Sequential images are not universal, or Caveats for using visual narratives in experimental tasks

Neil Cohn (neilcohn@visuallanguagelab.com)
Tilburg center for Cognition and Communication (TiCC), P.O. Box 90153, 5000 LE Tilburg, The Netherlands

Abstract

Sequential images have frequently been used as experimental stimuli in the cognitive and psychological sciences to explore topics like theory of mind, temporal cognition, discourse, social intelligence, and event sequencing, among others. The assumption has been that sequential images provide a fairly universal and transparent stimuli that require little to no learning to decode, and thus are ideal for non-verbal tasks in developmental, clinical, and non-literate populations. However, decades of cross-cultural and developmental research have actually suggested something different: that sequential image comprehension is contingent on exposure and practice with a graphic system. I here review this literature and advocate for more sensitivity to the "fluency" needed to understand sequential images.

Keywords: visual narratives; sequential images; experimental methods; cross-cultural cognition

Introduction

Researchers in the cognitive and psychological sciences have often relied on wordless sequential images like comics in experimental tasks. Most often, these tasks focus on using sequential images for elicitation, while aiming to investigate some other aspect of cognition. We find sequential images used in popular procedures for theory of mind (Baron-Cohen, Leslie, & Frith, 1986; Sivaratnam, Cornish, Gray, Howlin, & Rinehart, 2012), temporal cognition (Núñez & Cooperrider, 2013), discourse (Gernsbacher, 1985), social intelligence (Campbell & McCord, 1996), and event sequencing (Tinaz, Schendan, Schon, & Stern, 2006), not to mention the longstanding use of the Picture Arrangement Task as a measure in the WAIS-IQ test battery and other clinical assessments (Kaufman & Lichtenberger, 2006; Ramos & Die, 1986). The assumption has been that sequential images provide a universally understood medium of communication that is transparent to participants. They are believed to be understandable by everyone—including young children—with little learning or decoding necessary since they are assumed to rely on perceptual processing alone (e.g., McCloud, 1993).

This assumed transparency is likely underscored by the iconicity of images and a logic that may go something like this: Sequential images typically depict events visually, and everyone understands events transparently via perceptual processing; thus sequential images should be understandable to everyone. This thinking has lead to their frequent use in experiments for children and clinical populations, and in anthropological work, especially with non-literate populations.

However, empirical research about the comprehension of sequential images challenges these assumptions. Though some of this research is several decades old, they are supplemented by recent growing work on visual narratives, and the overall lessons remain relevant and important for consideration. Here, I will review this literature on sequential image comprehension, focusing on cross-cultural research, developmental research, and recent neurocognitive research. Altogether, such work will show that sequential images require exposure and practice with a graphic system in order to establish a "fluency" in comprehending this "visual language" (Cohn, 2013). Because of this, researchers should question the assumptions they hold about sequential images, and should be more careful in their use of visual narratives as stimuli for experimental tasks.

Understanding sequential images

Only recently has research on sequential image comprehension begun to explore the structure of visual narratives in the context of the cognitive sciences (Cohn, 2013). At their most complex, drawn sequential images—as found in comics—use a visual narrative structure that packages meaningful information into hierarchic constituents (Cohn, Jackendoff, Holcomb, & Kuperberg, 2014). Such structures extend beyond just the meaningful understandings of events between images (Cohn, Paczynski, Jackendoff, Holcomb, & Kuperberg, 2012), and seem to engage similar neural mechanisms as language processing (Cohn et al., 2014; Cohn et al., 2012; Magliano, Larson, Higgs, & Loschky, 2015). However, the foundations for sequential image comprehension are more basic.

Consider the sequence in Figure 1, which appeared as a stimulus in a study by Byram and Garforth (1980), discussed below. If a person recognizes this as a visual narrative sequence, it shows a boy watering plants under the hot sun. He begins to sweat, as indicated by water droplets jumping off his head in the second image. In the final panel, he is therefore shown with shirt off, watering himself instead of the plants. The ability construe the meaning of these successive images requires knowledge of causation both between the character and the sun, and between the contents of each image. Narratively, this sequence shows a set-up in the first image, an initiation of the event in the second image, and a climax in the final panel (Cohn, 2013). Such narrative states are cued by a variety of factors, including the change in position of the character between frames, and the conventionalized sweat drops leaping off the boy's head (Cohn, 2013; Forceville, 2011).

