

Matching Learning Style to Instructional Method: Effects on Comprehension

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While it is hypothesized that providing instruction based on individuals' preferred learning styles improves learning (i.e., reading for visual learners and listening for auditory learners, also referred to as the *meshing hypothesis*), after a critical review of the literature Pashler, McDaniel, Rohrer, and Bjork (2008) concluded that this hypothesis lacks empirical evidence and subsequently described the experimental design needed to evaluate the meshing hypothesis. Following the design of Pashler et al., we empirically investigated the effect of learning style preference with college-educated adults, specifically as applied to (a) verbal comprehension aptitude (listening or reading) and (b) learning based on mode of instruction (digital audiobook or e-text). First, participants' auditory and visual learning style preferences were established based on a standardized adult learning style inventory. Participants were then given a verbal comprehension aptitude test in both oral and written forms. Results failed to show a statistically significant relationship between learning style preference (auditory, visual word) and learning aptitude (listening comprehension, reading comprehension). Second, participants were randomly assigned to 1 of 2 groups that received the same instructional material from a nonfiction book, but each in a different instructional mode (digital audiobook, e-text), and then completed a written comprehension test immediately and after 2 weeks. Results demonstrated no statistically significant relationship between learning style preference (auditory, visual word) and instructional method (audiobook, e-text) for either immediate or delayed comprehension tests. Taken together, the results of our investigation failed to statistically support the meshing hypothesis either for verbal comprehension aptitude or learning based on mode of instruction (digital audiobook, e-text).

Keywords: learning styles, listening and reading comprehension, audiobooks, e-text

Teaching to individuals' perceived learning styles in hopes that they will achieve greater academic success is common practice within the field of education. Not only does the learning styles concept have widespread acceptance among educators (Dekker, Lee, Howard-Jones, & Jolles, 2012) but also it is accepted among the general public (Pashler, McDaniel, Rohrer, & Bjork, 2008).

The learning style literature, as well as learning style inventories, differs widely in the way that learning styles are conceived and assessed (see Coffield, Moseley, Hall, & Ecclestone, 2004, and Pashler et al., 2008, for review). For example, in the Gregorc Style Delineator (Gregorc, 1982), learning styles are defined by perception (concrete or abstract) and ordering (sequential or random). The Kolb's Learning Style Inventory (1985) emphasizes experiential learning and includes accommodating, diverging, converging, and assimilating styles. Herrmann's Brain Dominance Instrument (1996) categorizes learners as theorists (cerebral, left: the rational self), organizers (limbic, left: the safe-keeping self), innovators (cerebral, right: the experimental self), and humanitarians (limbic, right: the feeling self). Dunn and Dunn's Learning Styles Inventory (Dunn, Dunn, & Price, 1989) concentrates on modality-specific strengths and weaknesses (e.g., visual, auditory, tactile, and kinesthetic processing). In the current study, we focused on verbal comprehension, specifically, the extent to which verbal comprehension may be influenced by the modality of input: auditory (digital audio) or visual (e-text).

While the learning styles literature has been extensively discussed and reviewed, there are considerably more theoretical and descriptive discussions on this topic than there are empirical stud-

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ies. For example, Cassidy (2004) described the central themes and issues surrounding learning styles and the many instruments available for the measurement of learning styles with the goal of promoting research in the field. Kozhevnikov (2007) presented a literature review on cognitive styles, which served as a basis for the author's theory that suggests that cognitive styles represent heuristics that can be identified at multiple levels of information processing, from perceptual to metacognitive, and that individuals can be grouped according to the type of regulatory function they exert. Sternberg, Grigorenko, and Zhang (2008) divided learning and thinking into two basic styles: ability based and personality based, and advocated that both are important for instruction and assessment. They argued that teachers need to take into consideration differences in how students learn and think and design instruction accordingly to obtain optimal instructional outcomes.

The importance of evaluating students' learning styles and developing instructional methods that teach to specific learning styles has gained considerable support in the field of education, with many organizations and companies offering professional development courses for teachers and educators focused on the topic of learning styles. For this reason, Pashler, McDaniel, Rohrer, and Bjork (2008) were charged with reviewing the empirical evidence pertaining to the importance of assessing and teaching to students' learning styles for the journal *Psychological Science in the Public Interest*. In their review, they define *learning styles* as "the concept that individuals differ in regard to what mode of instruction or study is most effective for them. . . . The most common—but not the only—hypothesis about the instructional relevance of learning styles is the meshing hypothesis, according to which instruction is best provided in a format that matches the preferences of the learner (e.g., for a 'visual learner,' emphasizing visual presentation of information; p. 105)." After reviewing the literature, they found that while there is evidence that, if asked, both children and adults indicate preferences as to how they favor information be presented to them, and there is also evidence that people have specific aptitudes for processing different types of instruction, there is limited empirical evidence as to whether providing instruction in an individual's preferred learning style (i.e., listening for those with an auditory learning style or reading for those with a visual learning style) improves learning. Furthermore, they also concluded that the definitive study showing that individuals with a preferred auditory learning style learn better when listening rather than reading, and conversely, that those with a preferred visual learning style learn better when reading rather than listening, had not been conducted.

Given the lack of credible validation of learning-styles-based instruction, Pashler et al. (2008) described a three-step experimental design of the study that would need to be conducted, as well as the pattern of data that would need to be found, in order to conclude empirically that learning is significantly improved when individuals receive instruction tailored to their asserted learning style. In Step 1, participants must be divided into groups on the basis of their learning style. In Step 2, participants from each group must be randomly assigned to receive one of multiple instructional methods. In Step 3, participants must complete an assessment of the material that is the same for all students. For the learning styles meshing hypothesis to be supported, data analysis must reveal a specific type of interaction between learning style and instructional

method. That is, learning is optimal when individuals receive instruction in their preferred learning style, and the instructional method that proves most effective for individuals with one learning style is not the most effective method for individuals with a different learning style.

Pashler et al. (2008) also pointed out that educators as well as the general public fail to distinguish between learning style preferences and learning aptitude. They stated that "[t]here is, after all, a commonsense reason why the two concepts could be conflated: Namely, different modes of instruction might be optimal for different people because different modes of presentation exploit the specific perceptual and cognitive strengths of different individuals, as suggested by the meshing hypothesis" (pp. 109–110). However, the relationship between learning style preference and learning aptitude, specifically as it relates to the meshing hypothesis and verbal comprehension, has not been established empirically.

In 2012, Dekker, Lee, Howard-Jones, and Jolles reported that 94% of educators believed that students perform better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic). Given this continued widespread belief and the influence of learning styles on educational practice, coupled with the importance of verbal comprehension on educational outcomes, we conducted an investigation of the meshing hypothesis as it pertains to verbal aptitude and learning. We implemented the methodology and analyses proposed by Pashler et al. (2008) in order to directly test the following two research questions:

1. What is the extent to which learning style preferences (auditory, visual) equate to learning aptitudes (listening comprehension, reading comprehension)?

2. What is the extent to which learning style preferences and/or learning aptitudes predict how much an individual comprehends and retains based on mode of instruction (audiobook, e-text)?

In the first research question, we investigated the relationship between learning style preferences (as measured by a standardized learning style inventory) and learning aptitudes (as measured by a listening and reading comprehension assessment). Specifically, as applied to the relationship between verbal aptitude and learning style preference, the meshing hypothesis predicts that (a) there will be a positive correlation between auditory learning style preference and listening comprehension, (b) there will be a positive correlation between visual word learning style preference and reading comprehension, and (c) individuals with a visual learning style preference will comprehend better when they read rather than listen, and conversely, individuals with an auditory learning style preference will comprehend better when they listen rather than read.

In the second research question, we investigated the extent to which learning style preferences (auditory, visual) and/or learning aptitudes (listening comprehension, reading comprehension) predict how much an individual will learn and retain based on two different modes of instruction (audiobook, e-text). Specifically, the meshing hypothesis predicts that individuals with a visual learning style preference learn more when they read e-text rather than when they listen to an audiobook, and conversely, individuals with an auditory learning style preference learn more when they listen to an audiobook rather than read e-text. Analogous predictions would be expected with regards to the relationship between listening

comprehension aptitude and learning from an audiobook and reading comprehension aptitude and learning from e-text.

