Defecting From the Gutenberg Legacy: Employing Images to Test Knowledge Gaps
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Education-based knowledge gaps are well-documented across countries, media platforms, and content. Without exception, knowledge is measured through words not images. Given the centrality of sight in the natural history of Homo sapiens, the extraordinary visual acuity of humans, and the proliferation of screen-based visual media environments in contemporary life, an experiment was conducted to test the knowledge gap visually. Participants watched 8 audiovisual news stories. Simple recognition of story details and comprehension of that information were tested in verbal and visual modalities. Results offered the first confirmation of the knowledge gap in visual terms. Yet, gaps were significantly smaller employing visual than verbal measures, pointing to the need for continued efforts to develop visual measures for future memory studies.

Keywords: Knowledge Gap, Information Processing, Images, Experiment, Memory, Visual Processing.

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Over the past 40-plus years more than 200 studies have documented a persistent education-based information acquisition divide called the knowledge gap. Despite the robust findings, a number of scholars are growing uneasy about existing conceptualizations and measures of knowledge in contemporary knowledge gap research. Some of this contrariety is spurred by cognitive science evidence of visual processing as a potent mode of learning. Yet invariably, knowledge gaps have been measured through verbal tests. Visual memory and comprehension measures have not been employed, because researchers seem reluctant to operationalize knowledge in visual terms. Doris Graber (2001) referred to this research orientation as The Gutenberg Legacy, in which the written word is canonized as a conduit of information important for participatory citizenship. Images, by contrast, are treated as lacking serious information value—perhaps because they are inherently entangled with emotion by being processed via affective pathways in the brain. Dating back at least as far as the...
Enlightenment, emotion is seen as irreconcilable with logic and reason. This tradition still anchors most contemporary predictive models of knowledge acquisition and active citizenship (Marcus, Neuman, & MacKuen, 2000; Somit & Peterson, 1998) in the imperative of rational choice, enabled by verbal language.

The importance of verbal language in the cultural history of Homo sapiens stands beyond question. Yet, in the panoramic scope of evolutionary adaptation the human brain has had relatively little time to specialize for oral (40,000 to 50,000 years; see Holden, 2004) and written communication (about 5,000 years; see Houston, 2004). In comparison, visual acuity is not an acquired skill or literacy—it is a vital sense, capacitated by neurological adaptations over millions of years, that affords contemporary human cognition and behavior (Damasio, 1994; Gazzaniga, 1998; Parker, 2003). The idea that visual acuity drove the evolutionary course that produced Homo sapiens might appear lionized and distant as justification for contemporary media research. Yet media use patterns are transformed by rapidly unfolding and sweeping shifts from written words to audiovisuals. According to Cisco (2014), mobile traffic has increased 81% in 2013 and the forecast is that in 2018 video use will make up 69% of all global mobile data traffic.

The signs are clear. A post-Gutenberg era has sprung. Screen-based media environments with their life-like full motion images (entangled with ambient sound and speech) are likely to become as central as the printed word has been for the past five centuries. Testing information acquisition through user-preferred modalities made good research sense in a newspaper age; scholarly focus on the visual modality is urgently necessary now. The experimental work reported here makes an effort to advance a media research trajectory that recognizes the human acuity for visual processing and growing preference for using media in that modality. Specifically, we (re)tested the knowledge gap, a 4-decade-old theory built on verbal assessments of information gain. In doing so, we employed visual and verbal measures comparatively to understand two different layers of knowledge acquisition: encoding (recognition memory) and comprehension of information.

**Verbal knowledge gaps**

Since the mid-1970s, more than 200 studies have consistently documented differential knowledge gain across education or socioeconomic status (SES) groups (see Gaziano, 1997, 2010; Hwang & Jeong, 2009). Evidence is robust across cultural contexts (Bonfadelli, 2002; Hwang & Jeong, 2009; Nguyen & Western, 2007; Van Dijk & Hacker, 2003; Yang & Grabe, 2011), media platforms (Grabe, Kamhawi, & Yegiyan, 2009; Kim, 2008; Wei & Hindman, 2011), and content (Ettema, Brown, & Luepker, 1983; Grabe, Yegiyan, & Kamhawi, 2008; Jerit, Barabas, & Bolsen, 2006). Moreover, individual differences among audience members have been tested to explain the gap (Eveland & Scheufele, 2000; Kwak, 1999; Neuman, Just, & Crigler, 1992; Price & Zaller, 1993).

