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Knowledge Mediation and Narrowed Polysemy in Journalistic Interactive Visualizations

INBAL KLEIN-AVRAHAM
ZVI REICH
Ben-Gurion University of the Negev, Israel

This article explores the extent to which journalistic interactive visualizations (JIVs) carry out their role as a unique form of knowledge that is open for users' exploration and reading. To do so, we offer a tripartite epistemic model that merges existing theoretical approaches to journalistic, visual, and interactive knowledge. The study uses qualitative content analysis of items from eight leading news sites: *New York Times*, *Wall Street Journal*, *Guardian*, *Economist*, *Haaretz*, *Calcalist*, *Irish Times*, and *The Currency*. Findings show that contrary to their uniquely open potential, most JIVs are designed to narrow users' space for autonomous reading by employing two types of practices—unfitting visualization and naturalization of particular conclusions—which this article maps and exemplifies. The article concludes with a set of preliminary considerations for guiding a more cautious and democratic production of JIVs.

Keywords: visual journalism, interactive infographics, JIVs, journalistic knowledge, polysemy, quality journalism, visual rhetoric

Recent studies have repeatedly explored the use of interactive visualizations to limit the impact of biased journalistic reporting or to combat the spread of misinformation (e.g., Karduni et al., 2018; Koivunen-Niemi & Masoodian, 2020; Spinde, Jeggle, Haupt, Gaissmaier, & Giese, 2022; Zheng & Ma, 2022). However, the question arises as to whether journalistic interactive visualizations (hereinafter JIVs) are actually used to exploit their uniquely efficient and persuasive potential, promoting democratic and public-serving journalism. Advancing toward answering this question, the study focuses on knowledge mediation through JIVs.

JIVs are modifiable, illustrated items published on news or news-like websites. These dynamic visuals with alterable components invite users to influence the knowledge presentation or the knowledge presented. JIVs come in many forms, for example, scrollytelling (i.e., an item in which the scrolling function unfolds the story and its visual presentation) about environmental threats in Mexico (see Whelan, Ruiz, & Bracco, 2020), an interactive infographic explaining social distancing (Parshina-Kottas, Saget, Patanjali, Fleisher, & Gianorsoli, 2020), a data visualization on Merkel's successor (*Who Will Succeed Angela Merkel?*,

Inbal Klein-Avraham: inbalavr@post.bgu.ac.il
Zvi Reich: zreich@bgu.ac.il
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2021) in Germany, an interactive presentation about Trump's presidency (Smith & Longden, 2021), and any other form of interactive-visual journalism.

JIVs are a complex, impressive form of journalistic knowledge (Klein-Avraham & Reich, 2022). Their visual display and interactive interface inject additional epistemic aspects that affect their production (e.g., Hannaford, 2015; Klein-Avraham & Reich, 2022), the communication process (e.g., Bogost, 2007; Cairo, 2019; Franconeri, Padilla, Shah, Zacks, & Hullman, 2021), and information reception (e.g., Borgo et al., 2012; Schwabish, 2021). Said epistemic aspects are often acknowledged in parallel discourses, that is, epistemic discourses that focus distinctly on journalism (e.g., Ekström & Westlund, 2019), visualization (e.g., Drucker, 2020), or interactivity (e.g., Bogost, 2007). To accommodate a holistic yet clear discussion about the epistemology of JIVs, this article addresses the three facets that characterize JIVs as distinct forms of knowledge: journalistic knowledge, visual knowledge, and interactive knowledge.

This holistic and multidisciplinary perspective elucidates the outstanding epistemic powers that JIVs have as a form of knowledge (see also Ramsälv, Ekström, & Westlund, 2023). At their core and as a whole, JIVs are a form of journalistic knowledge (Ramsälv et al., 2023) that plays a central and influential role in democratic society (Ekström, 2002; Ekström & Westlund, 2019). Adding a visual display to that not only summons users to invest more cognitive resources (Franconeri et al., 2021) but also supports clearer communication (Ishii, Lyons, & Carr, 2019; see also Borgo et al., 2012; Schwabish, 2021) while serving as a powerful rhetoric tool (Cairo, 2019; Henik & Tzelgov, 1982; Pandey, Rall, Satterthwaite, Nov, & Bertini, 2015). Adding an interactive infrastructure to that, in turn, infuses heuristics used to evaluate both the mediated knowledge and the website (Sundar, Jia, Waddell, & Huang, 2015) and choice architecture that functions, too, as a persuasion tool (Bogost, 2007; Thaler, 2018).

Simultaneously, however, this triple-facet nature of JIVs involves a set of challenges that are intertwined in the production process of JIVs and the considerations involved (e.g., Engebretsen, Kennedy, & Weber, 2018; Klein-Avraham & Reich, 2022; Tandoc & Oh, 2017). Like all journalistic content, JIVs are first and foremost subjected to journalistic considerations and norms (see Ramsälv et al., 2023). However, incorporating both visualization and interactivity, JIVs are also bound to aesthetic, graphic (Drucker, 2020), and programming considerations and norms (Manovich, 2001).

Hence, JIVs constitute a fascinating form of knowledge. Their triple-faced nature incorporates multiple benefits as a knowledge form, an effective triple-layer rhetorical power, and a set of challenges associated with their production. Considering their persistent presence and increasing growth in the journalistic landscape, JIVs are an impressive form of knowledge—one that calls for scholarly attention.

This study explores how JIVs mediate knowledge, considering their unique characteristics and epistemic and rhetorical powers, by combining a theoretical epistemic approach and a methodological semiotic approach. The study is based on a qualitative content analysis of 200 JIVs sampled from eight leading general and financial news sites.

Findings reveal that the outstanding epistemic powers of JIVs are often harnessed to narrow polysemous reading, that is, limiting users' independent reading, interpretation, and conclusions. In other

words, instead of leveraging their impressive and complex nature to promote democratic and open-minded journalism, JIVs are often used as a means of argumentation and persuasion. Manifestations of contrast we found straightforward and unequivocal, as one can see, for example, in a JIV that allows users to tell their own story and reach their own insights (e.g., *Explore the Border*, n.d.), compared with a JIV that offers a single and limited narrative (Huang, Saget, & Ward, 2017).

