC), Card Rotations test (CR), Form Board Test (FB), and Paper Folding Test (PF); three of the visual-verbal measures were visual constructs of Visual Preference for Graphic Calculus tasks (VPG), Visual Preference for Algebraic Calculus task (VPA), and Visual Preference for Algebra tasks on the Mathematical Processing Instrument (MPI; Suwarsono, 1982). The remaining five were other measures of Advanced Placement Calculus (AP) exam score that was collected from teachers at the end of the study, two tests of calculus performance assessed by the derivative and antiderivative tests presented graphically and algebraically that yielded two scores labeled Mathematical Performance on Graphic calculus tasks (PGraphic) and Mathematical Performance on Algebraic calculus tasks (P Algebraic), and two tests by Ekstrom et al. (1976): Nonsense Syllogisms Test (NS) and Diagramming Relationships Test DR. The correlational matrix of Haciomeroglu (2015) demonstrates all possible correlations for pairings of the 12 measures (Appendix P).

The method of scoring measures included questionnaires, tests of algebra or calculus ability, two- and three-dimensional mental rotation test, and reasoning ability test. Measures were scored with response options, a choice of method, and a correct or incorrect response. The researcher first investigated students' preferences for visual or analytic processing with a derivative and an antiderivative task. After making this assessment, preference measures were analyzed with a correlational analysis. Results of the correlational analysis revealed statistically significant correlations between the two visual preference measures of Visual Preference for Graphic Calculus tasks and Visual Preference for Algebraic Calculus task and the three calculus performance measures of Advanced Placement Calculus exam score, Mathematical Performance on Graphic calculus tasks, and Mathematical Performance on Algebraic calculus tasks. The visual preference measure of Visual Preference for Algebra tasks on the Mathematical Processing Instrument did not correlate and had nonsignificant negative correlations with the three calculus performance measures.

The correlations between the three measures of visual preference and the measures of spatial ability and verbal-logical reasoning ability were either negative or nonstatistically significantly low. The researcher implicated that this lack of relationship suggested cognitive abilities may not predict students' preference for visual or analytic processing, and vice versa. Overall correlational results reveal that unlike the measures of spatial visualization ability of Form Board Test and Paper Folding Test and verbal-logical reasoning ability of Nonsense Syllogisms Test, and Diagramming Relationships Test, spatial orientation ability of Cube Comparisons Test, Card Rotations test did not correlate with and seems to be unrelated to calculus performance although visualizing mathematical objects from different perspectives is crucial to understanding calculus. Other significant correlations were correlations between spatial orientation ability measure of Cube Comparisons Test and the performance measure of Mathematical Performance on Graphic calculus tasks and Form Board's significant correlation with Performance on Algebraic tasks. Moreover, there were statistically significant correlations between the three measures of calculus performance: Advanced Placement Calculus exam, Mathematical Performance on Graphic calculus tasks, and Mathematical

Performance on Algebraic calculus tasks and correlations between Spatial Orientation ability measures Cube Comparisons Test and Card Rotations test and the verbal logical measures Nonsense Syllogisms Test and Diagramming Relationships were statistically significant.

Findings of the exploratory factor analysis on the 12 variables using the varimax rotation produced four factors with eigenvalues greater than one. Eleven of the 12 variables loaded onto four factors: spatial ability explaining 14% of the variance, calculus performance explaining 12% of the variance, verbal-logical reasoning ability explaining 9% of the variance, and preferred mode of processing explaining another 9% of the variance. The performance measures of mathematical Performance on Graphic calculus tasks also loaded heavily on the fourth factor. The visual preference measures of Mathematical Processing Instrument did not load on any of the four factors and did not correlate statistically significantly with any measure. The researchers noted that the Mathematical Processing Instrument test applied in this study was a modified version of the Mathematical Processing Instrument (MPI; Suwarsono, 1982). The original MPI test consists of 30 algebra problems, but only eight problems were used due to time constraints, and this might be the reason for low reliability and the lack of correlations in this study.

Findings of the multiple regression analysis revealed that spatial visualization ability, verbal-logical reasoning ability, preference for visual processing contributed statistically significantly to the variance in calculus performance. The scores on the tests of spatial orientation ability, spatial visualization ability, and verbal-logical reasoning ability were scaled and averaged to create three composite scores for each student:

composite Spatial Orientation ability score made up of Comparisons Test and Card Rotations test; composite Spatial Visualization ability score made up of Form Board Test and Paper Folding Test; and composite Verbal-Logical Reasoning ability score made up of Nonsense Syllogisms Test and Diagramming Relationships. Moreover, a standard multiple regression was performed between Advanced Placement calculus exam scores as the dependent variable and spatial orientation ability, Spatial Visualization ability, Verbal-Logical Reasoning ability, Visual Preference for Graphical calculus tasks, and Visual Preference for Algebraic calculus tasks as independent variables. The five predictor variables contributed to 25.3% of the variance in Advanced Placement calculus exam. A stepwise multiple regression analysis was also performed, when Advanced Placement calculus exam was regressed on the same variables, composite Verbal-Logical Reasoning ability score, composite Spatial Visualization ability score, and Visual Preference for Graphical Calculus tasks would enter the equation again. The predictor variables explained more than a fourth of the variance in Advanced Placement calculus exam scores.

The Rogowsky, Calhoun, and Tallal (2015) study examined the extent to which verbal comprehension is influenced by the modality of auditory measured by digital audio or visual measured with e-text input of 121 college participants. Specifically, the researchers sought to investigate the extent to which auditory and visual learning style preferences predict or equate to learning aptitudes of listening comprehension or reading comprehension and the extent to which learning style preferences or learning aptitudes predict how much an individual comprehends and retains information based on mode of instruction of audiobook or e-text.

A correlational analysis and an ANOVA analysis, and a regression equation were used to examine measures were based on scores obtained from an online standardized learning preference evaluation using the adult version of Dunn and Dunn learning styles model referred to as Building Excellence (BE) Online Learning Styles rated on 5-point Likert scale and on scores obtained from Verbal Comprehension measures of Listening Aptitude Test (L–AT) and Reading Aptitude Test (R–AT) that are derivative of The Gray Oral Reading Tests (GORT; 1963, 2012) used to assess listening and reading comprehension answered with multiple-choice questions.

Prior to on-site testing, all 121 participants completed the BE learning preference evaluation. Based on BE scores, participants were classified categorically and divided into four groups. Participants of these groups completed the Listening Aptitude Test and Reading Aptitude Test. Following aptitude testing, each student was randomly assigned to one of two instructional conditions, either audiobook or e-text and took a comprehension test. The correlational matrix of Rogowsky, Calhoun, and Tallal (2015) demonstrates all possible correlations for pairings of the six measures (Appendix Q).

A one-way analysis of variance (ANOVA), a correlational matrix analysis, and a regression analysis were applied to assess the extent to which learning style preferences predict or equate to learning aptitudes. Six total measures were examined, three of which were visual-verbal measures of preference: the BE Auditory learning style, the BE Visual word learning style, and the Difference between BE Auditory and Visual word learning styles. The remaining three tests were verbal aptitude measures of Listening aptitude, Reading aptitude, and Difference between Listening and Reading aptitude. Results of the ANOVA analysis showed that overall participants classified with as having a visual-word learning-style preference outperformed those classified as having a preferred auditory learning style on both the listening and reading comprehension aptitude tests. Results of the correlational analysis indicated that the correlation between visual word learning style preference and reading comprehension was neither positive nor statistically significant. The correlation between auditory learning style preference based on the BE auditory score and listening comprehension based on Listening Aptitude Test was negative. The regression equation found that the only variable that contributed statistically significantly to the listening comprehension score was BE auditory listening style.

The auditory learning style proved to be the only statistically significant predictor of both reading and listening comprehension scores, and in both cases this relationship was negative, that is, as individuals' auditory learning style preference scores increased, their performance on both the listening and reading comprehension aptitude tests decreased. Overall results indicated that differences in preferred learning style of auditory or visual-word were not found to statistically significantly predict differences in learning aptitude of listening or reading comprehension. There were no statistically significant results indicating that individuals with stronger auditory learning style preferences had higher listening comprehension aptitude than reading aptitude or that individuals with stronger visual word learning style preferences had higher reading than listening aptitude. Two other experiments were performed later in this article, but only data related to the first experiment is relevant. Moreover, the other experiments did not include contain a sufficiently adequate sample size for inclusion.

Studies examining three domains

There were four total studies that examined all three domains. The defining characteristics these four studies are summarized in Table 4.

Table 4
Summary of Studies Examining Three Domains, Group C

Domains Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
Mayer and Massa (2003)			
Ability, cognitive style, and learning preference domains	95 participants College-age students	Correlational analysis and Exploratory factor analysis with varimax rotation	Fourteen total measures were examined, 11 of which were visual-verbal measures: Three visual-verbal measures were spatial ability constructs • Card Rotation Test • Paper Folding Test • Verbal-spatial ability rating test Four visual-verbal measures were cognitive style constructs • Verbalizer-Visualizer Questionnaire • Santa Barbara Learning Style Questionnaire, • Verbal-Visual Learning Style Rating, • Cognitive Style Analysis Four visual-verbal tests were learning preference constructs • Multimedia Learning Preference (MMLP) Choice • MMLP Rating • MMLP Questionnaire • Learning Scenario Questionnaire Remaining three tests were general achievement measures: Mathematics Standard Achievement Test (SAT), SAT-Verbal, and Vocabulary test
Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)			
Ability, cognitive style, and learning preference domains	198 participants Undergraduate students	Correlational analysis and Regression analysis	Twelve total measures examined, nine were visual-verbal ability measures: Three were visuospatial and verbal objective ability • Minnesota Paper Form Board • Mental Rotations Test • Reading Comprehension Task Two were visuospatial and verbal subjective ability • Object-Spatial Imagery Questionnaire (OSIQ) preference for spatial visualization • OSIQ preference for object visualization Three were cognitive style measures • Verbalizer-Visualizer Questionnaire • Questionnaire of Visual and Verbal Strategy (QVVS) Visual • QVVS for verbal strategy One visual-verbal measure was a description verification test • Visuospatial description recall (accuracy) Remaining three tests were other measures of Descriptions and verification test for Abstract description recall (accuracy), Imagery strategy, and Repetition strategy

Table 4 continues

Table 4 Continued

Domain(s) Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Massa and Mayer (2006)	
Abilities, cognitive styles, and learning preference	114 participants College students	Correlational matrix and Confirmatory factor analysis with a varimax rotation	Thirteen total measures were examined, eleven of which were visual-verbal measures: Three visual-verbal measures were spatial ability constructs • Card Rotation Test • Paper Folding Test • Verbal-Spatial Ability Rating test Three visual-verbal measures were cognitive style constructs • Santa Barbara Learning Style Questionnaire • Verbal-Visual Learning Style Rating • Learning Scenario Questionnaire Four visual-verbal measures were learning preference constructs • Multimedia Learning Preference test • Multimedia Learning Preference Rating test • Multimedia Learning Preference Questionnaire • Verbalizer-Visualizer Questionnaire Remaining three tests were general achievement measures • Standard Achievement Test (SAT) - Mathematics, • SAT-Verbal, • Vocabulary test
		Burns and Hagelskamp (2017)	
Abilities, cognitive styles, and learning preference	355 participants High-school students	Correlational analysis and factor analysis	Thirty-eight total test and scale measured were applied, seven of which were visual-verbal measures Four of the 38 were ability measures, two of which were visual-verbal • Verbal ability • Spatial (spatial ability) The remaining three ability measures were other measures including Nonverbal ability, and Memory ability. Five of the 38 measures were cognitive style measures, two of which were visual-verbal • Discrimination (focusing versus scanning) • Categorization (narrow versus broad category width) The remaining three cognitive style measures were other measures including analytic ability of field independence and field dependence, Sequential processing (successive), Simultaneous processing (simultaneous), and Memory skill (Leveling versus sharpening) Seventeen of the 38 were learning style preference measures, three of which were visual-verbal • Visual preference • Auditory preference • Verbal-spatial preference The remaining fourteen preference measures were other measures including Emotional, Persistence orientation, Verbal risk orientation, Manipulative, Early morning study time, Late morning study time, Afternoon study time, Evening study time, Grouping, Posture, Mobility, Sound, Lighting, Temperature

Table 4 continues

Table 4 Continued

Domain(s) Examined	Sample Size & Age of Participants	Analyses Applied	Measures and Constructs Applied
		Burns and Hagelskamp (2017)	
Abilities, cognitive styles, and learning preference	355 participants High-school students	Correlational analysis and factor analysis	Eleven of the 38 measures were other measures of achievement ability including CAT5 vocabulary, CAT5 reading comprehension, CAT5 language mechanics, CAT5 language expression, CAT5 mathematics computation, CAT5 mathematics concepts and applications, PLAN English mechanics, PLAN English rhetoric, PLAN mathematics algebra, PLAN mathematics geometry, and PLAN reading.

Mayer and Massa (2003) examined whether the visualizer–verbalizer distinction could be sectioned into separate components. Two primary research questions were asked: Is the visualizer–verbalizer distinction unitary or multifaceted? Can valid and efficient measures of style and ability be produced from the visualizer–verbalizer distinction? To answer these questions, the researchers used both a correlational analysis and an exploratory-factor analysis to examine 14 measures on a sample of 95 college students.

Eleven of the 14 total measurers were tests of visual-verbal ability. Three of the visual-verbal measures were spatial ability constructs measured with a Card Rotation Test, a Paper Folding Test, and a Verbal-Spatial Ability Rating test. Four of the visual-verbal were learning preference measured with a Multimedia Learning Preference (MMLP) Choice test, a MMLP Rating test, a MMLP Questionnaire test, and a Learning Scenario Questionnaire test. Another four of the visual-verbal measures were tests of cognitive-style constructs including the Verbalizer-Visualizer Questionnaire, the Santa Barbara Learning Style Questionnaire, the Verbal-Visual Learning Style Rating, and Cognitive Style Analysis. The remaining three tests were other measures of general cognitive ability measured with the Standard Achievement Test (SAT) for Mathematics, the SAT for Verbal test, and a Vocabulary test. These measures typically were rated on a

5- or 7-point Likert scale, or rated as a true or false response, a timed test, or an online multi-frame selection. The correlational matrix of Mayer and Massa (2003) demonstrates all possible correlations for pairings of the 14 measures (Appendix R).

The correlational analysis examined relationships among measures that tapped general achievement, spatial ability, cognitive style, and learning style. Findings of the correlational analysis revealed four groups of statistically significantly correlated measures: (a) all three measures of general achievement, (b) all three measures of spatial ability, (c) all four measures of learning preferences, and (d) three of the four measures of cognitive style. The fourth cognitive-style measure, the Cognitive Styles Analysis measure had low correlations overall and did not correlate statistically significantly with any other measure.

In the exploratory factor analysis, Mayer and Massa's (2003) used a maximum likelihood extraction and a varimax rotation method. Findings of this factor analysis revealed four highly intercorrelated clusters of related variables called factors. The researchers identified these factors as general ability, spatial ability, cognitive style, and learning preference. Mayer and Massa (2003) concluded that overall findings of both the correlational matrix and the factor analysis confirmed support for different ways of distinguishing verbal and visual learners, concluding that the visualizer–verbalizer distinction is multifaceted and can be partitioned into four separate facets: general ability, spatial ability, cognitive style, and learning preferences.

In the second study examining all three domains, Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014) used a correlational analysis and a regression analysis to investigate the role of individual's visual-object, visual-spatial and verbal cognitive styles, cognitive abilities, and strategy use in the learning of visuospatial and abstract descriptions on a sample of 198 undergraduate students. In addition to visuospatial competence, the researchers also analyzed verbal ability as measured with reading comprehension, verbal style as measured with a preference for remembering words and sentences and the use of repetition-based strategies in relation to visuospatial text recall accuracy. The researchers hypothesized that both spatial abilities and cognitive styles might influence the accuracy of visuospatial description recall.

Twelve total measures were examined, nine of which were visual-verbal measures. Two of the visual-verbal measures were verbal constructs measured with the Reading Comprehension Task and the Questionnaire of Visual and Verbal Strategy (QVVS) that measured verbal strategy. Six of the visual-verbal measures were visual constructs measured with the Minnesota Paper Form Board, the Mental Rotations Test, the Object-Spatial Imagery Questionnaire (OSIQ) preference for spatial visualization, and the OSIQ preference for object visualization. The final two visual-verbal measures were a combined visual-verbal measures: a Description Verification test measured with the Visuospatial Description Recall ability and the Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977). The remaining three tests were other measures of ability measured with a Descriptions and Verification Test for Abstract Description Recall, an Imagery Strategy test, and a Repetition Strategy test. These measures were rated by participants' scores on Likert scale 1 to 5, timed test, multiple-choice questions, true-false items, questionnaire, but also included two and three dimensional tests of mental rotation ability and reading comprehension task. To make evaluations, the participants read short visuospatial and abstract (control) descriptions, and then answered multiple-choice questions and reported the strategies (imagery or repetition) used to memorize the content. The correlational matrix of Meneghetti et al. (2014) demonstrates all possible correlations for pairings of the 12 measures (Appendix S).

Results of the correlation analysis revealed that visual style identified by the Visual Strategy measure of QVVS correlated with accuracy of recall for both abstract and visuospatial descriptions (supporting results that visual preferences influence task performance; e.g., Mayer & Massa, 2003). Spatial visualization ability as measured by the Minnesota Paper Form Board, however, did not correlate with accuracy of visuospatial text recall. Moreover, the researchers found that the visual and verbal scores obtained with the Visual Strategy measure of QVVS statistically significantly correlated with one another, supporting the idea that visualizers and verbalizers are not at opposite ends of the same continuum but two positively related dimensions. The same person can adopt visual or verbal strategies to suit their tasks and goals, and choosing one does not exclude the other.

The researchers also performed a path analysis to analyze how cognitive abilities as measured with reading comprehension and visuospatial skills, and preferences as measured with object or spatial visualization or with verbalization might predict the learning of a visuospatial description, considering an abstract text for control purposes. The dependent variable was recall accuracy in answering the multiple-choice questions on the visuospatial and abstract descriptions, while the mediators were the strategies used, such as imagery for the visuospatial text and repetition for the abstract text.

Findings of the path analysis revealed a direct influence of verbal competence as measured with reading comprehension on description recall accuracy in both visuospatial and abstract texts. These results indicate that reading comprehension ability appears to directly affect recall accuracy for both types of text, confirming that verbal skills are involved in learning both visuospatial and abstract content as also was seen in former research by Meneghetti et al. (2009). Overall, the researchers concluded that visuospatial ability, visual style, and imagery strategy jointly influence the accuracy of visuospatial-description recall.

The next study by Massa and Mayer (2006) applied a correlational analysis and a confirmatory factor analysis to investigate whether students who score high on spatial ability, visual cognitive style, or visual learning preference learn better from a multimedia lesson containing visual-pictorial help screens, and if those scoring high on verbal ability, verbal cognitive style, or verbal learning preference learn better with word-text help screens. The study consisted of three experiments and a supplemental analysis. Only data related to the supplemental analysis is relevant and was discussed.

The supplemental analysis had a sample of 114 college students and examined 13 total measures, ten of which were visual-verbal measures: three of the visual-verbal tests were spatial ability constructs of Card Rotation Test, Paper Folding Test, and Verbal-Spatial Ability Rating test; another three visual-verbal measures were tests of cognitive-style constructs including the Santa Barbara Learning Style Questionnaire, the Verbal-Visual Learning Style Rating, and the Learning Scenario Questionnaire; and four of the visual-verbal measures were learning preference constructs of Multimedia Learning Preference test, Multimedia Learning Preference Rating test, Multimedia Learning Preference Questionnaire, and Verbalizer-Visualizer Questionnaire. The remaining three tests were general achievement measures of a Standard Achievement Test (SAT) for

Mathematics, a SAT for Verbal test, and a Vocabulary test. Seven of the total measures were adapted from existing instruments, and seven measures were created as original material for this study. Most of the measures were rating on a 5- or 7-point Likert scale, or rated as a true or false response, a timed test, or an online multiframe selection. The correlational matrix of Massa and Mayer (2006) demonstrates all possible correlations for pairings of the 13 measures (Appendix T).

Findings of the correlation matrix confirmed statistically significant correlations between the four cognitive-style measures, the learning preference measures, the spatial ability measures, and the general achievement measures. Findings of the confirmatory-factor analysis using maximum likelihood estimation confirmed a four-factor model. The three learning preference measures, and the three general achievement measures all loaded significantly on their corresponding factors. Two of the three spatial ability measures loaded significantly on the spatial ability factor. The third spatial ability measure, the Verbal-Spatial Ability Rating, had a loading that trended toward statistically significance.

Massa and Mayer (2006) concluded that the visualizer-verbalizer distinction was supported in two ways. First, the relations of the correlational analysis and of the four-factor structure for the confirmatory factor analysis enhanced reliability to their conclusions that cognitive style, learning preference, spatial ability, and general achievement are four separate relations and components. Second, consistent with the results of Mayer and Massa (2003), people appear to differ on the visualizer-verbalizer distinction with respect to cognitive style, learning preferences, and cognitive ability.

The final study that examined all three domains was a learning preference study performed by Burns and Hagelskamp (2017). This study used both a factor analyses and a correlational analysis to examine the construct validity of learning style preferences on a sample of 335 10th-grade female students. Four tests were administered included: the Test of Cognitive Skills (TCS; CTB Macmillan/McGraw-Hill, 1993), the Learning Style Profile (LSP; National Association of Secondary School Principals, 1989), the California Achievement Tests, Level 19 (CAT5; CTB/McGraw-Hill, 1992), and the ACT PLAN (ACT, n.d.) tests under normal school conditions to all 10th-grade students in October.

The researchers examined 38 tests and scales from four test batteries that were organized into three construct categories: 10 were ability and style measures -- four of which were ability and six of which were cognitive-style measures; 17 were learning style preference measures, and 11 were achievement measures. The first construct category of ability measures had two ability measures as tests of visual-verbal abilities including Verbal ability and Spatial ability. The remaining two ability measures were other measures of ability including Nonverbal ability and Memory ability. Two of the six cognitive-style measures were visual-verbal in nature including Discrimination (focusing versus scanning cognitive style) and Categorization (narrow versus broad category width cognitive style); the remaining four cognitive-style measures were other measures of cognitive ability including Analytic style (field independence versus field dependence), Sequential or Successive processing, Simultaneous processing, and Memory skill (leveling versus sharpening).

Three of the 17 measures of learning preferences were tests of visual-verbal in nature including Visual, Auditory, and Verbal-Spatial preference; the remaining 14 learning preference measures were other preference measures including Emotional, Persistence orientation, Verbal Risk orientation, Manipulative, Early Morning Study time, Late Morning Study time, Afternoon Study time, Evening Study time, Grouping, Posture, Mobility, Sound, Lighting, Temperature. Finally, all 11 of the achievement measures were other measures including CAT5 vocabulary, CAT5 reading comprehension, CAT5 language mechanics, CAT5 language expression, CAT5 mathematics computation, CAT5 mathematics concepts and applications, PLAN English mechanics, PLAN English rhetoric, PLAN mathematics algebra, PLAN mathematics geometry, and PLAN reading.

In the first analysis, 11 achievement measures were factor analyzed, next the 10 cognitive ability and cognitive-style measures, and then the 17 learning style preference measures. In the fourth step, the simple zero-order correlations between the achievement factor scores and each test or scale score were computed. In all factor analyses, exploratory factor analysis techniques were used. To investigate the number of common factors, two criteria were examined: the number of eigenvalues greater than unity and the scree plot. The principal-axis factor analysis with iterated communalities were extracted and rotated using both varimax (orthogonal) and promax (oblique, Kappa=2) procedures. Because the orthogonal solution is simpler, the varimax solution was retained unless there was a substantially better solution with the oblique rotation. Two criteria were considered in making this evaluation: the univocal nature of the oblique solution and the extent of correlation among the factors of the oblique solution.

The first factor analysis was performed on the achievement measures using a principal-axis method with Promax (Kappa=2) oblique rotation. The criteria of both a scree plot and of eigenvalues that are greater than one was used for determining the number of factors identified two factors. These two factors were extracted and were labeled language skills and mathematics skills. Moreover, the Language Mechanics subtest was dropped as it loaded on both factors.

The second factor analysis was run on the 10 ability and cognitive-style measures using a principal-axis method with a Promax rotation (Kappa=2). Both the scree plot and eigenvalues greater than one criteria used to identify factors suggested two factors. Due to the low correlation scores between these two factors, the simpler varimax rotation was run and the solution, along with the individual variable measures of sampling adequacy. The two eigenvalues (2.7 and 1.2) accounted for 39% of the total variance. There was a lack of shared common variance among most of the 10 measures. The three ability measures had the largest commonalities, but communalities of the two LSP ability measures of analytic and spatial ability were low. With the cognitive-style measures, other than the sequential and simultaneous processing measures, there was little shared variance, resulting in few factor loadings above .30. The researchers named the first factor as ability, but due to minimal shared variance the second factor could not be labeled with an identifying name.

The third factor analysis was performed on the learning preference measures. The initial results were difficult to interpret due to generally low magnitude of relationship exhibited by the measures. Communalities of some measures were so low that there was little common variance to analyze, and this lack of commonality prevented the statistical analysis from identifying a factor solution. After performing extensive iterations to investigate which variables were problematic, the three ELSIE modality preference measures were investigated the source of the problem.

Communalities are expected to lie between 0 and 1. When the final communality estimates might exceed 1 or if a communality equals 1, the situation is referred to as a Heywood case (Conti, Frühwirth-Schnatter, Heckman, & Piatek, 2014). In a Heywood (1931) case, a variable with communality greater than one prevented a solution. Similarly in this case, all three of the ELSIE modality preference measures showed communalities at .99. Once these measures were dropped, a principal-axis factor analysis was performed on the 14 remaining learning style preference measures. Eigenvalues greater than 1 suggested 5 factors, but the scree plot suggested 3 factors. Because the initial factoring of the correlation matrix would not converge after 100 iterations with 5 factors, the analysis was rerun with 3 factors specified, resulting in a converged solution after 16 iterations. The Promax rotation yielded low correlations among the 3 factors, so the factor analysis was rerun using varimax rotation. To help investigate if the factor model was appropriate, Kaiser's Measure of Sampling Adequacy (MSA) was applied to evaluate the overall sampling adequacy. The MSA criterion of .50 was used to indicate the appropriateness of identifying a factor, and this criteria was not reached by most of the individual variables whose MSA values were in the .50 range, suggesting a lack of correlation among the other measures factored.

As a result of their low communalities, half of the 14 remaining learning preference variables did not load on any of the three factors. The researchers found interpretation of the three factors challenging. Factor 1 had loadings of Persistence, Afternoon Study Time preference, a positive Posture (sitting in chair or at desk) preference, and a negative Mobility (being able to sit still) preference loading. The researchers tentatively named this factor as Active Studying, although they emphasized that one might surmise that other preferences (like Light, Group) would also load on this factor. The second factor had a negative loading from Posture (sitting or lying down) Preference, Mobility (taking breaks, moving while studying) Preference, and Sound (background music or sound) Preference, suggesting something of an opposite studying pattern from Factor I. The researchers tentatively labeled this second factor Passive Studying. Finally, the third factor was defined by two Morning Study Time Preference variables, suggesting the name Morning Studying. The researchers concluded that all three factor interpretations extended beyond usual limits by not having at least three variables with high factor loadings, as overall there was little patterning among the variables. These factors did not capture very much of the overall variance in the observed variables and did not make sense together enough that a researcher could adequately name the concept they represent.

Following the factor analyses, correlations between all ability, cognitive style, and learning style preference measures were correlated with the language and mathematics achievement factor scores. The achievement factor scores correlated .51, generating some consistency of correlations with the two measures. The five ability measures all correlated with both achievement measures and in the expected magnitude, ranging from a low of .24 to a high of .67. The five cognitive-style measures showed low to zero correlation with achievement, the highest correlation being .20 between sequential processing and mathematics achievement. The three ELSIE measures of modality preference show no correlation with achievement. A similar finding was shown for the 17 learning style preference measures, except for the measure of persistence. Persistence correlates .21 and .24 with language and mathematics achievement, respectively. Although not statistically significant, these correlations were higher than the majority of zero correlations demonstrated by the other preference measures.

The correlational matrix of Burns and Hagelskamp (2017) is displayed in Appendix U. There are three parts to this table. The first part is a table displaying the correlation pairings for variables of the study's ability and cognitive-style measures 1-10. The second part is a table displaying the correlation pairings for variables of the study's learning style preferences measures 11-27, and the third part is a table displaying the correlation pairings for variables of the achievement measures 28-38.

There were three basic findings of the correlation analysis. First, the ability measures correlated among themselves and demonstrated their expected relationship to achievement. They did not correlate with the other cognitive style and learning style preference measures. Second, except for the simultaneous and sequential processing cognitive-style measures, the other cognitive-style measures did not share much in common among themselves or with student achievement. Third, the learning style preference measures did not share much variance among themselves. The three modality preference measures had to be dropped from the factor analysis, due to multicollinearity issues relating to the nature of the measurement. Seven of the preference measures had such low commonalities that they did not produce any loadings of .30 or greater in the factor analysis. And outside of Persistence Orientation measures, the other learning preference measures did not correlate with achievement.

Summary

There were 21 total studies that met the search criteria to be included in this research. Some of these studies examined several different sample sets, resulting in a total of 24 different correlation matrices that were reexamined in this research. The general sample size in the number of participants in these 21 studies ranged from 95 to 390; the exception was one study that had 14,211 participants. The majority of studies clustered into three groupings of either ability studies, cognitive-style studies, or learning preference studies. In the original search for studies that examined the visual-verbal distinction, a domain grouping for multiple intelligence had been created. Only two studies, however, were in this group and not sufficient enough for an analysis. Therefore, these two studies were included in the cognitive-style group because multiple intelligences and the theory surrounding this construct grew out of the cognitive sciences (Scott, 2010; Silver, Strong, & Perini, 1997).

These three clustered groupings were further subdivided into six possible sets based on the domain(s) examined. These sets included studies that examined a single domain of either (a) abilities, (b) cognitive style, or (c) learning preferences; studies that examined two domains of either (d) abilities and cognitive styles or (e) abilities and learning styles; and (f) studies that examined all three domains. Group A includes studies with measures from a single domain that constitutes 52% of total studies. Group B includes studies with measures from two domains that constitutes 29% of the total studies. Group C includes studies with measures from all three domains that constitutes 19% of the total studies. Of particular interest were the four studies using measures from all three domains (Burns & Hagelskamp, 2017; Massa & Mayer, 2006; Mayer & Massa, 2003; and Meneghetti et al., 2014). All of these studies had used these three separate constructs of abilities, cognitive style, and learning preferences to identify the visual and verbal learner.

When subdivided into their six respective domain groupings, the sample size in the number of participants in these 11 studies of Group A, the single-domain group ranged from 100 to 269. The sample size in the number of participants in the 6 studies of Group B, the two-domain group ranged from 97 to 390, and the sample size in the number of participants in the four studies of Group C, the three-domain group ranged from 95 to 355 participants. The three domain grouping by type of domain and by the number of studies and matrices examined in each domain grouping are displayed in Table 5.