Knowledge gap research also moved from exclusively survey to experimental methodologies. Based on the mechanics of the limited capacity model (Craik &
Lockhart, 1972; Shiffrin & Schneider, 1977; Tulving & Thompson, 1973) of information processing (applied to media—see Lang, 2000), the knowledge gap (or news learning studies) tested memory formation at encoding, storage, and retrieval levels. Yet, most studies focused on encoding, using recognition tests (Grabe, Lang, Zhou, & Bolls, 2000; Grabe et al., 2009; Shoemaker, Schooler, & Danielson, 1989; Tremayne & Dunwoody, 2001) and confirmed that lower education groups processed (encoded) news information less efficiently than higher education groups (Grabe et al., 2000, 2008, 2009; Yang & Grabe, 2011). As a departure point of connection to survey and experimental evidence on the knowledge gap, we hypothesize that people with higher levels of education will outperform those with lower levels of education in verbal recognition tests of news information (H1).

A number of scholars have, however, grown uneasy about conceptualizing, quantifying, and measuring knowledge (Bonfadelli, 2002; Gaziano, 1997; Prior, 2014; Selwyn, 2004; Woodall, Davis, & Sahin, 1983) as encoding (recognition memory) rather than comprehension of news (Eveland, Marton, & Seo, 2004; Findahl & Höijer, 1985; Gaziano, 1997; 2010; Graber, 1988; Hindman, 2009; Hwang & Jeong, 2009; Robinson & Levy, 1986; Snoeijer, de Vreese, & Semetko, 2002; Woodall et al., 1983). The traditional view of informed citizenship as memory for cold hard facts is challenged by reconceptualizations of informed citizenship as applied understanding, comprehension, and even emotional involvement with social issues.

Information processing scholars treat comprehension and memory as two distinct cognitive processes (Ortony, 1978). Comprehension measures involve more than memory for discrete information and are more often used among researchers who do work on learning from news media (e.g., Robinson & Levy, 1986; Woodall et al., 1983) than those who work in the limited capacity tradition (Gunter, 1987; Lang, Zhou, Schwartz, Bolls, & Potter, 2000). Comprehension measures assess if participants have integrated information into a meaningful system of existing knowledge (Robinson & Levy, 1986; Tremayne & Dunwoody, 2001). While measures vary across studies, comprehension tests are centrally concerned with how well participants grasp the gist of a story or can apply acquired information in other contexts. These outcomes are arguably more conducive to the ideals of informed citizenship than remembering peripheral details like the names of people and places. Memory for details from a story is not seen as evidence that the audience understood what the story is about. At the same time, comprehension of the story does not necessarily assure memory of factual details contained in it (Graber, 1988). Yet, correlations between memory and comprehension are often reported (Basil, 1994; Edwardson, Kent, Engstrom, & Hofmann, 1992; Findahl & Höijer, 1985) and high education groups have been shown to verbally recount and comprehend material from text-based media at higher rates than low education groups (Grabe et al., 2009; Yang & Grabe, 2011). Given existing evidence—and in line with the preceding hypothesis for recognition memory—it is expected that the knowledge gap will persist in verbal comprehension test scores, such that people with higher levels of education will outscore those with lower levels of education (H2).
**Visual primacy and the knowledge gap**

In evolutionary circles explanations for why the human brain is better adapted for visual than verbal information processing are often based on the relatively short history of verbal language in the natural history of *Homo sapiens*. In this regard, Paivio (1971) argues that words are processed in a linear fashion—one at a time—while visuals are processed faster and holistically as an entanglement of verbal and visual memory records. When one of these routes fails at the retrieval stage, the other often can successfully manage the task (Paivio, 1971). This acknowledgement of visual primacy in *Homo sapiens* (and other primates) has unwrinkled the path for ontological shifts in cognitive and neuroscience thinking about the enmeshment of rationality and emotion.

