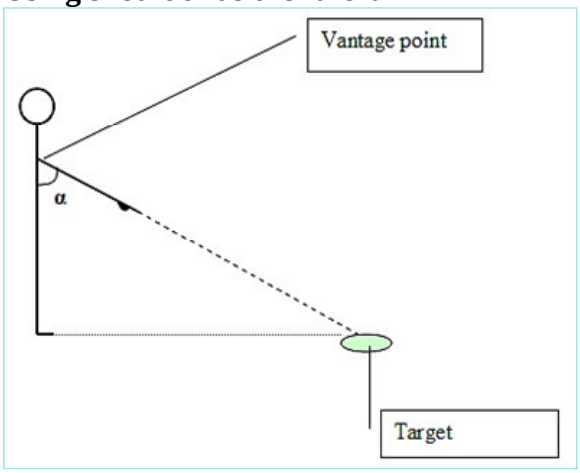
March 2008 MARTA'S PROJECT

Pointing to nearby targets is (1) lower with a tactile vantage point than with vision, and (2) underestimates foreshortening

John M. Kennedy & Marta Wnuczko
University of Toronto at Scarborough

When we point to an object in the distance, we are using a particular vantage point. But the vantage point can change depending on the task. If we are blindfolded, it may be a shoulder becomes the vantage point for pointing. Ideally, the shoulder, the arm, the finger and the target would lie on a straight line (Figure 1, left). If we are pointing with our eyes open, it is likely we would use an eye as the vantage point (Figure 1, right). The straight line joining the eye and the target, i.e. the line of sight, may influence the location of the arm and finger. In particular, the pointing finger might approach the line of sight, though the finger should stop short of occluding the target. In this theory, called Two-Fulcrums Theory, our arm will be more elevated more in pointing with vision than in pointing blindfolded.

Using shoulder as the fulcrum



Using eye as the fulcrum

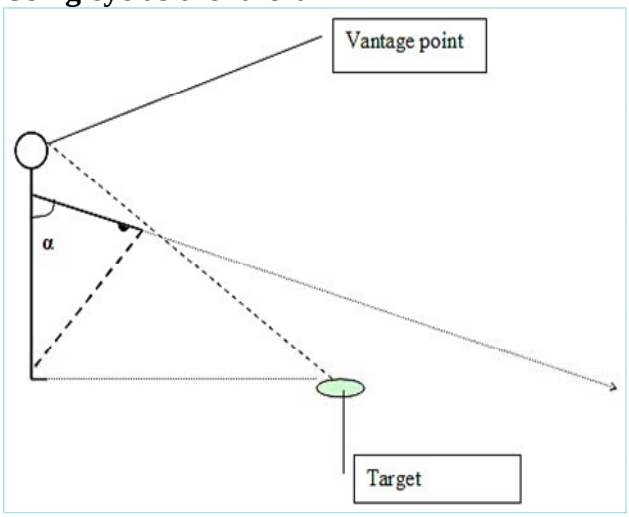


Figure 1. Pointing from different vantage points. The shoulder may be the fulcrum (left) in blindfolded pointing. The eye may be the fulcrum (right) in visual pointing, and the finger may approach the line of sight.

Both blindfolded and visually-governed pointing deal with the directions of targets, and are responding to matters of perspective. Equally-spaced objects, on a path stretching into the distance, project progressively closer in direction. That is, projections of the equally-spaced distances are subject to foreshortening. In both visual and blindfolded pointing, we should react to foreshortening by elevating our arm at progressively smaller angles (Figure 2). However, the ART theory (Juricevic & Kennedy, 2006) argues that vision underestimates the rate of foreshortening. That is, if two neighbouring and equal-sized spaces on a path subtend 3 degrees

(the nearer space) and 1 degree (the further space), vision will see the further space as unduly compressed. Vision would judge the further space should only shrink to say 2 degrees.

If vision underestimates foreshortening, how might this influence blindfolded pointing? Three possibilities are as follows. First, after visual inspection of equally-spaced distal targets, in pointing blindfolded underestimation of foreshortening may be apparent. This is the ART theory prediction. Second, direction perception may be independent of foreshortening. One may be able to point accurately at a target while misjudging its distance. In particular, if vision underestimates foreshortening, it may mistakenly judge the distances between equally-spaced distal targets is shrinking, but the directions may be accurately recorded. Logically, a third possibility is that blindfolded pointing may react to information about distance by overestimating foreshortening, that is pointing elevations may change minimally in blindfolded conditions. This might be true if tactile space is not well-related to distance beyond, say, arm's length i.e. tactile space is not Cartesian.