Table 5
Number of Studies and Matrices Examining In Each Domain Grouping

Number of Studies & Number of Matrices	Learning Preferences	Cognitive Styles	Abilities
		Group A	
11 Studies	5	4	2
14 Matrices	6	4	4
	Learning Preferences & Abilities	Cognitive Styles & Abilities	Learning Preferences & Cognitive Styles
		Group B	
6 Studies	3	3	0
6 Matrices	3	3	0
	Learning Preferences, Cognitive Styles, & Abilities		
		Group C	
4 Studies		4	
4 Matrices		4	

In the next chapter, the methodology used for this study will be described. Further defined in Chapter III is the initial screening procedures used to identify the 21 studies with 24 matrices for reanalysis and the characteristics of sample. In the preliminary analyses of the studies, the next chapter also identifies problems encountered in the analyses and changes that were made in the procedures.

CHAPTER III

METHODOLOGY

The purpose of this study was to investigate if there is empirical support for the visual- and verbal-conceptual distinction as it relates to domains of abilities, cognitive styles, and learning preferences. This chapter includes the methodology used for this study and is comprised of five sections: (a) research design; (b) sources of sample data; (c) sample and its characteristics; (d) procedures of choosing a factor-analysis procedure, including factor-extraction and rotation methods; and (e) preliminary analysis of studies including a secondary analysis of correlational matrices of studies that examined a single domain, two domains, and all three domains.

Research Design

This study is a secondary analysis of research studies identified as studying learner preference or learning styles. To be included in the secondary analysis, the studies needed to (a) propose to study the visual and verbal learner preference distinction, (b) have a correlation matrix with measures of the visual and verbal variables, and (c) have a sample size of at least 95. A total of 21 studies with 24 matrices were found that met these initial search criteria.

These studies were then further examined and the domain of the visual and verbal measures included in the study were classified according to whether the visual and verbal measures were primarily abilities, cognitive styles, or learner preferences, and further classified as to whether the studies included measures examining a single domain (abilities, cognitive styles, or learner preferences), included measures examining two domains (abilities and cognitive styles, abilities and learner preferences, and cognitive styles and learner preferences), or included measures from all three domains. These three groups were labeled Group A, Group B, and Group C, respectively. Group A had 11 studies and 14 matrices, Group B ad 6 studies and 6 matrices, and Group C had 4 studies and 4 matrices.

In each group, the age of participants was defined by school level. Classifications include (a) elementary-school students, which denotes grades kindergarten to fifth grade; (b) middle-school students, which denotes grades six to eight; (c) high-school students, which denotes grades 9 to12; (d) college, university, or undergraduate students, which denotes grades 13 to16, and (e) participants of all ages, which denotes students of nondelineated ages.

Two research questions were posed for this study:

1. Using a common factor-analysis procedure, do studies measuring the visual-verbal learner-preference dichotomy consistently identify the visual and verbal constructs?
2. In studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

To answer these research questions, this study applied a method that is commonly used to establish construct validity, a factor-analysis procedure (Westen, Drew, & Rosenthal, 2003). A factor-analysis procedure establishes construct validity of measures by "correlating each measure with a number of other measures and arguing from the pattern of correlations that the measure is associated with these variables in theoretically predictable ways" (Westen et al., 2003, p. 608). The factor-analysis process applies statistical, mathematical procedures to simplify variability among correlated variables

(Vogt & Johnson, 2011). This process makes associations between scales measuring similar constructs or the lack of associations with scales measuring different concepts, and highly intercorrelated variables are clustered together (McDowell, 2006; Reis et al., 2000; Streiner & Norman, 1989) and enables a large set of variables to be reduced to smaller sets called factors or latent variables that share a common variance (Bartholomew, Knott, & Moustaki, 2011; Yong & Pearce, 2013). These small sets can then be related conceptually and grouped together statistically (Child, 2006).

In effect, a factor-analysis method ensures that the scores from various tests or scales of instruments accurately measure the constructs they profess to measure. This process verifies construct validity by defining the variables that are related strongly to each other (Souza, Alexandre, & Guirardello, 2017). This methodology most efficiently fulfilled the purpose of this study: to investigate if there is empirical support for the visual and verbal conceptual distinction as it relates to the domains of abilities, cognitive styles, and learning preferences.

Sample

The sample selection included two parts. The first part involved obtaining the sample data. The second part involved defining the characteristics of sample.

Sources of sample data

To obtain relevant literature for the data of this study's sample and to synthesize the research, various articles were collected from educational journals and select doctoral dissertations. Several strategies were used to find relevant literature. From June through early August, 2018 electronic databases for published and unpublished works were scanned, including the databases of *ERIC, Proquest, Education Source, Fusion, Psych*

INFO, CINAHL, Sage, and Google Scholar. Later various journals also were searched including the *Journal of Intelligence, Journal of Instruction, International Journal of Instruction, Journal of Instructional Psychology, Journal of Learning and Instruction,* and *Learning and Individual Difference*.

Using each database's thesaurus, appropriate search terms were defined. The search was conducted on all source types, both with and without search limitations. Moreover, a series of search categories and various application of term combination were utilized. Initially, search constraints included limiting publication dates to the last 10 years and limiting to peer-reviewed journals. Later these search limitations were removed, and all studies that analyzed both the visual and the verbal distinction and included a correlation matrix were considered. Inclusion criteria included any grade level, United States and well as international studies, and all dates of publication. Sample size initially was limited to studies with samples greater than 100 but later was expanded to include studies with a sample of slightly less than this recommended size, and two additional studies were included: one of these studies had sample size of 97 and the other had a sample with 95 participants.

The search terms were connected within categories by an OR statement and across categories by an AND statement. Search terms applied were Quantitative OR Statistical Analysis OR "Statistical Analysis" OR Quantitative analysis OR "Quantitative analysis" OR Quantitative methods OR "Quantitative methods" OR statistical design OR "statistical design" OR Experimental Design OR "Experimental Design" OR Correlation OR Statistical Correlation OR "Statistical Correlation" OR Correlation Matrix, Instrument* OR Measure* OR Test* AND Learning Style OR "Learning Style" OR

Learning Preference OR "Learning Preference" OR Learning Modality OR "Learning Modality" OR Cognitive Style* OR "Cognitive Style*" OR Learning Strategies OR Learning-Style* Hypothesis, OR “Meshing Hypothesis” OR Meshing Hypothesis, OR “Meshing Hypothesis” OR Attribute*-By-Treatment, OR “Attribute-By-Treatment-Interaction” (ATI) OR Style-By-Treatment OR “Style-By-Treatment” OR Visual-Verbal Dimension AND Visual OR Auditory OR Oral OR Verbal OR Visual Learning OR "Spatial-Visual Ability" OR Visual Learner OR Visual Perception OR "Visual Perception" OR Auditory Learning or "Auditory Learning" Auditory Learner OR Auditory Perception OR "Auditory Perception" OR Verbal Learning OR "Verbal Learning" Visual Abilit* OR Visual Ability OR Auditory Abilit* OR Auditory Ability OR Spatial-Visual Ability OR "Spatial-Visual Ability" OR Spatial-Visual Dichotomy AND Learner.

In September 2018, several journal databases were further scanned aggregately without any search limitations. This scan included the *Journal of Intelligence* that was scanned entirely from 2012-2018; the full collection from *Journal of Instruction Delivery System*, from the *International Journal of Instruction*, from the *Journal of Instructional Psychology*, and from the *Journal of Curriculum and Instruction*. No additional, relevant articles were located in this search.

To ensure the best search possible, all located articles, literature reviews, or meta-analyses also were reviewed, and each of these documents were searched manually in the reference sections. Any relevant articles that appeared to meet the inclusion criteria, the titles and abstracts from citations were identified via the database search, and full copies of relevant studies were obtained and examined. Finally, searches were conducted from websites of research organizations and from the learning-style network and annotated bibliography of research. Moreover, researchers of articles and leading experts in the field were contacted to inquire if they may know of other articles than those retrieved during the database search. Once the search for relevant literature to include in this study was concluded, 21 studies were found and these have been included for illustrative contrast.

Characteristics of sample

Although the study selection criteria focused on the identification of learner-preference studies, the final selection of studies included studies in three groups: studies with measures in single domains, two domains, or three domains. By definition, Group C studies had measures in all three domains and included learner-preference measures. Group B studies had measures in two domains and half of these studies included learning-preference measures; the other half identified the learning-preference measures as cognitive-style measures. It was decided to keep these studies in the analysis because recent reviews of learning styles (Evans, Cools, & Charlesworth, 2010; Plass, Chun, Mayer, & Leutner, 1998) have included cognitive styles in their reviews, and some researchers use these two terms interchangeably. The Group A studies had measures in a single domain, and most of the studies in this group had measures of either learning preferences or cognitive styles. There were, however, two studies with only ability measures in this group. It was decided that all the Group A studies would be included in the analysis, including the two studies with only ability measures. The reason the two ability measures from the single-domain group were retained was because ability measures were also examined in the two-domain and three-domain groups, and because the results of the single-domain ability measures could serve as a contrast with the results of the single domain learning-preference and cognitive-style measures.

These 21 studies were compiled into categories based on the type of visual- and verbal-conceptual distinction analyzed and included three domain groups of abilities, cognitive styles, and learning preferences. These three domain groupings were then subdivided into six groupings: Group A studies that examine a single domain of abilities, cognitive styles, or learning preferences; Group B studies that examine two domains of either abilities and cognitive styles or abilities and learning styles; and Group C studies that examine all three domains.

Some defining characteristics of the 21 studies or experiments that met the inclusion criteria included in this reanalysis were the total studies' population by category of school age, these included 11 studies with college or undergraduate students as participants, 9 studies with high-school to elementary-school students, and one study with participants of all ages. Another defining characteristic was the dates of publication; the dates spanned 49 years from 1969 to 2018. When examined by decade of publication date, there were 4 articles that were published prior to 2000, 5 articles that were published from 2001-2010, and 12 articles that were published from 2011-2018. The majority of overall research studies were from both published (peer-reviewed journal articles) and unpublished sources. Specifically, 18 of the studies were articles published in academic journals, one study was a paper presented at an annual convention of the American Psychological Association, one study was a naval research report, and one was a manuscript submitted for publication.

Procedures

In performing the factor analysis for this study, there were four primary procedural decisions. First, a decision was made on the appropriate type of factor-analysis technique. Next, a decision was made on the best type of factor-extraction method and on the type of factor-rotation method (Yong & Pearce, 2013). Finally, a decision was made on the number of factors to retain. In the end, the procedure chosen for this study was to perform an exploratory factor analysis using a principal-axis factor-extraction method with a promax, oblique rotation and to retain eigenvalues greater than 1.0. An outline of processes involved in this decision and the purpose for selecting these specific procedures are defined in the following paragraphs.

Choosing a factor-analysis technique

In choosing a factor-analysis technique, both an exploratory-factor analysis and a confirmatory-factor analysis were considered. There was also an option of using a principal-component analysis. Each of these three methods serves different purposes. An exploratory-factor analysis attempts to uncover complex patterns by exploring the dataset and testing predictions (Child, 2006), and a confirmatory-factor analysis attempts to confirm hypotheses (Yong & Pearce, 2013). A principal-component analysis maximizes the total variance.

A principal-component analysis typically is not regarded as a form of factor analysis, the mathematical models on which it is based are different (Costello & Osborne, 2005). A key difference between a factor analysis and a principal-component analysis is that a principal-component analysis does not discriminate between shared and unique variance (Gorsuch, 1997; McArdle, 1990). A factor analysis, in turn, leaves the shared variance of variables partitioned from its unique variance and error variance to reveal the underlying factor structure.

Because this study sought to uncover various patterns by exploring the dataset, the exploratory-factor-analysis method was chosen initially. There were some studies where the matrix did not produce output with the factor-analysis method, however, the principal-component method had to be used in order for the program's solution to converge and generate output. As a result, the studies that did not produce output successfully when using the factor-analysis method, the principal-component method of analysis was applied.

Choosing a factor-extraction method

In choosing a factor-extraction method from the many different options available in the Statistical Package for the Social Sciences (SPSS) software package, such as the unweighted-least-squares, generalized-least-squares, maximum-likelihood, principal-axis factor, alpha-factoring, and image-factoring (Costello & Osborne, 2005), a principal-axis factor-extraction method was chosen. This method was selected because a principal-axis factoring uses a reduced correlation matrix, which consists of the correlations of the measures off the main diagonal and communalities on the main diagonal. The principal-axis factor analysis's reduced-correlation matrix, replacing the ones in the diagonal of the correlation matrix with estimates of how much variance in the item is explained by the factor structure and helps identify constructs. This approach proved most appropriate for this study because it attempts to identify latent constructs, rather than simply reducing the data and helps identify constructs, and the research of this dissertation is interested in the dimensions behind the variables.

Choosing a factor-rotation method

In choosing a factor-rotation method, the goal was to select a method where the factors could best be rotated or transformed to make them easier to interpret. The transformation procedure "rotates the factor axes" and increases the size of large factor loadings and decreases the size of small ones. There were two basic types of rotation techniques considered: the orthogonal rotation and the oblique rotation. For orthogonal methods some options of rotation include varimax, quartimax, and equamax, and for oblique methods of rotation, some options include direct oblimin, quartimin, and promax.

The main difference between orthogonal and oblique rotation is that orthogonal rotations produce factors that are that are not allowed to correlate, and the oblique rotation method allows the factors to correlate (Costello & Osborne, 2005). There are advantages with both rotation methods. The varimax orthogonal-rotation method maximizes variance that minimizes the number of variables that have high loadings on each factor and simplifies the interpretation of all factors. In contrast, the Promax oblique-rotation method involves raising the loadings to a power of four that ultimately results in greater correlations among the factors and achieves a simple structure (Gorsuch, 1983).

For this study, both a varimax, orthogonal-rotation method and a promax, oblique-rotation method were applied initially. In the final analysis, however, only the oblique results of the Promax (Kappa=4) solution was retained. The oblique rotation method of promax was selected because factors typically do correlate. Using the orthogonal rotation resulted in a loss of valuable information when the factors were correlated, and the oblique rotation appeared to render a more accurate solution (Costello & Osborne, 2005) and accomplished the objectives of this research.

Number of factors to retain

After selecting a rotation method, a decision was made on how many factors to retain. Once again, many different options were available, including the scree test, Velicer's MAP criteria, and parallel analysis and retaining all factors with eigenvalues greater than 1.0 (Velicer & Jackson, 1990). The method of examining eigenvalues greater than 1.0, known as the Kaiser rule, was chosen. It was chosen for this study because this method standardly is applied, is available in most statistical software packages, and is typically the default for the number of factors to retain (Costello & Osborne, 2005). Moreover, this method provides a rough estimate of the optimal number of factors that can be used to describe the data (Hutcheson & Sofroniou, 1999).

Defining a factor

The criteria for defining a factor in all the analyses was based on the shared variance in the factor loading and was set at the standard of .40, which means that the loading at or above .40 were used to interpret the magnitude of relationships exhibited or the extent of communalities between measures. Moreover, a factor needed to have two or more high-loading measures greater than .4 of the same construct.

Summary of factor-analysis procedures

Ultimately, it was decided to perform a principal axis factor analysis with Promax rotation (Kappa=4), using the initial criterion of 25 iterations but extending it to 100 iterations in several cases as described below. The criterion of "eigen values greater than 1" was used to investigate the number of factors to retain. All analyses were conducted using a short program in the syntax window of the Statistical Package for the Social Sciences (SPSS) GradPack version 25 software program.

Preliminary Analyses of Studies

As described earlier, the initial screening procedures of this study identified 21 studies with 24 matrices for reanalysis. Following the selection of the 21 studies with their 24 correlation matrices, a factor analysis was completed on each of the 24 matrices. Several problems were identified, and the following changes were made in the procedures. First, three of the matrices were identified as being "not positive definite," meaning that the analysis could not be completed because the extraction did not produce meaningful output, which occurs if one or more of the eigenvalues of the correlation matrix do not have positive numbers, or if there are linear dependencies among the variables or if there are more variables in the analysis than there are cases (Wothke, 1993). The matrices that were not positive definite included Andrusyszyn et al. (2001), Hajhashemi et al. (2018), and Rogowsky et al. (2015), and these matrices were dropped from further analysis.

Second, 15 of the matrices did not converge after 25 iterations. For these studies, the number of iterations was increased to 100, and the factor analyses for all these matrices converged before 100 iterations were reached. The only exception was the matrix in Blazhenkova et al. (2011) Experiment 2, which converged after 140 iterations. After examination of the output, it was decided to keep this matrix in the analysis.

Third, seven of the matrices had communality estimates for variables that exceeded one. For these matrices, principal component analysis with Promax rotation was completed in place of the principal axis factor analysis. In all cases, the communality estimates were less than one, and these matrices were retained in the analysis. These studies included Buktenica (1969); Sozcu (2014); Vahid Baghban (2012); Wintergerst et al. (2001); Yang and Kim (2011) examining two groups of students, a Chinese group and a South Korean group; Meneghetti et al. (2014); and Burns and Hagelskamp (2017), Part 1 of 2.

It is necessary to point out that communality estimates for a factor analysis are investigated first, prior to factoring, typically by using squared multiple correlation coefficients as the initial communality estimates and then iterating until the estimates stabilize. Communality estimates for principal components are estimated after the principal components analysis has been completed on a matrix with ones placed in the main diagonal. Communalities are obtained by then summing the squared component loadings for each variable.

The final tally of studies and matrices included in the preliminary analyses once the not positive definite studies were removed was 18 studies and 21 matrices. In this final amount, Group A had 9 studies and 12 matrices. Group B had 5 studies and 5 matrices, and Group C had 4 studies and 4 matrices.

Summary

In summary, this chapter provided a description of the methodology used for this study. The method of obtaining sample data and the characteristics of the sample involved a selection criteria that focused on the identification of learner-preference studies. Chosen for this study's methodology was an exploratory factor-analysis procedure using a principal-axis factor-extraction method with a promax, oblique rotation and to retain eigenvalues greater than 1.0. The criteria for the number of iterations to perform in the SPSS syntax originally was set at 25 iterations. Some matrices required more iterations to perform, and new criteria was set at 100. Only one matrix required more than 100 iterations.

In the selection process, because some researchers had referred to cognitive-style measures as learner-preference measures or used the two terms interchangeable (Evans, Cools, & Charlesworth, 2010; Plass, Chun, Mayer, & Leutner, 1998), it was decided to keep studies that examined both learning preferences and cognitive styles. In some of the other studies, the researchers identified learning-preference measures as learning-aptitude or learning-ability measures or used similar terms in the title of the study. These studies were kept as well because most of these also examined learning-preference measures along with visual- and verbal-conceptual distinction measures from the domain of abilities or cognitive styles or examined these measures across all three of these domain groups. Therefore, in this study ability measures also were included in the final analysis, and the results of the single-domain ability measures were intended to serve as a contrast with the results of the measures from the single domain of learning-preferences and cognitive-styles.

The initial screening procedures identified 21 studies with 24 matrices for reanalysis. Based on the results of the preliminary analyses, however, three additional studies were dropped because the matrices were not positive definite. As a consequence, there were 18 studies and 21 matrices that were analyzed in and are reported in chapter IV. In the next chapter the factor-analyses results of the 21 matrices are presented to investigate if studies using measures of the visual- and verbal-conceptual distinction within a single domain and across two and three domains of abilities, cognitive styles, and learning preferences consistently identified the visual and verbal constructs when using a common factor-analysis procedure. Also presented in Chapter IV is and examination of the extent of the relationship between the correlation coefficients of the visual and verbal factors when they are identified.

CHAPTER IV

RESULTS

The purpose of this study was to investigate if there is empirical support for the visual and verbal conceptual distinction as it relates to domains of abilities, cognitive styles, or learning preferences. This chapter is divided into three subsections. The first subsection examines the factor-analysis results within a single domain, Group A, to investigate if studies using measures of the visual- and verbal-conceptual distinction within a single domain of abilities, cognitive styles, and learning preferences consistently identified the visual and verbal constructs when using a common factor-analysis procedure. The second subsection examines the factor-analysis results across two domains, Group B, to investigate if studies using measures of the visual- and verbal-conceptual distinction across two domains of abilities, cognitive styles, and learning preferences consistently identified the visual and verbal constructs when using a common factor-analysis procedure. The third subsection examines the factor-analysis results across three domains, Group C, to investigate if studies using measures of the visual- and verbal-conceptual distinction across the three domains of abilities, cognitive styles, and learning preferences consistently identified the visual and verbal constructs when using a common factor-analysis procedure. In all three sections, attention is given to the correlation coefficients between the visual and verbal factors if and when they are identified.

There were 18 different studies examined in this research. Some of these studies had multiple sets of matrices, so the total number of matrices examined was 21. In each of the matrices, results were obtained from factor-analyses output generated by the

Statistical Package for the Social Sciences (SPSS) GradPack version 25 software program. In all the factor analyses, an exploratory-factor-analysis technique was used. Initially, a principal-axis-factoring extraction method was applied with both a varimax, orthogonal-rotation method and a promax, oblique-rotation method. Ultimately, the oblique results of the Promax (Kappa=4) solution was retained, and two matrices were examined: the pattern matrix (also known as the rotated-pattern matrix) and the factor-correlation matrix (also known as the factor-intercorrelation matrix). There were a few studies where the SPSS output only provided results of the initial-factor matrix and did not provide the output for the pattern- and factor-correlation matrices. In these cases, the initial-factor matrix results were retained.

The criteria for defining a factor in all the analyses was based on the shared variance in the factor loading and was set at the standard of .40, this to which means that the loading at or above .40 were used to interpret the magnitude of relationships exhibited or the extent of communalities between measures. In the SPSS subcommands, the criteria for iterating was set at 25 iterations initially, but not all the matrices converged successfully. More iterations were required, so a new criteria was set at 100 iterations. Even with 100 iterations, there were still some studies that did not converge, and the principal component (PC) method of analysis had to be used rather than the factor-analysis method (FA) of analysis in order for the program's solution to converge and generate output. In fact, with some matrices the solution only converged with the PC method and not with the FA method. When the PC method was applied, the Promax (Kappa=4) solution was again retained, and the same two matrices as those examined with the FA method were applied: the pattern matrix and the factor-correlation matrix. In the SPSS result tables of this research, the output of the pattern matrix and correlation matrix were reported in the tables; the factor matrix was reported if the pattern matrix was not provided in the output.

Kaiser's (1974) normalized measure of sampling adequacy (MSA) was estimated for each test or scale. The Kaiser measure varies from 0 to 1, with the minimal criterion for factoring the matrix or including the variable in the FA equal to or greater than .50 (Dziuban & Shirkey, 1974; Kaiser, 1970). Moreover, to define the loading values in all the tables, the measures and SPSS results that define the visual and verbal constructs related to the domains of abilities, cognitive styles, or learning preferences are highlighted with bold, green font. High-loading measures that define the verbal or visual constructs but are not related to the domain of abilities, cognitive styles, or learning preferences are emphasized with bold, underline, and red font. Other high-loading measures are emphasized with bold black font.

The results of each of the three subsections in this chapter are divided into three parts. The first part provides a brief overview and has a table summarizing the overall SPSS results of each the matrices for that group with emphasis on the visual and verbal constructs. The second part provides greater detail on the findings of each matrix with individual paragraphs that elaborate on the study and the statistical results of that particular matrix. Each of these defining paragraph summaries are then followed by two tables: one table displays the test name for each of the measures used in that particular study and the second table displays the SPSS result for that matrices of that particular study. The third part provides a comprehensive summary of the results of the finding for that group relative to the visual- and verbal-conceptual distinction.

The presentation of these three sections, all address the first research question, that is, to examine if studies measuring the visual and the verbal learner-preference dichotomy consistently identified the visual and verbal constructs. The results of this research identified 17 visual, or visual-verbal verbal factors in the 21 matrices, however, only one of these matrices had both a visual and verbal factor identified in the same matrix. Consequently, the second research question of examining the extent to which the visual and verbal factors that were identified were correlated with each other could not be addressed.

Overview of Subsection One

The first subsection that examines the factor-analysis results within the single-domain group, Group A, and it included 9 studies and 12 matrices. Two of these studies and four matrices were ability studies that examined the single domain of abilities including Buktenica (1969) with its three sets of matrices and Casey, Pezaris, Fineman, Pollock, Demers, and Dearing (2015). Another three studies and three matrices were cognitive-style studies that examined the single domain of cognitive style including Blazhenkova, Becker, and Kozhevnikov (2011) Experiment 1 and Blazhenkova et al. (2011) Experiment 2, and Sozcu (2014). The final four studies and five matrices were learning preference studies, all of which examined the single domain of leaning preferences including Leite, Svinicki, and Shi (2010); Vahid Baghban (2012); Wintergerst, DeCapua, and Itzen (2001); and Yang and Kim (2011) with its two sets of matrices. An overview table of the SPSS output derived from Group A’s matrices with emphasis on the findings of the visual and verbal constructs is defined in Table 6.

Table 6

Overview of SPSS Results for Group A: Matrices that Examine a Single Domain

Participants and Measures	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
		Buktenica (1969) Year 1 of 3		
140 Participants 7 Total measures, 2 of which were visual or verbal measures	Ability domain	6	FA method using the initial factor-matrix results	One factor was extracted. The visual- and verbal-ability constructs were not clearly defined. The details of these results are displayed in Table 8.1.
		Buktenica (1969) Year 2 of 3		
140 Participants 7 Total measures, 2 of which were visual or verbal measures	Ability domain	100	PC method using pattern matrix and factor-correlation matrix results	Two components were extracted. The visual- and verbal-ability components were defined along with two other achievement measures in Component #2. The details of these results are displayed in Table 8.2.
		Buktenica (1969) Year 3 of 3		
140 Participants 7 Total measures, 2 of which were visual or verbal measures	Ability domain	6	FA method using the initial factor-matrix results	One factor was extracted. The visual and verbal factors were not clearly defined. The details of these results are displayed in Table 8.3.
		Casey et al. (2015)		
127 Participants 9 Total Measures, 4 of which were visual or verbal measures	Ability domain	56	FA method using the pattern matrix and factor-correlation matrix results	Three factors were extracted. The visual-ability factor was defined with three visual-ability measures in Factor #2. The verbal construct was only defined with a single measure in Factor #1. The details of these results are displayed in Table 9.
		Blazhenkova et al. (2011) Experiment 1		
222 Participants 8 Total measures, 8 of which were visual or verbal measures	Cognitive Styles	13	FA method using the initial factor- matrix results	Two factors were extracted: Factor #1 was a visual-verbal cognitive-style factor defined with a visual-object and a verbal measure; Factor #2 was not well defined with a single visual-spatial measure.
		Blazhenkova et al. (2011) Experiment 2		
269 Participants 8 Total measures, 8 of which were visual or verbal measures	Cognitive Styles	147	FA method using the initial factor- matrix results	One factor was extracted: a visual-verbal cognitive-style factor defined with a visual-object and a verbal measure.

Table 6 continues

Table 6 Continued

Participants and Measures	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
		Sozcu (2014)		
157 Participants 10 Total Measures, 2 of which were visual or verbal measures	Cognitive Style	100	PC method using the pattern matrix and factor-correlation matrix	Four components were extracted. The visual-cognitive-style component was not well defined; it loaded on Component #3 along with a two other-cognitive-style measures. The verbal-cognitive-style component was defined by a single measure in component #4. The details of results are displayed in Table 11.
		***Leite et al. (2010)**		
14,211 Participants 4 Total Measures, 2 of which were visual or verbal measures	Learning Preferences	7	FA using FA using the initial factor-matrix results	One factor was extracted. The visual- and verbal-learning-preference constructs were not well defined. The result details are shown in Table 13.
		***Vahid Baghban (2012)**		
120 Participants 9 Total Measures, 2 of which were visual or verbal measures	Learning Preferences	100	PC using the pattern matrix and factor-correlation matrix results	Three components were extracted. The visual-learning-preference construct was defined in Component #3 as a single measure, and the verbal-learning-preference construct was defined in Component #2 along with a learning-strategy measure. The result details are shown in Table 14.
		***Wintergerst et al. (2001)**		
100 Participants 10 Total Measures, 2 of which were visual or verbal measures	Learning Preferences	100	PC method using The pattern matrix and factor-correlation matrix results	Four components were extracted. The visual-learning-preference measure was defined negatively in Component 3 where it also loaded heavily with and other non-visual measure; the verbal-learning-preference construct was not well defined. The result details are shown in Table 15.
		Yang and Kim (2011) with Chinese Students as Participants		
100 Participants 5 Total Measures, 2 of which were visual or verbal measures	Learning Preferences	56	FA method using pattern matrix and factor-correlation matrix results	Two factors were extracted. The visual- and verbal-learning-preference measures both loaded on Factor #2. The result details are shown in Table 16.1.

Table 6 continues

Table 6 Continued

Participants and Measures	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
Yang and Kim (2011) with South Korean Students as Participants				
104 Participants 5 Total Measures, 2 of which were visual or verbal measures	Learning Preferences	19	FA method using pattern matrix and factor-correlation matrix results	Two factors were extracted, and the visual and verbal constructs were not well defined. The visual-learning-preference measure loaded on Factor #1 along with two other learning-preference measures, and the verbal-learning-preference measure loaded on Factor #2 along with another non-verbal, kinesthetic measure. The result details are shown in Table 16.3.

Note: The studies that are marked with an asterisk are those in which the original researcher(s) also performed a factor-analysis or a principal-component procedure.

Detailed findings of SPSS results for group A

The Buktenica (1969) study analyzed the single-domain of abilities to investigate if reading achievement could be predicted through third grade with performance on group-administered, nonverbal auditory and visual perceptual tests administered beginning in the first grade on a sample of 140 elementary-grade students over a 3-year period. There were three sets of measures; one set for each year and each set examined the same seven measures for each of the 3 years: Year 1 of 3, Year 2 of 3, and Year 3 of 3. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 7.0.

Table 7.0
Test names and SPSS Abbreviations for Buktenica (1969)

Name of Measures		Abbr. for Measures	Type of Constructs
Buktenica (1969) Year 1 of 3			
1.	Science Research Associates Primary Mental Abilities Test for IQ (1958)	IQa	Other abilities
2.	Visual perceptual tests measured with Berry-Buktenica Visual–Motor Integration test (Buktenica, 1966)	VMIa or VisA	Visual abilities
3.	Auditory perceptual tests measured with the Wepman Auditory Discrimination Test (Wepman, 1964)	WADTa or VerbA	Verbal abilities

Table 7.0 continues

Table 7.0 Continued

Name of Measures		Abbr. for Measures	Type of Constructs
4.	Nonverbal Auditory Discrimination Ability (1968)	NVADTa	Other abilities
5.	Reading Total of Metropolitan Achievement Test (MAT; 1968)	MATa	Other abilities
6.	Word Knowledge test (MAT, 1968)	WKnowa	Other abilities
7.	Word Discrimination test (MAT, 1968)	WordDisa	Other abilities
	Buktenica (1969) Year 2 of 3		
1.	Science Research Associates Primary Mental Abilities Test for IQ (1958)	IQb	Other abilities
2.	Visual perceptual tests measured with Berry-Buktenica Visual–Motor Integration test (Buktenica, 1966)	VMIb or VisB	Visual abilities
3.	Auditory perceptual tests measured with the Wepman Auditory Discrimination Test (Wepman, 1964)	WADTb or VerbB	Verbal abilities
4.	Nonverbal Auditory Discrimination Ability (1968)	NVADTb	Other abilities
5.	Reading Total or MAT Total (MAT, 1968)	MATb	Other abilities
6.	Word Knowledge test (MAT, 1968)	WKnowb	Other abilities
7.	Word Discrimination test (MAT, 1968)	WordDisb	Other abilities
	Buktenica (1969) Year 3 of 3		
1.	Science Research Associates Primary Mental Abilities Test for IQ (1958)	IQc	Other abilities
2.	Visual perceptual tests measured with Berry-Buktenica Visual–Motor Integration test (Buktenica, 1966)	VMIc or VisC	Visual abilities
3.	Auditory perceptual tests measured with the Wepman Auditory Discrimination Test (Wepman, 1964)	WADTb or VerbC	Verbal abilities
4.	Nonverbal Auditory Discrimination Ability (1968)	NVADTc	Other abilities
5.	Reading Total (MAT, 1968)	MATc	Other abilities
6.	Word Knowledge test (MAT, 1968)	WKnowa	Other abilities
7.	Word Discrimination test (MAT, 1968)	WordDisa	Other abilities

Note: Year 1 of 3 is based on first-grade data; Year 2 of 3, second-grade data; Year 3 of 3, third-grade data. For the defining characteristics of the font colors applied refer to the note on Table 8.

