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Research Report

The notion of the motion: The neurocognition of motion lines in visual narratives

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ABSTRACT

Motion lines appear ubiquitously in graphic representation to depict the path of a moving object, most popularly in comics. Some researchers have argued that these graphic signs directly tie to the "streaks" appearing in the visual system when a viewer tracks an object (Burr, 2000), despite the fact that previous studies have been limited to offline measurements. Here, we directly examine the cognition of motion lines by comparing images in comic strips that depicted normal motion lines with those that either had no lines or anomalous, reversed lines. In Experiment 1, shorter viewing times appeared to images with normal lines than those with no lines, which were shorter than those with anomalous lines. In Experiment 2, measurements of event-related potentials (ERPs) showed that, compared to normal lines, panels with no lines elicited a posterior positivity that was distinct from the frontal positivity evoked by anomalous lines. These results suggested that motion lines aid in the comprehension of depicted events. LORETA source localization implicated greater activation of visual and language areas when understanding was made more difficult by anomalous lines. Furthermore, in both experiments, participants' experience reading comics modulated these effects, suggesting motion lines are not tied to aspects of the visual system, but rather are conventionalized parts of the "vocabulary" of the visual language of comics.

1. Introduction

The depiction of motion poses a challenge for static images. Motion lines (also called action or speed lines) offer a solution to this issue by attaching lines to a moving object to show the path of an action (as in Fig. 1). While motion lines are especially pervasive in the visual vocabulary used in comics across the world (Cohn, 2013a; McCloud, 1993), recent theories have hypothesized that their comprehension originates in the biological foundations of vision. Since moving objects leave behind "streaks" in the visual system when a viewer tracks an object (Geisler, 1999)—similar to a slow shutter speed of a camera—this

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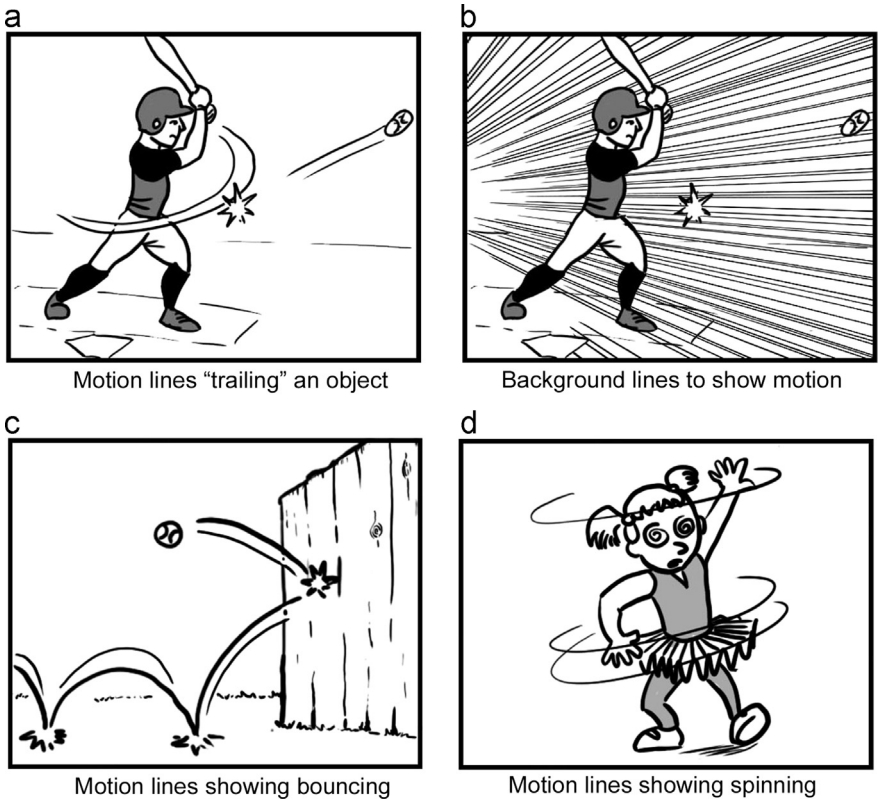

Fig. 1 – Different uses of lines to depict motion.

residual is argued to form the basis of our understanding about motion lines (Burr, 2000; Burr and Ross, 2002). Research following this idea has stressed that participants can better understand or remember the direction of moving objects when they have motion lines than when they do not (Burr and Ross, 2002; Kawabe and Miura, 2006; Kawabe et al., 2007; Kim and Francis, 1998). Thus, under this interpretation, motion lines are an iconic depiction of a basic aspect of human perception, rooted directly in the visual system.

Nevertheless, this "biological" origin for motion lines has several limitations. First, motion lines are understood by blind people comparably to sighted people when presented using raised-line pictures (Kennedy et al., 1990). Second, people of cultures unfamiliar with this style of drawing have trouble understanding that these lines depict motion, though they do understand iconic representations (Duncan et al., 1973; Kennedy and Ross, 1975; Winter, 1963). Third, the interpretation of motion lines changes as people age (Carello et al., 1986; Friedman and Stevenson, 1975; Gross et al., 1991; Mori, 1995; Nakazawa, 1998). Younger children often interpret motion lines as invisible yet iconic physical forces, such as wind or air moving, but only recognize them as symbolic conventions as they grow older (Gross et al., 1991). As children accept this symbolic meaning, they also rely less on postural cues to signify movement, which they do understand even at younger ages.

Fourth, motion lines vary in their representations cross-culturally, both in contexts like comics (Cohn, 2013a; McCloud, 1993), and in other drawing systems, like sand drawings created by Australian Aboriginals (Green, 2014; Munn, 1962). Fifth, motion lines in comics use a wide range of shapes, not only trailing laterally moving objects, but also showing manner of motion like bouncing or spinning (Fig. 1c and d), which cannot resemble lateral motion streaks (Cohn, 2013a; McCloud, 1993). Lines can also be placed behind a moving figure to converge onto a single point (as in Fig. 1b). These type of lines cannot appear in vision, but have been shown to be more effective at conveying motion than parallel lines (as in Fig. 1a), which do occur in vision (Ito et al., 2010). Altogether, these reasons provide a strong argument against the view of motion lines being tied to basic aspects of the biological visual system.

Additional research has studied motion lines in relation to their depiction of events. In general, images with motion lines are thought to be better at depicting the idea of motion than those that rely on only postural cues (Brooks, 1977; Friedman and Stevenson, 1975; Gross et al., 1991; Ito et al., 2010; Kawabe and Miura, 2006), though together motion lines and postural cues clarify an expected path of an action more than each component alone (Kawabe and Miura, 2006). Also, the number and length of lines used in a representation may influence the perceived speed that they convey: more lines and longer lines lead to participants interpreting faster movement (Hayashi et al., 2012). Furthermore, motion lines that trail an object have also been rated as more effective at depicting motion than a lack of lines, background lines, or lines moving in the wrong direction (Ito et al., 2010). Motion lines may facilitate comprehension and memory of depicted events more than when images lack motion lines because they help clarify the interaction between entities that otherwise may remain underspecified (Brooks, 1977).

Altogether, these findings point towards an alternative account for the understanding of motion lines that is not tied to the visual system alone. Rather, drawings are written in a "visual language" similar in underlying cognitive structure to