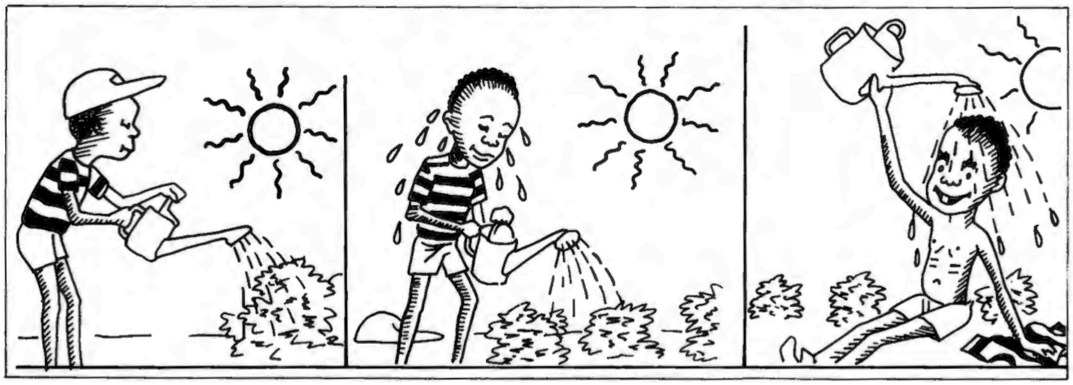

Figure 1: A simple sequence of images used in cross-cultural research in Botswana, from Byram and Garforth (1980).

Despite these narrative and causal relations, at the most simple level, understanding of sequential images requires only two basic constraints (Bornens, 1990; Cohn, In prep). First, a comprehender needs to understand that the characters and elements found in one image are the same referential entities as those in prior and subsequent images. This is the ***continuity constraint***. In Figure 1, this constraint guides our recognition that the character in the first frame is the same as the character in the second and third frames. Without adhering to the continuity constraint, we might interpret each frame as depicting a different scene and thus a different character. In this case, Figure 1 would not show one boy three times, but would show three separate boys.

Second, a comprehender must also recognize that these continuous referential elements take on different temporal, causal, spatial, and/or narrative states in comparison to those in the prior and subsequent images. In Figure 1, this ***activity constraint*** allows us to recognize not only that it is the same character across images, but that this character is in different *related* states in each frame (here, temporal/narrative states). Without this constraint, the images may be recognized as all showing the same referential elements (characters, background, etc.) but would not be distinguished as conveying a *sequence* with linkages between them. In other words, each image would be a scene unto itself. In Figure 1, each image would be its own scene of the same boy, if adhering to the continuity constraint, or of different boys, if flouting the continuity constraint.

The combination of the continuity and activity constraints provide the foundation for all other understanding of sequential images *as a sequence*. These very basic constraints are necessary for comprehenders to further construe more complex aspects of sequential images. For example, higher levels of sequential image comprehension involve the mapping of visual cues in images to narrative roles, the organization of those images into hierarchic constituents, and modification of those sequences using complex framing devices (Cohn, 2013, In prep). As will become clear in the next sections, most limitations in sequential image understanding do not reach these more complex levels. Rather, they demonstrate problems with these simple constraints on continuity and activity. Both high-level and low-level constraints operate on individual image sequences (like strips) and internally to the sequences of longer works (like comic books).

Cross-cultural fluency

The universality of sequential images is first called into question by considering cross-cultural research. In work from the 1960s-1980s, researchers examined wordless sequential images as a means to communicate non-verbally in cross-cultural settings, often with rural, non-literate individuals. Such work often had a practical intent for purposes of educational and/or humanitarian efforts on behalf of these populations, and similar efforts persist in contemporary efforts to use comics as a "universal" communicative tool (e.g., www.comicsunitingnations.org). However, this earlier work found sequential images to be fairly inadequate materials, because various populations did not construe the meaning of these stimuli as expected.

