
Raised line drawings are spontaneously explored with a single finger

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Received 28 July 1999, in revised form 10 January 2000

Abstract. In this study we examine the strategies used by blindfolded subjects asked to freely explore raised line drawings and identify what is depicted in them. We were particularly interested in how often a single finger is spontaneously used because in several studies subjects are forced to use only one fingertip and the extent to which this restriction may depress haptic perception is unclear. The results suggest that despite a variety of strategies, people ‘naturally’ use single fingertips sufficiently often to allow confidence in conclusions that are based on studies imposing this restriction.

1 Introduction

We sometimes need to explore our environment without vision, such as when trying to avoid obstacles in the dark, searching for a tool that is out of sight, or ‘looking’ for something in a pocket. It might seem that our movements in such circumstances are almost random. However, Lederman and Klatzky (1993) found eight stereotypical patterns of exploration that individuals use depending upon the object-property of interest. For example, these authors reported that lateral motion (a repetitive rubbing from side to side) was most often used to determine texture, but enclosure (dynamic moulding of the palm and/or fingers to the contours of an object) was used to gain information about an object’s shape. Solid, three-dimensional objects were used in this research, but exploring a two-dimensional raised line drawing might elicit some equally distinctive exploration strategies.

Tactile research dealing with the exploration of two-dimensional patterns typically sees participants using their fingertips or fingerpads, often as a requirement of the experimental task. The open palm is also used, but usually in situations where the participant has no choice, such as when the task involves print-on-palm stimuli or when a cookie-cutter shape is pressed onto it. In our present research in which we are using an apparatus we call the Tactile Display System or TDS (Richardson et al 1998) we require subjects to use one fingertip to explore raised line drawings in active and passive-guided conditions. We have found, as did Magee and Kennedy (1980), the performance of passive subjects to be sometimes better than that of active subjects. Richardson and Wuillemin (1981) wondered whether this unusual finding had something to do with the restricted or impoverished information available in the tasks concerned. It seemed possible that exploring a raised line drawing with one fingertip is a strategy subjects would rarely adopt spontaneously, that it might therefore be deemed ecologically invalid, and that conclusions drawn from the results of these studies might have little relevance to normal sensory processes.

In Magee and Kennedy’s (1980) study, all subjects were restricted to the use of one fingertip and none was allowed to retrace any movements. The raised line depicting the shape to be identified was followed around for only one lap. However, active subjects using the TDS (Richardson et al 1998) were allowed to move their fingertips anywhere they chose within a 12 cm × 12 cm horizontal plane and to retrace any path along the raised line as often as they liked within the time allowed. Passive subjects

were then guided, by the TDS, through the same pattern of movements that the active subjects had produced. Both active and passive subjects had their exploring finger held within a grip that was free to move along virtually frictionless tracks at right angles to each other. It was found that the passive subjects identified the drawings used by Magee and Kennedy more quickly than did the active subjects. Thus, being free to retrace does not seem to affect passive superiority in this task.

There remained the question whether using one finger is unusually restrictive, although this is not unknown in free exploration. For example, when Lederman and Klatzky (1993) asked participants to determine precise spatial details concerning an object's shape, they found that contour-following (moving a fingertip around the edge of surfaces) was quite common. However, we were interested whether subjects would spontaneously use a single finger when freely exploring raised line drawings. If they do spontaneously use a single finger, then tests of haptic exploration of such stimuli, when subjects are permitted to use only one finger, may be considered relevant to exploration in nonexperimental conditions such as in educational settings, or in the home.

2 Method

2.1 Participants

Eleven undergraduate students (one male and ten females) ranging in age from 18 to 42 years (mean age 26.6 years) volunteered. None of the participants had had prior experience with raised line drawings and none reported any tactual or visual problems.

2.2 Stimuli and materials

The three raised line drawings used are shown in figure 1—the outline of a face, a Christmas tree, and the word 'KEY' in capital letters. They were chosen to represent a reasonable variety of characteristics found in raised line drawings.