Visual-angle-subtended at a fixed vantage point is not the only source of information for the size of a space. The space can be filled with texture, and the number of texture units observed in two spaces can be the same, contrasting with the differences in visual-angle. Further, the lines and edges in a ground texture can be straight and continuous, and indicate the shape of a target contained within the texture. Further, the symmetry of the optical transformations of a target as it rotates or the vantage point moves around it can indicate it is square, despite the foreshortening at a given fixed vantage point. In addition, binocular information can specify size, shape and distance. However, once an observer is put at a fixed vantage point and blindfolded, direction judgments may be free of influences from visible texture, optical transformations and stereo.

Visually-governed pointing includes feedback and continuous correction, so in eyes-open pointing the pointing finger could always be close to the line of sight. Changes in arm elevation should reflect the correct rate of foreshortening.

Blindfolded pointing is based on prior visual inspection of targets set on textured ground. But, unlike visual conditions, blindfolded pointing allows no feedback error-signal, since the observer cannot see the pointing finger or feel the distal target. Hence, the predictions of the three theories above can be tested.

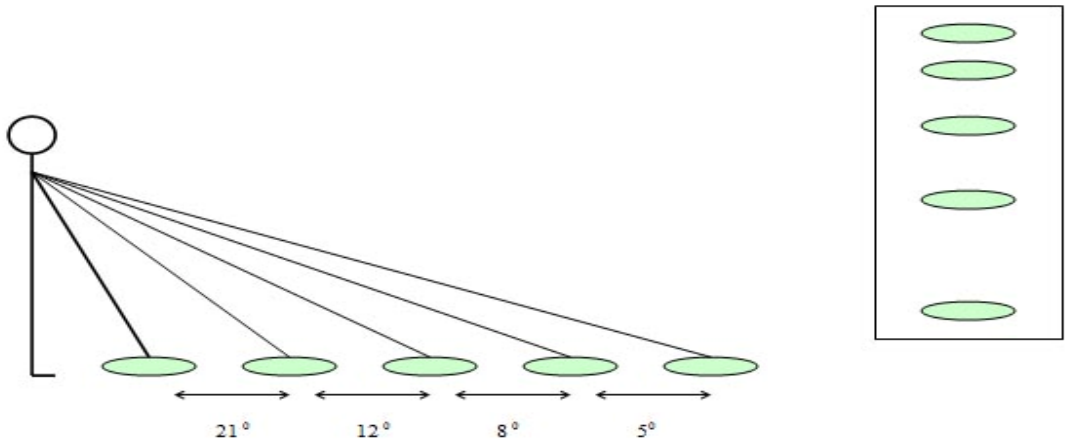


Figure 2. Blindfolded pointing to equidistant targets should result in progressively smaller increases in elevation, since the angles between successive directions are smaller (left). Prior to blindfolded pointing, the person visually notes targets projected in perspective (right).

Experiment 1 tests two main theories: First, the Two-Fulcrum theory that blindfolded pointing should be lower in elevation than visually-governed pointing. Second, the ART theory that foreshortening in the blindfolded condition should underestimate foreshortening. Participants pointed to equally-spaced targets on a straight path stretching in front of them. Participants pointed while blindfolded and with vision on successive trials.

Method

Participants

The participants were undergraduate psychology students, receiving a credit for participation. Eight women and two men participated (M = 21.33 years)

Materials and Procedure

A custom-made pointing apparatus was used. The participant put an index finger into a ring attached to the distal end of a straight stick, c. 60cm in length. The proximal end of the stick is attached to a protractor, which measures the angle of elevation of the stick, and hence the observer's arm. Participants pointed to designated targets (cardboard circles) while blindfolded and with vision. In Experiment 1, eight targets were used, and all target pairs were separated by the same distance.

Results

The results support Two-Fulcrum and ART theories.

As Two-Fulcrum theory predicted, pointing elevations in the blindfolded condition are smaller than in the visually-governed condition (Figure 3).