JIVs as a Form of Knowledge

To account for the triple-facet nature of JIVs—and lacking a single theoretical framework to do so—we offer a tripartite epistemic model that merges three theoretical discourses (see above), which separately address epistemologies and characteristics of journalistic, visual, and interactive forms of knowledge. As shown in Figure 1, we juxtapose the potential strengths, weaknesses, and quality standards that rise in each discourse and indicate the similarities to phrase a set of expectations of quality in JIVs as a form of knowledge.

Journalistic Knowledge

Journalism is a central and influential knowledge-producing institution in society (Ekström & Westlund, 2019) and a significant source of information (Ekström, 2002). It practices judgment about reality and functions as a conveyor of social conventions (Carlson, 2018; Ericson, 1998), as journalists' reports and classifications of people and events are perceived by their audiences as natural and logical.

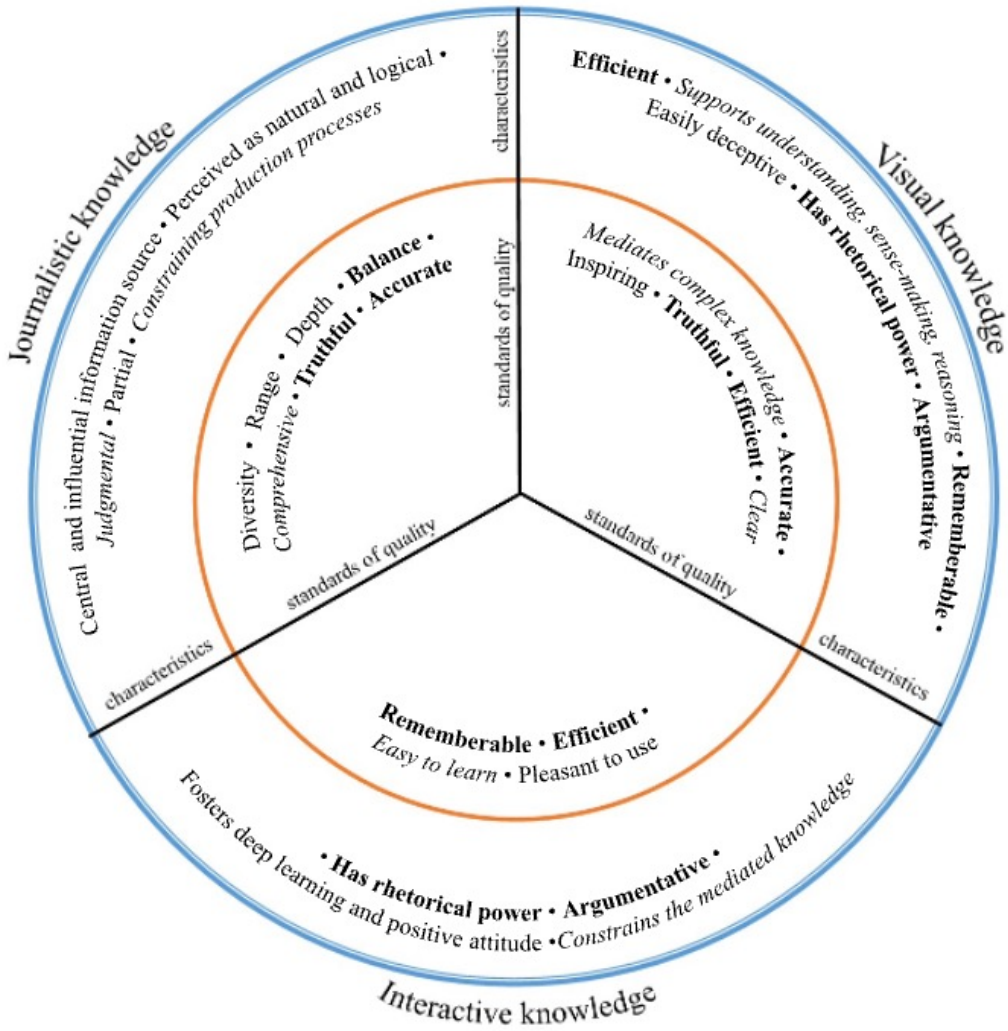

Figure 1. A tripartite epistemic model, marking the similar and corresponding characteristics and quality standards of the three basic forms of knowledge: journalistic, visual, and interactive.

Although "associated with claims to truth, promising to know with high certainty and provide authoritative information about current events" (Ekström & Westlund, 2019, p. 7), news can carry limited insight into "what has occurred and why this matters" (Carlson, 2018, p. 1760). Journalistic knowledge has numerous limitations, ranging from the interest in deviance through reliance on third-party testimonies to interpretations limited to given contexts (Ericson, 1998). Journalistic knowledge is regularly subjected to public scrutiny, mainly because of its "framing choices, story placement, and omissions" (Carlson, 2018, p. 1760).

These limitations are rooted, inter alia, in the personal, professional, organizational, and institutional procedures, routines, norms, conventions, and values that shape and construct journalistic messages (Shoemaker & Reese, 2014). In other words, journalistic knowledge is subjected to producers' propensities and ideologies, available resources, and the expertise and interests of its sources (Reich, 2014; Shoemaker & Reese, 2014).

R. K. Nielsen (2017) suggests that JIVs represent higher-order journalistic knowledge, classified as *news-as-relations.* He is referring to "forms of long-form, explanatory, data-enriched journalism [. . .], concerned with questions of causality [i.e., why does it happen] and teleology [i.e., for what purpose], with relations between events, and that offer this in a far more accessible and timely fashion" (R. K. Nielsen, 2017, p. 106). As a form of *news-as-relations*, JIVs are associated with "in-depth, detailed, and enduring investigations" (R. K. Nielsen, 2017, p. 106), with higher-order journalistic knowledge, contextualization, and an accepted quality standard in journalism (Lacy & Rosenstiel, 2015).

Quality journalism is often recognized as truthful, balanced, accurate, and comprehensive reporting (Lacy & Rosenstiel, 2015). It is also associated with (a) *diversity*, in the sense of equity and openness, inside stories or within publication offerings; (b) a *range* of sources and perspectives that can tame overriding biases and enhance intellectual independence; and (c) *depth,* by contextualizing the core information (Lacy & Rosenstiel, 2015). Some of these qualities—such as intellectual independence, comprehensiveness, truthfulness, and accuracy—are echoed in quality standards of visual knowledge.

