

# Active-Passive Paradigm in Assessing CCTV-Aided Reading

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## ABSTRACT

Six male and seven female English-speaking university students, with corrected vision of **20/20 (6/6)**, were trained using the closed circuit television system (CCTV) as a reading aid. This was an attempt to identify the essential factors in CCTV-aided reading. Active and passive observers were trained in pairs, with the passive observer being the yoked control of the active observer. The control participants were trained alone using the same reading material without the use of a CCTV. All participants used material from the Thurstone Reading Kit throughout the five training sessions and were given a pre- and postreading test to assess the increase in reading speed measured in words per minute (WPM). The active observers increased their reading speed to a greater extent than the passive observers, and the passive observers to a greater extent than the control participants. Suggestions are made pertaining to future experimentation and use of the CCTV.

**Key Words:** closed circuit television system, active-passive paradigm, low vision, perceptual training, reading speed

Perceptual and visual training is not a recent phenomenon. Gibson<sup>1</sup> presented a substantial literature review on perceptual judgments. In this article she reviewed many studies providing evidence that visual training has a positive effect on perceptual judgments. Gibson suggested that judgments related to visual acuity (foveal and

peripheral), and visual perception tasks could be improved with practice and/or training.

Recently, Barraga and her colleagues<sup>2-4</sup> have elaborated on the stages of visual and perceptual development in children. A literature review supports the assumption that the stages of development for visually impaired subjects are similar. It is their belief that a systematic training program is just as useful for training visually impaired subjects as it is for normally sighted children.

Additionally, Goodrich and his coresearchers<sup>5,6</sup> have presented evidence that eccentric residual vision or peripheral vision can be trained by using a variety of techniques. Some of these techniques use instruments such as rotating drums and strobe lights and involve the tracking of a target stimulus, which significantly improves the ability of the observers to use their remaining vision.

Thus, there is substantial evidence that the use of vision and visual perception can benefit from a variety of training programs.

## THEORIES OF PERCEPTION

Of importance in this regard is the active-passive paradigm as suggested by Held and Hein.<sup>7,8</sup> This paradigm is based on Von Holst's theory of reafference, which states that for perception to occur an observer needs both afferent information from the incoming visual stimulus on the retina and efferent information, which refers to the information about body movements. The efferent information is information in the central nervous system that is sent to the body parts for movements. Held and Hein further proposed that the efferent information has to be performed actively by the subject for the correlation of afferent information memory and efferent information memory to have beneficial or compensatory effects on visual perception.

Received February 20, 1986; revision received July 4, 1986.

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In his 1965 article, Held presented evidence from both human and animal studies. With humans, he distorted vision using prism goggles and had two conditions where one was passive and the other active. He concluded that an observer had to participate actively or produce physical movements him- or herself for any adaptation to occur. In a study with very young kittens, Held also had an active and passive condition where the passive condition was a yoked control of the active to any tactile and visual stimulus. The kittens were in a circular container where the stimuli were symmetrical on all sides. Both kittens were harnessed in a device that whenever the active participant made a motion the passive kitten was moved mechanically in the same way and thus received the same stimuli. Again he found that the active subjects could perform some visual-motor tasks that the subjects from the passive condition could not. Other researchers tried to repeat these results in similar conditions and found that there was adaptation by the active participants but that there was also some adaptation by the passive observers compared to the control subjects who did not adapt.<sup>9,10</sup>

Festinger<sup>11</sup> states that the capacity of stored efferent programs must be limited and thus, when visual distortion occurs, new efferent programs must be learned in correlation with the incoming visual stimulus to produce adaptation. Thus, in a situation of visual impairment, where the visual information is distorted, one has to learn new efferent programs to acquire an adequate perception of the world. That is to say, one has to replace the previous programs by new ones that will be appropriate for the altered visual information. If this hypothesis is correct, it would be beneficial to practice and train the visual system to achieve a proper correlation of both incoming and outgoing visual information and, thus, a better perception of the environment and a better functional capacity from the visual system.

### CCTV TRAINING

The CCTV, as a low vision aid, was first introduced by Potts et al.<sup>12</sup> Its use is primarily for reading and writing, bringing about great opportunities for visually impaired people who are not satisfied with, or cannot use, traditional low vision aids for nearwork. Among its advantages is the fact that it can magnify print from 3 to 60 times (depending on the model), whereas optical aids can only magnify visual information from about 1.5 to 12 times. Other advantages are contrast reversal or negative image, which most patients find agreeable,<sup>13</sup> contrast enhancement, increased depth of focus, reduction

in aberrations and distortions, reduction of postural tension, and reduction of the necessity for saccadic eye movements. However, controversies as to the usefulness of CCTV systems remain.<sup>13-16</sup> The main objections to the use of the CCTV would probably be its high cost and the necessity of manual dexterity and training.<sup>14</sup> Over the past decade, there has been some comprehensive research on different CCTV designs and applications.<sup>17-19</sup> At this point we can safely say the technical deficiencies are minimal. Although the design has been improved in recent years, the high cost and manual dexterity necessitated are still inherent problems of the CCTV.