In many cases, respondents had difficulty interpreting the sequential images as a sequence. For example, a study in Nepal found that many respondents did not understand that images repeated the same characters across a 3-image long sequence (Fussell & Haaland, 1978). Similar strain in interpretations were shown by respondents in Papua New Guinea (Bishop, 1977), where some individuals had difficulty construing sequences as conveying temporal orders (Cook, 1980), though this effect was improved with practice and familiarity with Western pictures and comics. An older study in Kenya likewise found that people had trouble recognizing a sequence of images as being in a sequence (Holmes, 1963). Additional work in Africa found that rural Bantu populations (Zulu and Tsonga) in South Africa interpreted sequential images as conveying temporal states of the same character (continuity and activity constraints) less than European counterparts, though this ability increased with age and acculturation (Duncan, Gourlay, & Hudson, 1973). Later work in South Africa found similar interpretations between South Africans and their British counterparts, with effects modulated by exposure to graphics and literacy (Liddell, 1996, 1997). Comparable accounts in Africa were found with the Basotho people (Jenkins, 1978) and in Botswana (Byram & Garforth, 1980).

In these studies, individuals did not seem to be construing sequential images *as a sequence*, and sometimes "misinterpreted" the contents of the individual images themselves (Duncan et al., 1973; Fussell & Haaland, 1978). Most often, these individuals interpreted each image as its own scene, and did not follow the continuity constraint binding each image to the next. It is noteworthy that these individuals typically lived in more rural communities, with little or no exposure to sequential images in the form of comics or picture books. Those who did have access to such materials—along with literacy—had a greater likelihood of making the sequential interpretations. Also, while many of these studies are fairly old and may not reflect the current status of such populations' understandings, the main point remains: Not everyone can comprehend sequences of images.

Some comparable findings have occurred in more recent work on temporal cognition. This research uses a "card sorting task" which asks participants to spatially arrange visual events, with the idea that the layout (vertical, horizontal, circular, etc.) can inform about possible spatial metaphors underlying temporal cognition (Núñez & Cooperrider, 2013). However, results using these tasks in native communities have been mixed, and, again, often depend on participants' familiarity with comics and/or written language (Le Guen & Pool Balam, 2012; Levinson & Majid, 2013). Such limitations have lead to critiques that "in small-scale communities…[these tasks may not be] well-suited…because they presuppose familiarity with materials and practices that, in fact, require considerable cultural scaffolding" (Núñez & Cooperrider, 2013, p. 225).

This necessity for exposure to a graphic system has been echoed in cross-cultural research on *production* of sequential images. For example, Japanese children, who are immersed in a culture of comics, draw far more advanced visual narratives than children from other countries like the United States or Egypt (Wilson & Wilson, 1987). A study in Egypt has made this role the most salient (Wilson, 2016). Suburban Egyptian children, who had exposure to illustrated books and comics, drew narratives with a similar proficiency as children in the United States. This starkly contrasted with the children from rural villages, who had little access to such visual culture, where *only 4-8%* of children drew coherent sequential visual narratives. In these cases, the images in the sequences were isolated objects or events, or had only loose semantic relations. This resembles the inability to establish continuity across sequential images, here in production rather than comprehension. Such findings reinforce that sequential image understanding cannot rely on the architecture of the visual perceptual system alone (Duncan et al., 1973; Fussell & Haaland, 1978).

Development of fluency

Because exposure and practice appear necessary for the understanding of sequential images, it implies the need for learning of this system of communication. We should then ask: what is the developmental trajectory for such comprehension? This question becomes particularly important given the widespread use of visual narratives in tasks for children (e.g., Baron-Cohen et al., 1986; Sivaratnam et al., 2012), particularly those used to ostensibly assess the age of onset of *other* cognitive functions, such as Theory of Mind or IQ.

In fact, developmental studies on sequential image comprehension date back almost 100 years. Research by Piaget and colleagues (Krafft & Piaget, 1925; Margairaz & Piaget, 1925), argued that not until the ages of 7 or 8 did children recognize that characters occurring across images were the same character at different states, rather than numerous different characters (i.e., the continuity constraint).