In *Descartes’ Error*, Damasio (1994) argued on the basis of neurological evidence that humans are not primarily thinking beings who also feel, but feeling beings who also think. Visual processing is singled out as the leading conduit of emotional involvement and the dominant mode of learning and building synaptic connections (Barry, 2005; Damasio, 1994). Yet, knowledge gain has been consistently measured through verbal means. Visual memory and comprehension instruments are strikingly underdeveloped because knowledge is not operationalized in visual terms. “The belief that audiovisuals are poor carriers of important information has become so ingrained in conventional wisdom,” Graber (2001) observes, “that it has throttled research” (p. 93). Her calls (Graber, 1988, 1990, 1996, 2001) for revising the way media and political communication scholars think about the importance of images as information sources have not been answered earnestly, which instigates the next hypothesis. Regardless of education level, recognition and comprehension scores will be higher when measured visually than verbally (H3).

Some notable exceptions to The Gutenberg Legacy are experimental studies examining the effects of candidate facial emotion on voter evaluations (Keating, Randall, & Kendrick, 1999; Rosenberg, Kahn, & Tran, 1991), Graber’s (1988, 1990, 2001) pioneering work on creating visual measures, and Prior’s (2014) effort to establish visual political knowledge measures. In a series of studies, Graber (2001) found that viewers recalled more visual than verbal themes from television. Prior (2014) employed visual (faces) and verbal (names) recognition questions to get to the encoding process of political knowledge. For example, a question like “Who is the current Senate Majority Leader?” represented a verbal prompt and featured four verbal (name) options. The visual version of the question featured the same verbal prompt but offered four visual representations of faces. Prior (2014) found that differences among college graduates and nongraduates declined significantly when knowledge was measured visually. This suggests that the potential of images as a knowledge equalizer might be unrealized due to the yardstick used to gauge knowledge (Prior, 2014). Indeed, the low levels of knowledge routinely reported in survey research and learning from news studies might partially be due to the kind of knowledge measures that are employed, and the circular logic that underlies them. For example, education
level has been linked to political knowledge which is measured through the written word, that requires literacy. It thus seems unsurprising that political knowledge and comprehension of political complexities—measured through the written word—are linked to formal education (Jennings, 1996; Nie, Junn, & Stehlik-Barry, 1996). Graber (1996) interprets these findings as a matter of literacy in aid of verbal processing. We argue that literacy also serves verbal knowledge measures. On the other hand, visual information processing requires no literacy, develops practically at birth, and enables most citizens to learn about their social world from a very young age. For unclear reasons, visual processing and visual measures of knowledge remain customarily idle in scholarly pursuits to understand informed citizenship.

It is noteworthy that when Tichenor, Donohue, and Olien (1970) first formulated the knowledge gap hypothesis, they suggested that audiovisual learning might enhance knowledge levels among less literate groups: “Since television use tends to be less correlated with education, there is a possibility that television may be a ‘knowledge leveler’ in some areas. Whether TV does in fact have such a leveling function seems to be an urgent matter for further research” (p. 170). More than 40 years later, there is no consensus about the potential of audiovisual learning as an equalizer across education groups. Some studies showed that visuals aid (Grabe et al., 2009; Gunter, 1987; Katz, Adoni, & Parness, 1977; McCarthy & Warrington, 1988) while others found that they inhibited memory especially when news stories contained discrepant information across visuals and verbals (Brosius, Donsbach, & Birk, 1996; Van der Molen & Klijn, 2003; Zhou, 2005) or when they were highly compelling (Grabe, Lang, & Zhao, 2003; Miller & Leshner, 2007; Newhagen & Reeves, 1992). Yet, these studies did not measure memory visually. They mostly tested the effects of audiovisual content using verbal information measures or, as Graber (2001) points out, “In tests of what viewers learn from television news, scholars have usually asked only for recall of the verbal message, assuming that the visuals mirrored the verbal texts or conveyed no significant substantive information at all” (p. 93). Thus, because visuals are not considered to have much information value, they are not used as an index of consequential processes such as memory formation or comprehension of social issues (Graber, 1990).