The first and third set of matrices (Year 1 of 3 and Year 3 of 3) in the Buktenica (1969) study produced essentially the same results. Both these sets converged with 25 iterations and one factor was extracted with six iterations, and the solution could not be rotated. Only the initial factor matrix was provided in both of these sets output. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is estimated at .699, an amount considered mediocre but acceptable (Kaiser, 1974). Overall, the visual and verbal constructs were not clearly defined. The highest loadings (> .9) were attributed to three achievement measures related to Word and Reading ability. The details of these results are displayed by year in Table 7.1, Year 1 of 3 and Year 3 of 3, respectively.

Table 7.1
Pattern-Matrix and Factor-Correlation-Matrix Results of
Buktenica (1969) Set 1 of 3 and Set 3 of 3

Factor Matrix[a] for Year 1 of 3

	Factor 1
IQa	**.539**
VisA A	**.482**
VerbA A	**.519**
NVADTa	**.622**
MATa	**.961**
WKnowa	**.922**
WordDisa	**.901**

Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 6 iterations required.

Factor Matrix[a] for Year 3 of 3

	Factor 1
IQc	**.537**
VisC A	**.476**
VerbC A	**.546**
NVADTc	**.560**
MATc	**.969**
WKnowc	.909
WordDisc	.931

Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 6 iterations required.

Note: Visual or verbal ability measures are indicated with A for Ability.

The second matrix set (Year 2 of 3) in the research of Buktenica (1969) was performed with 25 iterations and with 100 iterations. With both iterations, the communality of a variable exceeded 1.0. The solution was reran using the principal-component method of analysis. Two components were extracted with the rotation converging in 3 iterations. Factor 1 was defined with three achievement measures (two verbal and one mathematics). Factor 2 was defined with a visual- and a verbal-ability measure along with two other high-loading measures. The KMO measure of sampling adequacy estimated at .689 and .703, respectively, an amount considered good according to Kaiser (1974). Overall, the visual and verbal abilities constructs were not defined clearly. The details of these results are displayed by year in Table 7.2 as Year 2 of 3.

Table 7.2
PC Pattern-Matrix and Component-Correlation-Matrix Results of Buktenica (1969) Year 2 of 3

Pattern Matrix[a]

	Component 1	Component 2
IQb	-.048	**.832**
VisB A	-.084	**.769**
VerbB A	.083	**.605**
NVADTb	.164	**.660**
MATb	**.997**	.000
WKnowb	.991	-.039
WordDisb	.939	.047

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Component-Correlation Matrix

Component	1	2
1	1.000	.561
2	.561	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

In the next study, Casey et al. (2015) analyzed the single domain of abilities with a longitudinal analysis to investigate if first-grade spatial skills compared with arithmetic and verbal skills were predictors of two different types of fifth-grade mathematics reasoning: mathematics reasoning-spatial and mathematics reasoning analytical for a sample of 127 first-grade girls. There were a total of nine measures examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 8.0.

Table 8.0
Test names and SPSS Abbreviations for Casey et al. (2015)

Name of Measures		Abbr. for Measure	Construct
1.	1st Grade Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn and Dunn, 2003)	GradeOnePPV = Verb	Verbal ability
2.	1st Grade Block Design subtest of Wechsler Intelligence Scale for Children –Fourth Edition (WISC-IV; Wechsler, 2003)	GradeOneWISC = VisA	Spatial ability
3.	1st Grade Two-Dimensional Mental- transformation Task (Levine et al., 1999)	GradeOne2d = VisB	Spatial ability
4.	1st Grade Three-Dimensional Mental-Rotation task (Casey et al., 2008)	GradeOne3d = VisC	Spatial ability
5.	1st Grade Addition ability test (third session in spring in-school individual assessment)	GradeOneAdd	Other measure
6.	1st Grade Subtraction ability test (third session in spring in-school individual assessment)	GradeOneSub	Other measure
7.	Household income level (obtained from interview with mothers)	IL	Other measure
8.	Mother's years of education (obtained from interview with mothers)	MotED	Other measure
9.	Mother's spatial skills (obtained from an adapted mental-rotation test based on the Vandenberg Mental Rotation Test; Vandenberg & Kuse, 1978)	MotSS	Other measure

First, the syntax data were conducted with 25 iterations, but more iterations were required. The syntax was performed with 100 iterations; three factors were extracted with 56 iterations, and the rotation converged in 5 iterations. KMO measure of sampling adequacy was estimated at .754, an amount considered good according to Kaiser (1974). Factor 1 was not well defined with a single verbal-ability measure that loaded along with two other measures, household income level and Mother's years of education. Factor 2 was a visual-ability factor defined with three visual-ability measures. Factor 3 was general achievement factor for addition and subtraction. Overall, the visual-ability construct was defined, and the verbal-ability construct was not well defined. The details of these results are displayed in Table 8.1.

Table 8.1
Pattern-Matrix and Factor-Correlation-Matrix Results of Casey et al. (2015)

Pattern Matrix[a]

	Factor		
	1	2	3
IL	**.587**	-.051	.135
MotED	**1.022**	-.029	-.037
MotSS	.150	.399	-.006
VisA A	.007	**.668**	-.021
VisB A	-.013	**.600**	.092
VisC A	-.031	**.581**	-.032
GradeOneAdd	.108	-.021	**.728**
GradeOneSub	-.052	.026	**.876**
Verb A	**.468**	.212	-.046

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Factor-Correlation Matrix

Factor	1	2	3
1	1.000	.526	.473
2	.526	1.000	.414
3	.473	.414	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

The Blazhenkova et al. (2011) research involved validating a new questionnaire called the Children's Object–Spatial Imagery and Verbal Questionnaire (C-OSIVQ) on a sample of 222 elementary-grade to high-school students. The C-OSIVQ Questionnaire is a children's version of the original, adult questionnaire called the Object–Spatial Imagery and Verbal Questionnaire (OSIVQ; Blazhenkova & Kozhevnikov, 2009). In the original research of Blazhenkova et al. (2011) there were three experiments, and all three of them examined five or more additional measures that were mostly ability measures, but these ability measures were not included in the researchers' final correlation matrix data. As a result, all three experiments matrices examined a single rather than two domains. In the reanalysis, only two of the three experiments' results were examined, this to which was due to one experiment having too small of a sample size to meet the inclusion criteria of this research. The two matrices that were reexamined had the same three measures in both sets and examined two different sample groups. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 9.0.

Table 9.0
Test names and SPSS Abbreviations for Blazhenkova et al. (2011) Experiment 1

Name of Measures		Abbr. for Measures	Type of Construct
1.	Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Vis1	Visual Cognitive style
2.	C-OSIVQ spatial (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Vis2	Visual Cognitive style
3.	C-OSIVQ verbal (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Verb	Verbal Cognitive Style

In the researchers' original results, a principal-component analysis was performed on Experiment 1, and three factors were extracted: a visual-object-spatial factor, a visual-spatial factor, and a verbal factor. In the reanalysis, two factors were extracted with 13 iterations and the rotation converged in 3 iterations. The KMO measure of sampling adequacy was .456, which does not meet the standard minimal criterion of .50. Factor 1 was a visual-verbal cognitive-style factor defined with two measures: a visual-object-spatial measure and a verbal measure. Factor 2 was not well defined with a single visual-spatial measure. Moreover, only the SPSS output for the initial-factor matrix was provided. The details of these results are displayed in Experiment 1 Results of Table 9.1.

In the reanalysis of Blazhenkova et al.'s (2011) second experiment, more than 25 and more than 100 iterations were required, and the solution could not be rotated. Once again, only the output of the factor matrix was provided. The solution was conducted using the principal component method with the same results achieved. The KMO measure of sampling adequacy was .507, barely reaching the standard minimal criterion of .50. Ultimately, one factor was extracted with 147 iterations. This factor was identified as a visual-verbal cognitive-style factor defined by one visual-object-spatial measure, and one verbal measure. The details of these results are displayed in Experiment 2 Results of Table 9.1.

Table 9.1
Factor-Matrix Output for Blazhenkova et al. (2011) Experiment 1 and 2

Experiment 1 Results

Factor Matrix[a]

	Factor 1	Factor 2
Vis1 CS	**.667**	-.182
Vis2 CS	-.056	**.450**
Verb CS	**.632**	.232

Extraction Method: Principal Axis actoring.
a. 2 factors extracted. 13 iterations required.

Experiment 2 Results

Factor Matrix[a]

	Factor 1
Vis1 CS	**.933**
Vis2 CS	.113
Verb CS	**.599**

Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 147 iterations required.

Note: The visual or verbal cognitive-style measures are indicated with CS.

Next, the Sozcu (2014) study analyzed the single domain of cognitive styles to investigate relationships between the cognitive style of Field-Independent and Field-Dependent learners' attitudes toward e-learning, distance education, and other variables in learning and instructional behavior as learners experience e-learning, assessment in e-learning, and competencies in Learner Interface Design within an e-learning environment based on a group of 157 college students. Ten measures were examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 10.0.

Table 10.0
Test names and SPSS Abbreviations for Sozcu (2014)

Name of Measures		Abbr. for Measure	Type of Construct
1.	Levels of field dependence-independence (FDI) as measured by the Group Embedded Figures Test (GEFT; (Dwyer & Moore, 1991, 1992, 1994; Ipek, 1995, 2011)	FDI = Vis	Visual Cognitive Styles
2.	E-learning techniques (Sozcu, 2014)	elrn	Cognitive skill
3.	Attitudes about elearning instruction (Sozcu, 2014)	Atboutelrn	Attitude
4.	Attending distance-learning programs before (Sozcu, 2014)	Attenddislrn	Cognitive skill
5.	Locations for accessing distance education programs (Sozcu, 2014)	Locaccess	Other measure
6.	Knowledge levels about e-learning and distance education (Sozcu, 2014)	Knowelrndised	Cognitive knowledge
7.	Assessment in elearning instruction (Sozcu, 2014)	Assesselrn	Cognitive knowledge
8.	Knowledge about elearning instruction (Sozcu, 2014)	Knowelrnins	Cognitive knowledge
9.	Learner Interface Design features (Sozcu, 2014)	Lrndes	Cognitive knowledge
10.	Prefer reading materials (printed texts) in e-learning (Sozcu, 2014)	Prefnelrn =Verb	Verbal Cognitive Style

In the SPSS output of Sozcu's research (2014), more than 25 iterations were required. When conducted with 100 iterations, the communality of a variable exceeded 1.0, and many of the tables were not provided. The syntax was reentered using the principal-component method of analysis, and four components were extracted. KMO measure of sampling adequacy estimated at .684, a mediocre to good score (Kaiser, 1974). Component 1 and Component 2 were not well defined. Component 3 also was not well defined with a single visual-cognitive-style measure and another measure of general knowledge. Component 4 was defined by a single verbal-cognitive-style measure. Overall, the visual- and verbal-cognitive-style constructs were not well defined. The details of results are displayed in Table 10.1.

Table 10.1

PC Pattern-Matrix and Component-Correlation-Matrix Results of Sozcu (2014)

Component-Pattern Matrix[a]

	Component			
	1	2	3	4
Vis CS	-.082	-.078	**.643**	.277
elrn	.045	**.568**	-.102	.399
atboutelrn	**.706**	-.110	.321	.091
attenddislrn	.207	**.636**	-.240	-.047
locaccess	-.215	**.748**	.337	-.095
knowelrndised	.209	.076	**.686**	-.225
assesselrn	**.819**	-.014	.186	.060
knowelrnins	**.866**	.072	-.175	-.060
lrndes	**.870**	.052	-.083	-.011
Verb CS	.033	.030	.083	**.874**

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Component-Correlation Matrix

Component	1	2	3	4
1	1.000	.003	.128	.066
2	.003	1.000	-.062	-.083
3	.128	-.062	1.000	-.078
4	.066	-.083	-.078	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Note: The other high-loading measures are emphasized with bold black font. Visual or verbal cognitive-style measures are indicated with CS.

In the next study, Leite et al. (2010) examined the single domain of learning preferences and evaluated the reliability and validity of the Visual-Aural-Read-Kinesthetic (VARK) learning-style-inventory instrument (Fleming, 2001; Fleming & Mills, 1992), an instrument that evaluates the four sensory modalities used for obtaining information. Participants included 14,211 U.S. students of all ages who had taken the VARK learning-style-inventory test (Fleming, 2001) for the first time. Four measures were examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 11.0.

Table 11.0

Test name and Abbreviation for Leite, Svinicki, and Shi (2010) Measures

Name of Factor	Abbr. for Measure	Type of Construct
1. Visual measure of Visual-Aural-Read-Kinesthetic learning-style-inventory instrument (VARK; learning-style-inventory instrument (Fleming, 2001; Fleming & Mills, 1992)	Vis	Visual learning preference
2. Aural measure of VARK (Fleming, 2001; Fleming & Mills, 1992)	Aur (Hear) = Verb	Verbal learning preference
3. Read measures of VARK (Fleming, 2001; Fleming & Mills, 1992)	Read- Write	Other learning preference
4. Kinesthetic measures of VARK (Fleming, 2001; Fleming & Mills, 1992)	Kin	Other earning preference

In the SPSS output of Leite et al. (2010), one factor was extracted with seven iterations, and the solution could not be rotated. The same result were achieved with 100 iterations and with the PC method. The KMO measure of sampling adequacy estimated at .656, an amount considered mediocre (Kaiser, 1974). Only the initial factor matrix was provided in the SPSS output, and both the FA and PC method produced the same output: the visual- and verbal-learning-preference constructs were not well defined. The visual-learning-preference measure loaded along with three other learning-preference measures on the single other factor. The details are displayed in Table 11.1.

Table 11.1
Initial Factor-Matrix and Component-Matrix Results of Leite, Svinicki, and Shi (2010)

Factor Matrix[a]

	Factor
	1
Vis LP	.853
Verb LP	.783
RW	.480
Kin	.901

Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 7 iterations required.

Component Matrix[a]

	Component
	1
Vis	.886
Verb	.855
RW	.629
Kin	.899

Extraction Method: Principal Component Analysis.
a. 1 component extracted.

Note: Visual or verbal learning-preference measures are indicated with LP.

The Vahid Baghban (2012) was the next study that analyzed the single domain of learning preferences. The researcher sought to investigate whether any significant relationship existed between Iranian learners' learning style preferences in learning a language using visual, auditory, and kinetic learning as proposed by Reid (1984) relative to the preferred strategies used by the learners for specific language-learning strategies based on Oxford (1990), which included memory, cognitive, compensation, metacognitive, affective, and social. Nine measures were examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 12.0.

Table 12.0
Test names and SPSS Abbreviations for Vahid Baghban (2012)

Name of Measure or Test		Abbr. for Measures	Type of Construct
1.	Visual learning preference Learning Styles Inventory (LSI; Reid,1984)	Vis	Visual learning preference
2.	Auditory learning preference (LSI; Reid,1984)	Aud =Verb	Verbal learning preference
3.	Kinetic learning preference (LSI; Reid,1984)	Kin	Other Learning preference
4.	Memory (Oxford,1990)	Mem	Learning strategy
5.	Cognitive (Oxford, 1990)	Cognit	Learning strategy
6	Compensation (Oxford, 1990)	Comp	Learning strategy
7.	Metacognitive (Oxford, 1990)	Metacog	Learning strategy
8.	Affective (Oxford, 1990)	Affect	Learning strategy
9.	Social (Oxford, 1990)	Soc	Learning strategy

In the SPSS output results of Vahid Baghban's (2012) research, more than 25 iterations and more than 100 iterations were required. With greater iterations, the communality of a variable exceeded 1.0, and the extraction was terminated. The syntax was resubmitted using the principal-component method of analysis, and three components were extracted. The KMO measure of sampling adequacy estimated at .669, a mediocre to good amount (Kaiser, 1974). Component 1 was defined with five learning-strategy measures. Component 2 was defined with a verbal-learning-preference measure and an affective learning-strategy measure. Component 3 was defined with a single visual-learning-preference measure. Overall, the visual and verbal constructs were not well defined. The details of these results are displayed in Table 12.1.

Table 12.1
PC Pattern-Matrix and Component-Correlation-Matrix Results of Vahid Baghban (2012)

Pattern Matrix[a]

	Component 1	2	3
Vis LP	.154	.189	**.955**
Verb LP	-.038	**.788**	.332
Kin	**.610**	-.047	.256
Mem	**.566**	.219	-.235
Cognit	**.465**	**.401**	-.119
Comp	**.698**	-.143	.302
Metacog	**.527**	.238	-.171
Affect	-.216	**.872**	-.021
Soc	**.863**	-.264	-.031

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Component-Correlation Matrix

Component	1	2	3
1	1.000	.353	-.246
2	.353	1.000	-.317
3	-.246	-.317	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

The Wintergerst et al. (2001) study analyzed the single domain of learning preferences and evaluated the reliability and validity of a learning-style instrument: Reid's (1984) Perceptual Learning Style Preference Questionnaire (PLSPQ) on a sample of 100 English-as-a-Second-Language (ESL) university students. Ten measures were examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 13.0.

Table 13.0
Test names and SPSS Abbreviations for Wintergerst, DeCapua, and Itzen (2001)

Name of Factor Measure or Test	Abbr. for Factor	Type of Construct
1 of Perceptual Learning Style Preference Questionnaire (PLSPQ; Reid, 1984)	FI	Other learning preference
2 of PLSPQ (Reid, 1984)	F2	Other learning preference
3 of PLSPQ (Reid, 1984)	F3 or Vis	Visual learning preference
4 of PLSPQ (Reid, 1984)	F4 or Verb	Verbal learning preference
5 of PLSPQ (Reid, 1984)	F5	Other learning preference
6 of PLSPQ (Reid, 1984)	F6	Other learning preference
7 of PLSPQ (Reid, 1984)	F7	Other learning preference
8 of PLSPQ (Reid, 1984)	F8	Other learning preference
9 of PLSPQ (Reid, 1984)	F9	Other learning preference
10 of PLSPQ (Reid, 1984)	F10	Other learning preference

In the result of the output for Wintergerst et al. (2001), more than 25 iterations were required. When performed using 100 iterations, the communality of a variable exceeded 1.0. The syntax was resubmitted using the principal-component method of analysis. Four components were extracted, and the rotation converging in six iterations.

The KMO measure of sampling adequacy estimated at .642, a mediocre amount (Kaiser, 1974). In the results of the pattern-matrix solution, Component 1, 2, and 4 were not well defined, and Component 3 was defined with a negatively-loading visual-learning-preference measure and another unspecified measure. The visual- and verbal-learning-preference constructs were not well defined. The details of these results are displayed in 13.1.

Table 13.1
PC Pattern-Matrix and Component-Correlation-Matrix Results of Wintergerst et al. (2001)

Pattern Matrix[a]

	Component 1	2	3	4
F1	**-.477**	.302	-.373	.012
F2	-.116	**-.413**	**.437**	.288
Vis LP	.033	-.315	**-.626**	.148
Verb LP	-.224	**.462**	.271	.321
F5	.058	.067	**.716**	-.125
F6	**.728**	.025	.057	.121
F7	-.088	**-.658**	-.223	.164
F8	.089	**.751**	.009	.188
F9	.135	.050	-.186	.916
F10	**.879**	.178	-.099	.043

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Component Correlation Matrix

Component	1	2	3	4
1	1.000	-.367	-.051	-.083
2	-.367	1.000	-.159	-.040
3	-.051	-.159	1.000	.220
4	-.083	-.040	.220	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

In the final study of Group A, Yang and Kim (2011) analyzed the single domain of leaning preferences to explore relationships among perceptual learning styles, Ideal-Second-Language-Learning (L2) self, and Motivated L2 behavior of 330 high-school students from four countries: China (*n*=100), Japan (*n*=70), South Korea (*n*=104), and Sweden (*n*=56) using a modified and expanded version of Kim's (2009) Perceptual Learning Style and L2 Motivation Questionnaire. The Yang and Kim (2011) study examined five measures for each student in four different countries, that is, there were four sets of matrices, and each matrix examined the same five measures for each of these four countries. Only two of these matrixes were included in the reanalysis: the matrix that examined the Chinese and the South Korean students. The two matrices that were not included was due to their small sample size, which did not meet the minimum sample-size criteria to be included in this reanalysis; these included the matrix that examined the Japanese and the Swedish students. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 14.0.

Table 14.0
Test names and SPSS Abbreviations for Yang and Kim (2011)

	Name of Measures	Abbr. for Measures	Type of Constructs
	Chinese Students		
1.	Visual for China measured with Perceptual Learning Style and L2 Motivation Questionnaire (PLSL2MQ; Kim, 2009)	VisC	Visual
2.	Auditory for China measured with (PLSL2MQ; Kim, 2009)	AudC or VerbC	Verbal
3.	Kinesthetic for China measured with (PLSL2MQ; Kim, 2009)	KinC	Other learning preference
4.	Ideal L2 self for China measured with (PLSL2MQ; Kim, 2009)	IdlC	Other learning preference
5.	Motivational L2 behavior for China measured with (PLSL2MQ; Kim, 2009)	MotC	Other learning preference
	South Korean Students		
1.	Visual for Korea measured with (PLSL2MQ; Kim, 2009)	VisK	Visual
2.	Auditory for Korea measured with (PLSL2MQ; Kim, 2009)	AudK or VerbK	Verbal
3.	Kinesthetic for Korea measured with (PLSL2MQ; Kim, 2009)	KinK	Other learning preference
4.	Ideal L2 self for Korea measured with (PLSL2MQ; Kim, 2009)	IdlK	Other learning preference
5.	Motivational L2 behavior for Korea measured with (PLSL2MQ; Kim, 2009)	MotK	Other learning preference

In the results of the matrix that examined the Chinese students of the Yang and Kim (2011) study, more than 25 iterations were required. This syntax was reentered using 100 iterations, and two factors were extracted with 56 iterations. The KMO measure of sampling adequacy estimated at .660, an amount considered mediocre (Kaiser, 1974). In the results of the factor matrix, the visual- and verbal-learning-preference measures both loaded on Factor 1 along with another learning-preference measure. The details of these results are displayed in Table 14.1.

Table 14.1

Pattern-Matrix and Factor-Correlation-Matrix Results of Yang and Kim (2011)

Chinese Student Examined in Yang and Kim (2011)

Pattern Matrix[a]

	Factor 1	Factor 2
VisC LP	.002	**.798**
VerbC LP	.147	**.495**
KinC	-.103	**.461**
IdlC	**.649**	.026
MotC	**.831**	-.060

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Factor-Correlation Matrix

Factor	1	2
1	1.000	.461
2	.461	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

In the results of the matrix that examined the South Korean students of the Yang and Kim (2011) study, two factors were extracted with 19 iterations. The KMO measure of sampling adequacy estimated at .586, an amount considered mediocre according to Kaiser (1974).None of the factors were well defined. The visual-learning-preference measure and the verbal preference measure were both only defined by a single measure. The details of these results are displayed in Table 14.2.

Table 14.2

Pattern Matrix and Factor-Correlation Matrix Results of Yang and Kim (2011)

South Korean Students Examined in Yang and Kim (2011)

Pattern Matrix[a]

	Factor 1	Factor 2
VisK LP	.381	.395
VerbK LP	-.090	**.643**
KinK	-.019	**.588**
IdlK	**.860**	-.068
MotK	**.790**	-.040

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

Factor-Correlation Matrix

Factor	1	2
1	1.000	.256
2	.256	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Summary of findings for group A

Summarizing the statistical methods applied to the matrices in Group A, there were 9 studies and 12 matrices that were examined. In 8 of 12 matrices the FA method of analysis was applied, and in the other four matrices, the PC method of analysis was applied. Six of the 12 matrices required 26 to 100 iterations to produce output, and 5 required 25 or less iterations to produce output, and one matrix required over 100 iterations.

The objective of this reanalysis on Group A was to investigate if a secondary analysis of the 9 studies that analyzed a single domain of abilities, cognitive styles, or learning preferences measuring the visual-verbal learner-preference dichotomy within a single domain consistently identified the visual and verbal constructs when using a common factor-analysis procedure. In the overall statistical findings derived from examining the matrices in Group A, only three visual or verbal or visual-verbal factors or components were defined: one visual-abilities factor and two visual-verbal cognitive-style factors. All the other visual and verbal ability, cognitive-style, and learning-preference factors of were not well defined.

Overview of Subsection Two

The second subsection contains the factor-analysis results of studies using measures of the visual- and verbal-conceptual distinction across two domains of abilities, cognitive styles, Group B. This group included a total of 5 studies and 5 matrices that were examined. The studies of Group B consisted of two types of pairings. One pairing included three studies that examined the two domains of abilities and cognitive styles: two of the studies were performed by Federico and Landis (1979, 1984) and one study by Nah and Lane (1990). The second pairing of studies included two studies that examined the two domains of abilities and learning preferences: Danisman and Erginer (2017), and Haciomeroglu (2015).

As mentioned previously, in all the tables and matrices, the measures of the SPSS results that define the visual and verbal constructs related to the domains of abilities, cognitive styles, or learning preferences are highlighted with bold, green font. High-loading measures that define the verbal or visual constructs but are not related to the domain of abilities, cognitive styles, or learning preferences are emphasized with bold, underline, and red font. Other high-loading measures are emphasized with bold black font. An overview of the SPSS output derived from Group B's matrices with emphasis on the findings related to the visual and verbal constructs is defined in Table 15.

Table 15
Displaying SPSS Results of Group B: Five Studies that Examined Two Domains

Participants and Measures	**Domain Examined**	**Number of Iteration**	**FA or PA method**	**Findings of Study**
		Federico and Landis (1979)		
207 Participants 24 Total Measures, 2 of which were visual or verbal measures	Abilities and Cognitive Styles	22	FA method using the initial factor- matrix results	Eight factors were extracted: Factor #1 was a verbal-cognitive-ability measure and a word-cognitive-aptitude measure along with seven other technical-aptitude measures. Factors #2 through Factor #8 were technical-aptitude or ability measures. The visual-spatial construct was not well defined in any matrix.
		***Federico and Landis (1984)**		
201 Participants 24 Total Measures, 2 of which were visual or verbal measures	Abilities and Cognitive Styles	96	FA method using the initial factor- matrix results	Eight factors were retracted: Factor #1 was a verbal-cognitive-ability measure and a word-cognitive-aptitude measure along with 8 other technical-aptitude measures. Factor #2 through Factor #8 were technical-aptitude or ability measures. The visual-spatial construct was not well defined in any matrix.
		Nah and Lane (1990)		
390 Participants 12 Total Measures, 5 of which were visual or verbal measures	Abilities and Cognitive Styles	23	FA method using the initial factor- matrix results	Three factors were extracted: Factor #1 was a general-achievement measure defined with five achievement measures. Factor #2 was a visual factor defined with one a visual-spatial ability measure and two visual-spatial cognitive-style measures. F#3 was not well defined. The verbal construct was not well defined in any matrix.

Table 15 continues

Table 15 Continued

Participants and Measures	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
		Danisman and Erginer (2017)		
97 Participants 6 Total Measures, 3 of which were visual or verbal measures	Ability and Learning Preference	28	FA method using the initial factor- matrix results	Two factors were extracted: Factor #1 was a visual-verbal learning-preference factor with a visual learning preference-measure, a verbal learning-preference measure, and a reading-ability measure. Factor #2 was a visual-spatial and math-reasoning factor.
		***Haciomeroglu (2015)**		
150 Participants 12 Total Measures, 7 of which were visual or verbal measures	Ability and Learning Preference	67	FA method using the pattern matrix and factor-correlation matrix results	Four factors were extracted: Factor #1 was a visual-spatial-ability factor. Factor #2 was a math-calculus-achievement factor. Factor #3 was a verbal factor defined with two verbal ability measures. F#4 was defined by two visual-learning-preference measures.

Note: The studies that are marked with an asterisk are those in which the original researcher(s) also performed a factor-analysis or a principal-component procedure.

Detailed findings of the SPSS output for group B

In the Federico and Landis (1979) study, the researchers analyzed the two domains of abilities and cognitive styles. The researchers sought to identify cognitive characteristics that differentiate successful from unsuccessful Navy preparatory-school trainee graduates by trying to investigate if students who did not graduate and who did graduate differed statistically significantly on scores of cognitive styles or scores of cognitive abilities or on scores of cognitive aptitudes. The sample consisted of 207 college-age participants. There were 24 total measures examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 16.0.

