Perception of size in a ‘dynamic Ames room’

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Question:

What happens to size constancy when a room gradually expands?

Introduction

In the classic Ames room demonstration, failures of size constancy occur because of powerful assumptions about lines being parallel and orthogonal (figure). Here, we demonstrate a ‘dynamic’ Ames room in which observers can walk around but, as they do so, the entire room changes size (using virtual reality). The expansion of the room is centred on the cyclopean point (mid-way between the eyes) so it is almost imperceptible. Failures of constancy can be dramatic: subjects match objects that in fact differ in size by a factor of more than 3.

Methods

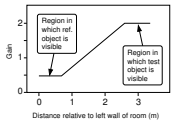
Equipment

Subjects viewed the virtual environment through an nVision DataVisor80 head mounted display. It has a wide field of view (112° total, 44° binocular overlap) and reasonably high resolution (1280 by 1024 pixels, size 3.4 arcmin). Separate images were rendered for each eye to give appropriate disparity information at a frequency of 60Hz (1).

Stimuli

Subjects viewed a virtual room with regular textures on the walls and floor (top panel, col. 2). The size of the virtual room varied according to the location of the subject in the real room. At the subject’s starting position the room had a ‘standard’ size of 3 x 3.5 m (gain = 1). From here the subject could move to the left where the room shrank progressively, in the limit to half the standard size (gain = 0.5), or to the right, where the room expanded up to twice the standard size (see figure). Movements forward and backward did not result in a gain change. The expansion or contraction of the virtual room was centred on the cyclopean point (midway between the eyes) so it was almost imperceptible.

In one control experiment (middle panel) the room remained a constant size (gain = 1). In another (bottom panel), there was no texture on the walls and the rooms remained a constant size. Subjects walked from a small room into one 4 times larger. These were equivalent sizes to the gain = 0.5 and gain = 2 sizes of the textured room in the first experiment (top panel).

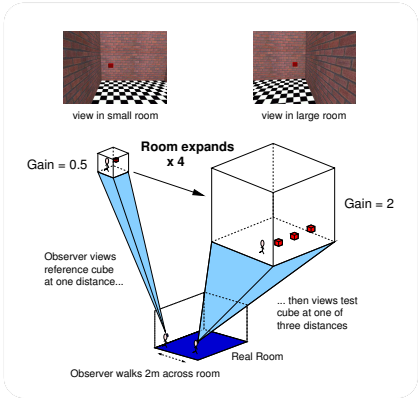


The reference object was a red cube positioned at 1.5*g* metres from the subject, where *g* is the gain of the room. Its size was 0.1 *g*. The reference object only appeared when the subject was within a restricted area, within which the gain was constant (see figure). This prevented simultaneous comparisons with the test object. The test object also appeared only when the subject was in a particular region (on the right of the room). Its viewing distance was 0.75*g*, 1.5*g* and 3*g* metres.

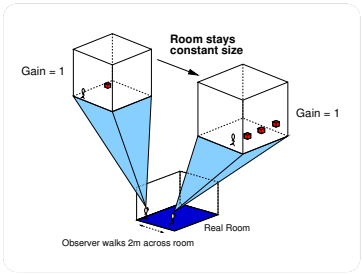
Psychometric procedure

The subject’s task was to compare the size of the test and reference objects in a single interval forced-choice paradigm. The reference object was always the same size and at the same viewing distance. 3 interleaved psychometric functions were used for test objects at the 3 distances. A 3 up, 1 down staircase method was used. We chose a wide starting range starting staircases at 0.5*g* and 2*g* times the reference size. 160 trials were collected per function. The data were fitted with a cumulative Gaussian by probit (2). The histograms show the bias (50% point) of the fitted curve and the error bars show the standard error of this value.

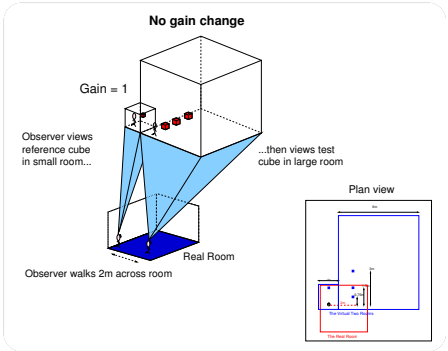
A dynamic ‘Ames’ room: expanding



A ‘normal’ virtual room: constant size

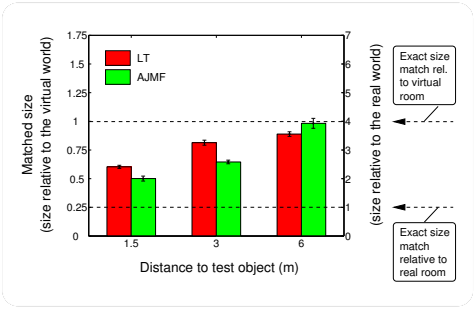


Two rooms: instantaneous size change



Results

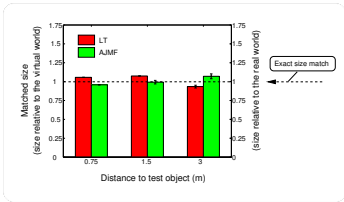
Observers ignore the expansion...



...at least for far viewing distances

Results

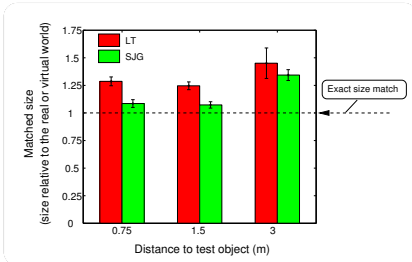
Size constancy remains...



...in a ‘normal’ virtual room

Results

Observers can still use 3D cues...



...to recover viewing distance

Discussion

- The effect of context on size judgements is well known (e.g. (3), (4) and many others) but the results here are a particularly dramatic example. Subjects perceived objects to be the same size that in fact differed by a factor of almost 4. Even at close viewing distances (1.5m), subjects matched objects that differed by a factor of 2 in size.
- The size matching results are a corollary of the subjective impression of stability of the room as observers walk through it. Observers report feelings of acceleration and deceleration if they walk at a regular pace, but no clear impression of an expanding room.
- The fact that the size illusion is smaller at close viewing distances is likely to be due to the greater reliability of stereo and motion parallax information here. It does not reflect a general failure of size constancy in the virtual environment, as results in the ‘normal’ (not expanding) virtual room show.
- Binocular disparity and motion parallax are demonstrably useful cues to viewing distance in the virtual environment when they are not pitted against a strong relative size cue. The lower panel shows that when subjects walk from a small room to one 4 times larger their judgements are very much more veridical. The change in room size is the same as in the first experiment but it is instantaneous and there is no texture size cue to conflict with the stereo information that the room is larger.

Conclusion

In the dynamic Ames room, the subject’s assumption that the room remains constant size has a powerful influence on size judgements, overcoming consistent and correct information from binocular disparities and motion parallax.

Answer:

Dramatic failures of size constancy can occur

References

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[3] E.G. Boring. *Sensation and perception in the history of experimental psychology*. New York: Appleton-Century-Crofts, 1942.

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