It has often been reported that, in the presence of static reference stimuli, briefly presented visual targets are perceived as being closer to the fixation point than they actually are. The first purpose of the present study was to investigate whether the same phenomenon can be demonstrated in a situation without static reference stimuli. Experiment 1, with position naming as the task, showed that such a central shift is also observed under these conditions. This finding is of importance because it completes an explanation for central near-location errors in the partial-report bar-probe task. The second purpose of the present study was to provide an explanation for these central shifts. For this explanation information about the exact size of the central shift is required. In Exps. 2, 3, and 4, with cursor setting as the task, it was attempted to assess more precisely the size of the central shifts. These experiments revealed that two different factors determine the results in cursor setting tasks; a factor "target position" and a factor "cursor position." Experiment 5 showed that it is the point of fixation, not the fixation point, that serves, at least in part, as the reference point in this type of task. All the findings together allow us to conclude that the target positions are underestimated by about 10%. From vision research it is known that saccadic eye movements, performed for bringing a target in the fovea, also show an undershoot of about 10%. It is therefore concluded that the system in charge of saccadic eye movements also provides the metric in visual space within a single eye fixation.

General introduction

This study is concerned with a peculiar phenomenon in the visual perception of spatial position: the tendency to perceive a briefly presented small stimulus as closer to the point of fixation than it actually is. This study has its origin in a problem of explanation, encountered with the partial-report bar-probe task (see Hagenaar & van der Heijden, 1997; see also below). In the course of our investigations, however, it appeared that the results obtained might have important consequences for theories of space perception and selective attention.

The partial-report bar-probe task, introduced by Averbach and Coriell (1961), is a classic tool for studying visual information processing and selective attention. In the most-often used version of the task, a horizontal row of letters is briefly exposed – for example, for 50 ms. The subjects have to name one letter of the row. That letter is indicated through a visual cue, for example, a briefly exposed small bar-marker in close spatial contiguity with the letter. The cue is presented before, during, or at various intervals after the exposure of the letter display.

This bar-probe task has produced a consistent pattern of results. Two main findings have often been reported. Firstly, accuracy of report depends upon moment of presentation of the cue. If the cue just precedes the letter or is shown simultaneously, accuracy is quite high (approximately 75% correct). The same result is found when the cue immediately follows the letter display. Accuracy decreases, however, when the cue is further delayed. At a delay of about 250 ms, accuracy reaches an asymptotic level of about 35% correct. Secondly, accuracy of report depends upon the position of the letter to be named. Accuracy of report is higher for the letters in the center and at the ends of the row than for letters in between, that is, the correct reports are
distributed in the shape of a “W” across positions (see, e.g., Averbach & Coriell, 1961; Mewhort, Campbell, Marchetti, & Campbell, 1981; Hagenaar & van der Heijden, 1995, 1997).

With regard to the interpretation of the results obtained with this task, three successive steps can be distinguished (see Hagenaar & van der Heijden, 1997). Initially, following Averbach and Coriell (1961), only the percentages of correct reports as a function of spatial position and of moment of appearance of the cue were regarded as pertinent. These percentages of correct reports were taken as unbiased estimates of the subject’s ability to identify the indicated letters. Therefore, initially, it was simply taken for granted that each error reflected a failure of perceptual analysis or of identification (see, e.g., Estes, 1978).

Later, following Townsend (1973), a detailed analysis of the errors was used. In this analysis, the erroneous responses are classified as either item errors or location errors, with an item error referring to the report of a letter that was not in the array, and a location error referring to the report of a letter that was in the array but not in the position indicated. It appeared that the great majority of errors were location errors and that most location errors were near-location errors, that is, they consisted of the name of a letter adjacent to the letter indicated (see, e.g., Mewhort et al., 1981; Hagenaar and van der Heijden, 1990; Hagenaar & van der Heijden, 1995, 1997). This outcome strongly suggested that it was not so much problems of perceptual analysis or identification, but problems of localization that imposed the major limitations on performance in partial-report bar-probe tasks (see, e.g., Campbell & Mewhort, 1980; Mewhort, 1987; Mewhort et al., 1981).

Recently, the near-location errors were further analyzed. Hagenaar and van der Heijden (1997) distinguished between central near-location errors and peripheral near-location errors, with a central near-location error referring to the report of an adjacent letter on the foveal side of the indicated letter, and a peripheral near-location error referring to the report of an adjacent letter on the peripheral side of the indicated letter. From this analysis it appeared that the great majority of near-location errors were central near-location errors; a preponderance of response letters came from a position adjacent to, and on the foveal side of, the target. This outcome not only supported the view introduced by Mewhort and associates that localization problems are the major source of errors in partial-report bar-probe tasks, but also suggested a detailed explanation of the location errors in terms of erroneous spatial perception of the briefly presented cue, that is, the bar.

The explanation forwarded by Hagaenar and van der Heijden (1997) was based on an observation reported by Rauk and Luuk (1980). These authors investigated the accuracy of the absolute judgements of the spatial position of briefly presented (0.5 ms) isolated dots that could be regarded as members of a horizontal (or vertical) one-dimensional array. They observed that subjects made many errors in naming the position of such a dot. In particular, they observed that “…in most cases the means of the erroneous responses were shifted towards the central fixation point…” From this observation they concluded “…a general tendency to estimate the position of an object as if it was more centrally located than it actually was” (Rauk & Luuk, 1980, p.150).

Rauk and Luuk were by no means the only investigators that observed these systematic position errors. Similar or closely related observations, for example, were reported by Bedell and Flom (1981); Leibowitz, Myers and Grant (1955); Mateeff and Gourevich (1983, 1984); Mateeff and Hohnsbein (1988); Mitran and Dimitrov (1982); Osaka (1977); O’Regan (1984); Rose and Halpern (1992); and Skavenski (1990).

Hagenaar and van der Heijden (1997) explained their main result – a preponderance of central near-location errors – by assuming that the letters in the row were perceived in the correct positions, but that the short-duration barmarkers that they used to indicate the position of the target were perceived like the dots in Rauk and Luuk’s (1980) experiments, that is, as being shifted towards the central fixation point. The additional assumption that, with simultaneous presentation of array and cue, the letter array helps in correctly fixing the position of the barmarker and that this help is increasingly lacking with an increasing temporal separation between array and cue, allowed them an explanation of why (central near) location errors increased with increasing cue delays.

In this way, it seemed as if a phenomenon often reported by basic vision research achieved an adequate explanatory status for a group of results obtained in an important, classical, visual information processing and selective attention task. Nevertheless, two important issues required further investigation.

Firstly, closer inspection of the vision research literature showed that the evidence supporting Hagenaar and van der Heijden’s (1997) explanation is not overwhelming. As stated, Hagenaar and van der Heijden invoked the assumption that the array can be of help in correctly fixing the position of the cue. In other words, they assumed that apparent central displacements of the cue will especially be observed in the absence of reference points in the visual field as in the bar-probe task with a delayed (or advance) cue. However, in the vision research literature, precisely these central displacements in the absence of reference points have apparently never been reported. In a review, Rose and Halpern (1992, p. 290) conclude, “What is common to all experiments is the use of static reference stimuli and brief or transiently presented target stimuli.” Thus, the stimulation situation used in vision research is different in an essential aspect from the situation in bar-probe tasks with a delayed (or advance) cue. Whether under the latter conditions, that is, in the absence of static reference points, central displacements will also be observed has still to be assessed. The demonstration of central displacements in the ab-