Table 16.0
Test names and SPSS Abbreviations for Federico and Landis (1979)

Name of Measures		Abbr. for Measures	Type of Construct
1.	Field-independence versus Field-Dependence measured with Hidden Figures Test, Part I (Ekstrom, French, Harmon, & Dermen, 1976)	FILDINDP	Other cognitive style
2.	Conceptualizing Style measured with Clayton-Jackson Object Sorting Test (Clayton & Jackson, 1961)	CONCSTYI	Other cognitive style
3.	Reflectiveness-Impulsivity measured with Impulsivity Subscale from Personality Research Test, Form E (Jackson, 1974)	REFLIMPL	Other cognitive style
4.	Tolerance Of Ambiguity measured with Tolerance of Ambiguity Scale from Self-Other Test, Form C (Rydell & Rosen, 1966)	TOLRAMBQ	Other cognitive style
5.	Category Width measured with Category Width Scale (Pettigrew, 1958)	CATWIDBH	Other cognitive style
6.	Cognitive Complexity measured with Group Version of Role Construct Repertory Test (Bieri, Atkins, Briar, Leaman, Miller, & Tripodi, 1966)	COGCOMPX	Other cognitive style
7.	Verbal Comprehension measured with Vocabulary Test, Part 1 (Ekstrom et. al., 1976)	VERBCOMP or VERB	Verbal Cognitive Ability
8.	General Reasoning measured with Arithmetic Aptitude Test, Part I (Ekstrom et. al., 1976)	GENLREAS	Other cognitive ability
9.	Associational Fluency measured with Controlled Associations Test, Part I (Ekstrom et. al., 1976)	ASSOFLUN	Other cognitive ability
10.	Logical Reasoning measured with Nonsense Syllogisms Test, Part I, (Ekstrom et. al., 1976)	LOGIREAS	Other cognitive ability
11.	Induction measured with Figure Classification Test, Part I (Ekstrom et. al., 1976)	INDUCTON	Other cognitive ability
12.	Ideational Fluency measured with Topics Test, Part I (Ekstrom et. al., 1976)	IDEAFLUN	Other cognitive ability
13.	General Information measured with General Information Subset, of Armed Services Vocational Aptitude Battery Test (ASVAB, 1968)	GENLINFO	Other cognitive aptitude
14.	Numerical Operations measured with Electronics Information Subtest, (ASVAB, 1968)	NUMROPER	Other cognitive aptitude
15.	Attention To Detail measured with Attention To Detail Subtest (ASVAB, 1968)	ATTNDETL	Other cognitive aptitude
16.	Word Knowledge measured with Word Knowledge Subtest (ASVAB, 1968)	WORDKNOL	Other cognitive aptitude
17.	Arithmetic Reasoning measured with Arithmetic Reasoning (ASVAB, 1968)	ARTHREAS	Other cognitive aptitude
18.	Space Perception measured with Space Perception Subtest (ASVAB, 1968)	SPACPERC or VIS	Spatial Cognitive Aptitude
19.	Mathematics Knowledge measured with Mathematics Knowledge Subtest (ASVAB, 1968)	MATHKNOL	Other cognitive aptitude
20.	Electronics Information measured with Electronics Information Subtest (ASVAB, 1968)	ELECINFO	Other cognitive aptitude
21.	Mechanical Comprehension measured with Mechanical Comprehension Subtest (ASVAB, 1968)	MECHCOMP	Other cognitive aptitude
22.	General Science measured with General Science Subtest (ASVAB, 1968)	GENLSCIE	Other cognitive aptitude
23.	Shop Information measured with Shop Information Subtest (ASVAB, 1968)	SHOPINFO	Other cognitive aptitude
24.	Automotive Information measured with Automotive Information Subtest (ASVAB, 1968)	AUTOINFO	Other cognitive aptitude

In the matrix results of the Federico and Landis's (1979) study, eight factors were extracted with 22 iterations, and the rotation converged in 13 iterations. The KMO measure of sampling adequacy estimated at .753, an amount considered mediocre to good

(Kaiser, 1974). In the results of the pattern matrix, the verbal construct was not well defined and the visual-spatial construct was defined only with a single measure in Factor 6, and the other factors were defined by aptitude or ability measures that primarily related to technical-aptitude measures. Both the visual-spatial and the verbal construct was not well defined. The details of these results are displayed in Table 16.1.

Table 16.1
Pattern-Matrix and Factor-Correlation-Matrix Output for Federico and Landis (1979)

Pattern Matrix[a]

	Factor 1	2	3	4	5	6	7	8
FILDINDP	-.063	-.218	-.026	**.618**	.016	.215	.057	-.015
CONCSTYI	-.099	.032	.030	.322	.020	-.097	-.155	.019
REFLIMPL	-.226	.096	-.022	**-.408**	-.005	.330	**.468**	-.070
TOLRAMBQ	.006	-.047	.027	-.035	.017	.049	-.046	-.350
CATEWIDH	.119	-.075	-.025	.048	-.065	-.050	**.635**	.262
COGCOMPX	.025	-.007	.034	.070	.097	-.042	**-.400**	.046
VERB_A	.095	.348	.010	.112	.195	-.304	.220	-.064
GENLREAS	.010	-.189	**.442**	.254	.056	.017	.177	-.262
ASSOFLUN	-.151	.041	-.108	.198	**.737**	.126	-.111	-.107
LOGIREAS	.162	-.046	.160	.186	-.042	-.104	.068	-.060
INDUCTON	-.173	.103	-.040	**.443**	.069	-.015	.099	.379
IDEAFLUN	.078	-.024	.120	-.099	**.597**	.081	-.090	.103
GENLINFO	.286	.254	.038	-.186	.167	.064	.090	-.072
NUMROPER	.056	-.138	**.833**	-.115	.154	.025	-.092	.200
ATTNDETL	-.040	-.018	.346	-.019	.007	-.093	.064	.395
WORDKNOL	-.052	**.988**	.046	-.211	.088	-.064	-.025	.051
ARTHREAS	-.016	.235	**.600**	-.042	-.144	.101	-.013	-.080
VIS_A	.033	-.062	.087	-.001	.099	**.522**	.033	-.105
MATHKNOL	-.148	.245	**.521**	.327	-.122	.105	-.069	.018
ELECINFO	.322	.244	-.027	.277	-.031	.179	-.117	-.055
MECHCOMP	.390	.087	-.004	.216	.074	**.473**	.046	.131
GENLSCIE	.089	**.709**	-.056	.052	-.101	.012	-.023	.038
SHOPINFO	**.764**	.008	.035	-.265	-.019	.075	-.052	-.094
AUTOINFO	**.791**	-.013	-.036	-.016	-.047	-.037	.062	.027

Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization. a. Rotation converged in 13 iterations.

Promax Factor-Correlation Matrix

Factor	1	2	3	4	5	6	7	8
1	1.000	.544	.348	.476	.218	.241	.212	-.226
2	.544	1.000	.379	.442	.394	.214	.348	-.345
3	.348	.379	1.000	.444	.277	-.039	.322	-.231
4	.476	.442	.444	1.000	.352	.074	.359	-.287
5	.218	.394	.277	.352	1.000	-.220	.370	-.122
6	.241	.214	-.039	.074	-.220	1.000	-.047	.085
7	.212	.348	.322	.359	.370	-.047	1.000	-.259
8	-.226	-.345	-.231	-.287	-.122	.085	-.259	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

In the next study, Federico and Landis (1984) administered the same test measures as those included in their former study (Federico and Landis, 1979) to another sample group of 201 high-school through college-age Navy recruits to investigate whether cognitive styles, abilities, and aptitudes provide complementary or redundant information. There were 24 total measures examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 17.0.

Table 17.0
Test names and SPSS Abbreviations for Federico and Landis (1984)

Name of Measures	Abbr. for Measures	Construct
1. Field-independence versus Field-Dependence measured with Hidden Figures Test, Part I (Ekstrom, French, Harmon, & Dermen, 1976)	FILDINDP	Other cognitive style
2. Conceptualizing Style measured with Clayton-Jackson Object Sorting Test (Clayton & Jackson, 1961)	CONCSTYI	Other cognitive style
3. Reflectiveness-Impulsivity measured with Impulsivity Subscale from Personality Research Test, Form E (Jackson, 1974)	REFLIMPL	Other cognitive style
4. Tolerance Of Ambiguity measured with Tolerance of Ambiguity Scale from Self-Other Test, Form C (Rydell & Rosen, 1966)	TOLRAMBQ	Other cognitive style
5. Category Width measured with Category Width Scale (Pettigrew, 1958)	CATWIDBH	Other cognitive style
6. Cognitive Complexity measured with Group Version of Role Construct Repertory Test (Bieri, Atkins, Briar, Leaman, Miller, & Tripodi, 1966)	COGCOMPX	Other cognitive style
7. Verbal Comprehension measured with Vocabulary Test, Part 1 (Ekstrom et. al., 1976)	VERBCOMP or VERB	Verbal Cognitive Ability
8 General Reasoning measured with Arithmetic Aptitude Test, Part I (Ekstrom et. al., 1976)	GENLREAS	Other cognitive ability
9. Associational Fluency measured with Controlled Associations Test, Part I (Ekstrom et. al., 1976)	ASSOFLUN	Other cognitive ability
10. Logical Reasoning measured with Nonsense Syllogisms Test, Part I, (Ekstrom et. al., 1976)	LOGIREAS	Other cognitive ability
11. Induction measured with Figure Classification Test, Part I (Ekstrom et. al., 1976)	INDUCTON	Other cognitive ability
12. Ideational Fluency measured with Topics Test, Part I (Ekstrom et. al., 1976)	IDEAFLUN	Other cognitive ability
13. General Information measured with General Information Subset, the Armed Services Vocational Aptitude Battery Test (ASVAB, 1968)	GENLINFO	Other cognitive aptitude
14. Numerical Operations measured with Electronics Information Subtest, (ASVAB, 1968)	NUMROPER	Other cognitive aptitude
15. Attention To Detail measured with Attention To Detail Subtest (ASVAB, 1968)	ATTNDETL	Other cognitive aptitude
16. Word Knowledge measured with Word Knowledge Subtest (ASVAB, 1968)	WORDKNOL	Other cognitive aptitude
17. Arithmetic Reasoning measured with Arithmetic Reasoning (ASVAB, 1968)	ARTHREAS	Other cognitive aptitude
18. Space Perception measured with Space Perception Subtest (ASVAB, 1968)	SPACPERC or VIS	Spatial Cognitive Aptitude or Ability
19. Mathematics Knowledge measured with Mathematics Knowledge Subtest (ASVAB, 1968)	MATHKNOL	Other cognitive aptitude
20. Electronics Information measured with Electronics Information Subtest (ASVAB, 1968)	ELECINFO	Other cognitive aptitude
21. Mechanical Comprehension measured with Mechanical Comprehension Subtest (ASVAB, 1968)	MECHCOMP	Other cognitive aptitude
22. General Science measured with General Science Subtest (ASVAB, 1968)	GENLSCIE	Other cognitive aptitude
23. Shop Information measured with Shop Information Subtest (ASVAB, 1968)	SHOPINFO	Other cognitive aptitude
24. Automotive Information measured with Automotive Information Subtest (ASVAB, 1968)	AUTOINFO	Other cognitive aptitude

In the reanalysis, more than 25 iterations were required. Applying 100 iterations, eight factors were extracted with 96 iterations, and the rotation converged in 11 iterations. The KMO measure of sampling adequacy estimated at .787, an amount considered good (Kaiser, 1974). In the results of the pattern matrix, the visual and the verbal constructs were not well defined, and the other factors were defined by other aptitude or ability measures that primarily related to technical skills. The details of these results are displayed in Table 17.1. The reanalysis findings of this study were consistent with those of Federico and Landis's (1984) original research.

Table 17.1
Pattern-Matrix and Factor-Correlation-Matrix Output for Federico and Landis (1984)

Promax-Pattern Matrix[a]

	Factor							
	1	2	3	4	5	6	7	8
FILDINDP	-.016	-.073	-.165	**.729**	-.049	-.080	.070	.002
CONCSTYL	-.110	.024	.009	.283	.032	-.172	-.020	-.023
REFLIMPL	-.135	-.026	.009	-.225	.022	.934	.126	-.054
TOLRAMBQ	-.008	-.050	-.054	.059	.059	.027	-.013	-.339
CATEWIDH	.141	.027	-.107	.151	.010	.213	.353	.275
COGCOMPX	-.005	.063	-.047	-.103	.191	-.123	**-.543**	-.003
VERB A	.081	-.019	.309	.074	.310	-.056	.332	-.029
GENLREAS	-.015	.383	-.174	.387	.147	.039	.145	-.211
ASSOFLUN	-.121	-.158	.053	.167	**.726**	-.028	-.146	-.100
LOGIREAS	.151	.139	-.104	.159	.061	-.084	.090	-.122
INDUCTON	-.135	.020	.088	**.464**	.080	-.094	.044	**.470**
IDEAFLUN	.069	.191	-.061	-.192	**.638**	.060	-.162	.039
GENLINFO	.349	.033	.214	-.128	.157	.097	.080	-.084
NUMROPER	-.012	**.876**	-.045	-.152	.106	-.016	-.127	.145
ATTNDETL	.000	**.446**	-.055	-.102	-.034	-.023	.063	.316
WORDKNOL	-.033	.052	**1.097**	-.274	.056	-.027	.017	.072
ARTHREAS	.013	**.556**	.248	.068	-.157	.007	-.004	-.092
VIS A	.175	.042	-.041	.142	.058	.170	-.377	-.060
MATHKNOL	-.066	**.459**	.175	.398	-.113	-.013	-.013	-.024
ELECINFO	**.457**	-.092	.168	.264	-.039	.005	-.068	-.042
MECHCOMP	**.577**	.011	.079	.203	.064	.073	-.208	.151
GENLSCIE	.132	-.077	.595	.156	-.097	.048	.016	.001
SHOPINFO	**.790**	.010	.013	-.239	-.052	-.081	-.024	-.099
AUTOINFO	**.869**	-.006	-.095	-.073	-.027	-.127	.141	.049

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 11 iterations.

Factor-Correlation Matrix

Factor	1	2	3	4	5	6	7	8
1	1.000	.372	.569	.517	.268	.202	.004	-.202
2	.372	1.000	.401	.511	.325	.007	.218	-.238
3	**.569**	**.401**	1.000	.548	.432	.173	.126	-.298
4	**.517**	**.511**	**.548**	1.000	.401	.198	.059	-.151
5	.268	.325	**.432**	**.401**	1.000	-.027	.359	-.013
6	.202	.007	.173	.198	-.027	1.000	-.108	.044
7	.004	.218	.126	.059	.359	-.108	1.000	-.098
8	-.202	-.238	-.298	-.151	-.013	.044	-.098	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

The Nah and Lane (1990) study analyzed the two domains of abilities and cognitive styles. The researchers had administered a multidimensional measure of cognitive style as well as achievement tests measuring academic areas of Korean language, mathematics, English, social studies, and science to a sample of 390 ninth-grade Korean students to examine 12 total measures. The test names, SPSS abbreviations for the names, and the construct they represent are defined in Table 18.0.

Table 18.0
Test names and SPSS Abbreviations for Nah and Lane (1990)

Name of Measures		Abbr. for Measures	Type of Construct
1.	Group Embedded Figures Test (oKman, Raskin, & Witkin, 1971)	GEmbFtest or Vis1	Visual-Spatial Ability
2.	Analytic Skill of Learning Style Profile (LSP; (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	AnSkill or Vis2	Visual-Spatial Cognitive Style
3.	Spatial Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	SpSkill or Vis3	Visual-Spatial Cognitive Style
4.	Discrimination Skill of LSP scale for (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	DisSkill or Vis4	Visual Cognitive Style
5.	Categorization Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	CatSkill or Verb	Verbal Cognitive Style
6.	Sequential Processing Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	SeqPSkill	Other Cognitive Style
7.	Memory Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	MemSkill	Other Cognitive Style
8	Korean Language (Kyohaksa Achievement Test, 1988)	KorLang	Achievement measure
9.	Mathematics (Kyohaksa Achievement Test, 1988)	Mathematics	Achievement measure
10.	English (Kyohaksa Achievement Test, 1988)	English	Achievement measure
11.	Social Studies (Kyohaksa Achievement Test, 1988)	SocStud	Achievement measure
12.	Science (Kyohaksa Achievement Test, 1988)	Science	Achievement measure

In the reanalysis of Nah and Lane's (1990) research, three factors were extracted with 23 iterations, and the rotation converged in four iterations. The KMO measure of sampling adequacy estimated at .906, an amount considered excellent according to Kaiser (1974). Factor 2 was a visual-cognitive-style-and-ability factor defined with two visual-cognitive-style measures and one visual ability measure. Factor 1 was defined with five general-achievement measures; Factor 3 was not well defined. The verbal construct was not well defined overall. The details of these results are displayed in Table 18.1.

Table 18.1
Pattern-Matrix and Factor-Correlation-Matrix Output for Nah and Lane (1990)

Promax-Pattern Matrix[a]

	Factor 1	Factor 2	Factor 3
Vis1 A	.014	**.709**	.023
Vis2 CS	.091	**.559**	.142
Vis3 CS	.012	**.688**	-.030
Vis4 CS	-.068	.110	.223
Verb CS	-.083	-.138	.212
SeqPSkill	.053	.145	.385
MemSkill	-.064	.345	.083
KorLang	**.586**	.316	-.114
Math	**.870**	-.015	.094
Eng	**.993**	-.203	.039
SocStud	**.742**	.043	-.118
Science	**.799**	.104	.016

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 4 iterations.

Promax-Factor-Correlation Matrix

Factor	1	2	3
1	1.000	**.686**	.039
2	**.686**	1.000	.212
3	.039	.212	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Note: Visual or verbal ability or cognitive style measures are indicated with A and CS, respectively.

The Danisman and Erginer (2017) analyzed the two domains of abilities and learning preferences. The researchers investigated 97 fifth graders' mathematical reasoning and spatial ability to identify the predictive power of learning styles on mathematical learning profiles. Six total measures were examined. The test names and SPSS abbreviations for the name along with the type of construct they represent are defined in Table 19.0.

Table 19.0
Test names and SPSS Abbreviations for Danişman and Erginer (2017)

Name of Measures	Abbr. for Measures	Type of Construct
1. Spatial Ability Test (SAT; Danişman, 2011)	Spat or Vis1	Ability
2. Visual Learning Style based on Test on Learning Styles (TLS; Erginer, 2002)	Vis or Vis2	Learning Preference
3. Auditory Learning Style test (TLS; Erginer, 2002)	Aud or Verb	Learning Preference
4. Mathematical Reasoning Test (MET; Danişman, 2011)	Reas	Ability
5. Kinesthetic Learning Style test (TLS; Erginer, 2002)	Kin	Learning Preference
6. Reading Learning Style test (TLS; Erginer, 2002)	Read	Learning Preference
7. Combined Learning Style (TLS; Erginer, 2002)	Comb	Learning Preference

In the reanalysis of Danisman and Erginer's (2017) research, more than 25 iterations were required. Using 100 iterations, two factors were extracted with 28 iterations, and the rotation converged in three iterations. The KMO measure of sampling adequacy was estimated at .797, an amount considered good (Kaiser, 1974). Factor 1 was a visual-verbal cognitive-style factor defined with a visual-cognitive-style measure, a verbal-cognitive-style measure, a reading-ability measure, and a combination learning-style measure. Factor 2 was defined as a mathematics-reasoning-and-spatial-ability factor. In all matrices, the verbal construct was not well defined independently. The details of these results are displayed in Table 19.1.

Table 19.1
Pattern-Matrix and Factor-Correlation-Matrix Output for Danişman and Erginer (2017)

Promax-Pattern Matrix[a]

	Factor 1	Factor 2
Reas	.100	**.508**
Vis1 A	-.100	**.817**
Read	**.855**	-.139
Vis2 LP	**.619**	.159
Verb LP	**.614**	-.018
Kin	.337	.318
Comb	**.468**	.157

Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization. a. Rotation converged in 3 iterations.

Factor-Correlation Matrix

Factor	1	2
1	1.000	**.578**
2	**.578**	1.000

Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization.

Note: Visual or verbal ability or learning-preference measures are indicated with A and LP, respectively.

In the Haciomeroglu (2015) study the two domains of abilities and learning preferences were analyzed. The researchers investigated if calculus tasks could be used to identify preferences for visual or analytic processing and if the resulting preferences could be used to examine relationship to calculus performance, to spatial, and to verbal-logical reasoning ability for 150 high-school students. There were 12 total measures examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 20.0.

Table 20.0
Test names and SPSS Abbreviations for Haciomeroglu (2015)

Name of Measures	Abbr. for Measure	Type of Construct
1. Advanced Placement Calculus exam (Standardized test of ability)	AP	Oher Ability (Mathematical)
2. Mathematical performance on graphic calculus tasks Haciomeroglu, 2015	PGraphic	Other Ability (Mathematical)
3. Mathematical performance on algebraic calculus tasks (Haciomeroglu, 2015)	PAlgebraic	Other Ability (Mathematical)

Table 20 continues

Table 20 Continued

Name of Measures		Abbr. for Measure	Type of Construct
4.	Cube Comparisons Test (Ekstrom, French, & Harman, 1976)	CC or Vis1	Spatial-Visual Ability
5.	Card Rotations Test (Ekstrom et al., 1976)	CR or Vis2	Spatial-Visual Ability
6.	Form Board Test (Ekstrom et al., 1976)	FB or Vis3	Spatial-Visual Ability
7.	Paper Folding Test (Ekstrom et al., 1976)	PF or Vis4	Spatial-Visual Ability
8.	Nonsense Syllogisms Test (Ekstrom et al., 1976)	NS or Verb1	Verbal Reasoning Ability
9.	Diagramming Relationships Test (Ekstrom et al., 1976)	DR or Verb2	Verbal Reasoning Ability
10.	Visual preference for graphic calculus tasks (Haciomeroglu, 2015)	VPG or Vis5	Visual Preference
11.	Visual preference for algebraic calculus tasks (Haciomeroglu, 2015)	VPA or Vis6	Visual Preference
12.	Visual preference for algebra tasks on the Mathematical Processing Instrument (MPI; Suwarsono, 1982	MPI or Vis7	Visual Preference

In the reanalysis, more than 25 iterations were required. Using 100 iterations, four factors were extracted with 67 iterations, and the rotation converged in six iterations. The KMO measure of sampling adequacy estimated at .780, an amount considered good (Kaiser, 1974). Factor 1 was a visual-spatial- ability factor defined with three visual-spatial ability measures. Factor 2 was defined with three mathematics-achievement measures. Factor 3 was defined with a single verbal measure. Factor 4 was a visual-learning-preference factor defined with two visual learning-preference measures. The details of these results are displayed in Table 20.1. These findings were similar to those of the original research by Haciomeroglu (2015) that produced four factors of (a) spatial ability, (b) mathematics-calculus performance, (c) verbal-logical reasoning ability, and (d) preferred mode of processing mathematics tasks.

Table 20.1
Promax-Factor-Pattern and Promax-Factor-Correlation-Matrix Output for Haciomeroglu (2015)

Promax-Pattern Matrix[a]

	Factor 1	2	3	4
AP	.054	**.648**	.131	-.080
PGraphic	.051	**.772**	.044	.162
PAlgebraic	-.030	**.597**	.060	-.093
Vis1 A	**.768**	-.068	.031	-.089
Vis2 A	**.726**	-.066	-.162	-.026
Vis3 A	**.450**	.042	.209	.068
Vis4 A	**.580**	.001	.009	.056
Verb1 A	-.075	.179	**.422**	.011
Verb2 A	-.036	-.110	**.914**	-.021
Vis5 LP	.004	.195	-.094	**.576**
Vis6 LP	-.037	-.243	.044	**.781**
Vis7 LP	.162	-.379	.172	.104

Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Promax-Factor-Correlation Matrix

Factor	1	2	3	4
1	1.000	**.497**	**.612**	.300
2	**.497**	1.000	**.572**	**.582**
3	**.612**	**.572**	1.000	.379
4	.300	**.582**	.379	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Summary of findings for group B

Summarizing the statistical methods applied in Group B, this group examined a total of five studies and five matrices. All five of the matrices examined in Group B were applied a FA method of analysis. Two of the five matrices required 25 or less iterations, three of the matrices required 26 to 100 iterations.

The objective of this reanalysis on Group B was to determine if a secondary analysis of the five studies that examined two domains of abilities, cognitive styles, or learning preferences to determine if these studies measuring the visual-verbal learner-preference dichotomy across two domains consistently identified the visual and verbal constructs when using a common factor-analysis procedure. In the overall statistical findings derived from the matrices of Group B, there were five total visual or verbal or visual-verbal factors defined. One of these factors was defined with two domains as a visual-ability-and-cognitive-style factor; the other four factors were defined with a single domains: one of the single-domain factors was a visual-verbal learning-preference factor that was defined with the single domain of learning preferences, one was a visual-spatial-ability factor that was defined with the single domain of abilities, one was a visual-learning-preference factor that was defined with two learning-preference measures, and one was a verbal ability factor defined with two verbal-ability measures. Overall, only one verbal factor was defined.

Overview of Subsection Three

The third subsection examined the factor-analysis results of studies using measures of the visual- and verbal-conceptual distinction across three domains of abilities, cognitive styles, and learning preferences and is referred to as Group C. Group C includes 4 studies and 4 matrices: Mayer and Massa (2003); Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014); Massa and Mayer (2006); and Burns and Hagelskamp (2017). An overview of the SPSS output derived from Group C's matrices with emphasis on the finding related to the visual and verbal constructs is provided in Table 21.

Table 21
Overview of SPSS Results for Group C: Matrices Examining Three Domains

Name of Study	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
*Mayer and Massa (2003)	Abilities, Cognitive Style, and Learning Preference	27	FA method using the pattern matrix and factor-correlation matrix results	Four factors were extracted, three were visual, or verbal, or visual-verbal factors. Factor 1 was one visual-verbal factor defined with a visual-verbal learning-preference measure, two visual-verbal cognitive-style measures, and a visual-spatial-ability measure. Factor 2 was a visual-verbal-learning-preference factor defined with three visual-verbal learning-preference measures. Factor 4 was visual-spatial-ability factor defined with two visual-spatial-ability measures.

Table 21 continues

Table 21 Continued

Name of Study	Domain Examined	Number of Iterations	FA or PC Method	Findings of Study
Meneghetti et al. (2014)	Abilities, Cognitive Style, and Learning Preference	100	PC method using the pattern matrix and component-correlation matrix results	Five components were extracted, two were visual components and one was a visual-verbal component. Component 1 was a visual component defined with three measures: one visual-cognitive-style measure, one visual-learning-preference measure, and one visual-verbal-ability measure. Component 2 was a visual component defined with two visual-ability measures and one visual-learning preference measure. Component 3 was defined with a visual-verbal-cognitive-style component, defined with a verbal- and a visual-cognitive-style measure.
*Massa and Mayer (2006)	Abilities, Cognitive Style, and Learning Preference	21	FA method using the pattern matrix and factor-correlation matrix results	Three factors were extracted, two of them were visual-verbal factors. Factor 1 was visual-verbal factor defined with four visual-verbal learning-preference measures and one visual-verbal cognitive-style measure.Factor 2 was a visual-verbal factor defined with two visual-ability measures and one visual-verbal cognitive-style measure
*Burns and Hagelskamp (2017)	Abilities, Cognitive Style, and Learning Preference	100	PC method using the pattern matrix and component-correlation matrix results	Ten components were extracted, one of these was a visual-verbal component. Component 7 was a visual-verbal-learning- preference factor defined with a visual- and a verbal-learning-preference measure

Note: The studies that are marked with an asterisk are those in which the original researcher(s) also performed a factor-analysis or a principal-component procedure.

Detailed findings of SPSS results for group C

The Mayer and Massa (2003) study analyzed all three domains to investigate if the visual-verbal distinction could be decomposed into separate components. Fourteen total measures were examined on a sample of 95 college students. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 22.0.

Table 22.0
Test names and SPSS Abbreviations for Mayer and Massa (2003)

Name of Measures	Abbr. for Measures	Type of Construct
1. Standard Achievement Test (SAT; Educational Testing service)	SAT Math	General Achievement, Intelligence Quotient (IQ) of Mathematics
2. SAT for Verbal test (Educational Testing service)	SAT Verb and Verb1	General Achievement (IQ) of Verbal Ability
3. Vocabulary test (Armed Services Vocational Aptitude Battery)	Voc Test and Verb2	General Achievement of Verbal Aptitude

Table 22.0 continues

Table 22.0 Continued

Name of Measures		Abbr. for Measures	Type of Construct
4.	Card Rotation Test (Ekstrom, French, & Harman, 1979)	Card Rotate and Vis1	Visual-Spatial Ability
5.	Paper Folding Test (Ekstrom, French, & Harman, 1979)	Paper Fold and Vis2	Visual-Spatial Ability
6.	Verbal-Spatial Ability Rating test (Mayer & Massa, 2003)	VS Ability and Vis3	Visual-Spatial Ability
7.	Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977)	VV Quest and VisVerb1	VisVerb Cognitive-Style
8.	Santa Barbara Learning Style Questionnaire (Mayer & Massa, 2003)	SBLSQuest and VisVerb2	VisVerb Cognitive-Style
9.	Cognitive Style Analysis (CSA, Riding, 1991)	CogSAn and VisVerb3	VisVerb Cognitive-Style
10.	Verbal-Visual Learning Style Rating (Mayer & Massa, 2003)	VVLS Rate and VisVerb4	VisVerb Cognitive-Style
11.	Learning Scenario Questionnaire test (Mayer & Massa, 2003)	LS Quest and VisVerb5	VisVerb Learning Preference
12.	Multimedia Learning Preference (MMLP) Choice test (Mayer & Massa, 2003)	MLPT Ch and VisVerb6	VisVerb Learning Preference
13.	MMLP Rating test (Mayer & Massa, 2003)	MMLP Rating and VisVerb7	VisVerb Learning Preference
14.	MMLP Questionnaire test (Mayer & Massa, 2003)	MMLP Quest and VisVerb8	VisVerb Learning Preference

In the reanalysis, when the syntax was conducted with 25 iterations, more than 25 iterations were required. The syntax was reentered with 100 iterations, and four factors were extracted with 27 iterations. Similar to the findings of the original researchers, in the results of this reanalysis four factors were extracted: general ability, spatial ability, cognitive style, and learning preference. The KMO measure of sampling adequacy estimated at .692, an amount considered in the mediocre to good range (Kaiser (1974). In the reanalysis, Factor 1 was a visual-verbal factor defined with four visual-verbal measures and one visual measure; one was a visual-verbal measures was a learning preference measure and the other three were visual-verbal cognitive-style measures. Factor 2 was also as a visual-verbal factor defined with three learning preference measures. Factor 3 was a mathematics- and verb-achievement factor defined with one mathematics achievement measure and two verbal achievement measures. Factor 4 was a visual-spatial factor defined with two visual-spatial measures. The details of these results are displayed in Table 22.1.

Table 22.1
Pattern-Matrix and Factor-Correlation-Matrix Results of Mayer and Massa (2003)

Pattern Matrix[a]

	Factor 1	2	3	4
SATMath	.203	-.095	**.712**	.011
Verb1	-.117	.080	.945	-.058
Verb2	-.119	-.075	.462	.156
Vis1 A	-.141	.085	.029	**.662**
Vis2 A	.094	.043	.054	**.814**
Vis3 A	**.424**	-.179	-.060	.314
VisVerb1 CS	**.469**	.066	-.206	-.023
VisVerb2 CS	**.774**	.151	.089	-.020
VisVerb3 CS	.068	.147	-.055	.047
VisVerb4 CS	**.875**	.019	.093	-.102
VisVerb5 LP	**.402**	.180	-.022	.083
VisVerb6 LP	.055	**.572**	.019	.086
VisVerb7 LP	-.008	**.823**	.022	-.016
VisVerb8 LP	.080	**.672**	-.105	.005

Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Factor-Correlation Matrix

Factor	1	2	3	4
1	1.000	.500	-.147	.247
2	.500	1.000	.178	-.062
3	-.147	.178	1.000	.121
4	.247	-.062	.121	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Note: Visual or verbal ability, cognitive-style, and learning-preference measures are indicated with A, CS, and LP, respectively.

In the next study, Meneghetti et al. (2014) analyzed all three domains to investigate the role of individual’s visual-object, visual-spatial and verbal cognitive styles, cognitive abilities, and strategy use in the learning of visuospatial and abstract descriptions on a sample of 198 undergraduate students. In addition to visuospatial competence, the researchers also analyzed verbal ability as measured with reading comprehension, verbal style as measured with a preference for remembering words and sentences and the use of repetition-based strategies in relation to visuospatial text recall accuracy. Twelve total measures were examined. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 23.0.