Indeed, most existing knowledge tests do not measure image-based recognition and comprehension. If cognitive scientists are right in arguing that Homo sapiens is generously endowed with visual information processing abilities—compared to verbal processing, which is a recent environmentally driven adaptation—the knowledge gap between higher and lower education groups might disappear if visual knowledge measures are employed. Grounded in this line of thinking, but lacking evidence for formal hypotheses, a research question (RQ1) prompts the comparison of education-based knowledge gaps measured through visual versus verbal modalities for both recognition and comprehension measures.

The time factor
Since Bartlett's (1932) seminal study on memory decay, the idea that memory records become less vivid and accurate over time has enjoyed substantial research attention.
Demographic factors such as education, age, and gender as well as the type of memory (episodic, source, spatial) and stimuli characteristics (emotional dimensions, faces, digits, word-pairs) have been tested for influencing memory decay. Few of these studies have employed stimuli that resemble news.

Dixon, Simon, Nowak, and Hultsch (1982) tested the effect of a week delay on three adult groups and found that although younger participants recalled text materials better than middle-aged and older participants, memory decreased over time for all three age groups. Meeter, Murre, and Janssen (2005) investigated memory for news among 14,000 participants worldwide asking questions about news that ranged from as recent as 2 days to 2 years old. Over time, participants forget information regardless of their initial learning rate. Some evidence points to education as inhibiting forgetting: the higher the education level, the slower the memory decay (Karrasch & Laine, 2003; Morrow & Ryan, 2002). In a knowledge gap study that employed a 48-hour time delay in measures of encoding, storage, and retrieval, Grabe et al. (2009) found evidence of greater memory declines for the low than high education group, across all three measures. With a week long delay, Bas and Grabe (2013) found that low education participants had stronger memory decay than higher educated participants. This offers some point of traction for a hypothesis (H4) predicting that, regardless of modality, the low education group will be associated with more recognition memory and comprehension decay than the higher education group.

Given the sparseness of evidence related to the interaction of audience education level, memory test modality, and time delay, the last research question (RQ2) asks for a comparison of modalities and participant education levels for each of the memory measures (recognition and comprehension).

Method

Design
This experiment employed a mixed factorial 2 (participant education level) × 2 (test modality) × 2 (time) model. Education level (high and low) was a between-subjects factor while modality (visual or verbal) and time (two times of measurement 1 week apart) were treated as within-subjects factors. The different levels of modality were represented by verbal and visual memory measures. Four random story sequences were constructed to control for the effects of order.

Participants
Eighty subjects participated in this study conducted in a small Midwestern city in the United States. Low (N = 40) and high (N = 40) education participants were recruited from the local university community, neighborhood e-mail distribution groups, Craigslist.com, and local charity organizations. A number of screening questions about age and education were used to select subjects. The high education group participants had all earned at least an M.A. degree. Participants in the low education group held no more than 2 years of vocational training. In order to control for
potential gender effects, equal numbers of men and women were recruited for the
two education groups. The lower age limit was set at 25 to allow time for education to
unfold while the upper age limit was fixed at 55 years. The average age of participants
in this study was 34 (high education = 32; low education = 36). Two participants in
the low education group and seven in the high education group self-identified as
ethnic minorities. An a priori power analysis revealed that with 76 subjects, effect
sizes of .25 should be detected with .95 power in this experimental design. With 80
participants, this study was adequately powered to detect effects.

Stimuli
Eight news stories were selected from a pool of 26 ABC news stories reported by Brian
Ross. His investigative reporting style is marked by the inclusion of factual informa-
tion linked to related contextual issues. For example, factual information about sexual
harassment of teenagers in the workplace was tied to the context of employees who
are uninformed about their rights and managers who receive little training on profes-
sional conduct. All stories aired on television and became available on the ABC news
website, some with additional material. They did not contain negatively compelling
images as operationalized by Newhagen and Reeves (1992). The civic importance of
the story issue and its potential to resonate across gender and socioeconomic groups
were used as guidelines for selection. For example, a story about illegal trade of Chi-
nese prisoner body parts was excluded based on the argument that its international
scope might not draw similar levels of interest and identification from all participants.
The chosen eight stories were about (a) corruption in higher administration of Federal
Public Housing, (b) illegal immigrant child labor in agriculture, (c) sleep-deprivation
among airline pilots, (d) malfunctioning brakes on Toyota cars, (e) abusive and illegal
debt collection practices, (f) sexual harassment of teenage employees in the fast food
industry, (g) animal abuse in milk production, (h) lethal but legal drugs.