Visual Knowledge

Drucker (2020) distinguishes between two types of visual knowledge: representational and nonrepresentational visualizations. While the former "assume a secondary status, as surrogates that stand for preexisting, a priori, already formulated knowledge" (Drucker, 2020, p.11), the latter produce "knowledge in a primary mode" (Drucker, 2020, p. 12) by the mere act of visualizing. In scientific contexts, published visualizations usually function as a confirmation of researchers' claims (Perini, 2005) rather than devices for testing scholarly hypotheses.

As mentioned above, visualizations make for a highly effective communicative tool (Drucker, 2014, 2020; Franconeri et al., 2021; Schwabish, 2021). They can communicate complex knowledge clearly and efficiently (Franconeri et al., 2021; Greussing, Kessler, & Boomgaarden, 2020; Jacob, 2020) while supporting understanding, reasoning, sense-making, and memorization (Borkin et al., 2013; Nærland, 2020; Tandoc & Oh, 2017). Harnessing particular cognatic processing (Franconeri et al., 2021; see also Henik & Tzelgov, 1982), visualizations are also distinctly persuasive to the point of misleading audiences (Kennedy, Hill, Allen, & Kirk, 2016; Pandey et al., 2015; Sacchi, Agnoli, & Loftus, 2007). Their rhetorical power is enabled, inter alia, by an overall sense of impersonality (i.e., unaffected by humans) and objectivity (Kennedy et al., 2016).

In practice, though, visualizations always involve heavy mediation (Drucker, 2014; Hullman & Diakopoulos, 2011). Their basic structure carries an argument that can easily be harnessed to advance a selected line of reasoning (Drucker, 2020). Since the visual language system lacks an articulated syntax

(Perini, 2005), visual knowledge relies heavily on eliciting associations and connotations (Drucker, 2014; Hullman & Diakopoulos, 2011; Jacob, 2020), thus cueing conscious and unconscious readings. For example, a black background in a visual display of casualties conveys a sense of grief. In contrast, the same black background in a historical item can inject a tone of nostalgia.

As repeatedly shown, not all visualizations are necessarily reliable. Tufte (2001) defines visual excellence and integrity as clear, precise, minimal, and efficient communication of complex knowledge. Excellent visualization, according to Tufte (2001), evokes "the greatest number of ideas" (p. 51) while portraying a truthful, accurate, and consistent account of the data (see also Cairo, 2016; Drucker, 2014).

Like quality journalism, visual knowledge aims to communicate complex knowledge truthfully and accurately. Visual knowledge also encapsulates great rhetorical power, such as interactive knowledge.

Interactive Knowledge

We refer to interactivity as a technological feature (Nash, 2012) that "allows users various forms of control over the technical interface" (Larsson, 2012, pp. 253–254). As its level or type alternates (i.e., type of cue and effect; see Young, Hermida, & Fulda, 2018), interactivity affords users different degrees of control over knowledge mediation (e.g., advancing a given narrative vs. drilling down a multilayered data set).

Though classifications of interactivity levels are varied (e.g., Schulmeister, 2003), they share some consistent principles. They range from minimal alterations to the presentation of fixed knowledge (e.g., advancing a narrative) through far-reaching visual manipulations of pre-given content (e.g., filtering or drill-down) to high interactivity levels that enable entry and analysis of new content (e.g., using a social calculator). Higher levels of interactivity are associated with high contingency, exposing idiosyncratic content to different users according to their unique sequences of clicking hyperlinks (Sundar et al., 2015).

High contingency, in turn, positively affects users' knowledge acquisition. It fosters deep learning and quicker recall and application of the acquired knowledge (Evans & Gibbons, 2007). High contingency also increases users' engagement, prompting positive attitudes toward both the mediated knowledge and the respective webpage (Sundar et al., 2015).

Like visualizations, interactivity has great rhetorical powers, termed *procedural rhetoric* (Bogost, 2007), as its architecture can construct and unfold arguments (see also Raessens, 2015; Thaler, 2018). Hence, interactivity can be used to amplify visual arguments in JIVs by supporting knowledge acquisition and promoting rhetorical functions.

In a journalistic context, interactivity can play a dual function: sustaining quality journalism (Lacy & Rosenstiel, 2015) while bounding the mediated knowledge to a set of technological constraints (Manovich, 2001). Interactivity can be harnessed to represent the mediated knowledge from multiple perspectives, thus enhancing the *range* of journalistic messages (discussed above). Conversely, using interactivity

subordinates the mediated knowledge to a set of cultural (e.g., reading direction) and computational (e.g., algorithmic logic) constraints associated with the digital interface (Bogost, 2007; Manovich, 2001).

When it comes to quality standards, the design of interactivity is often discussed in terms of user experience (hereinafter UX; J. Nielsen, 1993). UX considerations emphasize user accessibility to potential knowledge (J. Nielsen, 1993) by supporting learning, efficient and pleasant use, and memorizing. Once users learn how to use the system, they can enjoy a high level of productivity. Following these guidelines, UX designers aim for aesthetic, lightweight, and responsive digital products.

Hence, while UX considerations correspond with the aims of quality visualization, such as clarity and simplicity, they are somewhat at odds with other visual and journalistic quality criteria. For example, UX standards aim for pleasantness, ease, and lightness, while journalistic and visual quality considerations seek to communicate comprehensive and complex knowledge (see Lacy & Rosenstiel, 2015; Tufte, 2001).

This composite of characteristics and standards, presented in Figure 1, marks the capacity of JIVs to mediate higher-order journalistic knowledge. When aptly constructed and designed, JIVs can efficiently, attractively, and understandably provide an accurate and truthful account of comprehensive and contextual knowledge with a sense of equity and openness while enhancing independent intellectual thinking. In an age of encouraging the critical consumption of news (e.g., Frechette, 2019), the great epistemic power of JIVs must not be harnessed to hinder such efforts. Instead, JIVs should be used to encourage autonomous thinking and independent interpretation of knowledge on current affairs, as further detailed below.

Knowledge Mediation by JIVs

JIVs are associated with a series of positive traits. They constitute an innovative and attractive storytelling tool (de Haan, Kruikemeier, Lecheler, Smit, & van der Nat, 2018; Kennedy et al., 2021), a marker of postindustrial journalism (Anderson, Bell, & Shirky, 2015), and associated with higher-order journalistic knowledge and quality journalism (as described above).