Table 23.0
Test names and SPSS Abbreviations for Meneghetti et al. (2014)

Name of Measures	Abbr. for Measures	Type of Construct
1. Visuospatial description recall accuracy Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)	VSdescrecall or VisSpat1	Visual-Spatial Ability
2. Abstract description recall (accuracy) Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)	Abdescrecall	Other Ability
3. Imagery strategy Meneghetti, De Beni et al., 2013; Meneghetti, Ronconi et al., 2013).	Istrat	Other Ability
4. Repetition strategy Meneghetti, De Beni et al., 2013; Meneghetti, Ronconi et al., 2013).	Repstrat	Other Ability
5. Reading Comp Task (RCT; Cornoldi et al., 1991)	RComp or Verb1	Verbal Ability
6. Mental Rotations Test (MRT; Vandenberg & Kuse, 1978)	MenRotate or Vis2	Visual Ability
7. Minnesota Paper Form Board (MPFB; Likert & Quasha, 1941)	MinnPFB or Vis1	Visual Ability
8. Preference for spatial visualization (OSIQ; Blajenkova et al., 2006)	PrefSV or Vis3	Visual Learning Preference
9. Preference for object visualization (OSIQ; ; Blajenkova et al., 2006)	PrefOV or Vis5	Visual Learning Preference
10. Visual Strategy (QVVS; ; Antonietti & Giorgetti 1993, 1998)	VisS or Vis4	Visual Cognitive Style
11. Verbal Strategy (QVVS; Antonietti & Giorgetti 1993, 1998)	VerbS or Verb2	Verbal Cognitive Style
12. Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977)	VVQ or VisVerb2	Visual-Verbal Ability

In the reanalysis, more than 25 iterations were required to conduct the syntax; with 100 iterations, the communality of a variable exceeded one. The program was reentered using a principal component method, and five components were extracted and the rotation converged in eight iterations. Component 1 was a visual-component factor defined with one visual-cognitive-style measure, one a visual-learning-preference measure, and one visual-verbal ability measure. Component 2 was another visual-component factor defined with two visual-ability measured and one visual learning preference measure. Component 3 was a visual-verbal component defined with one visual- and one verbal-cognitive-style measure. Component 4 was not well defined with a visual-verbal measure and another-ability measure that related to imagery strategy. Component 5 was also not well defined with two other-ability measure related to recall skill and one verbal ability measure. The measure of sampling adequacy estimated at .553, an amount considered acceptable (Kaiser (1974). The details of these results are displayed in Table 23.1.

Table 23.1
Pattern-Matrix and Factor-Correlation-Matrix Results of Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)

Pattern Matrix[a]

	Component 1	2	3	4	5
VisSpat1 A	-.320	-.097	-.053	**.908**	.053
Abdescrecall	-.048	.013	.189	-.065	**.744**
Istrat	.284	.116	-.137	**.732**	-.011
Repstrat	.223	-.126	-.204	.102	**.663**
Verb1 A	-.277	.111	.289	.158	**.482**
Vis1 A	-.189	**.725**	-.033	-.070	.003
Vis2 A	.255	**.708**	-.096	-.054	.210
Vis3 LP	-.079	**.619**	.076	.110	-.245
Vis5 LP	**.646**	-.006	.291	.039	-.093
Vis4 CS	**.406**	-.041	**.650**	.193	-.029
Verb2 CS	-.033	-.018	**.878**	-.198	.122
VisVerb2 A	**.753**	-.041	-.084	-.170	.061

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 8 iterations.

Component-Correlation Matrix

Component	1	2	3	4	5
1	1.000	-.014	.055	.272	.071
2	-.014	1.000	.123	.107	.020
3	.055	.123	1.000	.266	.012
4	.272	.107	.266	1.000	.186
5	.071	.020	.012	.186	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

In the next study, Massa and Mayer (2006) examined all three domains. The researchers wanted to investigate whether students who score high on spatial ability, visual cognitive style, or visual learning preference learn better from a multimedia lesson containing visual-pictorial help screens, and if those scoring high on verbal ability, verbal cognitive style, or verbal learning preference learn better with word-text help screens. The sample was 114 college students, and 13 total measures were applied. The test names and SPSS abbreviations for these names along with the type of construct they represent are defined in Table 24.0.

Table 24.0

Test names and SPSS Abbreviations for Mayer and Massa (2006)

Name of Measures		Abbr. for Measures	Type of Construct
1.	Standard Achievement Test (SAT; Educational Testing service)	SAT Math	General Achievement, Intelligence Quotient (IQ) of Mathematics
2.	SAT for Verbal test (Educational Testing service)	SAT Verb and Verb1	General Achievement (IQ) of Verbal Ability
3.	Vocabulary test (Armed Services Vocational Aptitude Battery)	Voc Test and Verb2	General Achievement of Verbal Aptitude
4.	Card Rotation Test (Ekstrom, French, & Harman, 1979)	Card Rotate and Vis1	Visual-Spatial Ability
5.	Paper Folding Test (Ekstrom, French, & Harman, 1979)	Paper Fold and Vis2	Visual-Spatial Ability
6.	Verbal-Spatial Ability Rating test (Mayer & Massa, 2003)	VS Ability and Vis3	Visual-Spatial Ability
7.	Multimedia Learning Preference (MMLP) Choice test (Mayer & Massa, 2003)	MLPT Ch and VisVerb1	VisVerb Learning Preference
8.	MMLP Rating test (Mayer & Massa, 2003)	MMLP Rating and VisVerb2	VisVerb Learning Preference
9.	MMLP Questionnaire test (Mayer & Massa, 2003)	MMLP Quest and VisVerb3	VisVerb Learning Preference
10.	Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977)	VV Quest and VisVerb4	VisVerb Cognitive-Style
11.	Santa Barbara Learning Style Questionnaire (Mayer & Massa, 2003)	SBLSQuest and VisVerb5	VisVerb Cognitive-Style
12.	Verbal-Visual Learning Style Rating (Mayer & Massa, 2003)	VVLS Rate and VisVerb6	VisVerb Cognitive-Style
13.	Learning Scenario Questionnaire test (Mayer & Massa, 2003)	LS Quest and VisVerb7	VisVerb Learning Preference

Unlike the findings of the original research by Massa and Mayer's (2006) where a confirmatory-factor analysis was used and the researchers identified four factors: a learning-preference factor, a general-achievement factor, a spatial-ability factor, and a cognitive-style factor, in this reanalysis three factors were extracted with 21 iterations and the rotation converged in 10 iterations. The KMO measure of sampling adequacy estimated at .741, an amount considered good according to Kaiser (1974). In the reanalysis, Factor 1 was a visual-verbal factor defined with four visual-verbal learning-preference measures and one visual-verbal cognitive-style measure. Factor 2 was a visual factor defined with two visual-ability measures and one visual-verbal cognitive-style measure. Factor 3 was and mathematics- and verb-achievement factor defined with one mathematics-achievement measure and two verbal-achievement measures. The details of these results are displayed in Table 24.1.

Table 24.1
Pattern-Matrix and Factor-Correlation-Matrix Results of Mayer and Massa (2006)

Pattern Matrix[a]

	Factor 1	Factor 2	Factor 3
SATMath	.187	.064	**.939**
Verb1	.190	.380	.465
Verb2	-.120	.201	.469
Vis1 A	-.204	**.721**	.182
Vis2 A	-.135	**.694**	.210
Vis3 A	.247	.173	-.254
VisVerb1 LP	**.575**	.006	.190
VisVerb2 LP	**.830**	-.237	.020
VisVerb3 LP	**.880**	-.238	.091
VisVerb4 LP	.213	.393	-.170
VisVerb5 CS	.380	**.405**	-.199
VisVerb6 CS	**.421**	.352	-.204
VisVerb7 LP	**.540**	.206	.063

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 10 iterations.

Factor-Correlation Matrix

Factor	1	2	3
1	1.000	.511	-.321
2	.511	1.000	-.152
3	-.321	-.152	1.000

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

Note: High-loading measures that define the verbal or visual constructs but are not related to the domain of abilities, cognitive styles, or learning preferences are emphasized with bold, underline, and red font. Other high-loading measures are emphasized with bold black font. Visual or verbal ability, cognitive-style, and learning-preference measures are indicated with A, CS, and LP, respectively.

In the final study of this group, Burns and Hagelskamp (2017) analyzed all three domains to examine the construct validity of learning style preferences on a sample of 335 tenth-grade female students. Thirty-eight measures were examined into three construct categories: 10 were ability and style measures, 4 of the 10 were ability, and 6 of which were cognitive-style measures; 17 were learning-style-preference measures, and 11 were achievement measures. Only the 28 measures of abilities, cognitive-styles and learning-styles or learning-preferences were examined in this reanalysis; the 11 achievement measures were not included because they were analyzed separately by the original researchers and were not relevant to this research. The test names and SPSS abbreviations for these measures along with the type of construct they represent are defined in Table 25.0.

Table 25.0

Test names and SPSS Abbreviations for Burns and Hagelskamp (2017)

	Name of Measures	Abbr. for Measures	Type of Construct
1.	Nonverbal ability (Test of Cognitive Skills; TCS; CTB Macmillan/McGraw-Hill, 1993)	Non-verb	Other Ability
2.	Memory ability (TCS, 1993)	Memory	Other Ability
3.	Verbal ability (TCS, 1993)	Verbal or Verb1	Verbal Ability
4.	Analytic style (field independence versus field dependence) Learning Style Profile (LSP; National Association of Secondary School Principals, 1989)	Analytic	Other Ability
5.	Spatial ability Learning Style Profile (LSP, 1989)	Spatial or Vis1	Spatial Ability
6.	Discrimination (focusing verses scanning cognitive style) Learning Style Profile (LSP; 1989)	Discrimin and Vis2	Visual Cognitive Style
7.	Categorization (narrow verses broad category width cognitive style) Learning Style Profile (LSP, 1989)	Categorizat and Vis3	Visual Cognitive Style
8.	Successive (sequential) processing (LSP; Learning Style Profile; 1989)	Sequential	Other Cognitive Style
9.	Simultaneous processing Learning Style Profile (LSP, 1989)	Simultaneous	Other Cognitive Style
10.	Memory skill(leveling verses sharpening (LSP, 1989)	Mem skill	Other Cognitive Style
11.	Visual (LSP, 1989)	Visual or Vis4	Visual Learning Preference
12.	Auditory (LSP, 1989)	Auditory or Verb2	Verbal Learning Preference
13.	Emotional (LSP, 1989)	Emotional	Other Learning Preference
14.	Verbal-Spatial preference (LSP, 1989)	Verbal-Spatial or Verb3	Verbal Learning Preference
15.	Persistence orientation(LSP, 1989)	Persistence	Other Learning Preference
16.	Verbal Risk orientation (LSP, 1989)	Verbal Risk	Other Learning Preference
17.	Manipulative (LSP, 1989)	Manipulative	Other Learning Preference
18.	Early Morning Study time (LSP, 1989)	EarMornSt	Other Learning Preference
19.	Late Morning Study time (LSP, 1989)	LateMorningSt	Other Learning Preference
20.	Afternoon Study time (LSP, 1989)	AfternoonSt	Other Learning Preference
21.	Evening Study time (LSP, 1989)	EveningSt	Other Learning Preference
22.	Grouping (LSP, 1989)	Grouping	Other Learning Preference
23.	Posture (LSP, 1989)	Posture	Other Learning Preference
24.	Mobility (LSP, 1989)	Mobility	Other Learning Preference
25.	Sound (LSP, 1989)	Sound	Other Learning Preference
26.	Lighting (LSP, 1989)	Lighting	Other Learning Preference
27.	Temperature (LSP, 1989)	Temperat	Other Learning Preference

The original researchers analyzed three sets of matrices: one matrix examined 10 ability and cognitive style measures, the second matrix examined 17 learning-preference measures, and the third matrix examined 11 achievement measures. In the reanalysis the first and second matrix of the original research were combined to include 27 total measures: 17 learning-preference measures and 10 ability and cognitive-style measures.

In the reanalysis of these 27 measures, when conducted with 25 iterations, the communality of a variable exceeded 1.00. The program was reentered using the principal-component method; 10 components were extracted, and the rotation converged in 19 iterations. Similar to the original researchers' results, there was a lack of shared common variance among most of the measures. More specifically, with the results of the ability measures, one component, Component 1 (C1) was defined. This component was an ability measure comprised of four measures: a verbal-ability measure, a visual-ability measure, and two other-ability measures of nonverbal and memory.

With the results of the cognitive-style measures, only one visual measure loaded highly in Factor 4, which was not enough to define the factor. There was little shared variance among the other cognitive-style and learning-style variables, resulting in few factor loadings above .30. Overall with the results of the learning preference measures using both a varimax and a promax method, there was a general low magnitude of relationship between the measures. It was difficult to identify any components, but three learning-preference components were surmised: Component 2 was defined by three other-learning-preference measures -- Persistence and Posture both positively, and Mobility that loaded negatively, Component 3 was defined by three learning-preference measures -- one visual that loaded negatively, one verbal and one emotion -- both loading positively, Component 4 was defined by three time-of-day learning-preference measures -- two of these were Early-Morning- and Late-Morning-Study-Time that were both positive loading, and Afternoon-Study-Time that loaded negatively-- the other learning-preference components, Components 5 to 10 were not well defined. The KMO measure of sampling adequacy estimated at .932, an amount considered excellent (Kaiser, 1974). The details of these results are displayed in Table 25.1.

Table 25.1
Pattern- Matrix and Factor-Correlation-Matrix Results of
Burns and Hagelskamp (2017)

Component-Pattern Matrix[a] for Set 1

	1	2	3	4	5	6	7	8	9	10
Nonverb	**.796**	.006	-.021	.065	.047	.118	.037	.101	-.065	-.110
Memory	**.745**	-.061	-.071	.022	.120	-.231	-.150	.063	.137	-.137
Verb1 A	**.846**	-.025	.029	.058	-.011	.039	-.146	-.093	.041	-.056
Analytic	.209	-.035	.032	.113	-.221	**.431**	-.061	.123	-.119	.263
Vis1 A	**.420**	.107	.001	-.111	.017	.370	.170	.133	-.221	.075
Vis2 CS	.034	.039	.091	-.018	-.031	-.168	-.007	.242	**.745**	.062
Vis3 CS	.345	.019	.136	-.147	-.085	-.324	.393	.023	.011	.201
Sequential	.076	-.028	.074	.020	-.144	.119	.012	**.693**	.132	-.080
Simultaneous	.003	-.049	-.282	-.013	-.156	.287	-.117	**.611**	.128	.118
MemSkill	.064	-.175	.052	-.095	.205	.023	.039	**.402**	.291	.173
Vis4 LP	.038	.084	.041	**-.783**	.021	-.053	**-.497**	.017	-.002	.021
Verb2 LP	-.160	-.054	-.022	-.011	-.074	.099	**.913**	-.023	-.024	-.069
Emotional	.104	-.057	-.026	**.971**	.054	-.025	-.199	.016	.040	.029
Verb3 LP	.173	-.011	.080	-.005	-.102	-.043	.046	.030	-.074	**-.835**
Persistence	.102	-.143	**.704**	-.024	.062	.266	.033	-.154	.195	-.121
VerbalRisk	-.002	.155	.089	.046	.253	**.436**	.079	.056	.394	-.059
Manipulative	-.092	.151	.113	-.021	.183	**.782**	.052	.132	-.111	-.020
EarMornSt	-.121	-.243	-.102	-.041	**.688**	.114	-.014	-.019	.112	.210
LateMornSt	.187	.139	.016	.110	**.779**	.157	-.127	-.154	-.147	-.015
AfternoonSt	-.049	.091	**.842**	-.050	-.103	.059	-.008	.007	.071	-.029
EveningSt	-.075	.139	.102	.165	**-.400**	-.061	-.136	.003	**.489**	.043
Grouping	.037	-.312	.126	-.109	-.101	.204	-.098	**-.422**	-.109	.161
Posture	.022	**-.787**	-.025	.055	.053	-.145	.105	.075	.027	-.072
Mobility	.000	**.622**	-.361	-.049	.074	.050	-.008	-.012	-.028	-.067
Sound	-.019	**.711**	.225	-.051	-.075	.116	.032	-.006	.245	.012
Lighting	-.161	-.193	.309	-.021	-.013	.058	-.128	.378	-.253	-.327
Temperat	-.118	.137	**.404**	.174	.166	-.152	-.107	.088	-.225	.359

Extraction Method: Principal Component Analysis. Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 19 iterations.

Component-Correlation Matrix

Component	1	2	3	4	5	6	7	8	9	10
1	1.000	.057	.133	-.174	-.125	.227	.016	.184	.006	.213
2	.057	1.000	-.107	.028	-.025	-.136	.088	.033	-.062	.043
3	.133	-.107	1.000	-.012	.004	-.024	-.001	.124	-.130	.064
4	-.174	.028	-.012	1.000	.001	.051	.124	-.068	-.048	.008
5	-.125	-.025	.004	.001	1.000	-.167	.038	.093	-.014	-.044
6	.227	-.136	-.024	.051	-.167	1.000	.033	-.132	.240	.038
7	.016	.088	-.001	.124	.038	.033	1.000	.009	-.024	.129
8	.184	.033	.124	-.068	.093	-.132	.009	1.000	-.193	.146
9	.006	-.062	-.130	-.048	-.014	.240	-.024	-.193	1.000	-.083
10	.213	.043	.064	.008	-.044	.038	.129	.146	-.083	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Summary of findings for group C

Summarizing the statistical methods applied in Group C, there were four studies examined in this group with four matrices. In two of the four matrices, the FA method of analysis was applied; in the other two matrices, the PC method of analysis was applied. One of the five matrices required 25 or less iterations, and the other three matrices required 26 to 100 iterations.

The objective of this reanalysis on Group C was to determine if a secondary analysis of the four total studies and four matrices that examined all three domains that analyzed a single domain of abilities, cognitive styles, or learning preferences to determine if these studies measuring the visual-verbal learner-preference dichotomy across three domains consistently identified the visual and verbal constructs when using a common factor-analysis procedure. In the overall statistical findings derived from the matrices examined in Group C, there were nine total factors defined: seven visual-verbal factors or components and two visual factors or components. There were no verbal constructs that defined independently as a factor in this group.

The seven visual-verbal factors defined in this group included two visual-verbal factors with measures from all three of the domains, two visual-verbal factors with measures from two of the domains: one included measures from the two domains of learning-preferences and cognitive-style and the other one included measures from the two domains of abilities and cognitive-styles. The final three visual-verbal factors included measures from a single domain: two with learning-preference measures and the other one with cognitive-style measures. The two visual factors defined in Group C included one with measures from two domains of learning preferences and abilities and the other one was a visual factor that included measures from the single domain of abilities.

Summary of Chapter

This chapter examined the factor-analysis results of 18 studies that had 21 matrices in three subsections. The first subsection examined the results within a single domain, Group A. The second subsection examined the results across two domains, Group B; the third subsection examines the factor-analysis results across three domains, Group C. The purpose of the factor analyses twofold. First, the analyses investigated if studies using measures of the visual- and verbal-conceptual distinction in a single domain or across two or three domains of abilities, cognitive styles, and learning preferences support the visual- and verbal-conceptual distinction consistently identified the visual and verbal constructs when using a common factor-analysis procedure. Second, in all three groups, attention is also given to the correlation coefficients between the visual and verbal factors if and when they are identified.

The reanalysis of the 9 studies and 12 matrices that were examined in Group A, the overall statistical findings defined only three visual or verbal or visual-verbal factors: one visual-abilities factor was two visual-verbal cognitive-style factors. All the other visual and verbal ability, cognitive-style, and learning-preference factors were not well defined. The reanalysis of the five studies and five matrices examined in Group B, the overall statistical findings defined five total visual, verbal, or visual-verbal factors. One of these factors was defined with two domains as a visual-ability-and-cognitive-style factor; the other four factors were defined with a single domains: one of the single-domain factors was a visual-verbal cognitive-style factors that were defined with the single domain of cognitive styles, one was a visual-spatial-ability factor that was defined with the single domain of abilities, one was a visual-learning-preference factor that was defined with two learning-preference measures, and one was a verbal ability factor.

The reanalysis of the four studies and four matrices examined in Group C, the overall statistical findings defined seven visual-verbal factors and two visual factors. There were no verbal constructs that defined independently as a factor in this group. The seven visual-verbal factors defined in this group included two visual-verbal factors with measures from all three of the domains, two visual-verbal factors with measures from two of the domains: one included measures from the two domains of learning-preferences and cognitive-style and the other one included measures from the two domains of abilities and cognitive-styles. The final three visual-verbal factors included measures from a single domain: two with learning-preference measures and the other one with cognitive-style measures. The two visual factors defined in Group C included one with measures from two domains of learning preferences and abilities and the other one was a visual factor that included measures from the domain of abilities.

Overall, the results of this research identified 17 visual and verbal factors in the 21 matrices from 18 studies. There were six matrices that identified a visual factor; one was identified in Group A, three were identified in Group B, and two were identified in Group C. There was one matrix that identified a verbal factor; it was identified in Group B, and there were 10 matrices that identified a visual-verbal factor; two were identified in Group A, one was identified in Group B, and seven were identified in Group C.

In answer to the first research question, which examined if studies measuring the visual and the verbal learner-preference dichotomy consistently identified the visual and verbal constructs, the results of this study indicated that this learner-preference dichotomy was not consistently identified. Although the results of some matrices had measures that identified a visual construct and the results of some matrices had measures that identified a verbal construct, there was only one matrix with measures that identified both a visual and a verbal factor in the same study. In answer to the second research question, which examined the extent to which the visual and verbal factors that were identified correlated with each other between the correlations, this question could not be addressed. There was only one study had even a visual and a verbal factor defined independently in the same matrix.

As mentioned earlier in this chapter, the quality of all the correlation matrices analyzed in this research were tested with the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy to determine how suited the data from a study was for a factor analysis or if the results were impacted the size of sample used. This measure was applied to evaluate the overall sampling adequacy, and the KMO criteria of .50 was used to indicate the appropriateness of identifying a factor. More explicitly, the KMO statistic is a measure of the proportion of variance among the variables that might be common variance. The KMO returns values range between 0 and 1. A “rule of thumb” for interpreting the statistic is. A high KMO value between the range of .90 and 1 indicates the sampling is excellent; a low KMO value of less than 0.49 indicates the sampling is not adequate and that remedial action should be taken; a middle KMO value between the range of .50 and .89 are considered acceptable to varying degrees. For example, a KMO value between the ranges of .60 to.69 is considered acceptable but mediocre (Cerny & Kaiser, 1977; Kaiser, 1974).

Overall, in summary of the quality of the correlation matrices based on the KMO values of the 21 matrices examined in this research, only one matrix had a KMO value in the unacceptable range of less than .49, the rest of the KMO values were in the acceptable range, that is, 14% were in the .50 to .59 range, 71% were in the .60 to .89 range, and two were in the .90 to .99 range. A summary displaying the overall KMO values for the 21 matrices by range is provided in Table 26.

Table 26

KMO Values of 21 Matrices

Name of Study	KMO Value
.40 to .49 KMO range	
Blazhenkova et al. (2011) Experiment 1	.456
.50 to .59 KMO range	
Blazhenkova et al. (2011) Experiment 2	.507
Yang and Kim (2011) with South Korean students	.586
Meneghetti et al. (2014)	.553
.60 to.69 KMO range	
Sozcu (2014)	.684
Vahid Baghban (2012)	.669
Leite et al. (2010)	.656
Buktenica (1969) Set 1	.699
Buktenica (1069 Set 2	.689
Mayer and Massa (2003)	.692
Wintergerst et al. (2001)	.642
Yang and Kim (2011) with Chinese students	.660
.70 to.79 KMO range	
Casey et al. (2015)	.754
Buktenica (1969) Set 3	.703
Federico (1979)	.753
Federico (1984)	.787
Danisman and Erginer (2017)	.797
Haciomeroglu (2015)	.780
Massa and Mayer (2006)	.741
.90 to .99 KMO range	
Burns and Hagelskamp (2017)	.932
Nah and Lane (1990)	.906

Note: The KMO range values of this table are based on the Kaiser-Meyer-Olkin (KMO) Test is a measure of how suited the data from a study is for a factor analysis (Cerny & Kaiser, 1977; Kaiser, 1974).

CHAPTER V

SUMMARY, LIMITATIONS, DISCUSSION, AND IMPLICATIONS

The purpose of this study was to investigate if there is empirical support for the visual and verbal conceptual distinction as it relates to domains of abilities, cognitive styles, and learning preferences. This chapter is divided into seven subsections. These include a summary of the research, a summary of the results, the limitations, discussion of findings, conclusions, and a summary of the implications for research and for practice. The first subsection, summary of study provides a brief overview of the dissertation research, defining the purpose and significance of the study, the theoretical rationale used to set up the problem, the research questions, and the methodology applied.

Summary of the Study

In psychology and education, the visual-verbal conceptual distinction is a widely studied bipolar contrast in many areas, including working memory theories and left-brain and right-brain conceptualizations (Pashler et al., 2009). This conceptualization hypothesizes that people process information visually or verbally and sometimes using both channels, and it also proposes that individuals learn better when they receive information in their preferred learning style. This study focused on the use of the visual-verbal distinction in the field of psychological measurement.

The visual- and verbal-conceptual distinction has been the subject of much debate recently. There are two main issues that pose research problems: one is a construct-validity issue related to the extent that scores from a test measuring the visual- and verbal-conceptual distinction accurately reflect the construct being measured. The second one is an issue related to the use of different data analysis methods that collect and analyze the data from the visual- and verbal-conceptual-distinction measurements. To resolve these issues, this study investigated if there is empirical support for the visual- and verbal-conceptual distinction in the domains of abilities, cognitive styles, and learning preferences.

The findings of this study contributed to research by resolving issues related to the validity of the visual and verbal constructs and to the variables that measure those constructs. More precisely, the results addressed issues related to construct validity by applying a factor analysis method, which is a method commonly used to investigate construct validity (Boelen, van den Hout, & van den Bout, 2008; Fournier-Vicente, Larigauderie, & Gaonac'h, 2008), and the results of this study addressed issues related to using different data analysis methods and different methods of measure by applying a single method, one factor analysis procedure to examine the data among and between all three domain groups of abilities, cognitive styles, and learning preferences.

There is an educational need for this research because in the United States the practice of classifying students by their learning preference is common among teachers (Dekker, Lee, Howard-Jones, & Jolles, 2012; Pashler et al., 2009; Rogowsky, Calhoun, & Tallal, 2015), and this practice appears to pose an issue internationally as well (Howard-Jones, 2014; Dekker et al., 2012; Newton, 2015), indicating there is a global dimension to this need (Howard-Jones, 2014). Finally, it is important to address this problem because practitioners not only routinely use the visual-verbal conceptual distinction but also may not be using it correctly. Therefore, it is important to promote improved understanding of the strengths and weaknesses of measures relating to this distinction in educational practice. The findings of this study can provide empirical evidence to guide educational practitioners when deciding whether their students will or will not benefit from receiving instruction in a style that coincides with their visual or verbal preference.

Although teachers use learning preferences extensively, research suggests that there is not much evidence to support them as constructs (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973). In fact, there is compelling evidence to suggest that there are problems with construct validity, particularly with studies that examine cognitive styles and learning preferences (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973).

Among the academic community, research findings on the benefits of teaching students based on his or her visual or verbal preference vary considerably. In some studies, researchers found positive support (Claxton & Murrell, 1987; Dunn & Griggs, 2003; Garcia-Otero & Teddlie, 1992; Halpern, 1998; Hill, 1976; Kennedy, Fisher, & Ennis, 1991). In other studies, researchers found no support or negative support for accommodating students' visual or verbal preference (Constantinidou & Baker, 2002; Massa & Mayer, 2006; Pashler et al., 2009).

There are inconsistent and varying findings on research that examines the visual-verbal conceptual distinction, yet teachers continue to use these measures to design instruction and make learning decisions about students (Dandy & Bendersky, 2014; Dekker et al., 2012). For this reason, it is imperative to cross-analyze the way abilities, cognitive styles, and learning preferences are assessed to ensure construct validity of the tests or scales used to measure these constructs accurately measure them. The tests that measure and define the visual- and verbal-conceptual distinction can either be used to design and implement interventions that help students reach their potential more effectively or can be used to segregate and to label people (Wasserman, 2012).

To help resolve these issues, two research questions were posed for this study:

1. Using a common factor analysis procedure, do studies measuring the visual-verbal learner preference dichotomy consistently identify the visual and verbal constructs?

2. In studies that do identify the visual-verbal dichotomy using a common factor analysis, to what extent do the two factors correlate with each other?

The theoretical framework and model that underpins this study is one proposed by Mayer and Massa (2003). Results of both Mayer and Massa (2003) and Massa and Mayer (2006) supported that there are three ways of distinguishing verbal and visual learners, by individual differences in ability, cognitive style, and learning preference. This dissertation applied an adapted version of Mayer and Massa (2003) model. An illustration of this model is shown in Figure 1.

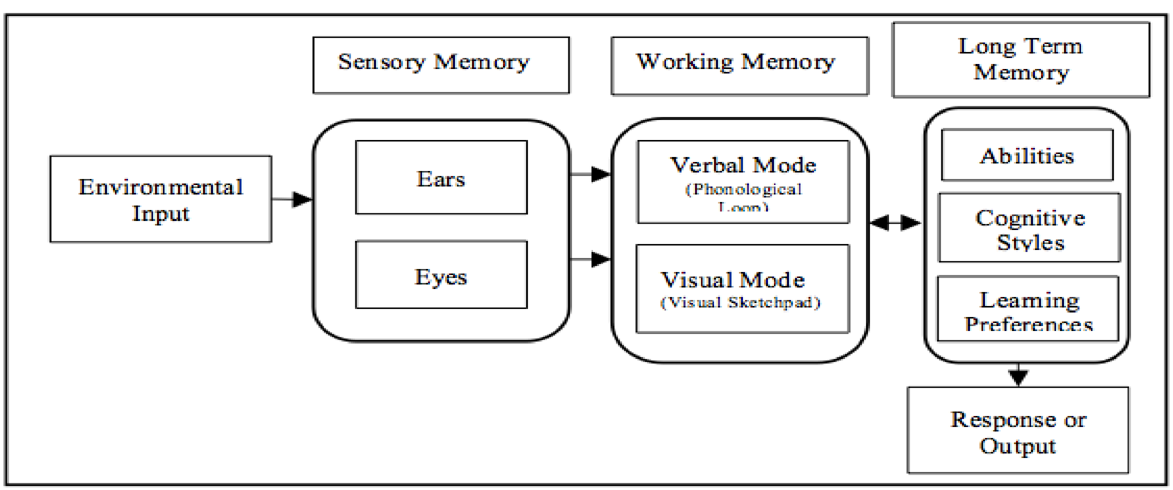

Figure 1. Reproduced from chapter 1; Adapted version of Mayer and Massa (2003) visual-verbal conceptual distinction.

To investigate if there is empirical support for the visual- and verbal-conceptual distinction as it relates to domains of abilities, cognitive styles, and learning preferences, this study examined 21 individual intercorrelation matrices from 18 different studies and that were illustrative of the visual and verbal contrast. In the analyses, each of these 21 correlation matrices were reexamined within and between domains in a secondary data analysis using the methodology of a factor analysis. Group A had 12 matrices from nine studies that examined the factor-analysis findings of the visual and verbal measures from a single domain of either abilities, cognitive styles, or learning preferences. Group B had five matrices from five studies that examined the visual and verbal measures across two domains of either abilities and cognitive styles or abilities and learning preferences, and Group C had four matrices from four studies that examined the visual and verbal measures from all three domains of abilities, cognitive styles, and learning preferences.

First the analyses investigated if studies using measures of the visual- and verbal-conceptual distinction either within a single domain or across two or three domains of abilities, cognitive styles, and learning preferences supported the visual- and verbal-conceptual distinction with measures that consistently identified the visual and verbal constructs when using a common factor-analysis procedure. Second, in all three groups, attention also was given to the correlation coefficients between the visual and verbal factors if and when they were identified.