Dependent variables
Memory was assessed using five-option multiple choice questions, at two points, 1
week apart. Simple verbal recognition questions featured a verbal prompt and ver-
bal answer options whereas visual recognition questions had a verbal prompt with
visual options to choose from (see Figure 1 for sample questions). Simple factual
recognition measurement, as is often done in studies of this kind, targeted familiarity
with the material and featured classic encoding measures. Each participant answered
a total of 64 simple recognition questions—16 in each modality (32 total) at each
time point (64 in total). Because simple recognition tests are criticized for not assess-
ing depth in understanding of issues, the study reported here developed questions
with the aim to get to comprehension. Applied knowledge or comprehension was
measured with one visual and one verbal question, per story, per time point, adding
up to another 32 questions in total—eight visual, eight verbal at each time point of
measurement. These questions required reasoning and called for application of the
verbal and visual material presented in the experimental stimuli. For example, simple
recognition (visual and verbal) of who regulates debt collection is enough for a correct answer, as shown in Figure 1. Comprehension, on the other hand, required not only remembering information given in the story (i.e., advice to consumers on how to protect themselves against collector abuse) but also application of that information in selecting an answer. Verbal and visual questions for recognition and comprehension were designed so that content and difficulty levels were comparable across modalities. Stimuli did not include negatively compelling images and therefore the memory and comprehension tests were also void of such material. Still images of people (serving coffee, walking on the street, in interview), objects (blueberries, tape recorder, cars), and places (airport, street scenes, home interior) were used.

**Procedure**

Data were collected from one participant at a time. Each was greeted at the experimental room that resembled a home/work office and then asked to take a seat at a desktop computer. Here a participant received information and instructions about the data collection activities. When they were ready, the viewing process was activated by the participant. The stories were presented on a computer screen with
a simple advance button to move linearly through the eight stories. After each story, participants answered evaluative questions. These and demographic and media use items (administered after viewing was completed) served as memory distractors. Memory and comprehension measures were completed next. Participants were thanked and scheduled for the second data collection a week later. There were no stimuli to watch at the second time point. Similar procedures were followed to collect memory data at Time 2.

Findings

Mixed (between- and within-subjects) ANOVA (analysis of variance) procedures were conducted on simple recognition and comprehension measures: 2 (education level of participants: higher and lower) × 2 (test modality: visual and verbal measures) × 2 (time: immediately after exposure and a week later). Results are summarized in Table 1. Post hoc paired comparisons were done to identify the critical cells in significant models.

Testing the knowledge gap across the board

The first and second hypotheses required testing main effects for education. Knowledge gaps were confirmed for both verbal simple recognition and verbal comprehension measures. Higher educated participants ($M = 5.96; SE = .19$) had higher verbal simple recognition scores than lower educated participants ($M = 3.79; SE = .19$). Similarly, verbal comprehension scores were significantly higher for the high ($M = 3.70; SE = .12$) than low ($M = 2.11; SE = .12$) education group.

Testing the impact of modality

Hypothesis 3 made a forecast for modality main effects on both recognition and comprehension tests such that visual tests would produce higher scores than verbal tests. This hypothesis was also supported. As Table 1 shows, there was a significant main effect in the predicted direction for test modality on simple recognition (visual: $M = 6.04, SE = .12$; verbal: $M = 4.88, SE = .13$) and comprehension (visual: $M = 3.15, SE = .08$; verbal: $M = 2.91, SE = .08$).