This uniqueness is translated into the production of JIVs, which differs from the one of traditional news (Engebretsen et al., 2018). It involves a new skill set (Tandoc & Oh, 2017; Usher, 2016), news values (Tandoc & Oh, 2017), larger co-productions, and greater costs (Hannaford, 2015; Loosen, 2021). The following addresses how these traits and conditions might reflect on the end product, considering JIVs' unique functions, storytelling capacities, potential argumentative use, and rhetorical attributes.

The literature often discusses the nature of JIVs as narratives (Weber, 2020; Weber, Engebretsen, & Kennedy, 2018). While many JIVs narrate or tell a story (Weber, 2020), others "show" the mediated knowledge (Weber, 2020; Weber et al., 2018), with or without enabling users to explore it on their own.

One can characterize a JIV on a continuum that ranges between *author-driven* and *user-driven* (Segel & Heer, 2010), based on the degree to which users can compile their own narrative. *Author-driven* narratives are linear, with heavy verbal messages and limited interactivity, and are associated with explanatory journalism. On the other hand, *user-driven narratives* are associated with exploratory

journalism. They tend to incorporate a high level of interactivity and lack both prescribed ordering and guiding messages (Weber, 2020; Weber et al., 2018).

Why do JIV producers turn to visual-interactive formats? On the one hand, they are using JIVs "to show something [. . .] that is hard to explain verbally" (Weber et al., 2018, pp. 197–198) and to "create a modern form of dialectic journalism" (Weber et al., 2018, p. 200). On the other hand, they maintain simplicity (Loosen, 2021), which could probably be easily described verbally, and give only an illusion of interactivity by providing linear and limited narratives (Appelgren, 2018). Given these contradictions between producers' functions and motivations, how, then, is knowledge eventually mediated via JIVs?

Although the literature points to the dissonance between producers' intentions and their final output and operationalizes the high standards expected from JIVs as a form of knowledge, it also provides no conclusive evidence of the extent to which these standards are met. Hence, this study is set to explore how JIVs mediate knowledge and whether they allow for autonomous reading and independent interpretation. It does so by focusing on the extent to which JIVs accurately and truthfully communicate comprehensive and contextual knowledge, allow independent exploration, and provide a sense of equity and openness. In doing so, the study attends to four *editorial layers* of meaning-making (see Hullman & Diakopoulos, 2011): the mediated knowledge, its visualization, its interactive design, and the accompanying textual messaging.

Methods

To explore knowledge mediation via JIVs, we conducted a qualitative content analysis. Employing a "*most different systems—similar outcomes"* design (Esser & Hanitzsch, 2012, p. 13; emphasis in original), we study eight leading news sites, one general and one financial, from four countries that represent larger and smaller news markets: *NYT, WSJ* (United States), *Guardian, Economist* (United Kingdom), *Haaretz,*[1] *Calcalist,*[2] (Israel)*, Irish Times,*[3] and *The Currency*[4] (Ireland). Following a comparative tradition that focuses on similarities (Esser & Hanitzsch, 2012), this study analyses reoccurring communicative practices, ensuring the findings are neither country nor outlet-specific.

[1] *Haaretz* is a leftwing-liberal "elitist" (Tenenboim-Weinblatt & Neiger, 2014) and rather central news outlet. Its website is the fourth top news site in Israel (*Top Websites Ranking*, 2023), available (mostly) for paying subscribers, and has an average of 3.5 million unique visitors per month (BZ, 2017).

[2] *Calcalist* is the top Israeli financial news site (*Top Websites Ranking*, 2023), associated with more popular journalism. This free-accessed website has 3.24 million unique visitors per month (Calcalist Service, 2019).

[3] *Irish Times* is "a quality broadsheet traditionally identified with the professional and managerial occupational classes" in Ireland (Marron & Brost, 2021, p. 281). Its website is available (mostly) to paying subscribers. With about 10.8 million unique users per month (*About the Irish Times*, n.d.), irishtimes.com is the second top news site in Ireland (*Top Websites Ranking*, 2023).

[4] *The Currency* is an online and subscription-only news outlet that focuses "on business, finance, economics, and public policy" (*About The Currency*, n.d., para. 2). Established in 2019, it is a young and relatively small organization.

Overall, 200 items were analyzed. Sampling was conducted in two phases: scraping and selection. During the first phase, we used the Search Engine Scraper (*Search Engine Scraper*, n.d.), employing various keywords and URL segments relevant to each website (e.g., "inurl:datablog" for the *Guardian* or "inurl:graphics" for *WSJ*). In the second phase, we conducted a *quota sampling* (Wimmer & Dominick, 2011) from the resulting outputs, choosing the first 25 non-sponsored JIVs with properly working interactive features while omitting duplicates, weekly features, and items with minimal complexity (e.g., containing only videos).

To decode how meanings are made and communicated, as well as the function and purpose of communicative features, the content analysis employed a semiotic approach (Kress, 2010). By "semiotic approach," we refer "to the exchange of messages and the system of signs that lie beneath them," focusing "on the interpretation of sign functions" (Matusitz, 2017, p. 1587). Dealing with multimodal texts (Kress, 2010), data gathering simultaneously paid attention to two parallel and interrelated layers of *meaning-making*. First, we coded attributes on their own accord, characterizing the visual design (e.g., use of color, type of visualization), the interactive design (e.g., interactive features, interactivity level), the mediated knowledge (e.g., numeric or textual data, topic), and the journalistic story (e.g., news beat, newsworthiness). Second, we coded the meanings made by the interplay of those attributes, for example, narrative openness, reliance on visualization versus text, visual accuracy and truthfulness, etc. Special attention was paid to rhetorical techniques and the degree to which users were allowed to construct their own narratives or reach their own conclusions.

Data analysis was conducted by one coder in three flows, employing a *Grounded Theory* approach (see Flick, 2009). In the first flow, a free and open coding process yielded an initial long list of categories, which were refined during the second flow, generalized in the third flow, and theorized into the model described throughout the findings.

To enhance coding credibility, we used peer examination (Anney, 2014) twice: during the first flow of the analysis, to verify the soundness of the categories, and during the third flow, to confirm the relevance and dependability of the findings.

Findings

The findings indicate that most JIVs published by the studied news organizations narrow polysemous reading. This means that rather than exploiting the unique capacity of JIVs to foster users' exploration and autonomous thinking, most JIVs advance particular interpretations and conclusions while suppressing contesting readings.