Method

Participants

In order to be included in this study, participants had to meet the following inclusionary criteria: age 25–40 years; college educated (bachelor's degree only); native speakers of English; normal hearing and vision (with correction); and no self-reported history of neurological or learning impairments. Potential participants outside this age range, who had more advanced degrees beyond a bachelor's degree, who had not graduated from college, or who had a history of neurological or learning disabilities were excluded. Based on these criteria, 121 participants from the New York City metropolitan area were selected. Of the total population of 121 subjects, 62 were male and 59 were female. The mean age of the participants was 30.6 years ($SD = 4.4$). All participants completed 16 years of education. This study examined the two research questions. For Research Question 1, the entire population of 121 individuals participated. These 121 individuals were then randomly assigned to four groups. Two of these groups (61 participants) participated in Research Question 2. The remaining participants who had been randomly assigned to the other two groups participated in a different study that was not focused on learning styles. The 61 participants in Research Question 2 were randomly assigned to a listening condition ($n = 30$) or a reading condition ($n = 31$). The analyses of Research Question 2 focused only on those participants who could be categorically classified as having an auditory or visual word learning style and who were randomly assigned to either a listening or reading condition. The final four subgroups included in Research Question 2 analyses were listening condition with auditory learning style ($n = 11$), listening condition with visual word learning style ($n = 10$), reading condition with auditory learning style ($n = 10$), and reading condition with visual word learning style ($n = 10$).

This study was conducted in accordance with the prescribed standards of the institutional review board of Rutgers University–Newark. All participants provided informed consent and were financially compensated for their participation.

Learning Styles Assessment

Prior to on-site testing, participants completed an online standardized learning styles preference inventory. Pashler et al. (2008) identified the Dunn and Dunn learning styles model as being one of the most popular learning styles assessment tools because of the constructs included as well as the broad age range of the assessments offered—from children as young as 3 years old through adults. For this study, we selected the adult version, the Building Excellence (BE) Online Learning Styles Assessment Inventory for ages 17 and older (Rundle & Dunn, 2010). The BE Learning Styles Inventory is a self-administered online survey that requires 20–25 min for completion. The assessment measure asks participants to decide if they *strongly disagree*, *disagree*, *are uncertain*, *agree*, or *strongly agree* after reading statements indicating, for example, whether the respondent remembers new information better by reading about it or by listening to a discussion about it (Rundle &

Dunn, 2010). The BE Learning Styles Inventory assesses individual learning and productivity styles based upon six domains: perceptual, psychological, environmental, physiological, emotional, and sociological. The perceptual domain is subdivided into the following six elements: auditory (input), visual picture, visual word, tactual, kinesthetic, and auditory verbal (output). The BE Learning Styles Inventory provides an individual's strengths and weaknesses pertaining to these six possible perceptual learning styles. For each learning style preference, individuals are placed into one of five bins that are continuous, ranging from very weak to very strong. For example, the five bins for auditory are classified as (1) *strong less auditory*, (2) *moderate less auditory*, (3) *it depends*, (4) *moderate more auditory*, and (5) *strong more auditory*. Within each bin, there is a 3-point range with the exception of Bin 3 (it depends) that has a 5-point range, for a total of 17 possible placements along the continuum for each perceptual element. For the purpose of this study, we focused only on those elements (auditory and visual word) that most relate to listening and reading comprehension, respectively.

The BE Learning Styles Inventory provides personalized reports that convert an individual's numerical score into instructional recommendations. For example, if a participant scores *strong less auditory* or *moderate less auditory* (Bin 1 or Bin 2, respectively/corresponding Placements 1–6), the recommendation prescribed by the BE Learning Styles Inventory would be that because listening is not a strength, the participant should rely on a stronger style when learning new material. If a participant scores *strong less visual word* or *moderate less visual word* (Bin 1 or Bin 2, respectively/corresponding Placements 1–6), the recommendation prescribed would be that because reading is not a strength, the participant should rely on a stronger style when learning new and difficult information. If a participant scores *it depends* in either auditory or visual word (Bin 3/corresponding Placements 7–11), the BE Learning Styles recommendation acknowledges that the participant is indifferent to the modality. He or she is encouraged to use one of his or her strengths when learning new information. If a participant scores *moderate more auditory/visual* or *strong more auditory/visual* (Bin 4 or Bin 5, respectively/corresponding Placements 12–17), the individual is advised to use that style most of the time when learning. While the automated computer scoring system generated scores and reports for each participant, the participants were not informed about the purpose of the study or given access to their scores or reports or given any feedback from this survey.

In this study, learning styles data were analyzed using two different scoring procedures. For correlation and regression analyses, data were analyzed using the full standard continuous 17-point scoring method provided by the BE Learning Styles Inventory. Three variables were used: BE auditory (range = from +1 to +17), BE visual word (range = from +1 to +17), and the difference between BE auditory and BE visual word (range from –17 to +17). In this study, participants' BE auditory scores ranged from +2 to +17, their visual word scores ranged from +5 to +17 and the difference between BE auditory minus BE visual word scores ranged from –11 to +8. ($M = -0.92$, $SD = 3.98$).

In addition, in order to follow the analysis prescribed by Pashler et al. (2008), which addressed the meshing hypothesis directly, individuals must first be divided into groups on the basis of their preferred learning style. For this purpose, participants were clas-

sified *categorically* as having primarily either an auditory or visual word learning style. We used the five bin categories provided by the BE Learning Styles Inventory: *strong less auditory/visual word* = 1; *moderate less auditory/visual word* = 2; *it depends* = 3; *moderate more auditory/visual word* = 4; and *strong more auditory/visual word* = 5. According to the BE Learning Styles Inventory, only participants who scored *moderate to strong more auditory* (either a 4 or 5) as well as *it depends* or *moderate to strong less visual word* (3, 2, 1) were instructed to use the auditory modality “much of the time.” For the purposes of this analysis, these participants were classified as having an auditory learning style ($n = 37$). Similarly, only participants who scored *moderate to strong more visual word* (either a 4 or 5) as well as *it depends* or *moderate to strong less auditory* (3, 2, 1) were instructed to use the visual word modality “much of the time.” These participants were classified as having a visual word learning style ($n = 31$). Of the 121 individuals who participated in Research Question 1, 53 participants could not be categorically classified as either auditory or visual word learners and, as such, were not included in the analyses that required categorical classification.

Verbal Comprehension Aptitude Measure

The goal of this study was to determine the extent to which learning style preference (auditory, visual) and/or verbal aptitude (listening comprehension, reading comprehension) relates to the effectiveness of instructional method (audiobook, e-text). Because there is no standardized assessment designed to directly compare listening and reading comprehension aptitude in adults, we developed a verbal comprehension aptitude test in both a listening and reading format using matched passages from two equivalent forms of the fourth edition of the Gray Oral Reading Test (GORT-4). GORT-4 is a standardized assessment measure composed of leveled passages that objectively measure oral reading rate, accuracy, fluency, and comprehension, as well as alerts to possible learning exceptionalities (Weiderholt & Bryant, 2000). GORT-4 (age range: from 6.0 to 18.11 years) consists of 13 passages that become increasingly difficult as the examinee progresses. After pilot testing all passages in college-educated adults, we selected passages 9, 10, 11, and 13 for use in this study. Passages 1-8 and 12 did not provide sufficient individual differences in our college-educated population and were not included. None of the individuals who participated in pilot testing were included in the current study. The selected passages ranged from 148 to 167 words ($M = 158$, $Mdn = 157$). Each passage was followed by five comprehension questions. To assess listening comprehension, we converted the selected passages from Form B of the GORT-4 into a digital audio recording. A professional audiobook narrator, who read at a steady pace and with natural intonation, recorded the passages. We will refer to this assessment as the *Listening Aptitude Test (L-AT)*. To assess reading comprehension, we asked each participant to read the selected passages from Form A of the GORT-4 silently. This assessment will be referred to as the *Reading Aptitude Test (R-AT)*.

Each of the 121 participants in this study was tested on both the L-AT and the R-AT. The order in which the L-AT and the R-AT were taken was counterbalanced to reduce the chance that the order of testing would adversely influence the results. Half of the participants completed the R-AT and then L-AT, where they read

the first four passages and then listened to the remaining four passages; the other half of the participants completed the L-AT and then R-AT, where they listened to the first four passages and then read the remaining four passages. Participants read each passage silently from a computer screen or listened through headphones to a digital audio recording.

Immediately after they read or listened to each passage, participants answered the five corresponding multiple-choice questions for that passage. Note that part of the answer from one of the questions on the R-AT was accidentally omitted. Therefore, data could only be collected from 19 of the 20 questions. To assure that the R-AT and the L-AT remained equivalent, the comparable question from the L-AT was also deleted from all analyses. The protocol designed by Pashler et al. (2008) to assess the meshing hypothesis requires individuals to complete an assessment that is the same for all participants. All participants answered the comprehension questions in the same (written) format. We chose to focus on this response format because most tests of comprehension are administered in writing. The program required a response for each question before the participant could proceed to the next question. Participants were not permitted to re-read or re-listen to any passage nor were they allowed to use the passage as a reference when answering the questions. No feedback was given.

Instructional Unit

Two modes of instruction were investigated for the same unit (audiobook, e-text). The content used across both of these instructional conditions was the preface and Chapter 17 of the nonfiction book, *Unbroken: A World War II Story of Survival, Resilience, and Redemption*, written by Laura Hillenbrand and read by Edward Hermann. The total content contained 3,184 words. Forty-eight multiple-choice questions were designed to assess the participants' comprehension. These 48 questions will be referred to as the *Unbroken* comprehension test.