Tests at the crossing of education and modality

RQ1 prompted a sequence of tests to assess the influence of different question modalities on knowledge acquisition across education groups. In short, there were significant interaction effects for modality and education on recognition and comprehension, as depicted in Figures 2 and 3. Overall, the low education group was more sensitive to modality differences. Post hoc paired comparisons confirmed that asking questions visually narrowed the knowledge gap. Yet, there was a persistent gap between education groups on both visual (low education: $M = 5.39, SE = .16$; high education: $M = 6.69, SE = .16$), $t(78) = -5.50, p = .001$, and verbal (low education: $M = 3.79, SE = .19$; high education: $M = 5.96, SE = .19$), $t(78) = -8.02,$
Table 1  F-Test Results for Analysis of Variance on Simple Recognition and Comprehension Measures

<table>
<thead>
<tr>
<th>Variables</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
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<tbody>
<tr>
<td><strong>Verbal measures only</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple recognition:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Effect, Education (H1)</td>
<td>64.47</td>
<td>.001</td>
<td>.452</td>
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<tr>
<td>Comprehension:</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Main Effect, Education (H2)</td>
<td>92.230</td>
<td>.001</td>
<td>.542</td>
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<td><strong>Simple recognition — full model</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Main Effect, Education</td>
<td>61.11</td>
<td>.001</td>
<td>.443</td>
</tr>
<tr>
<td>Main Effect, Modality (H3)</td>
<td>91.23</td>
<td>.001</td>
<td>.195</td>
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<tr>
<td>Education × Modality (RQ1)</td>
<td>12.96</td>
<td>.001</td>
<td>.028</td>
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<tr>
<td>Main Effect, Time</td>
<td>32.69</td>
<td>.001</td>
<td>.075</td>
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<tr>
<td>Time × Education (H4)</td>
<td>1.59</td>
<td>.211</td>
<td>.004</td>
</tr>
<tr>
<td>Time × Modality</td>
<td>.27</td>
<td>.605</td>
<td>.001</td>
</tr>
<tr>
<td>Time × Education × Modality (RQ2)</td>
<td>.002</td>
<td>.962</td>
<td>.000</td>
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<tr>
<td><strong>Comprehension — full model</strong></td>
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<tr>
<td>Main Effect, Education</td>
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<td>.487</td>
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<td>.001</td>
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<tr>
<td>Main Effect, Time</td>
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<td>.075</td>
<td>.014</td>
</tr>
<tr>
<td>Time × Education (H4)</td>
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<td>.075</td>
<td>.014</td>
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<tr>
<td>Time × Modality</td>
<td>8.55</td>
<td>.005</td>
<td>.008</td>
</tr>
<tr>
<td>Time × Education × Modality (RQ2)</td>
<td>.64</td>
<td>.428</td>
<td>.001</td>
</tr>
</tbody>
</table>

Note: df = 1.

$p = .001$, recognition measures. Yet, from Figure 2 it is clear that the gap narrowed on visual measures. Moreover, both education groups, low: $t(39) = 7.40, p = .001$; high: $t(39) = 5.70, p = .001$, scored significantly higher in visual, low: $M = 5.39, SE = .16$; high: $M = 6.69, SE = .16$, than verbal, low: $M = 3.79, SE = .19$; high: $M = 5.96, SE = .19$, recognition.

Figure 3 shows that comprehension data followed the trend of simple recognition. The knowledge gap was smaller for the visual than verbal measures, yet large enough to be statistically significant for both modalities: $t(78) = -6.01, p = .001$ and $t(78) = -9.60, p = .001$, respectively. Strikingly, while the low education group performed significantly better on visual ($M = 2.69, SE = .11$) than on verbal ($M = 2.12, SE = .12$) comprehension questions: $t(39) = 5.00, p = .001$, higher-educated people did not differ significantly in their comprehension of news across the two modalities: visual: $M = 3.60, SE = .11$; verbal: $M = 3.70, SE = .12, t(39) = -1.87, p = .069$.

Testing the time factor
Because lasting knowledge of social issues is conceptually linked to the idea of informed citizenship, the fourth hypothesis tested for time influences on memory
formation of news. The low education group was expected to show more simple recognition and comprehension memory decay than the high education group.

There were main effects for time on simple recognition measures (see Table 1) such that memory decay significantly progressed from Time 1 ($M = 5.83$, $SE = .13$) to a week later, at Time 2 ($M = 5.10$, $SE = .12$). Comprehension faded less dramatically over time (Time 1: $M = 3.12$, $SE = .08$; Time 2: $M = 2.94$, $SE = .09$), indicated by the main effect that only approached significance (see Table 1). It appears that once information is comprehended, as opposed to being simply encoded, it is less vulnerable to decay.