Take, for example, the private businesses' space race ("The Space Race is Dominated by New Contenders," 2018), which allows users a specific and limited story while blocking other alternative readings, such as a true comparison between entities (e.g., China vs. the United States). Ideally, the visualization could have allowed users a better sense of all the players in the global race to space, judging which of them were stronger, closer, and leading the race at different times; it could have allowed users to develop insights into the seeming associations between global power and involvement in the space race, on the drastic drop

in state launches during the 1990s and in NASA's lunches during the last decade, and much more. Instead, however, this JIV tells a single and simplistic story about the rise of commercial launches. Moreover, as this visualization omits so much information, it cannot be read as a standalone. To understand it, one must read and follow the written text.

Another example is Trump's possible nominees for the Federal Reserve Board (Shin, Davidson, & Van Dam, 2017). Instead of equally presenting the portraits of both acting board members and potential nominees (whose identities were mentioned in the text), the latter are represented by a duplicated portrait of Trump. In other words, instead of allowing users to evaluate the candidates themselves, the visualization points to the potential influence Trump will have on the board, as his portrait is presented all over the board. Moreover, in the course of narrowing polysemy, the item inaccurately implies that Trump not only has an equal influence to that of the other acting board members, but also a greater one because of his cumulative appearance.

These examples demonstrate why narrowing polysemy in JIVs is often a disappointing loss. Moreover, they demonstrate how narrowing polysemy can easily end up with hard-to-detect angling of the mediated knowledge. Putting it differently, even when said narrowed polysemy is not instrumentalized to promote tendentious interpretations, to the very least, it circumscribes the potential of JIVs to accurately and truthfully communicate comprehensive and contextual knowledge while providing a sense of openness and equity. In turn, circumscribing these quality standards depletes considerable parts of JIVs' journalistic, visual, and interactive quality.

Our analysis detects two types of practices that are being used to narrow polysemy in JIVs: unfitting visualization and naturalization of particular conclusions. The following subsections delineate the eight recognized practices for narrowing polysemy in JIVs, according to their two types (see Figure 2), while incorporating several examples. Some examples refer to the visual design and include a screenshot, whereas others include only a hyperlink to maintain the interactive features of the JIV. To communicate with non-Hebrew readers, all the examples are extracted from the six English-language websites. Unfortunately, most of them are paywalled, allowing free access to a limited number of items or none at all.

Unfitting Visualization

As suggested above, the findings indicate that the visualization of mediated knowledge is often designed to minimize users' space for independent interpretation. These practices include missing critical information, visual ambiguity, visual orchestration, and visual misrepresentation.

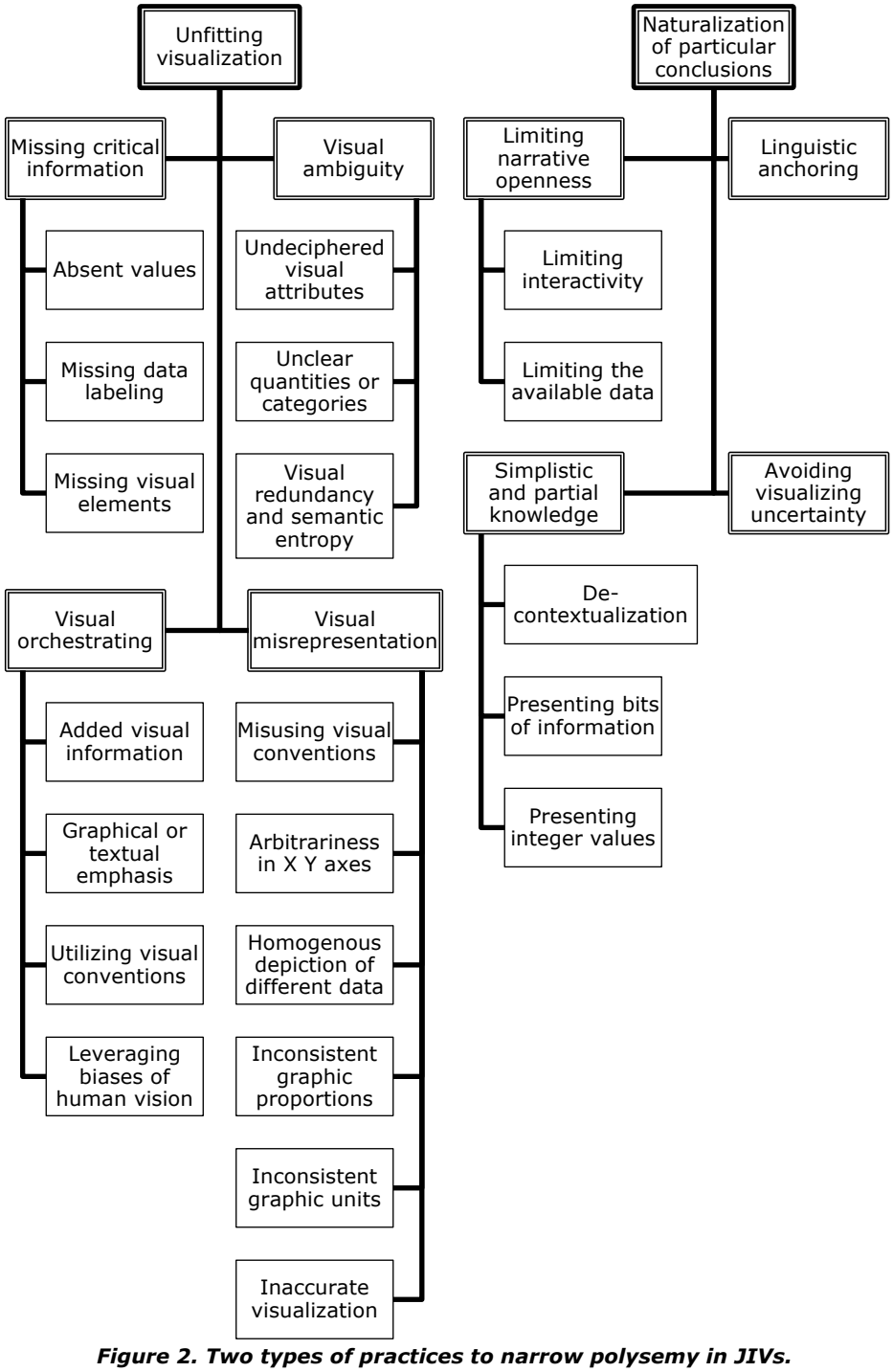

Figure 2. Two types of practices to narrow polysemy in JIVs.