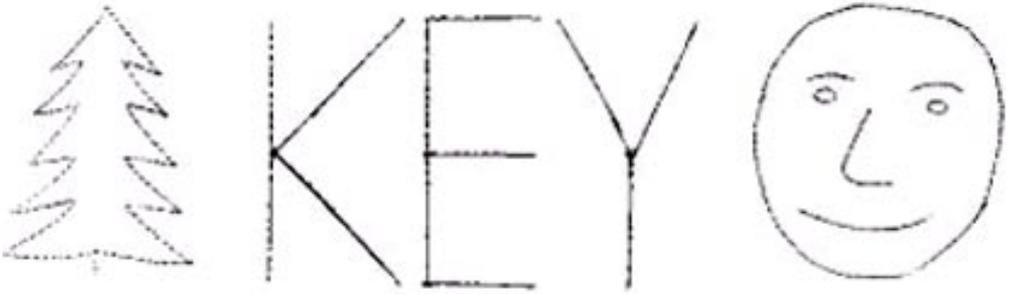


Figure 1. The raised line stimuli used in experiment 1.

Other than their shape as different objects or characters, the stimuli also differed in that the tree was symmetrical and made up of a continuous line while the face was semi-symmetrical and included internal but bounded detail. The letters were symmetrical (around the horizontal line in the case of K and E and the vertical for Y), they contained several junction points, and they required the negotiation of gaps between discrete aspects of the stimulus. A raised-line shape of a square was used as a practice figure. All of the stimuli were approximately 8.5 cm along their longer axes. They were prepared by drawing with a ballpoint pen on a special plastic sheet resting on a rubber-coated board. This method produces well-defined raised lines (Magee and Kennedy 1980; Kennedy 1993). The stimulus was then attached to a sheet of rigid plastic measuring 22 cm × 14 cm.

A Sony Hi-8 Handycam video camera was used to record the exploratory movements of the participants. The camera was mounted on a tripod, at about shoulder height, 1 m from the drawing, and to the right of the subject's medial plane.

2.3 Procedure

As a practice trial, participants were asked to examine a raised line drawing of a square. No instructions or suggestions were given how they should explore any of the stimuli. Participants were told that the study was concerned only with how they examined the stimuli while blindfolded. They were told that each stimulus was a drawing, that it should be recognisable, and that their task was to identify, as quickly and accurately as possible, what the drawing depicted.

The blindfolded participant stood before a table with the stimulus clamped to the table edge. The experimenter placed the participant's hands on the edges of the plastic backing sheet (see figure 2), started the video camera and a stopwatch, and asked the participant to begin. This procedure was repeated for each of the three stimuli, which were presented in a counterbalanced order across the eleven participants.

The experimenter recorded any comments or unusual movements made by the participants as their exploratory movements were videotaped. While the timer function of the camera was used for later analyses of the video recordings, a stopwatch was also kept in frame for latency measurements and timing of the 90 s or so allowed for exploration of each stimulus. No strict time limit was imposed but if subjects had not identified the drawing after 90 s, they were asked to make a guess and the trial was terminated.

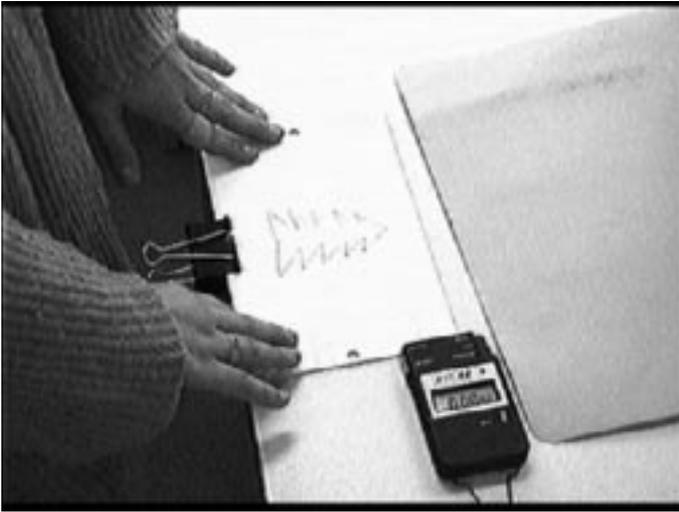


Figure 2. The stimulus setup.

3 Results and discussion

Statistics are descriptive since no hypotheses were proposed. The aim was to examine how individuals spontaneously explored raised line drawings, with particular interest in the frequency with which a single finger was used. Some trends emerged.