The fourth hypothesis, predicting a Time $\times$ Education interaction effect, found sparse support in this data set (see Table 1). The Time $\times$ Education interaction on simple recognition was not significant and it only approached significance on comprehension. Thus, recognition memory for simple facts, regardless of modality, decayed across education groups at a similar rate. Yet, comprehension decayed faster for the low education group. In fact, post hoc paired comparisons showed that the low education group was comprehending significantly better at Time 1 ($M = 2.59$, $SE = .12$) than Time 2 ($M = 2.23$, $SE = .13$), $t(39) = 2.07$, $p = .045$. The high education group’s comprehension held at exactly the same level ($M = 3.65$, $SE = .13$) over time ($t < 1$). This is graphically represented in Figure 4. Also noteworthy is that the
comprehension gap was significant at both time points: Time 1, $t(78) = -6.42$, $p = .001$ and Time 2, $t(78) = -7.74$, $p = .001$.

Although there were no predictions for Time $\times$ Modality interaction effects, a significant one (on comprehension) emerged from the ANOVA procedures used here to test hypotheses (see Table 1 and Figure 5). Regardless of participant education level, visual comprehension decayed less over time than verbal comprehension.
Post hoc paired comparisons of cells showed that there was a significant difference, \( t(79) = 3.94, p = .001 \), between visual (\( M = 3.13, SE = .09 \)) and verbal (\( M = 2.75, SE = .12 \)) comprehension at Time 2 and also a statistically notable decay of verbal comprehension (Time 1: \( M = 3.07, SE = .09 \); Time 2: \( M = 2.75, SE = .11 \)) over time, \( t(79) = 2.85, p = .006 \). No other cell comparisons produced significant differences.

RQ2 prompts testing for a three-way interaction of Education, Modality, and Time to compare gap sizes across visual and verbal modalities, over time. Neither the simple recognition nor comprehension three-way interactions were significant (see Table 1). The absence of interactions on both knowledge measures suggests that the intersection of independent variables is statistically unremarkable. Nonetheless, secondary analyses and visualizing them in graphic form provided clues to latent associations that might not surface in an overall interaction assessment. Figure 6 offers a side-by-side view of these results. The simple recognition graph illustrates the parallel influence of time on memory decay for both education groups with verbal testing producing lower scores than visual testing. Unsurprisingly, all post hoc paired comparisons were statistically significant, as can be expected from previously reported main effects and two-way interactions. Thus, while there is plenty of variance within levels of independent variables, it does not spill out in statistical association across independent variables.

Secondary analyses for comprehension, dissimilarly to simple recognition, showed reciprocal relationships across independent variables. From Figure 6 it is clear that lines cross and diverge in unparallel patterns. The high education group’s scores produced statistically sapless comparisons—they were practically immune to variation in test modality over time. Low education participants, in stark contrast,
showed significant over time decay in verbal, $t(39) = 2.279, p = .009$, compared to visual, $t(39) = .977, p = .334$, comprehension scores. To clarify this point, Figure 6 graphically shows how citizens with lower levels of education had diminished capacity in showcasing their comprehension of issues in verbal tests across time points. Visual tests of comprehension did not produce a significant depreciation over time, as is also clear from Figure 6.

**Concluding thoughts**

The results of this study offer the first known confirmation of the knowledge gap based on comparable visual and verbal knowledge measures. At the same time, markers of visual primacy also emerged from this data set. For example, there were robust main effects for modality (verbal vs. visual) on both memory and comprehension tests. Thus when traditionally used verbal recognition memory measures were matched by visual counterparts, participants (regardless of education level) performed better in visual than verbal tests. It is also clear that for comprehension, visual tests produced less evidence of time decay than the equivalent verbal measures. These findings provide reason to be somewhat cautious about the size of knowledge gaps that have been reported over more than 40 years of mostly survey research, based exclusively on verbal measures of knowledge. Indeed, education-based inequities in knowledge gain showed up with more vigor when verbal than visual measures were used. It is important to keep in mind though that while information acquisition gaps shrunk across test modalities, they did not disappear. Moreover, compared to education, modality
main effect sizes were small. Thus, the knowledge gap remains robust regardless of test modality and time delay. In that sense, Tichenor et al.’s (1970) knowledge gap hypothesis gained another evidentiary foothold in this data set.