Sloan<sup>20</sup> mentions that the usefulness of "expensive and nonportable closed circuit television readers can only be determined by comparison of such devices with other types of reading aids" (p. 162). From subsequent studies, it appears that CCTV systems compare quite favorably with other reading aids such as hand magnifiers and telescopic lenses.<sup>13, 15, 21</sup> Other studies have shown that some subjects who could not read at all with conventional reading aids have been able to read with the CCTV.<sup>18, 22</sup>

### PRESENT STUDY

Very little systematic research has been devoted to specific, operationally defined training techniques on the CCTV system. One exception is the work of Lagrow,<sup>23</sup> but the training technique used in this case is a very extensive one that lasts for a few months. Lagrow has suggested that the important training stages have yet to be identified. Thus, to design an adequate technique some very basic questions must first be answered. What exactly is being learned in the use of CCTVs? Is the reader just habituating to having visual material moving in front of the eyes compared to the usual situation where the eyes and head are moving and the reading material is stationary? Are the arm movements, in correlation with the visual movements on the screen, necessary elements in learning how to use the CCTV, as suggested by Held? It would appear that the question is whether subjects in an active condition involving arm movements with visual movements would learn to use the system more efficiently than in a passive condition with no arm movements.

One assumption made presently is that low vision subjects using a vision aid have a distorted perceptual image. In most cases adaptation has to take place, which is analogous to any other perceptual adaptation phenomenon. Therefore, techniques that have been shown to be efficient in improving visual adaptation in normally sighted subjects are assumed to be efficient also for low vision subjects in their adaptation to

vision aids. Subsequently, the theoretical assumptions in perceptual adaptation are also assumed to be involved for low vision.

Active, passive, and control conditions were used in this study, with reading speed as the dependent measure. As further control, normally sighted subjects were used, thus limiting the variability of different visual impairments that could interfere with the basic questions being addressed. The underlying hypothesis was that both active and passive conditions would improve reading speed with a CCTV as opposed to the control condition. Moreover, the active condition was expected to have a stronger positive effect on reading speed than the passive condition.

## METHODS

### Subjects

Six male and seven female English-speaking university students, with corrected vision of 20/20 (6/6), were trained using the CCTV.

### Apparatus

The Voyager CCTV system, manufactured by VTek, was used. This CCTV system consists of a 12 in (30.5 cm) screen (measured diagonally) with a magnification capacity of 3 to 45 times the original size. The camera is immediately under the monitor and projects the visual material from the X-Y movable table onto the screen. Standardized reading material was obtained from "Reading for Understanding" (Senior Kit) by T. Thurstone.<sup>24</sup> The scaling techniques for the text used are described by L. L. Thurstone.<sup>25</sup> The subjects all wore headphones and were subjected to white noise during the training sessions, to eliminate random distractions. Chin rests were also used by all groups for the pre- and posttraining reading tests, and by the active and passive groups during the training sessions.

### Procedure

All the participants were given a visual acuity test before the experiment and the criterion for acceptance was 20/20 (6/6) corrected vision. They were also tested with the use of the CCTV on their reading speed before training with a magnification level of 10times normal print size. This reading speed test was repeated at the end of the training sessions. All the subjects during these pre- and posttraining tests actively manipulated the reading material while being tested for reading speed, calculated in WPM. During these testing sessions, and throughout the training, the subjects read aloud.

The observers were separated randomly into three groups: an active, passive, and a control group consisting of 4, 4, and 5 participants, respectively. The initial reading speeds of the control, passive, and active groups were similar (61.19, 55.01, 58.99 WPM, respectively). The control group was required to participate in five training sessions; each training session consisted of reading 10 paragraphs of the Thurstone reading kit. These texts were not read on the CCTV but rather with normal print, inasmuch as the CCTV screen could not encompass a sufficient amount of print without a movement of the reading material on the screen. The participants were given white noise through headphones while reading aloud.