The question set was developed by a certified teacher of English (B.R.), who serves on the Pennsylvania State Standardized Assessment Panel where she reviews reading assessment items for content, rigor, alignment, bias, and universal and technical design. Questions were piloted for difficulty on a sample of 10 individuals meeting the eligibility requirements for participants in this study but were not participants in the study. The *Unbroken* comprehension test was given twice, once immediately following completion of the passage (Time 1) and again 2 weeks later (Time 2).

Procedure

After completing the Listening Aptitude Test (L-AT) and Reading Aptitude Test (R-AT), participants were randomly assigned to one of two instructional conditions for the *Unbroken* portion of the study. Participants in each of the instructional conditions received the preface and Chapter 17 of *Unbroken*, presented in one of two different formats. In the audiobook condition, participants used headphones to listen to both the preface and Chapter 17 of *Unbroken* presented on an electronic tablet in digital audiobook format. In the e-text condition, participants read both the preface and Chapter 17 of *Unbroken* presented on an electronic tablet in e-text format. A research assistant pre-cued the e-text or audio, as well as monitored the participant to assure that there were no

interruptions and that the participant understood how to use the equipment, was on-task, and did not extend reading/listening beyond the prescribed passages. Prior to administration of the passage for the audio condition, the volume was adjusted to a comfortable level. The audio condition lasted 16 min 24 s and was read at a pace of 149 words per minute. Participants in the e-text condition read at their own pace without time restraint. The replaying/fast-forwarding of audio and the re-reading/skipping of text were prohibited. The research assistant monitored participants' compliance.

Upon completion of Chapter 17, participants proceeded immediately (Time 1) to take the *Unbroken* comprehension test and answer 48 questions derived from the preface and Chapter 17. Participants were not allowed to use the e-text or digital audiobook as a reference. Each question was individually displayed in written text only on a computer screen, as is common in standard testing practices. The online multiple-choice assessment required a response for each question before the examinee could proceed to the next question. No feedback was given. In addition to the online, on-site immediate comprehension assessment (Time 1), participants completed the same multiple-choice assessment online 2 weeks later (Time 2) in order to evaluate their retention of the information in the story.

Results

Analyses for Research Question 1

Research Question 1 addresses the extent to which learning style preferences (auditory, visual word) as measured by the BE Learning Style Inventory equate to learning aptitudes (listening comprehension, reading comprehension) as measured by the L-AT and the R-AT.

To evaluate the equivalence of the L-AT and the R-AT for assessing comprehension aptitude in this population ($N = 121$), we calculated a paired-samples t test comparing the mean of the L-AT ($M = 13.9$, $SD = 3.4$) to the mean of the R-AT ($M = 12.8$, $SD = 2.8$). A significant difference was found, $t(120) = 3.54$; $p < .01$. The mean of the L-AT was significantly higher than the mean on the R-AT with an effect size of Cohen's $d = 0.32$. Although this difference was not ideal, it is important to note that the main hypothesis pertaining to the interaction between learning style and mode of instruction does not require that the R-AT and L-AT measures be equivalent.

Analyses using categorical learning style variables to predict learning aptitude: Implementing the Pashler et al. (2008) method. Pashler et al. (2008) prescribed a specific methodology for assessing the meshing hypothesis that requires that participants be categorically classified into two discrete learning styles (auditory learners or visual word learners). To follow this methodology explicitly, participants were classified into two discrete learning style categories: auditory learners ($n = 37$) or visual word learners ($n = 31$) as described in the Methods section.

A one-way multivariate analysis of variance (MANOVA) was calculated examining the effects of learning style preference groups (auditory, visual word) on the L-AT and R-AT scores to determine if learning style preference (auditory, visual word) predicts listening or reading comprehension aptitude. A significant effect of aptitude test (L-AT vs. R-AT) was found, $F(1, 66) =$

12.7; $p < .05$, with an effect size $\eta^2 = 0.16$, indicating that participants performed significantly better on one aptitude test (L-AT: $M = 14.1$, $SD = 3.5$) than on the other aptitude test (R-AT: $M = 12.8$, $SD = 2.9$). There was also a significant effect of learning styles preference (auditory vs. visual word), $F(1, 66) = 6.9$; $p < .05$, with an effect size $\eta^2 = 0.09$, indicating that participants in one learning styles preference group (visual word: $M = 14.4$, $SD = 4.0$) performed significantly better than the participants in the other learning styles preference group (auditory, $M = 12.6$, $SD = 3.6$). There was not a significant aptitude test (L-AT, R-AT) by learning styles preference (auditory, visual word) interaction, $F(1, 66) = 0.34$; $p > .05$. Further inspection of these results using one-way analyses of variance (ANOVAs) show that overall, participants in the visual word learning style group scored significantly higher on the L-AT, $F(1, 66) = 5.48$, $p < .05$ ($M = 15.16$, $SD = 3.10$), than participants in the auditory learning style group ($M = 13.22$; $SD = 3.65$). Participants in the visual word learning style group also scored significantly higher on the R-AT, $F(1, 66) = 4.91$; $p < .05$ ($M = 13.58$, $SD = 2.50$), than participants in the auditory learning style group ($M = 12.08$; $SD = 2.99$). These results indicate that participants who had a visual word learning style preference were significantly better at *both* listening and reading comprehension, compared to those who had an auditory learning style preference.

According to Pashler et al. (2008), acceptable evidence in support of the meshing hypothesis would show a crossover between two learning style preference groups (auditory, visual word) and listening and reading comprehension aptitude (L-AT, R-AT), as shown in Figure 1A. Figure 1B shows an example taken from Pashler et al. (2008) of one form of unacceptable evidence for the meshing hypothesis, where both auditory and visual word learning style preference groups score higher on the same method, and hence there is no crossover. Figure 1C shows the data from the current study. As shown in Figure 1C, contrary to the crossover pattern that would be expected to support the meshing hypothesis, the auditory and visual word learning style preference groups *both* scored higher on listening comprehension than on reading comprehension. It is important to note that not only was the L-AT performance better for both groups but also the superiority of the L-AT over the R-AT was similar for both groups. According to Pashler et al. (2008), this pattern corresponds to one example of unacceptable evidence in support of the meshing hypothesis.

However, classification of participants into two discrete groups reduces the sensitivity of continuous variables and also reduced the sample size by including only those participants who had a clear auditory or visual word learning style preference. To mitigate these concerns, we performed a final series of correlation and step-wise multiple regression analyses ($n = 121$) to evaluate whether there was a significant relationship between learning style preference (BE Learning Styles Inventory) and learning aptitude (L-AT, R-AT). For these analyses, variables from the BE Learning Styles Inventory based on the continuous 17-point standard BE scoring system were used to predict verbal comprehension aptitude scores on the L-AT and R-AT.

Correlation and regression analyses for Research Question 1. The relationship between learning style preference (BE Learning Styles Inventory) and listening and reading comprehension aptitude (L-AT and R-AT) was evaluated by a series of simple correlation analyses as well as stepwise multiple regression anal-

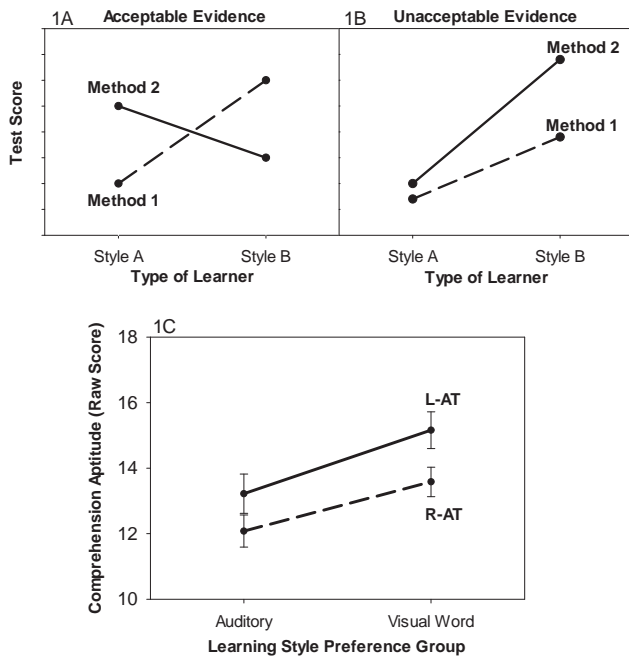


Figure 1. Graph A displays the pattern of evidence required to support the meshing hypothesis while Graph B displays one of several patterns of evidence that would constitute unacceptable evidence (according to Pashler et al., 2008). Graph C displays the results from the current study, which show that there is no crossover effect. Bars represent standard errors. The 95% confidence interval (CI) for the Listening Aptitude Test (L-AT) ranged from 12.10 to 14.33 for participants with an auditory learning preference and from 13.94 to 16.39 for participants with a visual learning preference. The 95% CI for the Reading Aptitude Test (R-AT) ranged from 11.17 to 12.99 for participants with an auditory learning preference and from 12.58 to 14.58 for participants with a visual learning preference.

yses. For these analyses, the following variables from the BE Learning Styles Inventory were used based on the 17-point standard BE scoring system: BE auditory score, BE visual word score, and the difference between the BE auditory score and the BE visual word score (BE auditory score – BE visual word score), to predict verbal comprehension aptitude. Verbal comprehension aptitude outcomes of interest included (a) predicting listening aptitude (L-AT raw score), (b) predicting reading aptitude (R-AT raw

score), and (c) predicting the difference between listening and reading aptitude (L-AT – R-AT raw score). Table 1 presents the means and standard deviations for each of the BE learning styles and verbal comprehension variables as well as the correlation matrix for these variables, and Table 2 presents the results of the multiple regression analyses.