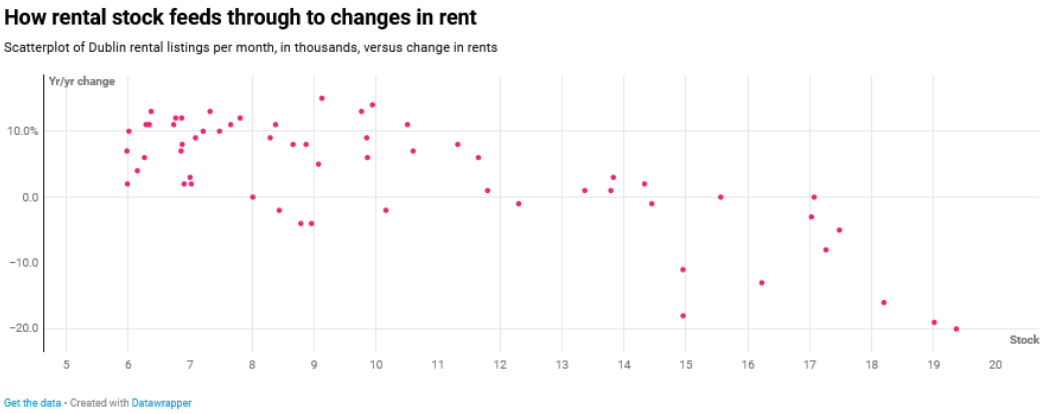

Figure 3. Missing information. The value each "dot" represents is unknown (Lyons, 2021, para. 6).

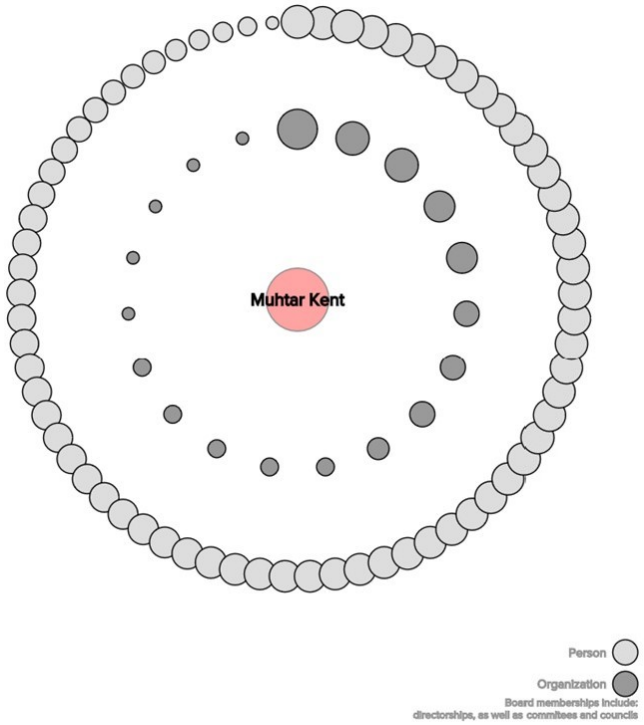

Figure 4. Visual Ambiguity—What does the changing diameter of the circles stand for? ("Drilling Down Into Davos Man," 2014, paragraph 4).

By *missing information*, we refer to the unavailability of visual, numerical, or textual elements essential for a clear and precise evaluation of the mediated knowledge. This can be seen in absent values (of quantities, measurements, or volume), missing data labeling, or missing visual elements that hinder critical evaluation, sometimes even comprehension, of the data. In this JIV (Lyons, 2021; see Figure 3), for example, the actual value of each "dot" in the scatterplot is missing. Although selective scale marks appear on the X- and Y-axes, the missing values force users to rely on authors' narration and interpretations, especially when they lack visual literacy and training in the critical assessment of visualizations.

Ambiguous depiction of the mediated knowledge also enhances users' dependence on authors' narration and interpretations. Such ambiguity can be seen in undeciphered visual attributes or items that use unclear quantities or categories. For example, in this JIV ("Drilling Down Into Davos Man," 2014; see Figure 4), it is unclear what the changing diameter of the circles stands for. Interestingly, the most frequent type of ambiguity was found in JIVs that visually displayed an overload of quantifiable values while suppressing their alphanumeric labeling.

Such combinations of visual redundancy and semantic entropy tend to emerge in visualizations of rich data with labels that appear (and disappear) on-demand or are nonexistent, like in this JIV (*What's Your Pay Gap?*, n.d.) about gender pay gaps. Although the design brilliantly depicts the consistent discrimination of women with regard to their salaries, the overload of superimposed visual signs impedes any attempt to evaluate the actual income gap between genders. Furthermore, one cannot explore this JIV and assess, for example, the percentage of occupations where female workers earn more, less, or similar to male employees. This prevailing technique, which can sometimes be justified professionally for aesthetic reasons, was found to be negligible when the visualization depicted the "raw" data. However, when the visualization limits itself to a particular interpretation, the resulting ambiguity limits the space for users' independent evaluation of the mediated knowledge. In such cases, ambiguous design functions as a rhetorical tool, confirming the accompanying textual message.

Visual orchestration refers to the use of specific visual cues (see above) to prompt a particular single reading and interpretation (see Franconeri et al., 2021). It can manifest in added visual information that invokes a particular extrapolation or by graphical and textual emphases that draw attention to specific parts of the visualization. Visual attributes can also be used to cue specific connotations or leverage the biases ingrained in the human visual system. For example, consider the gender pay gap JIV (*What's Your Pay Gap?*, n.d.) described earlier, which leverages the human vision's tendency to focus on overall trends rather than the location and meaning of individual marks. Indeed, putting extra visual weight on particular takes of the mediated knowledge is (more or less) an acceptable strategy to enhance clarity (e.g., Borgo et al., 2012; Cairo, 2019; Schwabish, 2021). However, we maintain that a clear visualization does not necessarily entail advancing particular interpretations, as further demonstrated below.