The active and passive groups were trained in pairs. Each person had his or her head positioned on a chin rest to control for movement and they were also wearing headphones producing white noise so that the oral reading of one member of the pair would not affect the other. The subject in the active condition was moving the reading material and the passive one was immobile while they were both reading. The actual training time varied in the sense that it was the amount of material covered that represented the training sessions. A training session was considered to be 10 short paragraphs with a completion task after each.

During the training, the center of the CCTV was placed at a distance of 15 in (38 cm) from the right eye of both the active subject and the passive subject. The chin rests of both observers were on an angle so that they were facing the CCTV in a direct line. This was to avoid having the observers look at the CCTV from a very sharp angle. In the pre- and posttraining reading tests, in which all observers participated, the CCTV was placed directly in front of the subject at a distance of 15 in (38 cm). During the reading test, the participants were told not to speed through the reading, but rather, were instructed to read at a pace that felt comfortable to them.

## RESULTS

The difference between the mean reading speeds of the pre- and posttraining tests was calculated for each subject using the following formula:

$$\frac{210 - 5(E)}{T}$$

where 210 is the number of words in the text, E is the number of errors (to control for very quick and inadequate reading), and T is the time it took the participants to read the text. These data are shown in Table 1. The range for the

TABLE 1. WPM increase for individual subjects, group means, and SE.

	Control (Subjects 1-5)	Passive (Subjects 6-9)	Active (Subjects 10-13)
	9.38	10.03	21.94
	5.25	7.07	33.25
	-1.12	23.46	53.66
	7.19	15.04	23.49
	5.02		
Mean WPM increase	5.14	13.90	33.08
SE	3.91	7.17	14.60

control subjects was an increase from -1.12 to 9.38 WPM for the passive group from 7.07 to 23.46 WPM and for the active group from 21.94 to 53.66 WPM.

The mean WPM increase for the control, passive, and active groups is shown in Table 1. A one-way analysis of variance was computed to establish whether there was a main effect by the control, active, and passive conditions. As can be seen in Fig. 1, there are definite differences between the three groups in the mean rate of increase in WPM.

The analysis of variance shows that this difference is highly significant,  $F(2,10) = 10.23$ ,  $p < 0.005$ . Furthermore a *post hoc* Scheffé test reveals that there is a significant difference between the three group means in increases of WPM. The observers performed better in the active condition vs. the passive condition, and in the passive condition vs. the control condition.

## DISCUSSION

The results demonstrate clearly that there is a difference between the control, passive, and active conditions in the acquisition of reading speed when using the CCTV. The observers performed better in the active condition vs. the passive condition, and in the passive condition vs. the control condition after the five training sessions. This supports the notion advanced by Held<sup>7</sup> that the active condition has a very positive effect on the adaptation of distorted perception or improvement of perceptual tasks. However, the results show a definite increase in the passive condition which could not be accounted for by the theory advanced by Held in 1965. The notion that efferent information to the eyes is important in perception, as suggested by Festinger,<sup>11</sup> is supported by the fact that in the passive condition there is a significant increase in the reading performance after training. Therefore, it would seem that the activity of the eyes in the

acquisition of perceptual tasks is an important factor. However, it is difficult to assess, in a given task, whether the active involvement of the eyes (efferent information) in correlation with the afferent information is more important in perception than the active involvement of the limbs (in this case the arm) in correlation with the same afferent input. In other words, the same mechanism might be involved in both these conditions and the fact that the active participants performed better after training may be due simply to an effect of summation. For instance, if two different stimuli affect the same receptor site, and they are both presented at the receptor site simultaneously, the receptors will be activated much more than if only one of them is presented. One could consider that the efferent information from the eyes is more important because the eyes are always involved in visual perception. However, a particular task might elevate the importance of the efferent information from the limbs and even if the eyes are important, the limb information might also be necessary. For example, the task required in this experiment puts emphasis on actual arm movements and it is a possibility that the exclusion of limb movements will ultimately never produce the same level of proficiency. Because many perceptual tasks in our environment involve adaptation of limb movements, it could be assumed that they are more or less important, depending on the task.