The 21 matrices were examined in three groupings: first within a single domain (Group A), next across two domains (Group B), and then across all three domains (Group C) of abilities, cognitive styles, and learning preferences. In Group A, the 9 studies and 12 matrices where the researcher(s) analyzed a single domain of abilities, cognitive styles, and learning preferences consisted of three different types: those that examined the single domain of abilities that included Buktenica (1969) who examined three sets of matrices and Casey et al. (2015); those that examined the single domain of cognitive style that included Blazhenkova et al. (2011) Experiment 1 and Experiment 2, and Sozcu (2014); and those that examined the single domain of leaning preferences that including Leite et al. (2010), Vahid Baghban (2012), and Wintergerst et al. (2001), and Yang and Kim (2011) who examined two sets of matrices.

In Group B, the five studies and five matrices where the researcher(s) examined two domain and these matrices consisted of two different types of pairings The first pairing of Group B were studies where the researchers examine the two domains of abilities and cognitive style and included three studies: Federico and Landis (1979), Federico and Landis (1984), and Nah and Lane (1990). The second pairing of Group B were studies where the researchers examined the two domains of abilities and learning preferences and included two studies: Danisman and Erginer (2017) and Haciomeroglu (2015). In Group C, the four studies and four matrices where the researcher(s) examined all three domains included Mayer and Massa (2003), Meneghetti et al. (2014)**,** Massa and Mayer (2006), and Burns and Hagelskamp (2017).

In each of the matrices, results were obtained from factor-analyses output generated by the Statistical Package for the Social Sciences (SPSS) GradPack version 25 software program. In all the factor analyses, an exploratory factor-analysis technique was applied using a principal-axis-factoring extraction method with an oblique-rotation method of the Promax (Kappa=4) solution, and two matrices were examined: the pattern matrix and the factor-correlation matrix.

Summary of the Results

In the results for Group A, there were 28 total visual, verbal, or visual-verbal measures represented in the 12 matrices that examined the factor-analysis findings of the visual and verbal constructs with measures from a single domain. Sixteen of these 28 measures were visual measures, and the other 12 were verbal measures. Overall, the factor-analysis results of this group defined three visual, verbal, or visual-verbal factors or components: one visual-abilities factor and two visual-verbal cognitive-style factors. All the other visual and verbal ability, cognitive-style, and learning-preference measures examined in the matrices of this group were not well defined, and none of the verbal factors were well defined independently.

There were a couple issues that might have effected or constrained the findings of Group A. One was the limited in the number of visual and verbal measures that were represented. As an example, the verbal measures in 9 of the matrices the verbal constructs were represented with only a single verbal measure; in all 12 of the matrices, the visual measures were represented with only a single visual measure, which can pose an issue because a minimum of two measures are necessary to define a factor and that factor must not be highly correlated with any other variables or must be fairly uncorrelated with other variables (Yong & Pearce, 2013, p. 80). Another issue with the studies in Group A was three of the matrices that were defined by only three measures, and all three of these measures were visual and verbal constructs.

In the results of Group B, there were 21 total visual, verbal, or visual-verbal measures represented in the five matrices that examined the factor-analysis findings of the visual and verbal constructs with measures across two domains of either ability and cognitive-style measures or ability and learning-preference measures. Fifteen of these measures were visual measures, and the other six were verbal measures. Overall, this group defined five visual, verbal, or visual-verbal factors. Only one of these three factors was represented with measures from two domains, a visual-ability and cognitive-style factor. The other four factors defined in this group were represented with measures from a single domain, including one that was a visual-spatial-ability factor, one that was a visual-learning-preference factor, one that was a visual-verbal learning-preference factor, and one that was a verbal factor. All the other visual and verbal ability, cognitive-style, and learning-preference factors examined in the matrices of this group were not well defined, and only one verbal factor was defined independently.

The results of the matrices of Group B were somewhat constricted by the number of verbal measures that were represented. For example, only 6 of the 21 total visual, verbal, or visual-verbal measures in this group were verbal measures. Additionally, the verbal measures were represented with only a single verbal measure in four of the five matrices of this group.

In the results of Group C, there were 41 total visual, verbal, or visual-verbal measures represented in the four matrices that examined the factor-analysis findings of the visual and verbal constructs with measures across all three domains. Sixteen of these measures were visual measures, another nine 9 verbal measures, and the other 16 were visual-verbal measures.

Overall, this group defined nine visual, verbal, or visual-verbal factors or components: two of these factors were represented with measures from all three domains, three of these factors were represented with measures from two domain, and four of these factors were represented with measures from one domain. The two factors that were represented with measures from all three domains were both visual-verbal factors. The three factors that had measures from two domains included (a) one visual-verbal factor that was represented with the two domains of learning preferences and cognitive styles, (b) another visual-verbal factor that was represented with measures from the two domains of abilities and cognitive styles, and (c) one visual factor that was represented with measures from the two domains of learning preferences and abilities. The final four factors defined in this group were represented with measures from a single domain and included two visual-verbal factors that were represented with learning-preference measures, one visual-verbal factor that was defined with cognitive-style measures, and one visual factor that was defined with measures from the single domain of abilities. All the other visual and verbal ability, cognitive-style, and learning-preference factors examined in the matrices of this group were not well defined, and none of the verbal factors were well defined independently.

Unlike the limited visual and verbal measures represented in the matrices of Group A and B, these measures appeared well represented in Group C. Each of the matrices of this group contained 7 to 12 visual, verbal, or visual-verbal measures. Of special interest were the 16 measures where the visual and verbal measures are combined by the researchers to produce visual-verbal measures, that is, the original researchers had designed or incorporated visual-verbal measures as part of their research. In the results of Group C, these combined visual-verbal measures generated seven of the nine factors that were defined.

Summarizing overall findings, there were 90 total visual, verbal, or visual-verbal measures represented in Group A, B, and C combined. The total number of visual, verbal, or visual-verbal factors or components that were defined collectively in Group A, B, and C was 17.

Although the SPSS results of Group A defined three factors, the results of Group B defined four single-domain factors, and the results of Group C defined four single-domain factors. The combined amounts resulted in 11 total factors that were defined with measures from a single domain.

Even though the SPSS results of Group B only defined one factor with two domains, the results of Group C also defined three two-domain factors, which resulted in a total of four factors that were defined by two domains. Lastly, in the SPSS results of Group C, although there were nine factors defined, only two of these factors were defined with all three domains. In summary, 11 of the total 17 factors that were identified in Group A, B, and C collectively were represented with measures from a single domain; 4 of the total 17 factors were represented with measures from two domains, and two of the overall factors defined were represented with measures from all three domains. Appendix W displays the total number of visual, verbal, and visual-verbal measures examined in Group A, B, and C; Appendix X displays the distribution of defined visual and verbal factors by domain group and factor represented; Appendix Y defines the factors grouped by visual, verbal, or visual-verbal representation.

Of special interest in the overall findings of Group A, B, and C altogether was the fact that 10 of the16 total factors that were defined were visual-verbal factors. This high concentration of visual-verbal factors may indicate that these two constructs are very closely related. It further suggests that the visual and verbal constructs may be difficult to separate from one another or they might maintain an interdependent relationship.

Limitations of the Study

There were several limitations with this research. One limiting factor was a contrasting quality of empirical studies across the domains. For this study, a broad net was included in the inclusion criteria to bring the various literatures together. Another weakness resulted from the current literature itself. Often the studies that were located were limited in constructs, single-item survey measurements, or scale construction involving the modification of one or more established measures. For example, over half of the studies in the learning-preference group used instruments that consisted of questionnaires that were rated with Likert or multiple-choice items that use various scales of measure. Not only do these scales vary in their estimate of ratings from one study to the next, which can make them unreliable, but the questions used for rating include opinionated data that introduces issues of construct validity (Johnson, Wood, & Blinkhorn, 1988; Loo, 1999; Mead, 2004).

Many of the matrices that examined learning preferences, only included preference measures that examined the relationship between one preference measure to another preference measure or to a learning-strategy-preference measure or other measures of specific preference (e.g., e-learning or distant learning), which can pose a problem for various reasons. One issue is these matrices do not partition out cognitive abilities or achievement, which can effect outcomes because measures of general intelligence account for almost 50% of the total variance among measures (Deary, Strand, Smith, & Fernandes, 2007; Jensen, 1998; MacKintosh, 2011). According to Jensen

(1982, 1998), there are many reasons for preferring factor solutions that contain a general intelligence "*g"* factor, such as the widespread practical validity of this factor as a predictor of individual outcomes. "The *g* factor, together with group factors, best represents the empirically established fact that, on average, overall ability differences between individuals are greater than differences among abilities within individuals, while a factor solution with orthogonal factors without *g* obscures this fact" (p. 73).

The literature was further complicated by the presentation of measures without a description of psychometric properties, making it difficult to assess the quality of measures or their relationships to outcomes. Moreover, there was a diversity of scales supposedly measuring the same constructs and difference in sample characteristics (gender, race, school age of participants, etc.).

Traditionally, the recommended sample size to perform an exploratory factor analysis has been 100 to 1,000 participants or 3 to 20 times the number of variables (Mundfrom, Shaw, & Lu Ke, 2005; Pearson & Mundfrom, 2010). Most of the strict rules regarding sample size for an exploratory factor analysis, however, have relaxed, and an adequate sample size partly is investigated by the nature of the data (Costello & Osborne, 2005; Fabrigar et al., 1999; MacCallum, Widaman, Zhang, & Hong, 1999). In general, the stronger the data, the smaller the sample can be for an accurate analysis. "Strong data" in factor analysis means uniformly high communalities without cross loadings, plus several variables loading strongly on each factor (Mulaik, 1990; Widaman, 1993).

In this dissertation, there were two studies having slightly less than the recommended minimum sample size of 100 participants. One had a sample size of 97 and the other a sample of 95. Notwithstanding, both of these studies were well executed, analyzed, discussed, and concluded.

A final limitation related to the measures of the studies in the reanalysis related to the measures of Group C where the researchers had combined many of the visual and verbal measures to produce visual-verbal measures, which posed a limitation because the purpose of the research in this study was to determine if studies measuring the visual-verbal learner-preference dichotomy consistently identified the visual and verbal constructs and to determine if studies that did identify the visual-verbal dichotomy using a common factor analysis, to what extent did the two factors correlate with each other. Making these investigations was not possible in matrices where the visual and verbal constructs were represented jointly.

Discussion

The purpose of this study was to provide empirical support for the visual- and verbal-conceptual distinction as it relates to domains of abilities, cognitive styles, and learning preferences. To make this evaluation, this study investigated whether studies using measures of the visual- and verbal-conceptual distinction in a single domain or across two or three domains of abilities, cognitive styles, and learning preferences support the visual- and verbal-conceptual distinction consistently identified the visual and verbal constructs when using a common factor-analysis procedure by examining three groups, and in all these groups, attention also was given to the correlation coefficients between the visual and verbal factors when they were identified.

There were 188 total measures of various abilities, cognitive styles, and learning-preferences analyzed in the 21 matrices of this research. These measures are displayed in

Appendix V. Of this total, 85 were ability measures, 41 cognitive-style measures, and 62 learning-preference measures. In the evidence of this study derived from the 188 total measures, there were 90 total visual, verbal, and visual-verbal measures examined in 22 different matrices. These overall measures were comprised of 35 ability measures, 27 cognitive-style measures, and 28 learning-preference measures, and the 21 matrices were analyzed in three groups: Group A, Group B, and Group C. In the overall results of the 21 matrices examined, 17 visual, verbal, or visual-verbal factors were defined.

The basic findings of each group were as follows: The factor-analysis results of the matrices of Group A that measured the visual-verbal learner preference dichotomy did not consistently identify the visual and verbal constructs. In the factor-analysis results of the 28 visual, verbal, or visual-verbal measures that represented the single domain group, 3 factors were defined. Nonetheless, in the final analysis, the matrices of Group B and Group C had 8 factors that loaded on and were defined with measures from the single domain. As a result, a total of 11 factors were defined with measures from a single-domain group, and six of these factors were visual-verbal factors.

The factor-analysis results of the matrices of Group B that measured the visual-verbal learner preference dichotomy did not identify consistently the visual and verbal constructs or provide support the visual and verbal conceptual distinction. In the factor-analysis results of the 21 visual, verbal, or visual-verbal measures that represented in matrices of the two-domain group, four factors were defined but only one of these factors was represented with measures from two domains. The other three factors were represented with measures from a single domain. In the final analysis, however, two of the matrices of Group C also had three factors that were defined with measures from the two-domain group. As a result, a total of four factors were defined with measures from a two-domain group, and two of these factors were visual-verbal factors.

The factor-analysis results of the matrices of Group C that measured the visual-verbal learner-preference dichotomy did somewhat identify consistently the visual and verbal constructs and support the visual- and verbal-conceptual distinction. In the factor-analysis results of the 41 visual, verbal, or visual-verbal measures that represented the three-domain group, nine factors were defined, but only two of these factors were defined with measures from all three domains, and both of these factors were visual-verbal factors. The remaining seven factors were defined with measures from either a single domain or two domains.

Worthy of discussion are the three studies that were not positive definite (NPD), including Hajhashemi et al. (2018), Andrusyszyn et al. (2001), and Rogowsky et al. (2015). When attempting to execute the program using a factor-analysis procedure with these three studies, an SPSS error message appeared stating, "The matrix is not positive definite. Extraction cannot be done. This extraction is skipped." When the matrix was NPD, none of the tables printed, including the initial KMO extraction results. When the syntax commands were resubmitted using a principal-component analysis, an SPSS error message appeared stipulating, "The matrix is not positive definite. This may be due to pairwise deletion of mission values." Once again, none of the output tables were provided. To investigte possible reasons why these three studies produced NPD results, several evaluations were undertaken, such as examining the purpose of the study, the number of participants, and the measures applied in the study.

All three of the studies that produced NPD results were studies where the researchers had analyzed learning-preference measures that were rated on a Likert-type scale or with multiple-choice questions or where the researchers had developed an instrument with a scale construction that was a modification of one or more established measures. The first study that produced NPD results was research by Hajhashemi et al. (2018). These researchers examined the single domain of cognitive styles, and the matrix only included correlations of Multiple Intelligence subscales. Although the researchers also applied a principal-component analysis, it was only used on the Online Video Experience Inventory items. The study had 111 participants and examined 12 total measures. A possible reason why this study produced NPD results might relate to the instrument that was used for the Multiple Intelligence subscales of the correlation matrix, the McKenzie's Multiple Intelligences (MI) Inventory. The scale of this instrument consists of 90 statements related to each of the nine intelligences proposed by Gardner (1999a, 1999b) and is rated on a Likert-type scale ranging from 1 to 5. This instrument might produce problematic factor-analysis output as it uses Liker-typet items, and these items are often unreliable as the questions used for rating include opinionated data which introduces issues of construct validity (Johnson, Wood, & Blinkhorn, 1988; Loo, 1999; Mead, 2004).

The second study that produced NPD results was research by Andrusyszyn et al. (2001). These researchers examined the correlations between learning preference items. A pairwise comparison was also applied, but it was only on the pairs of learning-preference measures. The study had 125 participants and examined 12 total measures. A possible reason why this study produced NPD results might relate to the instrument applied, a questionnaire designed by the researchers that included only measures of learning preferences with a combination of bipolar and paired comparisons rated on a five-point scale with multiple-choice or Likert-type item questions. Questionnaires that are rated on a scale or with multiple-choice questions tend to pose issues of construct validity (Johnson et al., 1988; Loo, 1999; Mead, 2004).

The third study that produced NPD results was research by Rogowsky et al. (2015). These researchers examined the two domains of abilities and learning preferences but only applied a correlation matrix to the learning preference measures. The study had 121 participants and examined six measures. A possible reason why this study produced NPD results might relate to the instruments that were used for the learning-preference evaluation. The adult version of Dunn and Dunn learning styles model referred to as Building Excellence (BE) Online Learning Styles is rated on 5-point Likert scale, and the online scores obtained from Verbal Comprehension measures of Listening Aptitude Test (L–AT) and Reading Aptitude Test (R–AT) that are derivative of The Gray Oral Reading Tests (GORT; 1963, 2012) used to assess listening and reading comprehension answered with multiple-choice questions. Similar to the previous two studies with NPD results, the researchers used an instrument rated on 5-point Likert scale, the BE Online Learning Styles. The results of Likert-rated instruments tend to pose issues of construct validity (Johnson et al., 1988; Loo, 1999; Mead, 2004). Moreover, the L-AT and R-AT scale construction involved an original instrument that the researchers developed that was a modification of one or more established measures.

Another point of discussion relates to the six studies that did not produce output in the SPSS program when using a factor-analysis method of analysis and a principal-component method needed to be applied instead. These studies include Buktenica (1969) Set 2 of 3, Sozcu (2014), Vahid Baghban (2012), Wintergerst et al. (2001), Meneghetti et al. (2014), and Burns and Hagelskamp (2017) Part 1 of 2. When attempting to use the factor-analysis method with 25 iteration, an error message stipulated that more than 25 iteration were required and the extraction was terminated by the SPSS program. When the matrix was resubmitted with different amount of iterations, the commonality of a variable exceeded 1.0, once again the extraction was terminated by the SPSS program, and many of the SPSS results tables did not print.

Several items were evaluated to determine possible reasons for these six studies not producing output in the SPSS program when using a factor-analysis method, such as the purpose of the study, the number of participants and measures applied, and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Overall, the number of participants in these six studies was sufficient, meeting the minimum requirement of 100 and ranging from 100 to 355. Furthermore, the KMO values in four of the studies were in the .6 range of adequate but mediocre, one was in the minimally adequate range of .5, and the final matrix was in the .4 range and did not meet the minimal requirement of sampling adequacy. A detailed explanation of the results from these evaluations for each of these six studies is provided in the following paragraphs.

In the first of these six studies, Buktenica (1969) used a correlational analysis to investigate if reading achievement could be predicted from first through third grade with performance on group administered, nonverbal auditory and visual perceptual tests administered in the first grade by following a sample of 140 elementary-grade students over a 3-year period. A total of 21 measures were administered: seven measures for each of the 3 years. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy estimated at .689, which is an acceptable but mediocre amount. A possible reason for this study not producing output in the SPSS program when using a factor-analysis method might relate to issues with the group-administered, nonverbal auditory and visual perceptual tests, an original instrument that the researchers developed that was a modification of one or more established measures.

In the Sozcu (2014) study, a correlation analysis, an independent-sample *t* test, and an Analysis of Variances (ANOVA) test were used to examine relationships between cognitive styles of Field Dependent learners' attitudes toward e-learning, distance education, and other variables in learning and instructional behavior as learners experience e-learning, assessment in e-learning, and competencies in Learner Interface Design within an e-learning environment on a group of 157 college freshman-undergraduate students. Ten total measures were examined. Eight of the 10 measures in the matrix were related to cognitive skill or knowledge related to e-learning or distance education. Only two measures was related to cognitive style, measuring Field Independence versus Field Dependence cognitive style. The KMO measure of sampling adequacy was estimated at .684, which is an acceptable but mediocre amount. A possible reason for this study not produces output in the SPSS program when using a factor-analysis method might relate to issues with the high concentration of measures in the matrix that were primarily related to cognitive skill or knowledge related to e-learning or distance education. Only two measures was related to cognitive style, measuring Field Independence versus Field Dependence cognitive style. These type of measures tend to be of opinionated data that can pose issues of construct validity (Mead, 2004).

Vahid Baghban (2012) examined nine total measures, two of which were visual-verbal constructs of Visual and Auditory. The remaining seven were other measures including Kinetic, Memory, Cognitive, Compensation, Metacognitive, Affective, and Social. This study's research was performed on 120 female Iranian college students studying English. Several instruments of measure were employed, including Michigan State University English Language Exam, Learning Styles Inventory (LSI) Reid's (1984) questionnaire, the Strategy Inventory for Language Learning (SILL), which is also referred to as the Language Learning Style (LLS) questionnaire. Three of the nine measures were Reid's learning-styles measures and the other six were learning strategy measures. The KMO measure of sampling adequacy was estimated at .669, which is an acceptable but mediocre amount. A possible reason for these this study not produced output in the SPSS program when using a factor-analysis method might relate to issues with the measures. All the measures analyzed were learning-styles measures and measures of learning-strategy use.

Wintergerst et al. (2001) study was another study that evaluated the reliability and validity of an existing learning-style instrument, examining Reid's (1984) Perceptual Learning Style Preference Questionnaire (PLSPQ). The researchers used a correlational analysis and an exploratory factor analysis with both a varimax and an oblimin rotation method to examine 100 English-as-a-Second-Language (ESL) university students for the relationship between the learning styles identified in the PLSPQ and the language background of participants. Reid's (1984) six learning-style scales consist of visual-scale items, auditory-scale items, kinesthetic-scale items, tactile-scale items, group-scale items, and individual-scale items. In this study, the item–total correlations were examined for the items in all scales. The validity of the hypothesized factor structure of the PLSPQ was examined through 10 factor measures. The KMO measure of sampling adequacy was estimated at .642, which is an acceptable but mediocre amount. A possible reason for this study not producing output in the SPSS program when using a factor-analysis method might relate to issues with the 10 factor measures used in the analysis that generated the item–total correlations for all scales.

Meneghetti et al, (2014) used a correlational analysis and a regression analysis to investigate the role of individual's visual-object, visual-spatial and verbal cognitive styles, cognitive abilities, and strategy use in the learning of visuospatial and abstract descriptions for a sample of 198 undergraduate students. In addition to visuospatial competence, the researchers also analyzed verbal ability as measured with reading comprehension, verbal style as measured with a preference for remembering words and sentences, and the use of repetition-based strategies in relation to visuospatial text recall accuracy. The researchers hypothesized that both spatial abilities and cognitive styles might influence the accuracy of visuospatial descriptive recall. Twelve total measures were examined. The KMO measure of sampling adequacy was estimated at .553, which is barely reaching the minimal acceptable amount of .5. A possible reason for this study not producing output in the SPSS program when using a factor-analysis method might relate to the study's sample size, which barely reached the minimal acceptable KMO measure of sampling adequacy of .50.

The Burns and Hagelskamp (2017) study used both a factor analyses and a correlational analysis to examine the construct validity of learning-style preferences on a sample of 335 10th-grade female students. Four tests were administered included the Test of Cognitive Skills (TCS; CTB Macmillan/McGraw-Hill, 1993), the Learning Style Profile (LSP; National Association of Secondary School Principals, 1989), the California Achievement Tests, Level 19 (CAT5) (CTB/McGraw-Hill, 1992), and the American College Testing PLAN English mechanics (ACT, n.d.) tests under normal school conditions to all 10th-grade students in October. The researchers examined 27 tests and scales from several test batteries that were organized into three construct categories: 10 were ability and style measures -- four of which were ability and six of which were cognitive-style measures; 17 were learning style preference measures. In the first part of this analysis, the 10 cognitive ability and cognitive-style measures, and then the 17 learning style preference measures were analyzed. There were five measures in the component pattern matrix with correlations that exceeded .80. The KMO measure of sampling adequacy was estimated at .932, an amount considered excellent (Kaiser, 1974). A possible reason for this study not producing output in the SPSS program when using a factor-analysis method might relate to multicollinearity issues with the five measures in the component pattern matrix with correlations that exceeded .80.

A final point of discussion are the limitations of visual and verbal measures in the matrixes examined. Although the researchers of the 18 studies used in this research were not specifically examining the visual and verbal distinction, their research analyzed both the visual and verbal measures in the study's correlation matrices, and many of these 21 matrices did use the visual and verbal constructs to predict or investigate certain outcomes, such as to investigate if preferences for visual and analytic processing could be used to examine relationships to calculus processing; to investigate if reading achievement could be predicted through third grade; to access whether spatial skills compared with arithmetic and verbal skills were predictors of two different types of fifth-grade mathematics reasoning (mathematics reasoning-spatial and mathematics reasoning analytical); and to examine if calculus tasks could be used to investigate preferences for visual or analytic processing. The results of these 18 studies' outcomes helped support the research of this reanalysis that did examine the visual and verbal measures.

Conclusions

In the results of Group A, 26 total factors were extracted, and three of these factors were defined as visual, verbal, or visual-verbal factors. For Group B, 25 total factors were extracted, and five of these factors were visual, verbal, or visual-verbal factors. The results of Group C found 22 total factors were extracted, and 9 of these were visual, verbal, or visual-verbal factors. Overall, there were 73 total factor extracted; 17 of these were visual, verbal, or visual-verbal factors: 6 were visual factors that were defined independently, one was a verbal factor that was defined independently, and the other 10 were visual-verbal factors.

In conclusion, to answer for the first research question, which examined if studies measuring the visual and the verbal learner-preference dichotomy identified consistently the visual and verbal constructs, the results of this study indicated that the learner-preference dichotomy was not consistently identified. Although the results of some matrices had measures that identified a visual construct and the results of some matrices had measures that identified a verbal construct, there was only one matrix with measures that identified both a visual and a verbal factor in the same study. The second research question, which examined the extent to which the visual and verbal factors that were identified correlated with each other between the correlations, could not be addressed.

There was only one study that even had a visual and a verbal factor defined independently in the same matrix.

In conclusion, the results of this study did not provide a convincing rationale for customizing different instruction programs for visual and verbal learners. Moreover, the finding of this study support the extensive research that suggests that there is not much evidence to support for learning-preference measures as constructs (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973). In the findings for both Group A and Group B, there was evidence to suggest that there are problems with construct validity, particularly with studies that examine cognitive styles and learning preferences that coincided with findings of other literature (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973).

Most importantly, the results of this study indicate that it may be difficult to separate the visual and verbal measures. In the overall findings of Group A, B, and C, 10 of the17 total factors that were defined were visual-verbal factors. This high concentration of visual-verbal factors may indicate that these two constructs are very strongly related. It further suggests that the visual and verbal constructs may be difficult to separate from one another or that they might maintain an interdependent relationship.

Implications for Research

The 21 matrices examined in this study indicate that there was considerable poor measurement and poor conceptualization of these constructs. Many of the researchers did not obtain the correct measures for these constructs. When a researcher did obtain the correct measures for the visual and verbal conceptual distinction, the measures did not tend to identify the visual and verbal constructs individually very well. In the matrices that examined learning-preference measures, there were inconsistent factor-analysis findings or the measures were not well defined as factors. There appeared be some overall conceptual problems related to the visual- and verbal-ability, cognitive-style, and learning-preference domains.

Examples of the visual and verbal measures not splitting out well is seen in two studies of this research that demonstrate the difficulty of separating the visual and verbal constructs: Mayer and Massa (2003) and Massa and Mayer (2006). In both of these studies, the researchers specifically addressed the visual and verbal distinction. In the Mayer and Massa (2003) study, the researchers analyzed all three domains to investigate if the visual-verbal distinction could be decomposed into separate components. Fourteen total measures were examined. Thirteen of these total measures were visual, verbal, or visual-verbal measures, and eight of these measures were visual-verbal measures combined. Similarly in the supplemental analysis of the 2006 study, Massa and Mayer (2006) wanted to determine if the same factor structure of the 2003 study would hold with other groups of participants drawn from the same population. The researchers examined all three domains using 13 measures, 12 of which were visual, verbal, or visual-verbal measures and 7 of these were visual-verbal measures combined.

For methodologists, there are implications in the results of this study that address the general system of teaching. For example, the results of this study do not provide a convincing rationale for customizing different instruction programs for visual and verbal learners. Likewise, the results of this research indicate that it is easier to identify the visual and verbal factors when there are two or more domains represented. The reason might be related to the way in which the correlations work, cognitive styles would tend to correlate and abilities would tend to correlate and separate. Therefore, it might be easier to identify the visual and verbal in a study with two or more domains. It might be that abilities and cognitive styles are different.

Implications for Practice

Almost all teachers believe that students learn better when they receive information in their preferred learning style (e.g., visual, verbal, or kinesthetic), and most teachers also believe it is intuitively correct to tailor teaching, learning situation, and learning materials to those preferences (Kirschner, 2017). In contrast, extensive research suggests that there is not much evidence to support for learning-preference measures as constructs (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973). In fact, there are very few researchers who report there is construct validity or reliability evidence that learning preference is measured well (Kirschner, 2017). Nonetheless, the issue remains a common practice among teachers that classify students by their learning preference or style (Dekker, Lee, Howard-Jones, & Jolles, 2012; Pashler et al., 2009; Rogowsky, Calhoun, & Tallal, 2015). The findings of this study provide further empirical evidence to guide educational practitioners when deciding whether their students will or will not benefit from receiving instruction in a style that coincides with their visual or verbal preference.

The finding of this study support the extensive research that suggests that there is not much evidence supporting learning-preference measures as constructs (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Massa & Mayer, 20006; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973). In the findings of both Group A and Group B, there was evidence to suggest that there are problems with construct validity, particularly with studies that examine cognitive styles and learning preferences that coincided with findings of other literature (Coffield et al., 2004; Curry, 1990; Kampwirth & Bates, 1980; Kavale & Forness, 1987; Mayer & Massa, 2003; Massa & Mayer, 2006; Pashler et al., 2009; Snider, 1992; Ysseldyke, 1973).

Most importantly, however, the results of this study indicate that it may be difficult to separate the visual and verbal measures from one another or these measures might maintain an interdependent relationship. As an alternative to classifying students by their learning preference and rather than applying one instructional method alone, it may be beneficial to provide students with information that is presented with both words and pictures. Consistent with what Mayer (2001) called the multimedia effect, the results of this study suggest that rather than applying one instructional method alone, students may benefit more from receiving information presented with both words and pictures. According to the Integrated Model of Text and Picture Comprehension theoretical model, "picture comprehension provides more direct access to mental model construction than does text comprehension, because pictures are immediately processed by the depictive subsystem, whereas text are first processed by the descriptive subsystem . . . [and this subsystem often leaves] some ambiguity that has to be removed via the depictive subsystem" (Schnotz, 2014, p. 87). In other words, when a picture is combined with auditory text, the pictorial and verbal information can be processed at the same time and be kept simultaneously in working memory, which improves a person's ability to perform and retain information (Mousavi, Low, & Sweller, 1995).

Future Direction

There is a need for further research. Worldwide, teachers classify students by their learning preference (Dekker et al., 2012; Howard-Jones, 2014; Newton, 2015; Pashler et al., 2009; Rogowsky et al., 2015). There are very few researchers, however, who say there is any kind of construct validity or reliability evidence or that it is measured well. The split between practitioners and researchers is astounding. The enormous disparity between the two groups needs resolution. Perhaps further conclusive information could be obtained by performing qualitative research, interviewing teachers to learn why they continue to use these measures, and this discrepancy finally can be resolved.

