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# An illusion of 3-D motion with the Ternus display

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**Abstract**

We attempted to eliminate the percept of element motion in the Ternus display by connecting the display elements so that they appeared to be a single object. On each trial, the display elements (two discs) appeared either separated or connected (either via a white line or side by side) and subjects reported whether they observed element motion or group motion at various ISIs. Although it was hypothesized that element motion would be eliminated in the connected condition, subjects observed element motion at short ISIs in the form of a three dimensional illusion in which one element appeared to rotate out in front of (or behind) the other. Implications for short range and long range motion processes are discussed.


*Keywords:* Apparent motion; Ternus display; Visual illusion; 3-D motion

## 1. An illusion of 3-D motion with the Ternus display

Eight decades ago, Ternus (1926, 1938) observed a bistable percept of apparent motion using a display consisting of three sequentially presented frames. In Frame 1 of a classic Ternus display, three discs appear equally spaced along a horizontal plane. Frame 3 consists of the same three discs shifted to the right, such that the outer disc from the first frame now appears in the location originally occupied by the center disc in the first frame (see Fig. 1). The first and third frames are separated by a blank interval (Frame 2) for a variable duration, which serves as the interstimulus interval (ISI). When the three frames are presented sequentially, subjects often report seeing one of two types of apparent motion, which are dependent on the duration of the ISI. When a brief ISI (e.g., ISIs < 50 ms) is used, subjects report seeing *element motion* in which the outer disc in the display is perceived as "jumping over" the other two (inner) discs in the display and landing in the location on the right. When a longer ISI (e.g., ISIs > 50 ms) is used, subjects report seeing *group motion* in which all of the discs in the display appear to move together to the right (Pantle & Picciano, 1976).

Braddick and Adlard's (1978; see also Braddick, 1974, 1980) distinction between short-range and long-range motion processes has generally been used to explain the percepts of motion in the Ternus display. Element motion is thought to be attributable to the lower level short-range motion process signaling non-motion in the two inner elements in the display between Frames 1 and 3 at short ISIs. This leads the higher level long-range motion process to signal element movement, with the outer element jumping from one side of the display to the other (Braddick & Adlard, 1978). At longer ISIs, however, the short-range process signals motion in the inner elements in the display, leading the long-range process to signal group motion with the three elements moving together in unison (Braddick, 1980; Braddick & Adlard, 1978; Pantle & Petersik, 1980; Pantle & Picciano, 1976; Petersik & Pantle, 1979).

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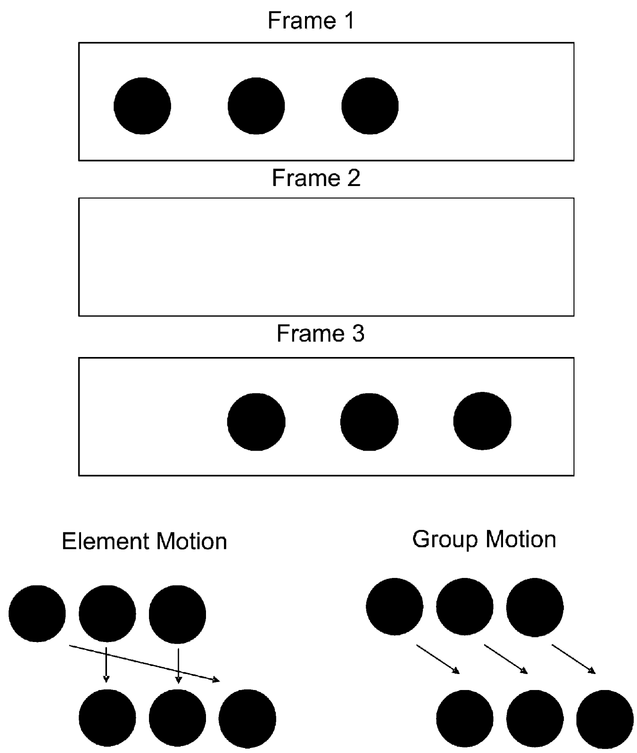


Fig. 1. A typical Ternus motion display. The three frames are presented sequentially. Element motion is observed when Frame 2 is shown for a short duration (less than 50 ms). Group motion is observed when Frame 2 is shown for a relatively longer duration (greater than 50 ms). The error bars represent the standard error of the mean.

Although Braddick's (1974, 1980; Braddick & Adlard, 1978) two-process distinction provides one explanation of apparent motion in the Ternus display, other accounts have recently emerged. For example, Scott-Samuel and Hess (2001) have demonstrated that the perception of element motion is influenced by changes in the spatial appearance of the elements in the Ternus display. They used displays consisting of elements that were defined either by static or dynamic noise and observed a reduction in the percept of element motion on dynamic noise trials: element motion was only perceived about 50% of the time with an ISI of 0 ms and was rarely perceived at any other ISI. On the basis of these results, along with data from other studies, Scott-Samuel and Hess (2001) argued that apparent motion in the Ternus display is mediated solely by long-range motion processing.

Researchers have also argued that the perception of motion in the Ternus display may be dependent on the degree to which the elements in the display lend themselves to perceptual grouping. For example, Kramer and Yantis (1997) reported an increase in the percept of group motion when the items in a modified Ternus display formed a coherent group relative to when the items appeared independent of one another. Moreover, Kramer and Yantis observed differences in the percept of group vs. element motion as a function of whether the displays were grouped with a stationary or moving context (see also Dawson, Nevin-Meadows, & Wright, 1994). Additionally, He and Ooi (1999) manipulated factors such as similarity, proximity, and common surface in modified Ternus displays and were able to consistently decrease the perception of element motion relative to similar displays in which the perceptual grouping of display elements was unlikely. Despite an increase in the percept of group motion with grouped displays, however, there was still a strong tendency to observe single element motion at short ISIs (e.g., ISIs < 40 ms). More recently, Alais and Lorenceau (2002) have demonstrated that the percept of group motion varies as a function of whether collinear or parallel displays are used (with more group motion being observed for collinear displays).

Although various grouping manipulations have substantially reduced the percept of element motion in Ternus displays at short ISIs, they do not eliminate the percept of element motion altogether. It should be possible, however, to completely eliminate element motion in a Ternus display by conjoining the separate elements into a single object. Simply put, element motion should not occur if there are not at least two separate and distinct elements in the display. In the present experiment, this was accomplished by using a principle of perceptual organization known as uniform connectedness in which closed regions of homogenous properties are perceived initially as a single unit (Palmer & Rock, 1994). Thus, the elements in the present experimental displays appeared either separated as in a standard Ternus experiment (separate condition), connected via a thin line (connect-line condition), or side by side with no space separating the elements (connect-touch condition). To increase the likelihood that the connected elements in our display would be viewed as a single object, we used two discs rather than three. Given that uniform connectedness has been shown to override powerful grouping principles such as proximity and similarity (Palmer & Rock, 1994) and given that grouping has already been shown to reduce the percept of element motion (e.g., Alais & Lorenceau, 2002; He & Ooi, 1999; Kramer & Yantis, 1997), we hypothesize that connecting the items should eliminate element motion altogether. Since there is only a single object in the two connected conditions, element motion should not be perceived even at the briefest ISI.

## 2. Method

### 2.1. Subjects

Fifteen undergraduate students from the University of Toronto volunteered to participate in the experiment,