Visual misrepresentation presents visual inconsistencies with the data or with cultural and visual conventions so that the visualizations convey an inaccurate or incorrect interpretation of the mediated knowledge. This practice is often discussed in the literature in terms of *deceptive visualization*, as its misleading effect stems either from exaggeration/understatement of the facts or from reversing the message altogether (see Pandey et al., 2015). Despite their controversial nature, visual misrepresentations

are not rare. We found them in a series of JIVs that demonstrated distorted use of visual conventions (for example, a pie chart) that presents 94% as if it were 100% (see Keyes, 2021), arbitrary allocation of values on the X- or Y-axes (e.g., the X-axis begins at 10,000; see Bracken & Horgan-Jones, 2020), homogenous depiction of different data, inconsistent graphic proportions, inconsistent graphic units, and inaccurate visual presentations.

A JIV (Eastwood, Jones, & Wolfe, 2017; see Figure 5), which maps former President Trump's potential conflicts of interest based on his financial connections, is another example. This visualization conglomerates different entities—such as assets, companies, and people—with different "financial weights," uniformly presenting them. This practice exaggerates the effect of the data, giving the impression that Trump is "tied down" by an overwhelming accumulation of intricate forces. Additionally, this JIV exhibits ambiguity through visual redundancy combined with semiotic entropy and visual orchestration, placing a snot-nosed profile photo of Donald Trump at the center of this convoluted web of connections. Regardless of the political stance behind it, this JIV demonstrates a combination of practices from the unfitting visualization type and how they lead to angled reporting.

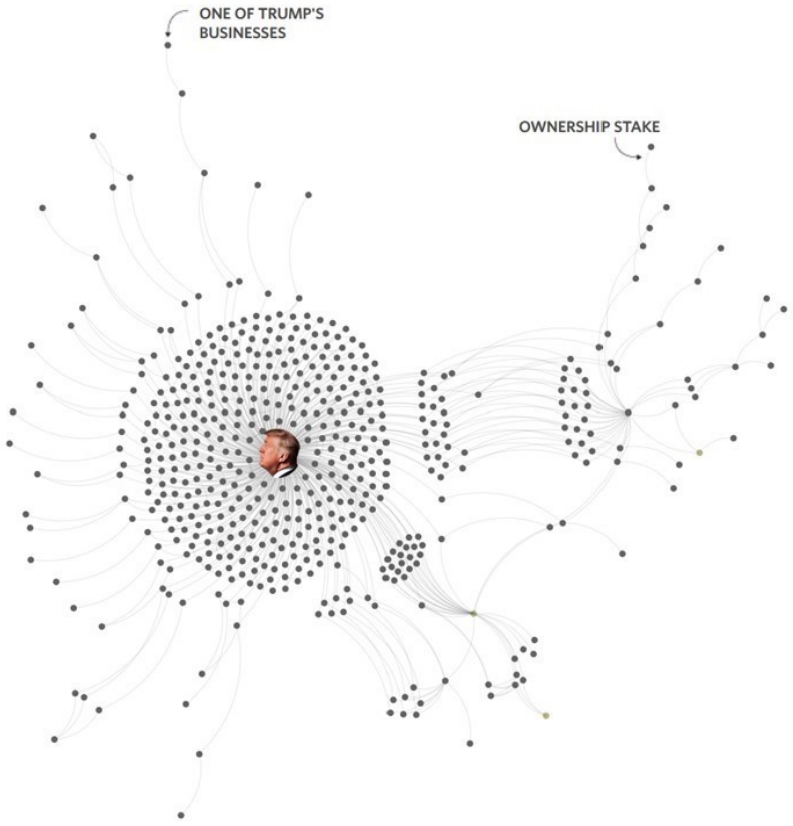

Figure 5. Deceptive visualization. Homogeneous presentation of different data (Eastwood et al., 2017).

Naturalizing Particular Conclusions

The second type of practice to narrow polysemy in JIVs is naturalizing particular conclusions and presenting knowledge in a constrained and purposeful manner so that the ensuing conclusion seems inevitable. Such practices, too, impede the capacity of JIVs to provide journalism and visualization of quality, frequently flattening the mediated knowledge and hindering users' independent sense-making. We recognize four such practices—limiting narrative openness, linguistic anchoring, mediating simplistic and partial knowledge, and avoiding visualizing uncertainty—which are delineated below.

The first practice that naturalizes particular conclusions is *limiting narrative openness*, thus steering users' "virtual stroll" toward a specific reading. The findings show that a vast majority of the studied JIVs used low to medium levels of narrative openness. Such restrictive narration was often attained either by limiting the filtering options of rich but fixed information or by providing an array of filtering options for limited volumes of information.

The concept of narrative openness paraphrases Segel and Heer's (2010) continuum (described above), referring to the level of interactivity and the extent to which it allows users to construct their own narratives and reach their own conclusions. Hence, narrative openness ranges between closed and highly open narratives. Closed narratives allow users to navigate toward a singular, predetermined conclusion (e.g., *Subterranean London—Immersive Interactive*, 2016). High levels of openness, however, allow users to compose their own narrative and reach their own conclusions, at least to some extent (e.g., Clark & Kiln, 2013; Van Dam, 2016). This practice incorporates the rhetorical power of interactivity by providing a constrained procedure that leads to particular ends.

Linguistic anchoring, alternatively, uses the text that accompanies JIVs as if it were a "voiceover" that leads to interpretive and connotative readings. For example, in a JIV by Pearce (2017), while the text narrates the story of LeBron James's record in the National Basketball Association (NBA), interactive visualization can be used to tell other stories, such as the characteristics of the NBA's most incredible talents. This finding became apparent when we considered which of the narratives—textual or visual—can be discarded with minimal loss of knowledge. Findings show that the text was consistently crucial for mediating the message. This practice is used to encumber alternative interpretations and conclusions while advancing a particular reading of the mediated knowledge.

The third practice for naturalizing particular conclusions involves mediating *oversimplified and partial knowledge*. More than informing the public, these JIVs are used to make a point by decontextualizing information, presenting only specific parts, or displaying integer rounded values. For example, a scrollytelling by Wolfe, Yeip, and Zinter (2016) explains the rise of Bernie Sanders in the Democrats' primary race of 2016 by cherry-picking bits of information, decontextualized quotations, and rounding numeric values so that they all support the preferred reading. Indeed, one may claim that mediating oversimplified and fragmented knowledge is a characteristic of journalism in general (Ekström, 2002; Ericson, 1998). However, it is highly disappointing and frustrating as far as JIVs are concerned, as it relinquishes the unique capacities of this "heavy-duty" form of knowledge to mediate comprehensive and contextual knowledge.