Each of the eleven participants used their index finger(s), either alone or in combination with other fingers, for more than 50% of their exploration time, but only three participants of the eleven explored an entire drawing with one *particular* finger (not necessarily an index finger) *exclusively* (see figure 3 for an example of this). Of greatest interest was that, on average, participants exploring the raised line drawings used a *single* finger for 64.6% of their total exploration time (standard deviation of 12.0%) while exploring the raised-line drawings. However, there was alternation between which hand was 'active' and whether it was the index finger or another in contact with the line. When use of hands alternated, there was a tendency for the left half of the drawing to be investigated by the left hand, and the right half of the drawing by the right hand.



Figure 3. An example of exclusive use of a single index finger. The right hand appears to be at rest or perhaps serving as a reference point.

In only 4 of the 33 explorations were multiple fingers of one hand used to simultaneously investigate different parts of the drawing (see figure 5). On these occasions, the index finger and the one next to it followed different lines, for example, the 'V' shape emanating from junctions in the K and Y letters. On all other occasions when more than one finger was used for part of the time (that is, for 25 of the 33 trials), the fingers were held close together so that they seemed to work as a single extended surface (see figure 4). In 6 explorations, participants were observed to use one hand to explore while the other was held stationary but with a finger of the stationary hand held in contact with the drawing. This seemed to serve the purpose of marking a reference point or 'anchor' while the other hand was active (see, for example, figures 4 and 6).



Figure 4. An example of using multiple fingers of at least one hand and sometimes two hands.

Five participants placed their whole hand palm-down on one of their three drawings at the beginning of their exploration and then moved this hand across the drawing for a period of up to 3 s. It was not clear whether they were concentrating on input from their fingers, their palm, or all of the skin surface in contact with the stimulus, but their intent may have been to obtain an initial global idea of the shape. It was noted that these particular participants did this with only one of the three stimuli (two subjects began exploring the face this way, two subjects the word 'KEY', and one subject the tree). This strategy did not appear more often for the first of the three stimuli presented to each subject than for the later-presented stimuli. If an effective strategy, one would have

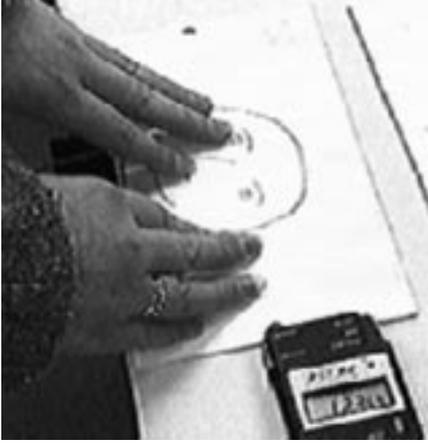


Figure 5. An example of using multiple fingers on different parts of the pattern.



Figure 6. An example of exploring with one (left) hand and using the other (right) as a reference or anchor point.

expected it to have been used by a subject more than once, but this was not the case, at least for this sample.

In 5 of the 33 trials the stimulus was not identified at all, while the 28 correct identifications were completed in 9–90 s. The mean latency for correct responses was 52.5 s with a standard deviation of 27.5 s. There was no apparent relationship between strategy and performance, although it would be worthwhile testing for this in further studies with a larger sample.

After exploring all three stimuli, participants were asked to say how they went about the task. Most described a process of “building up a picture in the mind” and none reported being aware of any conscious decision-making regarding movement of their hands. These reports, and the strategies used by the participants, are consistent with Lederman and Klatzky’s (1993) comment that “although subjects were usually unaware of what they did with their hands, the movements themselves were both purposive and systematic” (page 30).

No participant started at one extreme of the pattern (such as the top left corner) and methodically progressed through to the end of a line. All subjects made some retracing movements, some skipped from section to section, and there were idiosyncratic tendencies to dwell on certain features. This would suggest that while there are some common aspects to exploring raised line pictures, there is also a wide range of individual differences about which we know little. If ecological validity is a concern in

haptic studies, it would seem that choice of movement direction and, as Chapman (1993) has said, velocity of exploration, should be unrestrained. The TDS allows such freedom while restricting subjects to the use of one finger of their choice. The possibility that a one-finger restriction might threaten the validity of some findings prompted this focused study. The results suggest that the use of one finger at a time, albeit not necessarily the same finger, is a spontaneous strategy used frequently enough to justify this constraint in studies concerning the exploration of raised line drawings. Whether the same applies for blind subjects remains to be determined, as does the possible relationship between strategy and performance.

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