Predicting listening comprehension aptitude from learning style preference scores. The meshing hypothesis predicts a positive correlation between learning style preference and aptitude. That is, if auditory learning style equates to listening comprehension aptitude, as auditory learning style preference scores increase, listening comprehension aptitude score would also increase. As seen in Table 1, contrary to expectation based on the meshing hypothesis, the correlation between auditory learning style preference (based on the BE auditory score) and listening comprehension (based on the L-AT score) was negative ($-.31, p < .01$). To further test whether other learning style variables influence listening comprehension aptitude, we calculated multiple linear regression analyses to determine the extent to which participants' listening comprehension aptitude (L-AT) could be predicted based on their BE auditory learning style score, BE visual word learning style score, and the difference between their BE auditory and BE visual word scores. As seen in Table 2, a significant regression equation was found, $F(1, 119) = 12.96, p < .001$, with an R^2 of .10. The only BE learning style variable that contributed significantly to the listening comprehension score was the BE auditory learning style score. This single variable contributed a correlation coefficient of $R = .31, R^2 = .10 (SE = 3.28), p < .001$. Participants' predicted listening comprehension score is equal to 17.20 (constant) + -0.30 (BE auditory learning style score), indicating a negative relationship between the BE auditory learning style score and the listening comprehension aptitude score. The coefficient model shows that for every 1 point that the BE auditory learning style score decreased, the listening comprehension score increased 0.30 points. BE visual word learning style score and the difference between BE auditory learning style score and BE visual word learning style score failed to contribute any significant variance beyond that already accounted for by the BE auditory learning style score. This analysis demonstrated that only the BE auditory learning style score accounted for a significant portion of the listening comprehension variance. However, contrary to what would be predicted by the meshing hypothesis, this relationship

Table 1
Descriptive Statistics and Correlation Matrix for the Predictor Variables Entered into the Multiple Regression Aptitude Model for Research Question 1

Variable	M	SD	1	2	3	4	5	6
1. Listening aptitude	13.87	3.44	—	.46	.66	-.31**	-.14	-.21*
2. Reading aptitude	12.81	2.78		—	-.37	-.24**	-.04	-.19*
3. Difference between listening and reading aptitude	1.67	3.28			—	-.13	-.11	-.054
4. BE auditory learning style	10.98	3.55				—	.081	.85**
5. BE visual word learning style	11.89	2.13					—	-.46**
6. Difference between BE auditory and visual word learning styles	-0.92	3.99						—

Note. $n = 121$; BE = Building Excellence.
* $p < .05$. ** $p < .01$.

Table 2
Coefficients for the Significant Predictor Variables Entered into the Multiple Regression Model for Listening Aptitude, Reading Aptitude, and Difference Between Listening and Reading Aptitude for Research Question 1

Variable	<i>B</i>	<i>SEB</i>	β	<i>R</i>	<i>R</i> ²
Listening aptitude				.31	.10
Constant	17.20	0.97	**		
BE auditory learning style score	-0.30	0.084	-.31**		
Reading aptitude				.24	.06
Constant	14.84	0.81	**		
BE auditory learning style score	-0.18	0.070	-.24**		
Difference between listening and reading aptitude	—	—	—		

Note. The following predictor variables were entered into the model for (a) listening aptitude, (b) reading aptitudes, and (c) difference between listening and reading aptitudes; Building Excellence (BE) auditory learning style score; BE visual word learning style score; and the difference between BE auditory and BE visual word score. Only the variables listed above made significant contributions to these models. No variables made significant contributions to the model for difference between listening and reading aptitude. Shown are the coefficients (*B*), the standard error of the coefficients (*SEB*), as well as standardized coefficient (β), and the correlation. *N* = 121.

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

was negative. That is, as auditory learning style preference increased, performance on a listening aptitude test decreased.

Predicting reading comprehension aptitude from learning preference scores. The meshing hypothesis would predict that if visual word learning style preference equates to reading comprehension aptitude, as participants' visual word learning style preference score increased, their reading comprehension aptitude score would also increase. As shown in Table 1, the correlation between visual word learning style preference (based on the BE visual word score) and reading comprehension (based on the R-AT score) was neither positive nor significant (-.04). To further test whether other learning style variables influence reading comprehension aptitude, we calculated a multiple linear regression analysis to determine the extent to which participants' reading comprehension aptitude (R-AT) could be predicted based on their BE auditory learning style score, BE visual word learning style score, and the difference between their BE auditory and BE visual word scores. As seen in Table 2, a significant regression equation was found, $F(1, 119) = 7.01$, $p < .01$, with an R^2 of .06. However, the only BE variable that contributed significantly to the reading comprehension score was the BE auditory learning style score. This single variable contributed a correlation coefficient of $R = .24$, $R^2 = .06$ ($SE = 2.72$), $p < .01$. Participants' predicted reading comprehension score is equal to 14.84 (constant) + -0.18 (BE auditory learning style score), indicating a negative relationship between BE auditory learning style score and reading comprehension aptitude score. The coefficient model shows that for every 1 point that the BE auditory learning style score decreased, the reading comprehension score increased 0.18 points. Contrary to the assumption that a visual verbal learning style preference would predict higher reading scores, neither the BE visual word learning style score nor the difference between the BE auditory learning style score and BE

visual word learning style score contributed any significant variance beyond that already accounted for by the BE auditory learning style score. This analysis demonstrated that auditory learning style was also the only significant predictor of reading comprehension scores, and this relationship was again negative.

Predicting the difference between listening comprehension aptitude and reading comprehension aptitude from learning preference scores. The meshing hypothesis would predict that individuals who have a stronger auditory learning style preference would also have a higher listening versus reading comprehension aptitude score, and conversely, those who have a stronger visual word learning style preference would also have a higher reading versus listening comprehension aptitude score. A multiple linear regression was calculated to determine the extent to which participants' difference between listening comprehension aptitude (L-AT) and reading comprehension aptitude (R-AT) could be predicted based on their BE auditory learning style score, BE visual word learning style score, and the difference between their BE auditory and BE visual word scores. This regression analysis most completely tests the meshing hypothesis, which not only predicts a simple relationship between learning style preference and comprehension aptitude but also and more specifically predicts that individuals with different learning styles will perform differentially with different modes of input. The results of this analysis failed to support this prediction. None of the variables (BE auditory learning style score, BE visual word learning style score, or the difference between BE auditory and BE visual word scores) contributed significantly to the difference between listening comprehension aptitude and reading comprehension aptitude.

Discussion of analyses for Research Question 1. Pashler et al. (2008) pointed out that learning style preferences and learning aptitudes are often considered to be overlapping constructs. After all, it seems intuitive that individuals who prefer to listen would perform better on a test of listening than reading comprehension and, conversely, those who prefer reading would perform better on a test of reading than listening comprehension. This relationship is referred to as the *meshing hypothesis*. Research Question 1 was designed as an empirical test of this hypothesis, as it pertains to verbal comprehension aptitude. Participants completed the BE Learning Styles Inventory as well as both a listening and a reading comprehension aptitude test. A series of analyses were calculated to determine the extent to which auditory and visual word learning style variables predicted listening and/or reading comprehension aptitude. Both a continuous score (based on the 17-point scale established by the BE Learning Style Inventory) and a categorical classification of participants as either an auditory learner or visual word learner were included in these analyses. This categorical classification was based on the 5-point BE scale and included only those participants with a strong difference between their auditory and visual word reading preference scores. Regardless of whether continuous or categorical scores from the BE Learning Styles Inventory were used, the results were consistent in failing to provide statistically significant support for the meshing hypothesis. Contrary to the expectations predicted by the meshing hypothesis, that a high visual word learning style score would be the best predictor of a high reading comprehension aptitude score, and conversely, that a high auditory learning style score would be the best predictor of a high listening comprehension aptitude score, auditory learning style proved to be the only 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. Thus, the results using the BE learning style preference scores both as a continuous scale as well as a discrete categorical measure of auditory and visual word learning style preference fail to demonstrate a significant positive relationship between (a) auditory learning style preference and listening aptitude, (b) visual word learning style preference and reading aptitude, or (c) a differential effect of learning style preference on performance on a listening compared with a reading comprehension aptitude test. These findings fail to support the construct that an individual's learning style (auditory, visual word) is positively correlated with their listening and reading aptitude. Taken together, these data fail to provide statistical support for the meshing hypothesis, at least as it pertains to verbal comprehension (listening vs. reading) aptitudes.