Practical implications can be derived from the results of this experiment. The results show that active participation of the limbs is important in the acquisition of reading proficiency with the CCTV. If one were to design a training proce-

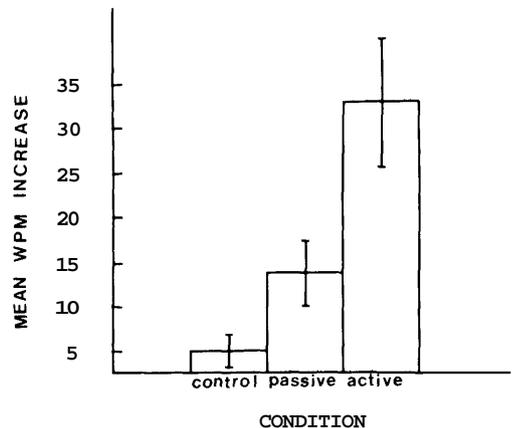


FIG. 1. WPM increase as a function of the control, passive, and active conditions in normally sighted subjects reading with the CCTV. Error bars indicate a 2 SE range.

dure for the use of such a device, it would be very important to include some manual dexterity tasks such as tracking figures on the screen with the use of the X-Y table. Thus, one could design a training program consisting of a hierarchy of simple to difficult tracking tasks, which would probably have a beneficial influence on reading, before involving comprehension tasks. The assumption is that if a task is kept simple by not requiring high levels of comprehension, a low vision subject would learn to use the CCTV much more quickly and the later comprehension tasks would probably be less difficult. One can easily imagine that if a person has a very severe visual impairment and is asked to read using the CCTV without training, that it may be very difficult and, for some, almost impossible.

In many clinics, the eligibility of a low vision subject for subsidies for CCTV's is based on a limited trial evaluation of their efficiency with the instrument. Unfortunately these evaluations are quite arbitrary because, as this study shows, simple training on the CCTV might make an enormous difference in a subject's capability to use such a device. The previous assumption was that if the remaining vision of a low vision subject was not good enough to start with they would waste time and money if made eligible for a CCTV. These assumptions were not based on any empirical evidence. A suggestion stemming from the present study is that a brief systematic training session be given to low vision subjects on a CCTV, made available in the clinical setting and, subsequent to that, some evaluation may be made as to the usefulness of the instrument for that user.

Another suggestion that stems from this research is that if CCTV's were not made immediately available to the low vision subject, it is probable that they could still improve their ability to use the CCTV. The results show that there is some improvement in the passive condition, and if training was made available that simulates the passive condition as in the present study, it is probable that the user would improve in the use of a CCTV if the latter was subsequently made available. For instance, some kind of video system that hooks up to a normal television system, which would consist of magnified print similar to what is seen on the CCTV, could be made available to the low vision subject, so that the latter could benefit from similar visual stimuli and achieve some adaptation that would be transferable to the use of the CCTV. Furthermore, multihandicapped people can benefit from training vision alone.

The present study suggests several possibilities for further research. It is possible that what is being trained in the normally sighted partici-

pants of the present research is, to some extent, the use of peripheral vision. That is, at the early stages of the training, the subjects probably perceive a limited number of letters in the foveal area (fewer than we usually perceive when reading normal print). What may happen during training is that the subjects become better at using the available information in the periphery, which they were not accustomed to use initially. An interesting paradigm for the assessment of whether they are learning to use peripheral vision would be to have two conditions where the observers have the same amount of information in their central vision to start with, but in one of the conditions the extra information in the periphery would not be made available. For instance, if in the first condition one could have four letters available to central vision at normal magnification, and throughout the training only four letters are made available by a restricted window size, you would not expect any improvement if, as is assumed, the improvement in the present study was due to peripheral viewing. The second condition would basically be identical to the active condition that was used in this study. Of course, under both conditions the observer would be manipulating the reading material. If the results show a parallel improvement, then one could conclude that the improvement in the present study might be due to (1) improvement of some cognitive strategy in extrapolating information from only a few letters made available to the observer and/or (2) the improvement of, or replacement of, prior eye movement strategies (now rendered unadaptive by the onset of visual impairment) with new, more adaptive strategies. However, if the results show more improvement in the second condition, this would support the hypothesis that the use of peripheral vision is being trained.

The active-passive paradigm was labeled such by Held.<sup>8</sup> At the time it served its purpose well because Held assumed that it was only the active participation of the observer's limbs that was important in acquisition of visual perception. However, the results of the present study suggest that in the "passive" condition there remains an active participation of the eye muscles. Thus in further research using the same paradigm, it would be inadequate terminology to use active-passive as a label for this procedure. A suggestion might be to use the label "eye-limb" participation for the active condition, and just "eye" participation in the passive condition. This would be an important distinction inasmuch as the active-passive label might lead to confusion as to the actual conditions involved in such a paradigm.

Further research can also investigate the ef-

iciency of training programs with the use of the CCTV. A hierarchical training program can be designed and empirically verified with low vision subjects. Needless to say, much work needs to be done along this line. Furthermore, it is clear that much can be gained by continued experimentation in this area, which would improve the clinical procedures used in the rehabilitation of visually impaired subjects.

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