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APPENDICES

Appendix A

Correlation Matrix for Variables of Buktenica (1969)

Correlation Matrix for Variables of Buktenica (1969)

	Measures	1	2	3	4	5	6	7
1.	IQa	1.00						
2.	IQb	1.00						
3.	IQc	1.00						
4.	**VMIa**	.43	**1.00**					
5.	**VMIb**	**.43**	**1.00**					
6.	**VMIc**	**.43**	**1.00**					
7.	**WADTa**	**.40**	**.26**	**1.00**				
8.	**WADTb**	**.40**	**.22**	**1.00**				
9.	**WADTc**	**.40**	**.27**	**1.00**				
10.	NVADTa	.45	.37	.50	1.00			
11.	NVADTb	.45	.40	.42	1.00			
12.	NVADTc	.45	.35	.35	1.00			
13.	MATa	.43	.40	.43	.52	1.00		
14.	MATb	.43	.37	.40	.51	1.00		
15.	MATc	.43	.40	.49	.48	1.00		
16.	WKnowa	.41	.38	.44	.53	.97	1.00	
17.	WKnowb	.41	.34	.39	.45	.97	1.00	
18.	WKnowc	.41	.37	.47	.45	.97	1.00	
19.	WordDisa	.43	.41	.38	.48	.96	.88	1.00
20.	WordDisb	.43	.39	.39	.53	.96	.88	1.00
21.	WordDisc	.43	.41	.48	.49	.96	.88	1.00

Note: *N* = 140. Visual-verbal measures are in bold font. Abbreviations that signify the measures are: Science Research Associates Primary Mental Abilities Test for IQ (1958) = IQa, IQb, IQc; visual perceptual tests measured with Berry-Buktenica Visual-Motor Integration test (Buktenica, 1966) = VMIa, VMIb, VMIc; auditory perceptual tests measured with the Wepman Auditory Discrimination Test (Wepman, 1964; WADTa, WADTb, WADTc);tests of Non-Verbal Auditory Discrimination Ability (1968) = NVADTa, NVADTb, NVADTc; Reading Total or MAT Total = MATa, MATb, MATc; 3 Word Knowledge tests = WKnowa, WKnowb, WKnowc; and 3 Word Discrimination tests = WordDisa, WordDisb, WordDisc.

Buktenica (1969)

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Appendix B

Correlation Matrix for Variables of
Casey, Pezaris, Fineman, Pollock, Demers, and Dearing (2015)

Correlation Matrix for Variables of Casey, Pezaris, Fineman, Pollock, Demers, and Dearing (2015)

	Measures	1	2	3	4	5	6	7	8	9
1.	IL	1.00	.60	.28	.24	.16	.12	.34	.33	.35
2.	MotED	1.00	.36	.30	.32	.26	.42	.34	.56	
3.	Mot SS	1.00	.33	.41	.18	.18	.18	.14		
4.	**1stWISC**	**1.00**	**.35**	**.42**	**.20**	**.24**	**.31**			
5.	**1st2D**	**1.00**	**.33**	**.28**	**.29**	**.32**				
6.	**1st3D**	**1.00**	**.17**	**.17**	**.25**					
7.	1stAdd	1.00	.66	.24						
8.	1stSub	1.00	.21							
9.	**1stPPVT**	**1.00**								

Note: N = 127. Abbreviations that signify the measures are: Income level = IL; Mothers' years of education = MotED; Mothers' spatial skills = MotSS; 1st Grade Wechsler Intelligence Scale for Children (WISC-IV) = 1stWISC; 1st Grade Two Dimensional Mental transformation Task (Levine et al., 1999) = 1st2D; First Grade Three-Dimensional Mental Rotation task (Casey et al., 2008) =1st3-D; 1st Grade Addition = 1stAdd; 1st Grade Subtraction = 1stSub; First Grade Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn and Dunn, 2007) = 1stPPVT

Casey, Pezaris, Fineman, Pollock, Demers, and Dearing (2015)

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Appendix C

Correlation Matrix for Variables of
Blazhenkova, Becker, and Kozhevnikov's (2011) Experiment 1

Correlation Matrix for Variables of Blazhenkova, Becker, and Kozhevnikov's (2011) Experiment 1

	Measures	Obj	Spat	Verb	VVIQ	DPT	MRT	PFT	AW
1.	Obj	1.00	−.12	.38	.42	.18	−.01	−.03	.10
2.	Spat		1.00	.07	.13	.11	.42	.34	.18
3.	Verb			1.00	.10	.06	.03	−.06	.31

Note: N = 222. For abbreviations that signify the measures: Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object = Obj, C-OSIVQ spatial = Spat, C-OSIVQ verbal = Verb, Vividness of Visual Imagery Questionnaire = VVIQ, Degraded Pictures Test = DPT, Mental Rotation Test = MRT, Paper Folding Test = PFT, and Arranging Word Test = AW.

Blazhenkova, Becker, and Kozhevnikov (2011)

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Appendix D

Correlation Matrix for Variables of
Blazhenkova, Becker, and Kozhevnikov's (2011) Experiment 2

Correlation Matrix for Variables of Blazhenkova, Becker, and Kozhevnikov's (2011) Experiment 2

Measures	Obj	Spat	Verb	VVIQ	DPT	MRT	PFT	AW
Obj	1.00	.11	.56	.54	.26	.07	.05	.17
Spat		1.00	.06	−.00	−.05	.49	.31	.17
Verb			1.00	.55	.39	.22	.29	.37

Note: $N = 269$. For abbreviations that signify the measures: Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object = Obj, C-OSIVQ spatial = Spat, C-OSIVQ verbal = Verb, Vividness of Visual Imagery Questionnaire = VVIQ, Degraded Pictures Test = DPT, Mental Rotation Test = MRT, Paper Folding Test = PFT, and Arranging Word Test = AW.

Blazhenkova, Becker, and Kozhevnikov (2011)
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Appendix E

Correlation Matrix for Variables of
Hajhashemi, Caltabiano, Anderson, and Tabibzadeh (2018)

Correlation Matrix for Variables of Hajhashemi, Caltabiano, Anderson, and Tabibzadeh (2018)

	Measures	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	EL	1.00												
2.	Mot	.48	1.00											
3.	MI	.32	.02	1.00										
4.	Intra	.23	-.02	.69	1.00									
5.	BodKin	.32	.04	.78	.52	1.00								
6.	VrbLng	.08	-.11	.77	.46	.58	1.00							
7.	MusRhy	.28	-.02	.64	.40	.47	.47	1.00						
8.	Inter	.23	.09	.75	.34	.51	.61	.35	1.00					
9.	Nat	.19	.04	.73	.44	.43	.47	.34	.58	1.00				
10.	LogMath	.19	-.05	.75	.43	.57	.52	.42	.53	.49	1.00			
11.	Vis	.32	.09	.74	.32	.47	.49	.45	.58	.60	.48	1.00		
12.	Exist	.23	.08	.65	.43	.51	.38	.27	.36	.39	.44	.42	1.00	
13.	Age	.19	-.16	.14	-.01	.18	.16	.34	.09	.09	.02	.21	.07	1.00

Note: *N* = 111. Abbreviations that signify the measures are: (1) Learning Experience (LE), (2) Motivation (Mot), (3) Overall MI (MI), (4) Intrapersonal (Intra), (5) Bodily Kinesthetic (BodKin), (6) Verbal Linguistic (VrbLng), (7) Musical Rhythmic (MusRhy), (8) Interpersonal (Inter), (9) Naturalist (Nat), (10) Logical Mathematical (LogMath). (11) Visual (Vis), (12) Existential (Exist), (13) Age (Age).

Hajhashemi, Caltabiano, and Anderson (2018)

This matrix table was copied from *International Journal of Instruction, 11*, and was authored by Hajhashemi, K., Caltabiano, N., Anderson, N. (2018). Multiple Intelligences, Motivations and Learning Experience Regarding Video-Assisted Subjects in a Rural University. Copyright Permission to use Table 4 on page 176 was granted through open access Creative Commons Attribution License under *International Journal of Instruction* 2/5/2020.

Appendix F

Correlation Matrix for Variables of Sozcu (2014)

Correlation Matrix for Variables of Sozcu (2014)

	Measures	1	2	3	4	5	6	7	8	9	10
1.	FDI	1.00									
2.	Elrn	-.053	1.00								
3.	Atboutelrn	.103	-.001	1.00							
4.	Attenddislrn	-.109	.138	.022	1.00						
5.	Locaccess	.009	.120	-.147	.177	1.00					
6.	Knowelrnde	.104	-.057	.352	-.028	.076	1.00				
7.	Assesselrn	.074	.050	.745	.061	-.075	.263	1.00			
8.	Knowelrni	-.001	.057	.393	.154	-.069	.136	.559	1.00		
9.	Lrndes	.096	.062	.469	.125	-.067	.135	.589	.783	1.00	
10.	Prefnelrn	.041	.061	.131	.016	-.048	-.030	.104	.057	.061	1.00

Note: *N* = 157. Abbreviations that signify the measures are: Levels of FDI = FDI; E-learning techniques = Elrn; Attitudes about elearning instruction = Atboutelrn; Attending distance learning programs before =Attenddislrn; Locations for accessing distance education programs = Locaccess; Knowledge levels about e-learning and distance education = Knowelrnde; Assessment in elearning instruction = Assesselrn; Knowledge about elearning instruction = Knowelrni; Learner Interface Design features = Lrndes; PrAfer reading materials (printed texts) in e-learning = Prefnelrn.

Sozcu (2014)
This matrix table was copied from *Turkish Online Journal of Distance Education, 15* (2), and was authored by Sozcu, O. F. (2014). The Relationships between Cognitive Style of Field Dependence and Learner Variables in E-Learning Instruction. Copyright Permission granted to use Table 2 on page 127 through open access Turkish Online Journal of Distance Education 2/2020.

Appendix G

Correlation Matrix for Variables of
Andrusyszyn, Cragg, and Humbert (2001)

Correlation Matrix for Variables of Andrusyszyn, Cragg, and Humbert (2001)

	Measures	1	2	3	4	5	6	7	8	9	10	11	12
1.	OnOwn	1.00											
2.	SmlGrp	-.61	1.00										
3.	LrgGrp	-.54	-.03	1.00									
4.	BigP	.03	.00	.00	1.00								
5.	SetForMe	-.30	.08	.25	.01	1.00							
6.	Theory	.00	-.10	.10	.00	-.22	1.00						
7.	Hear	-.23	.08	.27	.06	.32	-.07	1.00					
8.	Read	.26	-.14	-.21	-.29	-.03	.07	-.06	1.00				
9.	Discuss	-.10	.31	-.20	.12	.06	.00	-.31	.05	1.00			
10.	Obs	.01	-.10	.04	-.10	-.01	-.26	-.05	-.02	-.36	1.00		
11.	Do	.00	.00	.08	-.01	-.31	-.02	-.31	-.46	-.25	.11	1.00	
12.	Refl	.08	.00	.00	.29	-.17	.21	-.21	-.47	-.16	-.41	.00	1.00

Note: N= 125. Abbreviations that signify the measures are:(1) Prefer to learn new things on my own rather than with others = OnOwn; (2) Prefer to learn in smaller groups (15 or fewer) = SmlGrp; (3) Prefer to learn in larger groups (more than 15) = LrgGrp; (4) Prefer to learn by considering the big picture vs. by focusing on the details = BigP; (5) Prefer to learn by having my learning plan set for me vs. by setting my own learning plan = SetForMe; (6) Prefer to learn by focusing on theoretical concepts vs. by focusing on concrete examples = Theory; (7) Prefer to learn by hearing them = Hear; (8) Prefer to learn by reading them = Read; (9) Prefer to learn by discussing things = Discuss; (10) Prefer to learn by observing them = Obs; (11) Prefer to learn by doing things = Do; (12) Prefer to learn by reflecting on things = Refl.

Andrusyszyn, Cragg, and Humbert (2001)

This matrix table was published in the *Journal of Nursing Education,* 40 (4), and was authored by Andrusyszyn, M. Cragg, C.E., Humbert, J. (2001). Nurse Practitioner Preferences for Distance Education Methods Related to Learning Style, Course Content, and Achievement, copyright permission to use Table 2 on page 167 was granted by SLACK Incorporated on 2/3/2020.

Appendix H

Correlation Matrix for Variables of Leite, Svinicki, and Shi (2010)

Correlation Matrix for Variables of Leite, Svinicki, and Shi (2010)

Measures		1	2	3	4
1.	**Vis**	**1.00**	**.601**	**.463**	**.799**
2.	**Aur**	**1.00**	**.437**	**.737**	
3.	RW	1.00	.330		
4.	Kin	1.00			

Note: N = 14,211. Abbreviations that signify the measures are: Visual = Vis; Aura= Aur; Read-Write = RW; Kinesthetic = Kin.

Leite, Svinicki, and Shi (2010)

This matrix table was copied from *Educational and Psychological Measurement 70*(2), and was authored by Leite, W. L., Svinicki, M., & Shi, Y. (2010). Attempted Validation of the Scores of the VARK: Learning Styles Inventory With Multitrait–Multimethod Confirmatory Factor Analysis Models. Copyright Permission to use Table 1 on page 334 was granted by Mary Ann Price, Rights Coordinator SAGE Publishing with email on 2/24/2020.

Appendix I

Correlation Matrix for Variables of Vahid Baghban (2012)

Correlation Matrix for Variables of Vahid Baghban (2012)

	Measures	1	2	3	4	5	6	7	8	9
1.	**Vis**	**1.00**								
2.	**Aud**	**.036**	**1.00**							
3.	Kin	.084	.101	1.00						
4.	Mem	-.112	.117	.253	1.00					
5.	Cognit	-.008	.221	.130	.557	1.00				
6.	Comp	.138	.042	.124	.269	.154	1.00			
7.	Metacog	-.116	.202	.227	.417	.398	.267	1.00		
8.	Affect	-.060	.307	.034	.254	.295	-.011	.233	1.00	
9.	Soc	-.049	.084	.364	.340	.396	.350	.350	-.087	1.00

Note: N = 120. Abbreviations that signify the measures are: (1) Visual = Vis, (2) Auditory = Aud, (3) Kinetic = Kin, (3) Memory = Mem, (5) Cognitive = Cognit, (6) Compensation = Comp, (7) Metacognitive = Metacog, (8) Affective = Affect, and (9) Social = Soc.

Vahid Baghban (2012)
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Appendix J

Correlation Matrix for Variables of
Wintergerst, DeCapua, and Itzen (2001)

Correlation Matrix for Variables of Wintergerst, DeCapua, and Itzen (2001)

	Measure	1	2	3	4	5	6	7	8	9	10
1.	F1	1.00									
2.	F2	-.21	1.00								
3.	F3	.00	-.08	1.00							
4.	F4	.20	.00	-.20	1.00						
5.	F5	-.16	.13	-.09	.09	1.00					
6.	F6	-.22	.13	.10	-.19	.01	1.00				
7.	F7	-.18	.08	.09	-.13	-.04	.12	1.00			
8.	F8	.26	-.11	-.07	.25	-.01	-.13	-.19	1.00		
9.	F9	-.04	.08	.04	.09	-.01	.04	.02	.03	1.00	
10.	F10	-.30	-.07	.10	-.21	-.08	.33	.13	-.10	.05	1.00

Note: $N = 100$. For abbreviations that signify the measures: (1) Factor 1 = FI, (2) Factor 2 = F2, (3) Factor31 = F3, (4) Factor 4 = F4, (5) Factor 5 = F5, (6) Factor 6 = F6, (7) Factor 7 = F7, (8) Factor 8 = F8, (9) Factor 9 = F9, (10) Factor 10 = FI0.

Wintergerst, DeCapua, and Itzen (2001)

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Appendix K

Correlation Matrix for Variables of Yang and Kim (2011)

Correlation Matrix for Variables of Yang and Kim (2011)

	Measures	1	2	3	4	5
1.	**VisC**	**1.00**				
2.	**VisJ**	**1.00**				
3.	**VisK**	**1.00**				
4.	**VisS**	**1.00**				
5.	**AudC**	**.450**	**1.00**			
6.	**AudJ**	**.298**	**1.00**			
7.	**AudK**	**.276**	**1.00**			
8.	**AudS**	**.221**	**1.00**			
9.	KinC	.330	.221	1.00		
10.	KinJ	-.023	.231	1.00		
11.	KinK	.278	.363	1.00		
12.	KinS	.086	.225	1.00		
13.	IdlC	.263	.254	.083	1.00	
14.	IdlJ	.361	.251	-.011	1.00	
15.	IdlK	.390	.061	.024	1.00	
16.	IdlS	.371	.243	.102	1.00	
17.	MotC	.258	.281	.065	.530	1.00
18.	MotJ	.360	.166	.015	.661	1.00
19.	MotK	.352	-.010	.135	.659	1.00
20.	MotS.	.395	.286	.166	.700	1.00

Note: N = 330. For abbreviations that signify the measures:Visual for China, Japan, Korea, and Sweden = VisC, VisJ, VisK, and VisS. Auditory for China, Japan, Korea, and Sweden = AudC, Aud J, AudK, and AudS. Kinesthetic for China, Japan, Korea, and Sweden = KinC, KinJ, KinK, and KinS. Ideal L2 self for China, Japan, Korea, and Sweden = IdlC, IdlJ, IdlK, and IdlS. Motivated L2 behavior for China, Japan, Korea, and Sweden = MotC, MotJ, MotK, and MotS.

Yang and Kim (2011)

This matrix table was copied from *English Teaching, 66(1),* and was authored by Yang, J. S., & Kim, T. Y. (2011). The L2 Motivational Self-System And Perceptual Learning Styles of Chinese, Japanese, Korean, and Swedish Students. Copyright Permission granted to use Table 3 on page 151 with open access under Creative Commons Attribution License 2/10/2020.

Appendix L

Correlation Matrix for Variables of
Federico and Landis' (1979), Measures 1-11 & 12-24

Correlation Matrix for Variables of Federico and Landis' (1979), Measures 1-11

	Measure	1	2	3	4	5	6	7	8	9	10	11
1.	FILDINDP	1.00										
2.	CONCSTYI	.14	1.00									
3.	REFLIMPL	-.12	-.14	1.00								
4.	REFLIMPL	.01	.03	-.00	1.00							
5.	CATWIDBH	.11	-.05	.16	-.06	1.00						
6.	COGCOMPX	-.08	.03	-.13	-.02	-.19	1.00					
7.	VERBCOMP	.13	.08	-.06	.06	.20	-.14	1.00				
8.	GENLREAS	.23	.11	-.02	.15	.15	-.06	.41	1.00			
9.	ASSOFLUN	.16	.09	-.09	.01	.08	.02	.39	.17	1.00		
10.	L0GIREAS	.12	.05	-.12	.03	.16	.03	.18	.35	.11	1 00	
11.	INDUCTON	.15	.09	-.11	-.10	.19	.01	.15	.15	.15	-.00	1.00
12.	IDEAFLUN	.01	.04	-.02	-.00	.05	.03	.20	.14	.38	.08	.12
13.	GENLINFO	.04	.01	.07	.03	.06	-.10	.33	.18	.20	.15	.01
14.	NUMROPER	.07	.06	-.11	-.02	.11	.07	.18	.37	.07	.10	.08
15.	ATTNDETL	-.00	.03	-.04	-.11	.08	-.03	.04	.02	-.04	.09	.12
16.	WORDKNOL	-.02	.05	.09	.06	.04	-.06	.52	.16	.28	.11	.07
17.	ARTHREAS	.08	.03	-.05	.06	.05	-.10	.23	.38	.07	.22	.04
18.	SPACPERC	.15	-.05	.08	.08	.02	-.09	-.03	.09	.10	-.00	.03
19.	MATHKNOL	.27	.14	-.05	.03	.08	-.03	.29	.41	.16	.23	.12
20.	ELECINFO	.24	.03	-.09	.06	.02	.02	.28	.24	.15	.20	.10
21.	MECHCOMP	.30	.05	.04	-.01	.11	-.00	.19	.24	.15	.18	.18
22.	GENLSCIE	.04	.02	-.03	.06	.12	-.00	.32	.16	.17	.17	.09
23.	SHOPINFO	.00	-.07	-.11	.04	.05	-.00	.17	.12	.01	.11	-.13
24.	AUTOINFO	.12	.05	-.13	.06	.14	-.05	.28	.18	.03	.18	.01

Matrix continued

Correlation Matrix for Variables of Federico and Landis' (1979), Measures 12-24

	Measure	12	13	14	15	16	17	18	19	20	21	22	23	24
1.	FILDINDP													
2.	CONCSTYI													
3.	REFLIMPL													
4.	REFLIMPL													
5.	CATWIDBH													
6.	COGCOMPX													
7.	VERBCOMP													
8.	GENLREAS													
9.	ASSOFLUN													
10.	LOGIREAS													
11.	INDUCTON													
12.	IDEAFLUN	1.0												
13.	GENLINFO	.18	1.00											
14.	NUMROPER	.21	.13	1.00										
15.	ATTNDETL	.11	.02	.28	1.00									
16.	WORDKNOL	.22	.41	.15	.00	1.00								
17.	ARTHREAS	.06	.22	.39	.08	.35	1.00							
18.	SPACPERC	.01	.12	.07	.02	.11	.20	1.00						
19.	MATHKNOL	.11	.19	.40	.12	.30	.50	.11	1.00					
20.	ELECINFO	.10	.32	.11	.09	.38	.22	.24	.40	1.00				
21.	MECHCOMP	.15	.31	.12	.00	.35	.26	.34	.31	.51	1.00			
22.	GENLSCIE	.12	.33	.02	.07	.60	.30	.17	.33	.42	.40	1.00		
23.	SHOPINFO	.06	.29	.10	.08	.26	.22	.17	.14	.35	.45	.30	1.00	
24.	AUTOINFO	.13	.34	.12	.02	.27	.22	.14	.19	.47	.47	.29	.49	1.00

Note: N = 207. For abbreviations that signify the measures: Field-independence versus field-dependence = FILDINDP, conceptualizing style = CONCSTYI, reflectiveness-impulsivity = REFLIMPL, tolerance of ambiguity = REFLIMPL, category width – CATWIDBH, cognitive complexity COGCOMPX, verbal comprehension = VERBCOMP general reasoning = GENLREAS, associational fluency = ASSOFLUN, logical reasoning = LOGIREAS, induction = INDUCTON, ideational fluency = IDEAFLUN, general information = GENLINFO, numerical operations = NUMROPER, attention to detail = ATTNDETL, word knowledge = WORDKNOL, arithmetic reasoning = ARTHREAS, space perception = SPACPERC, mathematics knowledge = MATHKNOL, electronics information = ELECINFO, mechanical comprehension = MECHCOMP, general science = GENLSCIE, shop information = SHOPINFO, automotive information = AUTOINFO.

Federico and Landis (1979)
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Appendix M

Correlation Matrix for Variables of
Federico and Landis' (1979), Measures 1-11 & 12-24

Table of Correlations for Variables of Federico and Landis (1984)

	Measures	1	2	3	4	5	6	7	8	9	10	11
1	FILDINDP	1.00										
2	CONCSTYI	.18	1.00									
3	REFLIMPL	-.13	-.15	1.00								
4	REFLIMPL	.02	.04	-.00	1.00							
5	CATWIDBH	.11	-.04	.17	-.06	1.00						
6	COGCOMPX	-.I2	.02	-.I3	-.02	-.18	1.00					
7	VERBCOMP	.17	.09	-.08	.08	.21	-.17	1.00				
8	GENLREAS	.30	.16	-.06	.15	.15	-.10	.43	1.00			
9	ASSOFLUN	.18	.10	-.10	.03	.07	.00	.40	.21	1.00		
10	LOGIREAS	.12	.08	-.13	.03	.10	.02	.20	.35	.12	1.00	
11	INDUCTON	.21	.10	-.13	-.10	.23	-.01	.19	.21	.18	.01	1.00
12	IDEAFLUN	.04	.05	-.00	.02	.06	.04	.24	.20	.39	.10	.14
13	GENLINFO	.09	.02	.06	.04	.08	-.12	.35	.23	.22	.18	.03
14	NUMROPER	.13	.09	-.13	-.01	.11	.04	.20	.42	.08	.11	.14
15	ATTNDETL	.03	.02	-.04	-.11	.09	-.03	.05	.07	-.04	.11	.12
16	WORDKNOL	.04	.09	-.00	.06	-.08	.56	.24	.29	.12	.11	.22
17	ARTHREAS	.15	.07	-.09	.07	.05	-.13	.26	.45	.11	.23	.10
18	SPACPERC	.15	-.04	.09	.08	.03	.19	-.01	.10	.10	-.01	.03
19	MATHKNOL	.34	.18	-.08	.05	.09	-.07	.32	.48	.19	.25	.19
20	ELECINFO	.26	.04	-.01	.07	.05	-.01	.30	.25	.16	.21	.12
21	MECHCOMP	.23	.09	.02	-.01	.11	.03	.23	.28	.18	.18	.22
22	GENLSCIE	.19	.05	.04	.07	.12	-.03	.36	.24	.19	.18	.13
23	SHOPINFO	.02	-.05	-.11	.04	.05	-.01	.18	.13	.02	.11	-.11
24	AUTOINFO	.13	.06	-.13	.06	.14	-.06	.29	.19	.04	.18	.03

Matrix Continued

	Measures	12	13	14	15	16	17	18	19	20	21	22	23	24
1	FILDINDP													
2	CONCSTYI													
3	REFLIMPL													
4	REFLIMPL													
5	CATWIDBH													
6	COGCOMPX													
7	VERBCOMP													
8	GENLREAS													
9	ASSOFLUN													
10	LOGIREAS													
11	INDUCTON													
12	IDEAFLUN	1.00												
13	GENLINFO	.18	1.00											
14	NUMROPER	.25	.17	1.00										
15	ATTNDETL	.09	-.02	.29	1.00									
16	WORDKNOL	.22	.44	.20	.00	1.00								
17	ARTHREAS	.11	.27	.44	.11	.40	1.00							
18	SPACPERC	.00	.13	.08	-.02	.11	.20	1.00						
19	MATHKNOL	.16	.24	.45	.15	.36	.55	.12	1.00					
20	ELECINFO	.11	.34	.14	-.06	.42	.25	.24	.42	1.00				
21	MECHCOMP	.20	.36	.17	.03	.39	.30	.33	.36	.53	1.00			
22	GENLSCIE	.11	.35	.08	-.05	.62	.36	.16	.39	.44	.43	1.00		
23	SHOPINFO	.07	.31	.11	-.07	.27	.23	.17	.16	.37	.45	.31	1.00	
24	AUTOINFO	.14	.35	.13	.07	.28	.23	.14	.21	.47	.47	.28	.50	1.00

Note: N = 201. For abbreviations that signify the measures: Field-independence verses field-dependence = FILDINDP, conceptualizing style = CONCSTYI, reflectiveness-impulsivity = REFLIMPL, tolerance of ambiguity = REFLIMPL, category width –CATWIDBH, cognitive complexity COGCOMPX, verbal comprehension = VERBCOMP general reasoning = GENLREAS, associational fluency = ASSOFLUN, logical reasoning = LOGIREAS, induction = INDUCTON, ideational fluency = IDEAFLUN, general information = GENLINFO, numerical operations = NUMROPER, attention to detail = ATTNDETL, word knowledge = WORDKNOL, arithmetic reasoning = ARTHREAS, space perception = SPACPERC, mathematics knowledge = MATHKNOL, electronics information = ELECINFO, mechanical comprehension = MECHCOMP, general science = GENLSCIE, shop information = SHOPINFO, automotive information = AUTOINFO.

Federico and Landis (1984)

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Appendix N

Correlation Matrix for Variables of Nah and Lane (1990)

Correlation Matrix for Variables of Nah and Lane (1990)

	Measures	1	2	3	4	5	6	7	8	9	10	11	12
1.	GEmbFtest	1.00											
2.	AnSkill	.47	1.00										
3.	SpSkill	.50	.45	1.00									
4.	DisSkill	.02	.10	.12	1.00								
5.	CatSkill	-.12	-.07	-.11	.07	1.00							
6.	MemSkilll	.24	.24	.13	.09	.03	1.00						
7.	MemSkill	.25	.19	.21	.10	-.02	.10	1.00					
8.	KorLang	.48	.49	.49	.02	-.15	.12	.19	1.00				
9.	Math	.43	.42	.45	.04	-.15	.19	.15	.66	1.00			
10.	Eng	.36	.36	.34	.00	-.12	.13	.11	.66	.74	1.00		
11.	SocStud	.39	.36	.36	-.01	-.14	.08	.13	.64	.64	.66	1.00	
12.	Science	.49	.43	.45	.03	-.16	.17	.20	.71	.78	.72	.66	1.00

Note: N = 390. For abbreviations that signify the measures: (1) Group Embedded Figures Test = GEmbFtest, (2) Analytic Skill = AnSkill, (3) Spatial Skill = SpSkill, (4) Discrimination Skill = DisSkill, (5) Categorization Skill = CatSkill, (6) Sequential Processing Skill = SeqPSkill, (7) Memory Skill = MemSkill, (8) Korean Language = KorLang, (9) Mathematics = Math, (10) English = Eng, (11) Social Studies = SocStud, (12) Science = Science.

Nah, Lane, and Fuqua (1990)

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Appendix O

Correlation Matrix for Variables of Danisman and Erginer (2017)

Correlation Matrix for Variables of Danisman and Erginer (2017)

	Measures	Spatial	Reading	Visual	Auditory	Kinesthetic	Combined
1	Reasoning	.43*	.28*	.36*	.20	.30*	.25*
2	Spatial		.20	.37*	.23*	.35*	.28*
3	Reading			.57*	.44*	.35*	.42*
4	Visual				.47*	.38*	.31*
5	Auditory					.27*	.37*
6	Kinesthetic						.45*

Note: N=97.*Level of significance at p < .05.Visual-verbal measures are in bold font. For abbreviations that signify the measures: Spatial Ability Test = Spatial, Visual Learning Style test = Visual, Auditory Learning Style test = Auditory, Mathematical Reasoning Test (MET) = Reasoning, Kinesthetic Learning Style test = Kinesthetic, and Reading Learning Style test = Reading.

Danişman and Erginer (2017)

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Appendix P

Correlation Matrix for Variables of Haciomeroglu (2015)

Correlation Matrix for Variables of Haciomeroglu (2015)

	Measure	1	2	3	4	5	6	7	8	9	10	11	12
1.	AP	1.00											
2.	PGraphic	.62*	1.00										
3.	PAlgebraic	.42*	.54*	1.00									
4.	CC	.23	.28*	.20	1.00								
5.	CR	.16	.24	.04	.50	1.00							
6.	FB	.38*	.40*	.28*	.45*	.23	1.00						
7.	PF	.33*	.33*	.15	.36*	.35*	.47*	1.00					
8.	NS	.30*	.40*	.17	.20	.14	.27	.10	1.00				
9.	DR	.36*	.40*	.23	.34*	.18	.37*	.30*	.41*	1.00			
10.	VPG	.31*	.51*	.18	.09	.08	.19	.17	.18	.16	1.00		
11.	VPA	.11	.28*	.11	.02	.01	.15	.08	.12	.11	.40*	1.00	
12.	MPI	-.08	-.08	-.05	-.07	.04	.12	.09	-.08	.11	-.09	.06	1.00

Note: *N* = 150. *p < .05 (adjusted). For abbreviations that signify the measures: AP = Advanced Placement Calculus exam score; PGraphic = mathematical performance on graphic calculus tasks; PAlgebraic = mathematical performance on algebraic calculus tasks; CC = Cube Comparisons Test; CR = Card Rotations Test; FB = Form Board Test; PF = Paper Folding Test; NS = Nonsense Syllogisms Test; DR = Diagramming Relationships Test; VPG = visual preference for graphic calculus tasks; VPA = visual preference for algebraic calculus tasks; MPI = visual preference for algebra tasks on the Mathematical Processing Instrument (MPI).