Limitations of analyses for Research Question 1. One potential concern for the analyses reported for Research Question 1 was that the L-AT and R-AT were not matched for difficulty. It is important to emphasize that the tests developed for this study to assess listening and reading comprehension aptitude, while derived from two equivalent forms of a standardized, normed reading test (GORT-4), were not given in the standard format on which these norms were based. The main question of interest is whether there was a *differential* pattern of results for auditory compared with visual word learners when listening compared with reading. In this study, both the auditory and the visual word learning style preference groups scored higher on the listening than on the reading comprehension aptitude test. This could be an indication that the listening version of the test was easier than the written version. While equivalent scores would have been more ideal, it is important to note that it is the *pattern* of the results, rather than the absolute values, that is critical in addressing the meshing hypothesis. As shown in Figure 1C, the difference in listening compared with reading performance resulted in parallel lines for the auditory learners compared with the visual word learners. That is, while participants classified by the BE Learning Style Inventory as auditory learners did, indeed, score higher on a comprehension test when they listened to versus read passages, participants classified as visual word learners showed a similar pattern; that is, they also scored higher on this same comprehension test when they listened to versus when they read the test passages—and to the same degree. Taken in context, the results from Research Question 1 are contrary to the pattern that would be expected based on the meshing hypothesis, at least as it applies to tests of listening and reading comprehension aptitude. However, this research question does not address the issue of whether learning and retention of “real-world,” nonfiction material, presented using different instructional methods, is affected by an individual's preferred learning style. This was the focus of Research Question 2.

Analyses for Research Question 2

Research Question 2 addresses the extent to which learning style preferences (as measured by the BE Learning Style Inventory) and/or learning aptitudes (as measured by the L-AT and R-AT) predict how much an individual comprehends and retains based on

mode of instruction (audiobook, e-text) as measured by the *Unbroken* comprehension test.

The validity of the *Unbroken* comprehension test was evaluated to assure that results obtained from this test were an accurate measure of comprehension. To do this, the comprehension score of each participant on the *Unbroken* comprehension test at Time 1 was compared with the same participant's total comprehension aptitude score (total verbal comprehension aptitude = L-AT + R-AT). A Pearson correlation coefficient was calculated. A positive correlation was found, $r(119) = 0.59, p < .001$, indicating that there was a significant relationship between participants' scores on the total verbal comprehension aptitude test and participants' scores on the *Unbroken* comprehension test at Time 1. This analysis showed that participants who had higher comprehension scores as indicated by the total verbal comprehension aptitude test also had higher comprehension scores on the *Unbroken* test at Time 1, providing construct validity for this test. Next, a Pearson correlation coefficient was calculated for the relationship between the *Unbroken* comprehension test at Time 1 and Time 2. A strong positive correlation was found, $r(118) = 0.86, p < .01$, indicating a significant linear relationship between the two variables. Participants who performed well on the *Unbroken* comprehension test at Time 1 performed well on this same test at Time 2. This linear relationship indicates strong test-retest reliability for the *Unbroken* comprehension test.

A 2 (modes of instruction) \times 2 (time) mixed-design ANOVA was calculated to evaluate the effects of mode of instruction (audiobook, e-text) and time (Time 1, Time 2) on the *Unbroken* comprehension test scores. There was a main effect of time (Time 1 vs. Time 2), $F(1, 58) = 37.3; p < .05$. However, there was no significant main effect for mode of instruction, $F(1, 58) = 0.25; p > .05$. In addition, there was not a significant mode of instruction by time interaction, $F(1, 58) = 0.08; p > .05$. These results indicate that there was no difference in difficulty on the *Unbroken* comprehension test when presented by audiobook versus e-text. Moreover, all participants performed better in both instructional conditions at Time 1 than Time 2.

Analyses using categorical learning style variables to predict learning via audiobook versus e-text mode of instruction at Time 1: The Pashler et al. (2008) method. When the meshing hypothesis is applied to education theory and practice, it is assumed that learning will be more effective when material is presented in an instructional mode that meshes with the individual's preferred learning style. Pashler et al.'s (2008) meshing hypothesis pertaining to learning style preference and modes of instruction predicts that individuals with a visual learning style preference will comprehend better when they read rather than listen, and conversely, individuals with an auditory learning style preference will comprehend better when they listen rather than read. The Pashler et al. (2008) roadmap for evaluating the meshing hypothesis empirically begins by dividing participants into distinct learning style preference groups. Therefore, for this analysis, participants were classified as auditory or visual word learners based on their BE Learning Styles Inventory results, as described in the Methods section.

Results from Research Question 1 showed that there were significant differences in reading and listening aptitude for study participants based on their learning style preference. Recall that participants with a visual word learning style preference achieved

both higher listening and reading aptitude scores than participants in the auditory learning style preference group. As a result, to control for any effect of potential differences in total verbal comprehension aptitude, based on the random assignment to instructional condition in Research Question 2, we conducted all analyses both with and without co-varying out the effect of total reading and listening aptitude. No significant differences were found with or without the covariance. As such, only the ANOVA results are reported. Table 3 shows the *Unbroken* comprehension test raw scores (total number correct out of 48) by learning style preference group (auditory, visual word) and instructional condition (audiobook, e-text) at Time 1 and Time 2. A between-subjects 2 (learning style preference) \times 2 (mode of instruction) ANOVA was performed using these data to examine the effect of different learning style preferences (auditory, visual word) and different modes of instruction (audiobook, e-text) on the *Unbroken* comprehension test scores at Time 1. The results of this analysis showed that the main effect for learning style preference was significant, $F(1, 37) = 6.11$; $p < .05$, indicating a significant difference between participants with an auditory learning style preference ($M = 30.57$; $SD = 5.89$), and those with a visual word learning style ($M = 34.40$; $SD = 3.33$). This demonstrates that *Unbroken* comprehension at Time 1 was affected by learning style preference, with the participants with visual word learning styles performing better. However, the main effect for instructional condition (audiobook, e-text) was not significant, $F(1, 37) = .15$; $p > .05$, with no significant difference in performance on the *Unbroken* comprehension test at Time 1 between participants in the audiobook condition ($M = 32.10$; $SD = 6.00$) and those in the e-text condition ($M = 32.80$; $SD = 4.16$). Finally, the interaction between instructional condition (audiobook, e-text) and learning style preference (auditory, visual word) was not significant, $F(1, 37) = 0.42$; $p > .05$, indicating that providing instruction in a mode that matched an individual's learning style preference did *not* result in significantly better learning. Figure 2C shows the results of this analysis.

According to Pashler et al. (2008), acceptable evidence in support of the meshing hypothesis would show a crossover between the two learning style preference groups and two modes of instruction, as shown in Figure 2A. Figure 2B shows an example from Pashler et al. (2008) of unacceptable evidence for the meshing hypothesis, where both auditory and visual word learning style preference groups score higher on the same method of instruction, and hence there is no crossover. As seen in Figure 2C, contrary to

Table 3
Unbroken Comprehension Test Raw Scores (Total Number Correct Out of 48) by Learning Style Preference Group and Instructional Condition at Time 1 and Time 2

Instructional condition	Building Excellence learning preference					
	Auditory			Visual word		
	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>
Audiobook (Time 1)	11	29.82	7.10	10	34.60	3.27
E-text (Time 1)	10	31.40	4.43	10	34.20	3.55
Audiobook (Time 2)	11	26.64	7.06	10	32.70	4.30
E-text (Time 2)	10	28.10	4.07	10	31.80	4.34