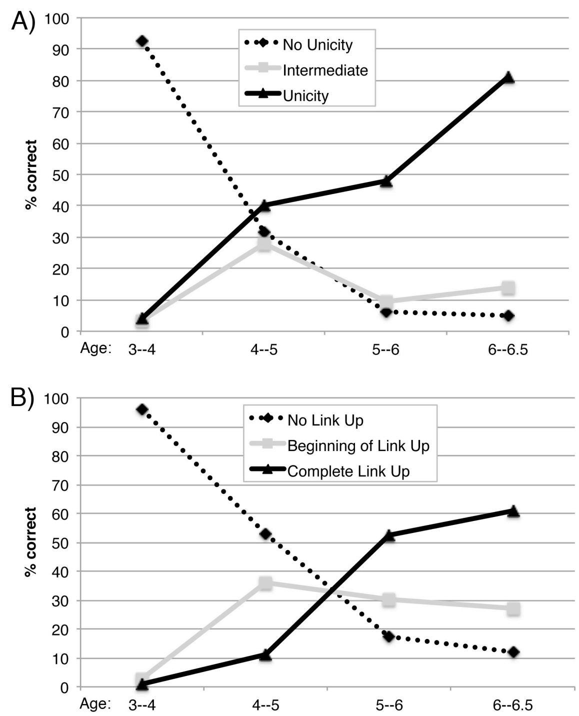

Figure 2: Graphs of data adapted from Bornens (1990). "Unicity" (A) refers to the ability to recognize that characters in one image were the same as those in a prior image (the "continuity constraint"). "Link up" (B) refers to the recognition that characters in one image were in a successive state than those in a prior image (the "activity constraint"). In both cases, these abilities are poor under age 5, but proficient by age 6.

More recent research has suggested the understanding of the continuity constraint in children of much younger ages. Bornens (1990) assessed children's verbalized understandings of several sequential image scenarios for both their ability to grasp "unicity" (i.e., continuity constraint) and "link up" (i.e., activity constraint) of characters across images. Figure 2 adapts the results from this study into graphs (provided numerically in the paper). As depicted in Figure 2A, children at or below the age of 4 had significant difficulty in maintaining continuity of characters between images, but started understanding that characters across images repeat in different states by age 4 and 5, before progressing to a full understanding at age 6. A similar finding appeared for children's ability to "link up" the actions of the events between images (the continuity constraint), as depicted in Figure 2B. It is also noteworthy that these findings were modulated by children's socio-economic status, with those from less "culturally privileged" environments not reaching proficiency until between ages 5 and 7, perhaps suggesting a difference in exposure to visual material, as in the findings of visual narrative "fluency" discussed above.

The ages of onset for sequential image comprehension in this study are consistent with other findings. For example, arranging images into a logically and/or temporally ordered sequence is difficult for 2 and 3 year olds (Weist, Atanassova, Wysocka, & Pawlak, 1999; Weist, Lyytinen, Wysocka, & Atanassova, 1997), but can be done proficiently by 4 or 5 year olds (Fivush & Mandler, 1985; Friedman, 1990; Weist et al., 1999; Weist et al., 1997). Children by around the age of 5 can also reconstruct logically ordered sequences better than random image sequences (Brown, 1975). Additional work has shown that the ability to recognize and infer missing images from a visual narrative begins around age 5 (Brown & French, 1976; Schmidt & Paris, 1978; Schmidt, Paris, & Stober, 1979), though this ability is modulated by the degree to which sequences maintain a continuity of common characters across images (Kunen, Chabaud, & Dean, 1987). Both picture arrangement and the ability to infer omitted information appear to continue developing into later years, though age alone does not determine proficiency: it is modulated by experience with comics (Nakazawa, 2016).

Such findings overall suggest that the continuity and activity constraints come online between the ages of 4 and 5. However, given the findings in cross-cultural research, such ages likely reflect age of onset when children have cultural exposure to sequential images.

Experience in fluent populations

The studies discussed above imply that the understanding of sequential images requires exposure to visual narratives, and in such context, follows a consistent developmental trajectory. What about the understanding of sequential images by adults in cultures with rich visual narratives? Sequential images should pose no problems to experimental participants so long as they are healthy, college-aged adults from visually rich cultures, right?

First, there are no guarantees that participants have acquired the requisite "fluency" to gain proficiency in comprehending sequential images, even if they belong to a broader culture that has rich visual narratives. Without assessment, we cannot simply assume that everyone in a given culture will behave uniformly. While no studies have yet to explicitly study the range of such fluencies, anecdotes abound from individuals who claim that they "can't understand comics."