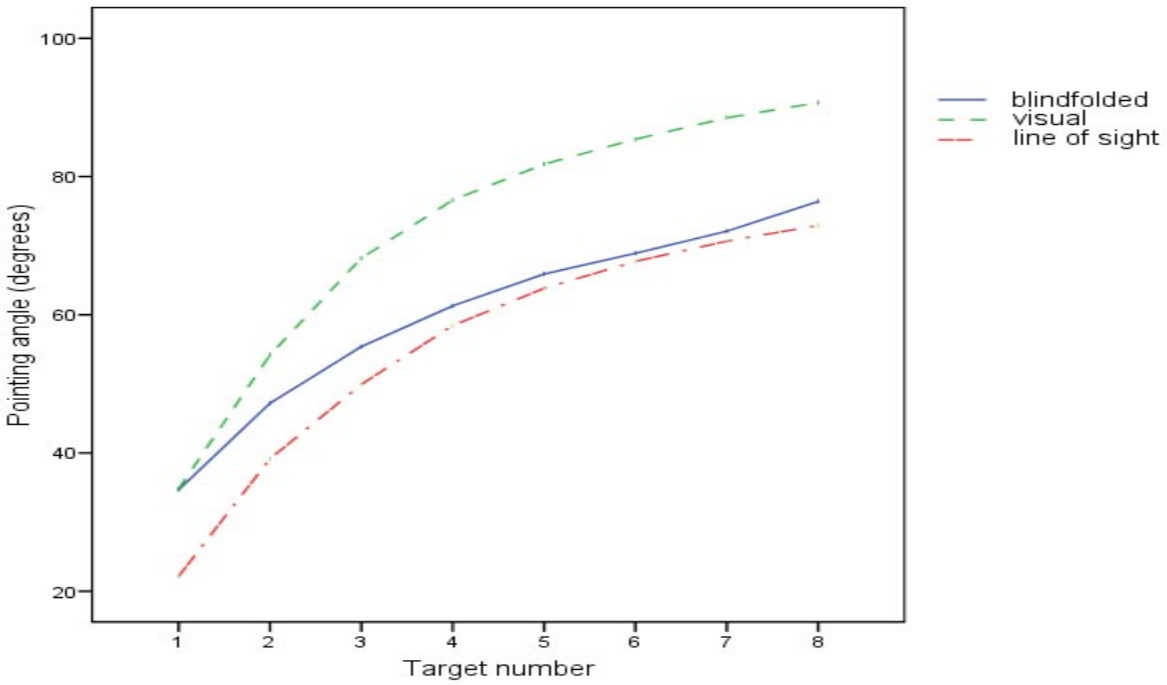


Figure 3. Blindfolded pointing angles are lower than visual pointing angles and higher than the 'line of sight' angles. The line of sight angle is the angle between the vertical and the line of sight, which joins the eye height with the observed target.

Furthermore, as ART theory predicted, the change of pointing angles between target pairs is underestimated in the blindfolded condition (Figure 4).