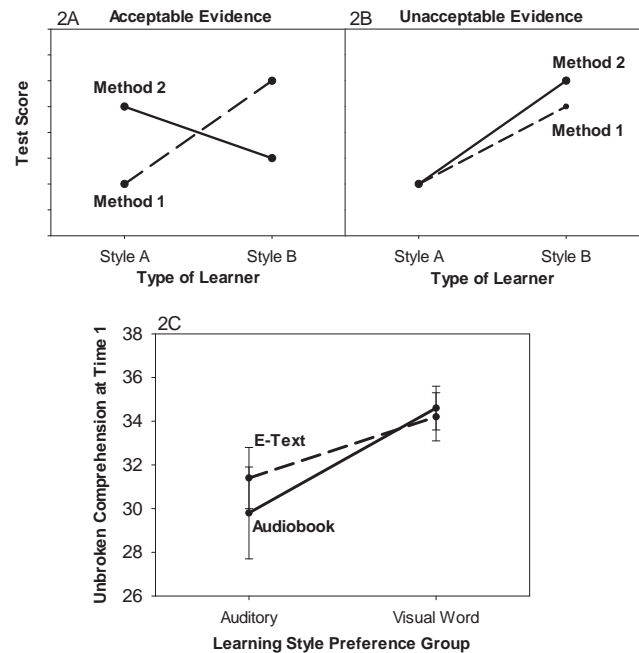


Figure 2. Examples of (A) acceptable evidence and (B) unacceptable evidence for the meshing hypothesis (according to Pashler et al., 2008). Graph C displays the results from this study and corresponds to one of Pashler et al.'s (2008) examples of unacceptable evidence. Error bars represent standard errors. The 95% confidence interval (CI) for the audiobook condition ranged from 26.82 to 32.81 for participants with an auditory learning preference and from 31.46 to 37.74 for participants with a visual learning preference. The 95% CI for the e-text group ranged from 28.26 to 34.54 for participants with an auditory learning preference and from 31.06 to 37.34 for participants with a visual learning preference.

the crossover pattern that would be expected to support the meshing hypothesis, results from the current study show there is minimal difference based on instructional condition for participants in either the auditory or visual word learning style preference groups. According to Pashler et al. (2008), this pattern corresponds with one example of unacceptable evidence in support of the meshing hypothesis.

Two-week retention (Time 2). It is possible that presenting instruction in a mode that meshes with an individual's learning style may affect longer term retention of information. To address this possibility, we calculated a 2 (learning style preference) \times 2 (mode of instruction) ANOVA to examine the long-term (2-week) effect of instructional condition (audiobook, e-text) and learning style preference (auditory, visual word) on *Unbroken* comprehension test scores at Time 2. The results at Time 2 parallel those found at Time 1. That is, the main effect for learning style preference was significant, $F(1, 37) = 9.18$; $p < .05$, indicating that *Unbroken* comprehension test scores at Time 2 were affected by learning style preference. Participants with an auditory learning style preference performed significantly more poorly ($M = 27.33$; $SD = 5.74$) than those with a visual word learning style preference ($M = 32.25$; $SD = 4.23$). The main effect of group was not significant, $F(1, 37) = .03$; $p > .05$, with no significant difference between participants using an audiobook ($M = 29.52$; $SD = 6.55$), and those using e-text ($M = 29.95$; $SD = 4.51$). Finally, the

interaction between instructional condition and learning style preference was not significant, $F(1, 37) = 0.54; p > .05$, indicating that providing instruction in a mode that matched an individual's learning style preference did not result in significantly better retention.

There were no significant interactions between learning style preference and mode of instruction based on a categorical classification of participants into two discrete groups, those with an auditory and those with a visual word learning style. However, classification of participants into two discrete groups reduced the sensitivity of continuous variables and also reduced the sample size by including only those participants who had a clear auditory or visual word learning style preference. To mitigate these concerns, we conducted a final series of correlation and stepwise multiple regression analyses to evaluate whether there was a significant relationship among learning style preference (BE Learning Styles Inventory), learning aptitude (L-AT, R-AT), and mode of instruction (digital audiobook, e-text). For these analyses, variables from the BE Learning Styles Inventory based on the continuous 17-point standard BE scoring system and verbal aptitude scores based on the L-AT and R-AT were used to predict (a) learning outcomes from the audiobook mode of instruction and (b) learning outcomes from the e-text mode of instruction (Table 4).

Correlation and regression analyses for Research Question 2.

Predicting audiobook learning outcomes from learning style preference and verbal aptitude scores at Time 1. The meshing hypothesis predicts a positive correlation between learning style preference and instructional mode. That is, as auditory learning style preference scores increase, learning outcomes via the audiobook mode of instruction, but not via the e-text mode of instruction, would also increase. As seen in Table 4, counter to what would be predicted by the meshing hypothesis, when the Pearson correlation was calculated examining the relationship between auditory learning style preference and learning from an audiobook, a weak negative correlation that was not significant was found, $r(28) = -.30, p > .05$. When the Pearson correlation was calculated examining the relationship between visual word learning

style preference and learning from an audiobook, the results were similar; a weak negative correlation that was not significant was found, $r(28) = -.24, p > .05$.

Similarly, to further test whether any other learning style or aptitude variables influenced learning outcomes from the audiobook mode, a multiple linear regression was calculated to determine the extent to which participants' learning of nonfiction material presented in audiobook format (instructional condition) could be predicted based on their learning style preference (BE auditory, BE visual word, and the difference between BE auditory and BE visual word scores) as well as comprehension aptitude (R-AT, L-AT, and verbal comprehension aptitude difference). As seen in Table 5, a significant regression equation was found, $F(1, 28) = 16.18, p < .001$. Listening aptitude (L-AT) was the only variable that contributed significantly to the comprehension of the material presented via the audiobook condition. This single variable contributed a correlation coefficient of 0.61, $R^2 = .37 (SE = 5.43), p < .001$. The regression equation showed that comprehension of material in the audiobook instructional condition was equal to 15.71 (constant) + 1.15 (listening comprehension aptitude), indicating a positive relationship between listening aptitude, and auditory instruction. The coefficient model shows that for every 1 point the audiobook comprehension increased, the listening aptitude score increased 1.15 points. This analysis demonstrated that only a component of aptitude (L-AT) contributed significantly to the variance in learning based on auditory instruction. BE auditory learning style score, BE visual word learning style score, and the difference between BE auditory and BE visual word score, as well as reading aptitude (R-AT), and the difference between listening aptitude and reading aptitude (L-AT-R-AT), failed to contribute any significant variance beyond that already accounted for by the listening aptitude score.

Predicting e-text learning outcomes from learning style preference and verbal aptitude scores at Time 1. The meshing hypothesis predicts a positive correlation between learning style preference and instructional mode. That is, as visual word learning style preference scores increase, learning outcomes via the e-text

Table 4
Descriptive Statistics and Correlation Matrix for the Predictor Variables Entered into the Multiple Regression Model for the Audiobook and e-Text Instructional Conditions at Time 1 as Described in Research Question 2

Condition	n	M	SD	Unbroken comprehension test results at Time 1					
				1	2	3	4	5	6
Audiobook	30	30.87	6.70	.61**	.45*	.19	-.30	-.24	-.14
1. Listening aptitude	30	13.17	3.52		.46*	.58**	-.40	-.08	-.30
2. Reading aptitude	30	12.30	3.25			-.46**	-.42*	-.03	-.34
3. Difference between listening and reading aptitude	30	0.87	3.54				-.01	-.05	.02
4. BE auditory learning style	30	10.50	3.95					-.04	.88**
5. BE visual learning style	30	11.80	2.23						-.30**
6. Difference between BE auditory and visual learning styles	30	-1.30	4.62						
E-text	31	31.35	5.40	.70**	.45*	.39*	-.25	.05	-.24
1. Listening aptitude	31	14.42	3.74		.43*	.72**	-.40*	-.01	-.33
2. Reading aptitude	31	13.10	2.72			-.31	-.20	.19	-.26
3. Difference between listening and reading aptitude	31	1.32	3.54				-.27	-.16	-.14
4. BE auditory learning style	31	10.97	3.70					-.05	.86**
5. BE visual learning style	31	11.97	2.30						-.56**
6. Difference between BE auditory and visual learning styles	31	-1.00	4.46						

Note. BE = Building Excellence.
* $p < .05$. ** $p < .01$.

Table 5
Coefficients for the Significant Predictor Variables Entered into the Multiple Regression Model for Audiobook and E-Text Learning at Time 1 as Described in Research Question 2

Variable	<i>B</i>	<i>SEB</i>	β	<i>R</i>	<i>R</i> ²	<i>N</i>
Audiobook						
Learning				.61	.37	30
Constant	15.71	3.89	**			
Listening aptitude	1.15	0.29	.61**			
E-text						
Learning				.70	.49	31
Constant	16.80	2.86	**			
Listening aptitude	1.01	0.19	.70**			

Note. The following predictor variables were entered into the model for audiobook and e-text learning: listening aptitude; reading aptitude; difference between listening and reading aptitude; Building Excellence (BE) auditory learning style score; BE visual word learning style score; and the difference between BE auditory and BE visual word score. Only the variables listed above made significant contributions to the model. Shown are the coefficients (*B*), the standard error of the coefficients (*SEB*), as well as standardized coefficient (β), and the correlation. *N* = 30 (audiobook); *N* = 31 (e-text).

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

mode of instruction, but not via the audiobook mode of instruction, would also increase. As shown in Table 4, when the Pearson correlation coefficients were calculated, there was a weak positive correlation between visual word learning style preference and learning from e-text, $r(29) = .05$, $p > .05$, and a weak negative correlation between auditory word learning style preference and learning from e-text ($r(29) = -.24$, $p > .05$). However, neither correlation was significant.