Second, more empirically grounded data has shown that even when the basic ability to understand sequential images seems intact (i.e., the continuity and activity constraints), and visual narratives take more complex characteristics, various aspects of comprehension are modulated by frequency of comic reading. For example, Nakazawa (2016) has designed the Chiba University Comics Comprehension Test (CCCT), which involves a battery of tests including picture arrangement and fill-in-the-blank tasks. The CCCT has been used to assess the comprehension of sequential images in both children and adults. In general, Nakazawa (2016) has found that the ability to understand comics is modulated by age and expertise, with college students (who most frequently read comics) having greater proficiency than both younger children/teenagers and older adults. However, Japanese college students were shown to be more proficient in their visual narrative comprehension than American college students (Nakazawa & Shwalb, 2012). This difference was attributed to the relative pervasiveness of manga readership throughout Japanese society, in contrast to the more niche subculture of comics readership in the United States.

In addition, recent research has included a measure of "comic reading experience" in both behavioral and neurocognitive testing of visual narrative processing. The Visual Language Fluency Index (VLFI) questionnaire assesses the frequency with which individuals read and draw a variety of types of visual narratives (comic books, comic strips, graphic novels, Japanese manga), and their self-rated "expertise" in that understanding. This information is combined in the following formula to compute a "VLFI score", weighted more to comprehension (comic reading) than production (comic drawing):

$$\left(\begin{matrix}\mathit{Mean\ Comic\ Reading\ Freq.}\\ \mathit{x\ Comic\ reading\ expertise}\end{matrix}\right)+\left(\frac{\mathit{Comic\ Drawing\ Freq.x\ Drawing\ Ability}}{2}\right)$$

This metric has been shown to correlate with a range of manipulations to sequential images—particularly more complex aspects of narrative structure—in measurements including response times, viewing times, and the amplitudes of neural responses in event-related brain potentials (Cohn & Kutas, 2015; Cohn & Maher, 2015; Cohn et al., 2012). Resources related to the VLFI can be found at: http://www.visuallanguagelab.com/resources.html.

Such findings suggest that, even with proficiency in the basic understandings of sequential images with healthy, college-aged adults, experience modulates the processing of visual narratives. Thus, if sequential images are used as an elicitation for probing *other* cognitive abilities, there is no guarantee that participants will be uniform in their comprehension of those stimuli without some form of assessment.

Conclusion

Altogether, the studies in this review suggest that sequential image understanding is a culturally learned ability contingent on exposure and practice with visual narratives, such as comics and illustrated picture books. Such findings distinctly contrast with the general assumptions that sequential images are transparently understood, universal across cultures, and require no explicit learning (e.g., McCloud, 1993). Given that many experimental procedures have used sequential images as stimuli, researchers should be sensitive to these issues when designing studies and tasks. Such findings also call into question the degree to which results found in prior experiments are reflective of the actual cognition that is being tested (theory of mind, time-space metaphors, IQ, etc.) or if they reflect the ability of participants to understand sequential images at a basic level. For example, do picture arrangement tasks really inform about space-time metaphors (Núñez & Cooperrider, 2013) or IQ (Kaufman & Lichtenberger, 2006; Ramos & Die, 1986), or are these confounded by visual narrative fluency?

In many cases, drawn sequential images may not be necessary, as technological advancement makes the use of videos far easier for tasks requiring elicitation. While more complicated aspects of visual narrative patterning do appear difficult for naïve film viewers to understand, lower level issues like the continuity or activity constraints appear to be spared (Ildirar & Schwan, 2015; Schwan & Ildirar, 2010). This may be due to filmic use of basic percepts (instead of drawings) and their pervasive temporality and movement, which requires less decoding than drawn conventions.

Nevertheless, this does not mean that experimentation should avoid sequential images completely. If sequential images are used as stimuli, researchers are encouraged to assess the "fluency" of their participants in this "visual language" (i.e., using the VLFI or CCCT), just as they would be expected to assess participants' proficiency in other expressive systems, like language.

Given that research on sequential images has only recently progressed with seriousness in the cognitive sciences, future work should examine additional behavioral "fluency" assessments beyond the VLFI or CCCT. It is also unclear whether fluency varies based on the specific tasks involved in sequential images (e.g., picture arrangement vs. elicitation). In addition, studies will need to investigate just how general cognitive processes (memory, perception, attention) interact with visual narrative specific aspects of sequential image comprehension and fluency. Together, such efforts will further inform our understandings of sequential image comprehension, and the degree to which they may be used in other experimental tasks.

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