Haciomeroglus (2015)
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Appendix Q

Correlation Matrix for Variables of Rogowsky, Calhoun, & Tallal (2015)

Correlation Matrix for Variables of Rogowsky, Calhoun, & Tallal (2015)

	Variable	1	2	3	4	5	6
1.	Lis	1.00	.46	.66	-.31**	-.14	-.21*
2.	Read		1.00	-.37	-.24**	-.04	-.19*
3.	DifLisRead			1.00	-.13	-.11	-.54
4.	**BEaud**				**1.00**	**.081**	**.85****
5.	**BEvis**					**1.00**	**-.46****
6.	**DifAudVis**						**1.00**

Note. N = 121; *p<.05. **p<.01. For abbreviations that signify the measures: Listening Aptitude = Lis, Reading aptitude = Read, Difference between listening and reading aptitude = DifLisRead, Building Excellence (BE) auditory learning style = BEaud, BE visual word learning style = Bevis, Difference between BE auditory and visual word learning styles = DifAudVis.

Rogowsky, Calhoun, and Tallal (2015)

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Appendix R

Correlation Matrix for Variables of Mayer and Massa (2003)

Correlation Matrix for Variables of Mayer and Massa (2003)

	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	SAT Math	1.00													
2.	SAT Verb	.63	1.00												
3..	Voc Test	.30	.47	1.00											
4.	Card Rotate	.13	.08	.16	1.00										
5.	Paper Fold	.14	.07	.18	.52	1.00									
6.	VS Ability	.10	-.22	-.08	.23	.37	1.00								
7.	VV Quest	-.13	-.27	-.21	-.02	.10	.24	1.00							
8.	SBLS Quest	.11	-.06	-.10	.08	.24	.26	.46	1.00						
9.	Cog S An	.00	-.08	-.02	.09	-.00	.00	.02	.19	1.00					
10.	VVLS Rate	.10	-.14	-.11	-.01	.20	.31	.40	.74	.14	1.00				
11.	LS Quest	-.01	-.02	-.11	.02	.24	.21	.27	.44	.17	.44	1.00			
12.	MLPT Ch	.11	.13	-.04	.02	.13	.08	.15	.31	.21	.36	.30	1.00		
13.	MLPT Rate	.17	.15	-.07	.04	.00	-.04	.21	.48	.07	.39	.25	.48	1.00	
14.	MMLP Quest	.00	.02	-.07	-.08	.07	.10	.28	.43	.09	.37	.29	.42	.59	1.00

Note: N = 95. For abbreviations that signify the measures:Standard Achievement Test (SAT) for Math = SAT Math, the SAT for Verbal test = SAT Verb, and a Vocabulary test = Voc Test, Card Rotation Test = Card Rotate, a Paper Folding Test - Paper Fold, and a Verbal-Spatial Ability Rating test = VS Ability, Verbalizer-Visualizer Questionnaire = VV Quest, the Santa Barbara Learning Style Questionnaire = SBLS Quest, Cognitive Style Analysis = Cog S An, the Verbal-Visual Learning Style Rating = VVLS Rate, a Learning Scenario Questionnaire test = LS Quest, Multimedia Learning Preference (MMLP) Choice test = MLPT Ch, a MMLP Rating test = MLPT Rate, a MMLP Questionnaire test = MMLP Quest.

Mayer and Massa (2003)
This matrix table was copied from *Journal of Educational Psychology, 95, and was authored by* Mayer, R. E., & Massa, L. (2003). Three facets of visual and verbal learners: Cognitive ability, cognitive style, and learning preference. Copyright Permission to reuse Table 3 on page 83 was granted through Copyright Clearance Center on 12/1/2019.

Appendix S

Correlation Matrix for Variables of
Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)

Correlation Matrix for Variables of
Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)

	Measures	1	2	3	4	5	6	7	8	9	10	11	12
1.	Visuospatial description recall (accuracy)	1.00											
2.	Abstract description recall (accuracy)	.18**	1.00										
3.	Imagery strategy	.34**	.04	1.00									
4.	Repetition strategy	.12	.23**	.23**	1.00								
5.	Reading Comp Task	.20**	.21**	.09	.10	1.00							
6.	Mental Rotations Test	.01	.00	-.03	-.14	.13	1.00						
7.	Minnesota Paper Form Board	-.01	.07	.23*	.07	.08	.21**	1.00					
8.	Preference for spatial visualization (OSIQ)	.05	.00	.04	-.11	.00	.25**	.17*	1.00				
9.	Preference for object visualization (OSIQ)	.07	.03	.21**	.06	.03	-.12	.11	.02	1.00			
10.	Visual Strategy (QVVS)	.17*	.14*	.38**	.04	.14*	-.05	.05	.06	.38**	1.00		
11.	Verbal Strategy (QVVS)	.04	.10	.01	.03	.14*	.01	.07	.06	.10	.40**	1.00	
12.	VVQ	-.04	.03	.13	.11	-.05	-.05	-.03	-.07	.24**	.22**	-.09	1.00

Note: N=198. For abbreviations that signify the measures: (1) Visuospatial description recall accuracy= VSdescrecall, (2) Abstract description recall (accuracy) = Abdescrecall, (3) Imagery strategy = Istrat, (4) Repetition strategy = Repstrat, (5) Reading Comp Task = RComp, (6) Mental Rotations Test – MenRotate, (7) Minnesota Paper Form Board = MinnPFB, (8) Preference for spatial visualization (OSIQ)= PrefSV, (9) Preference for object visualization (OSIQ) = PrefOV, (10) Visual Strategy (QVVS) = VisS, (11) Verbal Strategy (QVVS) = VerbS, and (12) Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977)= VVQ.

Meneghetti, Labate, Grassano, Ronconi, Lucia; and Pazzaglia, (2014)
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Appendix T

Correlation Matrix for Variables of Massa and Mayer (2006)

Correlation Matrix for Variables of Massa and Mayer (2006)

	Measure	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	SAT Math	1.00												
2.	SAT Verb	.42	1.00											
3.	Voc Test	.47	.14	1.00										
4.	**Card Rotate**	.15	.30	.23	1.00									
5	**Paper Fold**	.16	.36	.16	.45	1.00								
6.	**VS Ability**	.10	-.22	-.08	.23	.37	1.00							
7.	**MLPT Ch**	.10	.22	-.03	.10	.12	.06	1.00						
8.	**MLPT R**	-.05	.10	-.17	.03	-.05	.33	.37	1.00					
9.	**MLP Quest**	-.04	.13	-.04	-.07	.06	.29	.40	.58	1.00				
10.	**VV Quest**	-.16	.18	-.06	-.17	.27	.37	.19	.27	.24	1.00			
11.	**SBLS Quest**	-.16	.13	-.15	.30	.20	.27	.36	.36	.36	.45	1.00		
12.	**VVLS Rate**	-.15	.13	-.13	.23	.16	.39	.33	.33	.40	.41	.70	1.00	
13.	**LS Quest**	.02	.26	-.12	.15	.28	.24	.32	.41	.43	.35	.43	.46	1.00

Note: N = 114. For abbreviations that signify the measures: Standard Achievement Test (SAT) for Math = SAT Math, the SAT for Verbal test = SAT Verb, and a Vocabulary test = Voc Test, Card Rotation Test = Card Rotate, a Paper Folding Test - Paper Fold, and a Verbal-Spatial Ability Rating test = VSAbility, Multimedia Learning Preference (MMLP) Choice test = MLPT Ch, a MMLP Rating test = MLPT Rate, a MMLP Questionnaire test = MMLP Quest, Verbalizer-Visualizer Questionnaire = VV Quest, the Santa Barbara Learning Style Questionnaire = SBLS Quest, the Verbal-Visual Learning Style Rating = VVLS Rate, a Learning Scenario Questionnaire test = LS Quest.

Massa and Mayer (2006)

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Appendix U

Correlation Matrix for Variables of Burns and Hagelskamp (2017),
Ability & Cognitive Style Measures 1-10,
Learning Style Preferences Measures 11-27

Correlation Matrix for Variables of Burns and Hagelskamp (2017), Ability & Cognitive Style Measures 1-10, Learning Style Preferences Measures 11-27, and Achievement Measures 28-38

	Ability & Cognitive Style Measures	1	2	3	4	5	6	7	8	9	10
1.	Non-verb	--									
2.	Memory	.36	--								
3.	**Verbal**	**.60**	**.39**	**--**							
4.	Analytic	.28	.14	.20	--						
5.	**Spatial**	**.40**	**.20**	**.33**	**.27**	**--**					
6.	**Discrimin**	**.04**	**.07**	**.07**	**.03**	**.02**	**--**				
7.	**Categorizat**	**.18**	**.13**	**.13**	**.08**	**.18**	**.03**	**--**			
8.	Sequential	.24	.13	.13	.18	.15	.12	.11	--		
9.	Simultaneous	.16	.14	.11	.17	.18	.15	.02	.23	--	
10.	Mem Skill	.13	.13	.10	.07	.11	.09	.04	.20	.12	--
11.	**Visual**	**.07**	**.20**	**.17**	**-.05**	**.02**	**.07**	**.03**	**.05**	**.06**	**.07**
12.	**Auditory**	**-.04**	**-.19**	**-.18**	**.01**	**.06**	**-.04**	**.06**	**-.04**	**-.06**	**-.03**
13.	Emotional	-.04	-.07	-.04	.05	-.07	-.03	-.09	-.01	-.02	-.05
14.	**Verb-Spatial**	**.04**	**.06**	**.00**	**-.05**	**-.08**	**.00**	**-.06**	**.02**	**-.05**	**-.08**
15.	Persistence	.13	.09	.16	.13	.11	.06	.04	.06	-.05	.09
16.	Verbal Risk	.08	.03	.09	.08	.11	.12	-.04	.03	.09	.08
17.	Manipulative	.18	-.01	.07	.19	.17	-.01	.03	.08	.12	.18
18.	EarMornSt	-.07	-.03	-.15	-.07	-.05	.04	-.06	-.04	-.04	-.07
19.	LateMornSt	.08	.07	.04	-.03	.04	-.07	-.06	-.05	-.06	.08
20.	AfternoonSt	.04	.01	.10	.10	.08	.05	.12	.11	-.05	.04
21.	EveningSt	-.01	-.01	.01	.05	-.08	.12	-.03	.04	.03	-.01
22.	Grouping	.00	-.03	.04	.05	.05	.00	-.01	.00	-.08	.00
23.	Posture	-.06	.01	-.04	-.04	-.13	-.04	-.01	.03	.02	-.06
24.	Mobility	-.04	.01	-.06	-.09	.04	.01	.04	-.05	.03	-.04
25.	Sound	.08	.02	.06	.04	.10	.10	.04	.06	-.02	.08
26.	Lighting	.00	.00	-.03	-.06	.05	-.04	-.04	.11	-.05	.00
27.	Temperat	-.01	-.03	-.04	.03	-.03	-.04	.03	-.01	-.02	-.01

Matrix Continued

	Learning Style Preferences Measures	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
11.	Visual	--																
12.	Auditory	-.59	--															
13.	Emotional	-.70	-.16	--														
14.	Verb-Spatial	.06	-.03	-.05	--													
15.	Persistence	.01	.00	-.01	.09	--												
16.	Verbal Risk	-.07	.06	.05	-.07	.16	--											
17.	Manipulative	-.08	.06	.04	-.03	.20	.19	--										
18.	EarMornSt	-.02	-.01	.04	-.15	.03	.05	.06	--									
19.	LateMornSt	-.01	-.05	.07	-.01	.02	.07	.10	.30	--								
20.	AfternoonSt	.06	-.04	-.04	.03	.48	.05	.05	-.14	-.02	--							
21.	EveningSt	-.03	.00	.04	-.01	.06	.04	-.01	-.14	-.13	.02	--						
22.	Grouping	.02	-.02	-.01	.04	.18	-.04	.02	.02	.00	.08	-.01	--					
23.	Posture	-.06	.02	.05	.05	.12	-.04	-.03	.16	-.03	.00	-.11	.10	--				
24.	Mobility	.01	.00	-.02	-.02	-.30	.05	-.02	-.09	.09	-.24	.03	-.08	.39	--			
25.	Sound	.03	.01	-.05	.00	.01	.09	.12	-.13	-.06	.11	.13	-.11	-.35	.24	--		
26.	Lighting	.08	-.09	.00	.08	.12	-.06	-.01	.03	-.05	.20	-.02	.03	.14	-.15	-.2	--	
27.	Temperat	.05	.00	.06	-.07	.04	-.06	-.01	.00	.12	.14	-.07	.00	-.01	-.11	.01	.06	--

Note: N = 335. For abbreviations that signify the measures: Non-Verbal ability = Non-verb,Memory ability = Memory, Verbal ability = = verbal,Analytic style (field independence versus field dependence) = Analytic, Spatial ability = Spatial, Discrimination (focusing versus scanning cognitive style) = Discrimin, Categorization (narrow versus broad category width cognitive style) = Categorizat, Sequential processing = Sequential, Successive processing = Successive, Simultaneous processing = Simultaneous, Memory skill(leveling versus sharpening = Mem skill, Visual = Visual, Auditory = Auditory, Emotional = Emotional, and Verbal-Spatial preference = Verbal-Spatial, Persistence orientation = Persistence, Verbal Risk orientation = Verbal Risk, Manipulative = Manipulative, Early Morning Study time = EarMornSt, Late Morning Study time = LateMorningSt, Afternoon Study time = AfternoonSt, Evening Study time = EveningSt, Grouping = Grouping, Posture = Posture, Mobility = Mobility, Sound = Sound, Lighting = Lighting, Temperature = Temperat

Burns and Hagelskamp (2017)

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Appendix V

Names of All Measures Used in This Research:
Abilities, Cognitive Styles, and Learning Preferences

Names of All Measures Used in This Research:
Abilities, Cognitive Styles, and Learning Preferences

Name of Ability Measures	Construct Defined
Science Research Associates Primary Mental Abilities Test for IQ (1958)	Other abilities
Visual perceptual tests measured with Berry-Buktenica Visual–Motor Integration test (Buktenica, 1966)	Visual
Auditory perceptual tests measured with the Wepman Auditory Discrimination Test (Wepman, 1964)	Verbal
Non-Verbal Auditory Discrimination Ability (1968)	Other abilities
Reading Total of Metropolitan Achievement Test (MAT; 1968)	Other abilities
Word Knowledge test (MAT, 1968)	Other abilities
Word Discrimination test (MAT, 1968)	Other abilities
1st Grade Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn and Dunn, 2003)	Verbal ability
1st Grade Block Design subtest of Wechsler Intelligence Scale for Children –Fourth Edition (WISC-IV; Wechsler, 2003)	Spatial ability
1st Grade Two-Dimensional Mental- transformation Task (Levine et al., 1999)	Spatial ability
1st Grade Three-Dimensional Mental-Rotation task (Casey et al., 2008)	Spatial ability
1st Grade Addition ability test (third session in spring in-school individual assessment)	Other measure
1st Grade Subtraction ability test (third session in spring in-school individual assessment)	Other measure
Household income level (obtained from interview with mothers)	Other measure
Mother's years of education (obtained from interview with mothers)	Other measure
Mother's spatial skills (obtained from an adapted mental-rotation test based on the Vandenberg Mental Rotation Test; Vandenberg & Kuse, 1978)	Other measure
Verbal Comprehension measured with Vocabulary Test, Part 1 (Ekstrom et. al., 1976)	Verbal Cognitive Ability
General Reasoning measured with Arithmetic Aptitude Test, Part I (Ekstrom et. al., 1976)	Other cognitive ability
Associational Fluency measured with Controlled Associations Test, Part I (Ekstrom et. al., 1976)	Other cognitive ability
Logical Reasoning measured with Nonsense Syllogisms Test, Part I, (Ekstrom et. al., 1976)	Other cognitive ability

Induction measured with Figure Classification Test, Part I (Ekstrom et. al., 1976)	Other cognitive ability
Ideational Fluency measured with Topics Test, Part I (Ekstrom et. al., 1976)	Other cognitive ability
General Information measured with General Information Subset, of Armed Services Vocational Aptitude Battery Test (ASVAB, 1968)	Other cognitive aptitude
Numerical Operations measured with Electronics Information Subtest, (ASVAB, 1968)	Other cognitive aptitude
Attention To Detail measured with Attention To Detail Subtest (ASVAB, 1968)	Other cognitive aptitude
Word Knowledge measured with Word Knowledge Subtest (ASVAB, 1968)	Other cognitive aptitude
Arithmetic Reasoning measured with Arithmetic Reasoning (ASVAB, 1968)	Other cognitive aptitude
Space Perception measured with Space Perception Subtest (ASVAB, 1968)	Spatial Cognitive Aptitude
Mathematics Knowledge measured with Mathematics Knowledge Subtest (ASVAB, 1968)	Other cognitive aptitude
Electronics Information measured with Electronics Information Subtest (ASVAB, 1968)	Other cognitive aptitude
Mechanical Comprehension measured with Mechanical Comprehension Subtest (ASVAB, 1968)	Other cognitive aptitude
General Science measured with General Science Subtest (ASVAB, 1968)	Other cognitive aptitude
Shop Information measured with Shop Information Subtest (ASVAB, 1968)	Other cognitive aptitude
Automotive Information measured with Automotive Information Subtest (ASVAB, 1968)	Other cognitive aptitude
Group Embedded Figures Test (oKman, Raskin, & Witkin, 1971)	Visual-Spatial Ability
Spatial Ability Test (SAT; Danişman, 2011)	Ability
Cube Comparisons Test (Ekstrom, French, & Harman, 1976)	Spatial-Visual Ability
Card Rotations Test (Ekstrom et al., 1976)	Spatial-Visual Ability
Form Board Test (Ekstrom et al., 1976)	Spatial-Visual Ability
Paper Folding Test (Ekstrom et al., 1976)	Spatial-Visual Ability
Nonsense Syllogisms Test (Ekstrom et al., 1976)	Verbal Reasoning Ability
Diagramming Relationships Test (Ekstrom et al., 1976)	Verbal Reasoning Ability
Card Rotation Test (Ekstrom, French, & Harman, 1979)	Visual-Spatial Ability

Paper Folding Test (Ekstrom, French, & Harman, 1979)	Visual-Spatial Ability
Verbal-Spatial Ability Rating test (Mayer & Massa, 2003)	Visual-Spatial Ability
Visuospatial description recall accuracy Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)	Visual-Spatial Ability
Abstract description recall (accuracy) Meneghetti, Labate, Grassano, Ronconi, and Pazzaglia (2014)	Other Ability
Imagery strategy Meneghetti, De Beni et al., 2013; Meneghetti, Ronconi et al., 2013).	Other Ability
Repetition strategy Meneghetti, De Beni et al., 2013; Meneghetti, Ronconi et al., 2013).	Other Ability
Reading Comp Task (RCT; Cornoldi et al., 1991)	Verbal Ability
Mental Rotations Test (MRT; Vandenberg & Kuse, 1978)	Visual Ability
Minnesota Paper Form Board (MPFB; Likert & Quasha, 1941)	Visual Ability
Verbalizer-Visualizer Questionnaire (VVQ; Richardson, 1977)	Visual-Verbal Ability
Card Rotation Test (Ekstrom, French, & Harman, 1979)	Visual-Spatial Ability
Paper Folding Test (Ekstrom, French, & Harman, 1979)	Visual-Spatial Ability
Verbal-Spatial Ability Rating test (Mayer & Massa, 2003)	Visual-Spatial Ability
Non-Verbal ability (Test of Cognitive Skills; TCS; CTB Macmillan/McGraw-Hill, 1993)	Other Ability
Memory ability (TCS, 1993)	Other Ability
Verbal ability (TCS, 1993)	Verbal Ability
Analytic style (field independence versus field dependence) Learning Style Profile (LSP; National Association of Secondary School Principals, 1989)	Other Ability
Spatial ability Learning Style Profile (LSP, 1989)	Spatial Ability
Name of Cognitive Style Measures	**Measures Defined**
Levels of field dependence-independence (FDI) as measured by the Group Embedded Figures Test (GEFT; (Dwyer & Moore, 1991, 1992, 1994; Ipek, 1995, 2011)	Visual
E-learning techniques (Sozcu, 2014)	Cognitive skill
Attitudes about elearning instruction (Sozcu, 2014)	Attitude
Attending distance learning programs before (Sozcu, 2014)	Cognitive skill
Locations for accessing distance education programs (Sozcu, 2014)	Other measure
Knowledge levels about e-learning and distance education (Sozcu, 2014)	Cognitive knowledge
Assessment in elearning instruction (Sozcu, 2014)	Cognitive knowledge
Knowledge about elearning instruction (Sozcu, 2014)	Cognitive knowledge
Learner Interface Design features (Sozcu, 2014)	Cognitive knowledge

Prefer reading materials (printed texts) in e-learning (Sozcu, 2014)	Verbal
Object-Spatial Imagery and Verbal Questionnaire for Children (C-OSIVQ) object (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Visual Cognitive style
C-OSIVQ spatial (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Visual Cognitive style
C-OSIVQ verbal (Blazhenkova, Becker, & Kozhevnikov, 2009, 2011)	Verbal Cognitive Style
Field-independence versus Field-Dependence measured with Hidden Figures Test, Part I (Ekstrom, French, Harmon, & Dermen, 1976)	Other cognitive style
Conceptualizing Style measured with Clayton-Jackson Object Sorting Test (Clayton & Jackson, 1961)	Other cognitive style
Reflectiveness-Impulsivity measured with Impulsivity Subscale from Personality Research Test, Form E (Jackson, 1974)	Other cognitive style
Tolerance Of Ambiguity measured with Tolerance of Ambiguity Scale from Self-Other Test, Form C (Rydell & Rosen, 1966)	Other cognitive style
Category Width measured with Category Width Scale (Pettigrew, 1958)	Other cognitive style
Cognitive Complexity measured with Group Version of Role Construct Repertory Test (Bieri, Atkins, Briar, Leaman, Miller, & Tripodi, 1966)	Other cognitive style
Analytic Skill of Learning Style Profile (LSP; (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	Visual-Spatial Cognitive Style
Spatial Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	Visual-Spatial Cognitive Style
Discrimination Skill of LSP scale for (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	Visual Cognitive Style
Categorization Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	Verbal Cognitive Style
Sequential Processing Skill of LSP (Keefe, Monk, Letteri, Languis, & Dunn, 1986)	Other Cognitive Style
Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977)	VisVerb Cognitive-Style
Santa Barbara Learning Style Questionnaire (Mayer & Massa, 2003)	VisVerb Cognitive-Style
Cognitive Style Analysis (CSA, Riding, 1991)	VisVerb Cognitive-Style
Verbal-Visual Learning Style Rating (Mayer & Massa, 2003)	VisVerb Cognitive-Style
Visual Strategy (QVVS; ; Antonietti & Giorgetti 1993, 1998)	Visual Cognitive Style
Verbal Strategy (QVVS; Antonietti & Giorgetti 1993, 1998)	Verbal Cognitive Style
Verbalizer-Visualizer Questionnaire (VVQ, Richardson, 1977)	VisVerb Cognitive-Style
Santa Barbara Learning Style Questionnaire (Mayer & Massa, 2003)	VisVerb Cognitive-Style
Verbal-Visual Learning Style Rating (Mayer & Massa, 2003)	VisVerb Cognitive-Style
Discrimination (focusing verses scanning cognitive style) Learning Style Profile (LSP, , 1989)	Visual Cognitive Style
Categorization (narrow verses broad category width cognitive style) Learning Style Profile (LSP, 1989)	Visual Cognitive Style
Successive (sequential) processing (LSP; Learning Style Profile; 1989)	Other Cognitive Style

Simultaneous processing Learning Style Profile (LSP, 1989)	Other Cognitive Style
Memory skill(leveling verses sharpening (LSP, 1989)	Other Cognitive Style
Name of Learning Preference Measures	**Construct Defined**
Visual measure of Visual-Aural-Read-Kinesthetic learning-style-inventory instrument (VARK; learning-style-inventory instrument (Fleming, 2001; Fleming & Mills, 1992)	Visual learning preference
Aural measure of VARK (Fleming, 2001; Fleming & Mills, 1992)	Verbal learning preference
Read measures of VARK (Fleming, 2001; Fleming & Mills, 1992)	Other learning preference
Kinesthetic measures of VARK (Fleming, 2001; Fleming & Mills, 1992)	Other earning preference
Visual learning preference Learning Styles Inventory (LSI; Reid,1984)	Visual learning preference
Auditory learning preference (LSI; Reid,1984)	Verbal learning preference
Kinetic learning preference (LSI; Reid,1984)	Other Learning preference
Memory (Oxford,1990)	Learning strategy
Cognitive (Oxford, 1990)	Learning strategy
Compensation (Oxford, 1990)	Learning strategy
Metacognitive (Oxford, 1990)	Learning strategy
Affective (Oxford, 1990)	Learning strategy
Social (Oxford, 1990)	Learning strategy
Factor 1 of Perceptual Learning Style Preference Questionnaire (PLSPQ; Reid, 1984)	Other learning preference
Factor 2 of PLSPQ (Reid, 1984)	Other learning preference
Factor 3 of PLSPQ (Reid, 1984)	Visual learning preference
Factor 4 of PLSPQ (Reid, 1984)	Verbal learning preference
Factor 5 of PLSPQ (Reid, 1984)	Other learning preference
Factor 6 of PLSPQ (Reid, 1984)	Other learning preference
Factor 7 of PLSPQ (Reid, 1984)	Other learning preference
Factor 8 of PLSPQ (Reid, 1984)	Other learning preference
Factor 9 of PLSPQ (Reid, 1984)	Other learning preference
Factor 10 of PLSPQ (Reid, 1984)	Other learning preference
Visual measure with Perceptual Learning Style and L2 Motivation Questionnaire (PLSL2MQ; Kim, 2009)	Visual
Auditory measure of (PLSL2MQ; Kim, 2009)	Verbal
Kinesthetic for China measured with (PLSL2MQ; Kim, 2009)	Other learning preference
Ideal L2 self for China measured with (PLSL2MQ; Kim, 2009)	Other learning preference

Motivational L2 behavior for China measured with (PLSL2MQ; Kim, 2009)	Other learning preference
Kinesthetic Learning Style test (TLS; Erginer, 2002)	Learning Preference
Reading Learning Style test (TLS; Erginer, 2002)	Learning Preference
Combined Learning Style (TLS; Erginer, 2002)	Learning Preference
Visual preference for graphic calculus tasks (Haciomeroglu, 2015)	Visual Preference
Visual preference for algebraic calculus tasks (Haciomeroglu, 2015)	Visual Preference
Visual preference for algebra tasks on the Mathematical Processing Instrument (MPI; Suwarsono, 1982	Visual Preference
Learning Scenario Questionnaire test (Mayer & Massa, 2003)	VisVerb Learning Preference
Multimedia Learning Preference (MMLP) Choice test (Mayer & Massa, 2003)	VisVerb Learning Preference
MMLP Rating test (Mayer & Massa, 2003)	VisVerb Learning Preference
MMLP Questionnaire test (Mayer & Massa, 2003)	VisVerb Learning Preference
Preference for spatial visualization (OSIQ; Blajenkova et al., 2006)	Visual Learning Preference
Preference for object visualization (OSIQ; ; Blajenkova et al., 2006)	Visual Learning Preference
Multimedia Learning Preference (MMLP) Choice test (Mayer & Massa, 2003)	VisVerb Learning Preference
MMLP Rating test (Mayer & Massa, 2003)	VisVerb Learning Preference
MMLP Questionnaire test (Mayer & Massa, 2003)	VisVerb Learning Preference
Learning Scenario Questionnaire test (Mayer & Massa, 2003)	VisVerb Learning Preference
Visual (LSP, 1989)	Visual Learning Preference
Auditory (LSP, 1989)	Verbal Learning Preference
Emotional (LSP, 1989)	Other Learning Preference
Verbal-Spatial preference (LSP, 1989)	Verbal Learning Preference
Persistence orientation(LSP, 1989)	Other Learning Preference
Verbal Risk orientation (LSP, 1989)	Other Learning Preference
Manipulative (LSP, 1989)	Other Learning Preference
Early Morning Study time (LSP, 1989)	Other Learning Preference
Late Morning Study time (LSP, 1989)	Other Learning Preference
Afternoon Study time (LSP, 1989)	Other Learning Preference
Evening Study time (LSP, 1989)	Other Learning Preference
Grouping (LSP, 1989)	Other Learning Preference
Posture (LSP, 1989)	Other Learning Preference
Mobility (LSP, 1989)	Other Learning Preference

Sound (LSP, 1989)	Other Learning Preference
Lighting (LSP, 1989)	Other Learning Preference
Temperature (LSP, 1989)	Other Learning Preference

Name of Achievement Measures	**Construct Defined**
Korean Language (Kyohaksa Achievement Test, 1988)	Achievement measure
Mathematics (Kyohaksa Achievement Test, 1988)	Achievement measure
English (Kyohaksa Achievement Test, 1988)	Achievement measure
Social Studies (Kyohaksa Achievement Test, 1988)	Achievement measure
Science (Kyohaksa Achievement Test, 1988)	Achievement measure
Mathematical Reasoning Test (MET; Danişman, 2011)	Ability
Advanced Placement Calculus exam (Standardized test of ability)	Oher Ability (Mathematical)
Mathematical performance on graphic calculus tasks Haciomeroglu, 2015	Other Ability (Mathematical)
Mathematical performance on algebraic calculus tasks (Haciomeroglu, 2015)	Other Ability (Mathematical)
Standard Achievement Test (SAT; Educational Testing service)	General Achievement, Intelligence Quotient (IQ) of Mathematics
SAT for Verbal test (Educational Testing service)	General Achievement (IQ) of Verbal Ability
Vocabulary test (Armed Services Vocational Aptitude Battery)	General Achievement of Verbal Aptitude
Standard Achievement Test (SAT; Educational Testing service)	General Achievement, Intelligence Quotient (IQ) of Mathematics
SAT for Verbal test (Educational Testing service)	General Achievement (IQ) of Verbal Ability
Vocabulary test (Armed Services Vocational Aptitude Battery)	General Achievement of Verbal Aptitude

Note: Visual or verbal ability, cognitive-style, and learning-preference measures are indicated with bold, green font.

Appendix W

Total Number of Visual, Verbal, and Visual-Verbal Measures Examined
In Group A, Group B, and Group C

Total Number of Visual, Verbal, and Visual-Verbal Measures Examined
In Group A, Group B, and Group C

	Visual	Verbal	Visual-Verbal	Totals
Group A	16	12	0	28
Group B	15	6	0	21
Group C	16	9	16	41
Totals	47	27	16	90

Appendix X

Distribution of Defined Visual and Verbal Factors or Components by Domain Group the Factor Represented

Distribution of Defined Visual and Verbal Factors or Components by Domain Group the Factor Represented

	Factors Represented with Group A's FA Results	Factors Represented with Group B's FA Results	Factors Represented with Group C's FA Results	Totals
Group A	3	4	4	11
Group B		1	3	4
Group C		0	2	2
Totals	3	5	9	17

Appendix Y

Defined Factors Grouped by Visual, Verbal, or
Visual-Verbal Representation

Defined Factors Grouped by Visual, Verbal, or Visual-Verbal Representation

	Visual Factors Defined	Verbal Factors Defined	Visual-Verbal Factors Defined	Total Number of Visual, Verbal or Visual-Verbal Factors Defined
Group A	1	0	2	3
Group B	3	1	1	5
Group C	2	0	7	9
Total	6	1	10	17