To further test whether any learning style or aptitude variables influence learning outcomes from the e-text mode of instruction, a multiple linear regression was calculated to determine the extent to which participants' learning of nonfiction material presented in e-text format (instructional condition) could be predicted based on their learning style preference (BE auditory, BE visual word, and the difference between BE auditory and BE visual word scores) as well as comprehension aptitude (R-AT, L-AT, and verbal comprehension aptitude difference). As shown in Table 5, a significant regression equation was found, $F(1, 29) = 27.67$, $p < .001$ with an R^2 of .49. Contrary to what would be predicted by the meshing hypothesis, however, the only variable that contributed significantly to the learning of the material presented in the e-text condition was listening comprehension aptitude (L-AT). This single variable contributed a correlation coefficient of $R = .70$, $R^2 = .49$ ($SE = 3.93$), $p < .001$. The regression equation showed that comprehension of material in the e-text instructional condition was equal to 16.80 (constant) + 1.01 (L-AT), indicating a positive relationship between listening comprehension aptitude and learning from e-text instruction. The coefficient model shows that for every 1 point e-text learning increased, listening comprehension aptitude increased by 1.01 points. This analysis demonstrated that only listening comprehension aptitude (L-AT) contributed significantly to the variance in learning material presented via e-text instruction. BE auditory learning style score, BE visual word learning style score, and the difference between BE auditory and BE visual word score, as well as R-AT, total verbal comprehen-

sion aptitude, and the verbal comprehension aptitude difference failed to contribute any significant variance in learning beyond that already accounted for by the L-AT.

Predicting audiobook and e-text learning outcomes from learning style preference scores only at Time 1. When both verbal comprehension aptitude and learning style preference variables were entered into multiple regression analyses to predict learning via either audiobook or e-text modes of instruction, only aptitude measures proved to significantly predict learning outcomes. In a final attempt to find a significant relationship between learning style preference and effects of instructional mode on learning, we conducted a regression analysis using *only* learning style preference variables (BE auditory, BE visual word, and the difference between BE auditory and BE visual word scores) to predict (a) audiobook and (b) e-text learning outcomes. The results of these analyses failed to provide any statistically significant support for the meshing hypothesis in that none of the BE learning style preference variables accounted for a statistically significant amount of variance for either audiobook ($p > .05$) or e-text ($p > .05$) learning outcomes.

Predicting audiobook and e-text learning outcomes from learning style preference and verbal aptitude scores at Time 2. Even if learning style preferences do not affect immediate learning of material based on mode of instruction (audiobook, e-text), it is possible that presenting instruction in a mode that meshes with an individual's learning style may affect longer term retention of information. Just as was done using the categorical variables for learning style preference, all analyses were repeated using the continuous variables based on the 2-week retention data obtained at Time 2. The results of these analyses are shown in Tables 6 and 7. As can be seen by directly comparing the correlation matrices obtained at Time 1 (Table 4) with those obtained at Time 2 (Table 6), as well as the multiple regression models obtained at Time 1 (Table 5) with those obtained at Time 2 (Table 7), the results were very similar at Time 2 to those found at Time 1. The only significant correlation found between audiobook learning and auditory learning style preference was found at Time 2, and this correlation was negative ($-.39$, $p < .05$). Similarly, results from the stepwise multiple regression analyses were similar at Time 2 to those found at Time 1; only aptitude scores positively predicted audiobook and e-text learning, with no significant learning preference variables entering the model (Table 7). Thus, similar to the results pertaining to immediate learning obtained at Time 1, the results obtained at Time 2 failed to provide any statistically significant evidence that showed that providing individuals with instruction in a mode that meshes with their learning style preference results in significantly better long-term retention of information.

Discussion of analyses for Research Question 2. Research Question 2 investigated the meshing hypothesis as it pertains to mode of instruction. Specifically, the meshing hypothesis predicts that participants with an auditory learning style preference will learn material better when instruction is presented via a listening mode than when it is presented via a written mode and, conversely, those with a visual word learning style preference will learn material better after having read it rather than having listened to it. An ANOVA was calculated to determine if the experiment provided any statistically significant evidence that showed that the

Table 6

Descriptive Statistics and Correlation Matrix for the Predictor Variables Entered into the Multiple Regression Model for Audiobook and E-Text Learning at Time 2 as Described in Research Question 2

Condition	n	M	SD	Unbroken comprehension test results at Time 2					
				1	2	3	4	5	6
Audiobook learning	30	28.20	7.76	.70**	.58**	.16	-.39*	-.25	-.21
1. Listening aptitude	30	13.17	3.52		.46*	.58**	-.40*	-.08	-.30
2. Reading aptitude	30	12.30	3.25			-.46**	-.42*	-.03	-.34
3. Difference between listening and reading aptitude	30	0.87	3.54				-.01	-.05	.02
4. BE auditory learning style	30	10.50	3.95					-.04	.88**
5. BE visual learning style	30	11.80	2.23						-.52**
6. Difference between BE auditory and visual learning styles	30	-1.30	4.62						
E-text learning	30	29.13	5.85	.66**	.52**	.32	-.23	.19	-.28
1. Listening aptitude	30	14.60	3.66		.54*	.70**	-.36*	.06	-.32
2. Reading aptitude	30	12.97	2.67			-.21	-.29	.13	-.30
3. Difference between listening and reading aptitude	30	1.63	3.15				-.17	-.05	-.12
4. BE auditory learning style	30	10.80	3.64					-.12	.87**
5. BE visual learning style	30	11.87	2.27						-.60**
6. Difference between BE auditory and visual learning styles	30	-1.07	4.53						

Note. BE = Building Excellence.

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

method most effective for instructing individuals with one learning style is *not* the most effective method for individuals with a different learning style. The results of these analyses failed to provide empirical support for the meshing hypothesis. No significant interactions were found between learning style preference (auditory, visual word) and instructional method (digital audiobook, e-text) for either immediate learning or 2-week retention of verbal information.

A second series of simple and multiple regression analyses were conducted using continuous variables of both learning style preference as well as verbal comprehension aptitude. When both learning style and verbal comprehension aptitude variables were pitted against each other in multiple regressions to predict learning

via either digital audiobook or e-text, only the aptitude variables accounted for a significant amount of variance in learning. When only learning style variables were entered into these multiple regression analyses, they failed to account for a significant amount of variance in learning. Thus, regardless of scoring method used (categorical or continuous), the results from Research Question 2 failed to find a significant interaction between learning style preferences (auditory, visual word) and instructional method (digital audiobook, e-text) on learning or retention of information from a nonfiction text.

General Discussion

According to Pashler et al.'s (2008) recent review of the learning styles literature, there is widespread belief among educators and the general public alike that individuals learn better when they are presented instruction in the modality that capitalizes on their learning style preference. Pashler et al. (2008) focused on the extent to which auditory and visual learning style preferences influence verbal comprehension. Specifically, they focused on the meshing hypothesis that proposes that individuals with a visual learning style preference will learn more when information is presented to them in a written format, and conversely, those with an auditory learning style preference will learn more when instruction is presented to them in a listening format. They also pointed out that the meshing hypothesis may have led to the belief that learning style preferences and learning aptitudes for verbal comprehension are similar constructs. Their review of the literature led them to conclude, however, that there is little empirical evidence to support a direct relationship between learning style preferences (auditory, visual) and either (a) verbal comprehension aptitude (listening vs. reading) or (b) differential learning outcomes based on different modes of instruction (e.g., audiobook vs. e-text). However, they also concluded that the definitive study had not been conducted, and therefore, they prescribed a detailed roadmap for the experimental methodology that would be needed to address these important issues empirically as well as explicit examples of

Table 7

Coefficients for the Significant Predictor Variables Entered into the Multiple Regression Model for Learning From Audiobook and E-Text at Time 2, as Described in Research Question 2

Variable	B	SEB	β	R	R ²	n
Audiobook						
Comprehension				.76	.57	30
Constant	2.65	4.41				
Listening aptitude	1.21	0.31	.55*			
Reading aptitude	0.78	0.34	.33**			
E-text						
Comprehension				.66	.43	40
Constant	13.77	3.42	**			
Listening aptitude	1.05	0.23	.66**			

Note. The following predictor variables were entered into the model for audiobook and e-text learning: listening aptitude; reading aptitude; difference between listening and reading aptitude; Building Excellence (BE) auditory learning style score; BE visual word learning style score; and the difference between BE auditory and BE visual word score. Only the variables listed above made significant contributions to the model. Shown are the coefficients (B), the standard error of the coefficients (SEB), as well as standardized coefficient (β), and the correlation. $N = 30$ (audiobook); $N = 30$ (e-text).

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

the patterns of data that would either support or refute the meshing hypothesis.