The last practice to naturalize unfolding conclusions is *avoiding visualizing uncertainty* (see MacEachren et al., 2012). While textual journalism regularly conveys limited certainty using linguistic modalities such as "perhaps" or "probably" (see Rom & Reich, 2020), equivalent visual practices were undetected, although existing. Moreover, the text accompanying the visualizations often refers to them as a direct representation of knowledge rather than a mediated one. The outcome, therefore, is a highly persuasive communication tool (see above) with non-limited certainty, which leaves a minimal room, or no room at all, for contested reading.

To sum up, these four practices to naturalize particular conclusions—limiting narrative openness, linguistic anchoring, mediating oversimplistic and partial knowledge, and avoiding visualizing uncertainty—eventually yield JIVs that suppress alternative interpretations and critical evaluation of the mediated knowledge. Sometimes, especially when combining several techniques at once, the "narrowing" design leads to tendentious reporting, as explained and demonstrated above.

As the eight practices presented above are prevalent in the vast majority of the studied cases, a few JIVs succeed in mediating complex and polysemous knowledge that allows independent interpretation and critical reading. Exploiting the interactive-visual interface, these rare JIVs facilitate and even encourage users' own inquiry and original thinking. They relate to users as active partners in processing, authoring, and narrating the information. See, for example, the Economist's chart of every world-cup goal (The Data Team, 2018) and the NYT's infographics about the shooting patterns of two NBA teams (see White, Ward, & Ericson, 2012). Despite their scarcity, such JIVs show that clarity can be gained while steering clear of advancing certain conclusions or particular points of view.

Discussion

Although adorned with outstanding epistemic powers—to efficiently mediate rich and complex knowledge while fostering autonomous thinking—most JIVs undergo a process of chipping at their polysemous readings, diminishing it into a narrowed predesigned one. By minimizing users' space for independent interpretation and reasoning, such JIVs impede the standards of quality journalism and quality visualization and undermine journalistic opportunities to constitute a free market of ideas.

Based on a critical qualitative content analysis of 200 JIVs from eight leading news sites *(NYT, WSJ, Guardian, Economist, Haaretz, Calcalist, Irish Times,* and *The Currency*), this study detected two types of practices for narrowing polysemous reading: the use of unfitting visualizations and the naturalization of particular conclusions. By unfitting visualization—that is, omitting critical information, creating visual ambiguity, employing visual orchestration, or visual misrepresentation—JIV producers promote a preferred narration and interpretation and encourage users to cast no doubt on the knowledge presented. By either limiting narrative openness, applying textual anchoring, oversimplifying the mediated knowledge, or avoiding visualizing uncertainty, JIV productions naturalize particular conclusions and dismiss alternative interpretations. Although probably not maliciously applied, both types of practices undermine readers' opportunities for critical evaluation of the mediated knowledge at times when—and in an information environment where—they are most needed (see Frechette, 2019).

One should bear in mind that narrowed polysemy, or promotions of *preferred readings* (see Hall, 2005), are not new, neither in news production nor in visualization. Journalists routinely narrow polysemy by choosing a narrative line field (e.g., Ericson, 1998) and framing a story (Entman, 1993). In visual journalism, too, every graphic construct conveys an argument (Drucker, 2022), and every published photo was selected, cropped, and captioned (e.g., Barnhurst, 1994) to narrow the range of connotations (Barthes, 1977).

Nevertheless, there is an unacceptable narrowing of polysemy, as the findings demonstrate. Beyond undermining the outstanding epistemic powers of JIVs described above and hindering their capacity to demonstrate higher-order journalistic knowledge (R. K. Nielsen, 2017), communicating fragmented and sometimes tendentious knowledge is especially hazardous in JIVs because of their outstanding rhetorical and persuasive powers (Bogost, 2007; Drucker, 2014). Studies show that at least some of the recognized practices to narrow polysemy can easily mislead audiences (Pandey et al., 2015), even when accompanied by accurate verbal explanations (O'Brien & Lauer, 2018). Nærland (2020) explains that at their worst, JIVs actually "contribute to the erosion of informed and critical citizenship" (p. 68).

Where, then, should one draw the line between acceptable and unacceptable uses of narrowed polysemy in JIVs?

There is an elusive line to be reached in the design and production of JIVs—a line that separates clarity from argumentation, visual cleanliness from vagueness, and journalistic attractiveness from inflated dramatization. Hence, designing and producing quality JIVs is a labyrinthine task. One that requires mitigating the complexities and challenges ingrained in the triple-facet nature of JIVs (see above), the journalistic realm with the crisis and realities it faces (Canavilhas, Campos Domínguez, & García Orosa, 2023; Pickard, 2020), as well as the particularities of each data set, event, or story.

Therefore, striving for a more cautious and democratic use of JIVs, we offer a set of preliminary considerations that incorporate a multidisciplinary perspective and may guide when and how narrowed polysemy should be incorporated into JIVs.

From a social-epistemology perspective (see Goldman, 1991), the polysemous reading of JIVs should be narrowed only when the communicated story is free from matters of belief, values, and tastes. On the other hand, narrowing polysemy in JIVs is encouraged when it cultivates the audience's well-being (Klein-Avraham & Reich, forthcoming; see also Goldman, 1991).

From a cognitive perspective (see Franconeri et al., 2021) and in the bounds of the social-epistemology one, narrowing polysemy in JIVs should be leveraged to "allow viewers to use their powerful visual systems to understand patterns in data across science, education, health, and public policy" (Franconeri et al., 2021, p.110).

From a behavioral perspective, narrowing polysemy in JIVs should be used to nudge users toward information and choices that will benefit users' lives, according to their own judgment (see Thaler, 2018), and not merely to "take control over the audience control" (Appelgren, 2018, p. 308).

To conclude, this study unravels how JIVs are being used to mediate knowledge, mapping two types of practices that narrow polysemous reading while suggesting guiding considerations as to when and how such practices should be used.

Although based on multinational data across time, the study is not free of limitations. Based on content analysis, it cannot reflect the actual effects of the narrowed polysemy on various audiences of JIVs. Hence, future studies are needed to explore how these and other practices affect knowledge acquisition among audiences or broaden the limited scope of the current study, for example, by conducting a cross-cultural comparison that will focus on differences between news organizations and countries.

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