Althaus (2012) recommends our discipline would benefit from normative assessments that situate evaluative scholarly stances within larger debates. The inevitability of audiovisual screen-based technology as the dominant future conduit of media use prompted us to take stock of existing knowledge measures, stretching and adapting them into visual instruments of measurement. Doing so strays from the dominant research paradigm, grounded in enlightenment convictions about the supremacy of rational thought, facilitated by words. Testing the knowledge gap visually aligns with political scientists such as Doris Graber and Markus Prior who have pioneered the idea that both visual and verbal modalities should be used to measure news retention and knowledge (Graber, 1994, 1996; Prior, 2014). As Prior (2014) cautioned, however, it is not always possible to ask questions visually. In working to accomplish this goal we discovered the extraordinary challenge of posing the same questions in two modalities, which probably explains why researchers have avoided visual measures for so long. Yet, as Figure 1 demonstrates, comparable measures for both modalities testing simple recognition and applied conceptual knowledge (comprehension) can be accomplished.

Moving beyond simple recognition measures generated important insights. A growing number of scholars have noted that recognition memory tests might not offer an assessment of knowledge that would capacitate informed citizenship. Compared to other measures of information gain (e.g., simple recognition, cued recall, or free recall), lasting comprehension is arguably the grandest of achievements in knowledge acquisition. This cognitive accomplishment is also central to the traditional mission of journalism: to inform citizens, across all demographic lines, for participatory democratic practice.

In this data set, different patterns emerged for education groups on simple recognition memory and comprehension over time. While simple recognition memory decayed at similar levels for both groups over the course of 1 week, comprehension declined only in the low education group. This finding deserves further investigation to find out if (a) comprehended material is more robust over time than encoded details, once it is committed to memory and (b) if this information processing aptitude is a byproduct of formal education. If the trend (education helps to retain comprehension) holds up under further scrutiny, it might be indicative of a cognitive strategy not to exhaust finite cognitive means in the service of absorbing and retaining simple details. Perhaps this shows a preference for deriving insights (e.g., what to do when a debt collector is abusive or judging who is responsible for illegal child labor) on how to navigate a complicated social environment. Future research is needed to test this differential in managing cognitive reserves. It might very well be that citizens retain what is conducive to productive maneuvering through life (comprehension) more than scattered details (simple recognition). Differential life and occupational demands across high- and low-education groups might lead to
different habitual cognitive strategies (e.g., automaticity, elaboration, analytical) that serve optimal functioning in response to environmental demands. Clearly, different memory measures produce rifts across education groups. Of particular interest is the intersection of education, modality, and time delay. Lower education groups show memory decay most clearly for verbal comprehension. Future research, with adequate statistical power to detect three-way interactions, is needed to shed more light on how images might cognitively capacitate people with lower education levels. Moreover, field experiments and ethnographic work could advance insight into how different education groups use media in an increasingly screen-based environment. This study’s data set suggests that, in the longer term, high-education groups seem better positioned to employ encoded information to the benefit of comprehension. These information navigation skills are likely to perpetuate existing education-based social and economic hierarchies. From a macro vantage point, incorporating media literacy (with emphasis on visuality) in formal education curricula seems overdue.

This study offers an increment in slow-rising evidence that images should be included in assessments of knowledge. The structural exclusion of citizens with lower levels of formal education from experimental studies through the overuse of convenient undergraduate subject pools is a matter of weak (but sometimes tolerable) external validity in social science practice. What is untenable, however, is continued verbal-only measures of how citizens acquire information from media. This tradition engenders a type of measurement bias against citizens with lower levels of education who have greater ability to exhibit what they encode and comprehend through visual assessments. At the risk of overstatement: It is time for an amiable ontological defection from The Gutenberg Legacy.

References
Testing the Knowledge Gap Visually

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