We conducted an investigation of the meshing hypothesis with college-educated adults following the research methods laid out by Pashler et al. (2008) to address two research questions. In Research Question 1, we used these methods to assess the extent to which an individual's learning style preference (auditory, visual word) was consistent with his or her learning aptitude for verbal comprehension (listening, reading). In Research Question 2, we used these methods to assess the extent to which an individual's learning style preference (auditory, visual-word) differentially affected how much they would learn and retain from nonfiction text presented using two different modes of instruction (digital audiobook, e-text).

Results from Research Question 1 showed that differences in preferred learning style (auditory, visual word) were *not* found to significantly predict differences in learning aptitude (listening vs. reading comprehension). That is, there were no statistically significant results that showed that individuals with stronger auditory learning style preferences had higher listening comprehension aptitude than reading aptitude or, conversely, that individuals with stronger visual word learning style preferences had higher reading than listening aptitude. Instead, participants classified with a preferred visual word learning style outperformed those classified as having a preferred auditory learning style on both the listening and reading comprehension aptitude tests. These results show that learning style preference and aptitude are not comparable constructs. Thus, the results from Research Question 1 failed to provide statistically significant support for the meshing hypothesis, at least as it pertains to the relationship between learning style preference (auditory, visual word) and verbal comprehension aptitude (listening, reading), respectively.

Similar to the results from Research Question 1, the results from Research Question 2 also failed to provide statistically significant empirical evidence supporting the meshing hypothesis, either for immediate learning or long-term retention of information presented via two different modes of instruction (audiobook, e-text). Regardless of whether categorical or continuous measures of learning styles were used or which method of analysis (ANOVA, simple correlations, multiple regression analyses) was chosen, there were no significant findings that showed that providing instruction to individuals in a mode that meshed with their preferred learning style resulted in better learning or retention of information compared with instructing them in their nonpreferred mode.

In conclusion, at least for verbal comprehension, no statistically significant evidence was found in this investigation to support the construct (a) that learning style is equivalent to learning aptitude or (b) that providing instruction in the modality that meshes with an individual's preferred learning style will result in significantly better learning or retention than presenting the same instruction in an individual's nonpreferred learning style.

Overall Limitations of the Study

One potential limitation in interpreting the results of Research Question 1 was that the L-AT and R-AT proved not to be matched for difficulty. Both the auditory and the visual word learning style preference groups scored higher on the listening than on the

reading comprehension aptitude test. This could be an indication that the listening version of the test was easier than the written version. We pointed out that while equivalent scores on the L-AT and the R-AT would have been more ideal, it is the *pattern* of the results, rather than the absolute values, that is critical in addressing the meshing hypothesis. That is, the main question of interest is whether there is a *differential* pattern of results for participants with an auditory preference compared with a visual word learning style preference in respect to listening compared with reading aptitude, and the analyses showed that there was not. The results from Research Question 2 also addressed this issue. Recall that in this case there was *no* significant main effect of condition (audiobook, e-text) on performance on the *Unbroken* comprehension test. There was also no significant interaction found between learning style preference and instructional condition. This provides further evidence that the failure to find significant support for the meshing hypothesis in Research Question 1 was not likely due to differences in listening versus reading test difficulty.

A second limitation of the study discussed for Research Question 1 pertained to the fact that regardless of mode of instruction, comprehension was assessed using written questions only. The same limitation also applies to Research Question 2. We considered that holding the format of the assessment constant would allow only one variable (in this case, mode of instruction) to be varied within the study. A written format was chosen over a listening format because this is consistent with how most tests are given. However, it could be argued that using the same (written) format for the assessment of learning may have favored those individuals who had a stronger visual learning style preference and, thus, masked evidence supporting the meshing hypothesis. Indeed, it was found in both Research Questions 1 and 2 that participants with a visual word learning style preference performed significantly better than those with an auditory learning style preference on both the listening and reading comprehension tests, both of which were assessed by written questions. However, it also should be recalled that both learning style preference groups performed better on the listening aptitude test than the reading aptitude test in Research Question 1, even though both were assessed with written questions. Regardless of these potential limitations to the study design, it should be kept in mind that the critical test of the meshing hypothesis rests in finding a significant *interaction* between learning style preference and either aptitude (Research Question 1) or learning based on mode of instruction (Research Question 2). This was not found in either case. Nonetheless, it may be important in future studies to determine if the meshing hypothesis may be supported if both modes of instruction as well as assessment measures of aptitude or learning are given in both a listening and a written format.

Participants in this study were college-educated adults, and therefore, the results can only be generalized to similar populations with well-developed listening and reading comprehension skills. It will be particularly important for future research to repeat this same study with children of different ages who are in the process of developing reading skills to determine the extent to which mode of instruction, learning aptitude, and learning style preference may affect individual differences in learning outcomes at different stages during the development of language and literacy skills. It would also be important to determine longitudinally the extent to which mode of instruction or learning styles influence literacy

outcomes when instruction is provided over a longer period of time.

This research focused narrowly on verbal comprehension skills and the extent to which learning differed when instruction is presented via an audiobook compared with e-text. While there are many different schemes for classifying individual learning styles, we used only one learning style inventory (the Rundle and Dunn Building Excellence Inventory) and within that inventory focused only on auditory and visual word learning styles. Thus, the degree to which the results of this study generalize to other disciplines or other learning styles cannot be established by this study. Furthermore, instruction used in this study was given only one time and relied on participants learning information from the preface and one chapter in a nonfiction book. The extent to which the results of this study can be generalized to other forms of instruction, longer durations of instruction, and other types of material cannot be established.

In Research Question 2, the sample size was substantially reduced by the random placement of participants into different instructional conditions (audiobook, e-text) and because of the categorical analyses. Therefore, for several of the analyses concerned with finding relations among individual differences in learning style preferences or aptitudes and mode of instruction, the lack of statistical significance may be influenced by a lack of power due to a modest sample size. Nonetheless, when the results from both Research Question 1, which included a much larger sample size ($N = 121$) and Research Question 2 ($n = 61$) are considered in their entirety, they consistently fail to provide any empirical evidence that suggests individuals will learn significantly better when they are provided instruction in a mode that meshes with their preferred or stronger learning style than in a mode that does not.

Conclusion

The American education system as well as the general public has come to believe that optimal learning occurs if individuals are taught in their preferred learning style. Dekker et al. (2012) surveyed 242 primary and secondary school teachers from the United Kingdom ($n = 137$) and the Netherlands ($n = 105$) who were enthusiastic about applying neuroscientific findings into their instruction. It was assumed that this population, given their high level of interest, would be current on effective research-based practices. The participants were given statements and were asked if the statements were “correct,” “incorrect,” or “do not know.” Results showed that 93% of teachers from the United Kingdom and 96% of teachers from the Netherlands answered “correct” to the statement: “Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).” The results of this study demonstrate how pervasive the misinformation of learning styles is in everyday classroom practice around the world.

The idea of teaching to an individual’s learning style is attractive. According to learning styles theory, if an individual is struggling to learn new material, it is possible that his or her poor performance results from not being taught in a mode that meshes with the individual’s preferred learning style. Thus, educators and professional development leaders spend time and resources assessing their students’ learning style and developing instruction to

specifically match a student’s preferred learning styles. It is common for lesson plans to include a section in which teachers are asked to explain how they will accommodate the different learning styles of students in their classroom. Therefore, the findings from this study have considerable relevance for educational theory and practice.

The main finding from Research Questions 1 and 2 that may have a substantial influence on current educational practice is that when participants were categorized by their preferred learning style, either auditory or visual word, those who were classified as visual word learners performed better, compared with auditory learners, on verbal comprehension measures. In other words, visual word learners scored higher than auditory learners on both the reading and the listening aptitude tests and the *Unbroken* comprehension tests. Therefore, and counter to current educational beliefs and practices, educators may actually be doing a disservice to auditory learners by continually accommodating their auditory learning style preference by providing them instruction that meshes with their auditory learning style, rather than focusing on strengthening their visual word skills. It is important to keep in mind that 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. Rather than continually accommodating auditory learners’ preference with increased instruction in an auditory format, auditory learners might benefit more from receiving instruction that specifically targets and strengthens their visual word skills.

In a review of the learning styles literature, Pashler et al. (2008) did not find empirical support to justify matching instruction to learning style. He and his collaborators brought to light several pressing concerns. First, too often individuals allow their intuitions to shape their beliefs. We base our educational practice on trial and error, or we are complicit in always doing what has always been done. Changing the minds of teachers and teacher educators with regards to learning styles is no small feat. Pashler et al. (2008) 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). The goal of this study was to provide more empirical evidence to guide educational practitioners in making sound judgments pertaining to whether their students will or will not benefit from receiving instruction that meshes with their preferred learning style or aptitude. In the current study, we failed to find any statistically significant, empirical support for tailoring instructional methods to an individual’s learning style.

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