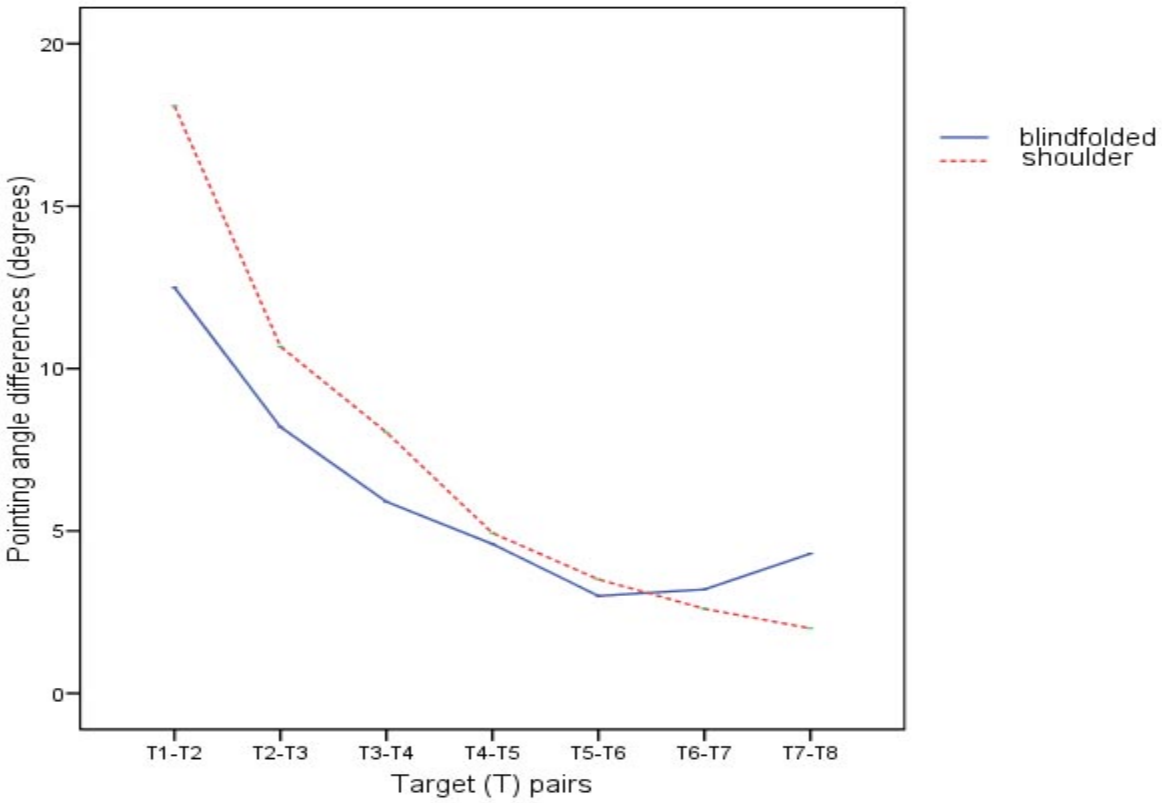


Figure 4. Change of pointing angles between Target Pairs is less blindfolded than is correct: **Foreshortening is underestimated in touch for nearby targets, with the differences becoming non-significant for more distal pairs.** The label 'blindfolded' stands for the results obtained in the blindfolded condition of the experiment. The label 'shoulder' stands for the correct pointing angle changes, according to linear perspective, using the shoulder as the vantage point.

Conclusion

The results support the ART theory. Foreshortening occurs at all vantage points, visual and tactile. However, ART theory contends shows that we do not react to perspective according to perspective geometry. We underestimate foreshortening. The results of Experiment 1 show that we underestimate foreshortening in touch. The results of Experiment 2, however, are accounted for by perspective geometry, but not the predictions of the ART theory.

By way of data-analysis problems, test yourself on two findings. Why is blindfolded pointing elevation the same as line-of-sight for more distant targets (Figure 3)? And in Figure 4, why do differences between Target Pairs become non significant for more distant pairs?

By way of a theoretical problem, to test your skill at deriving predictions from theories, please answer the following. How should the participants point if the targets are arranged at different spacings, and the differences in the elevations of the targets are all equal? This layout in shown in Figure 5.

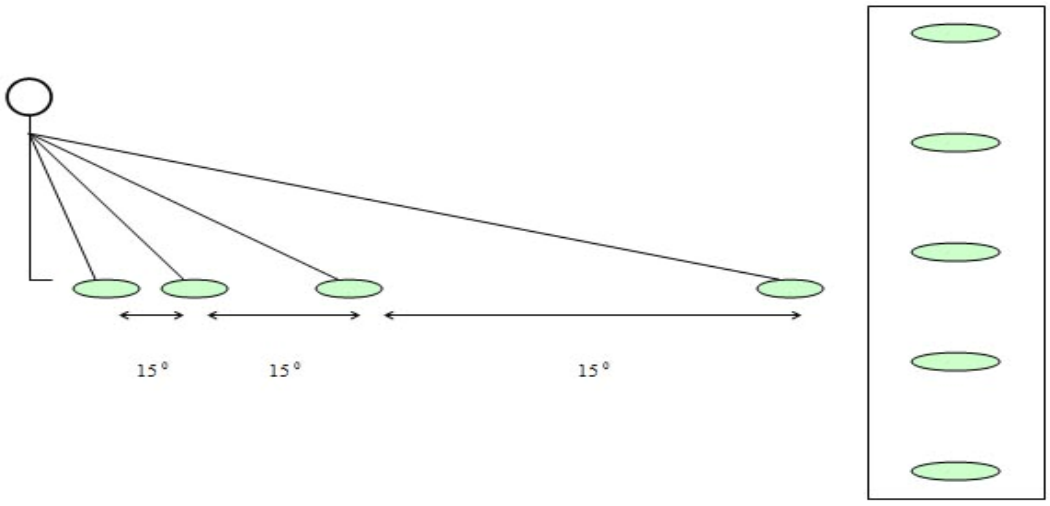


Figure 5. Blindfolded pointing to targets separated by the same target-to-target angular separation (left). Because angular changes between projected targets are the same (right), the pointing angle differences between pairs of targets will be equal (in this example, 15^0)