Change in Visual Perceptual Detection Distances for Low Vision Travelers as a Result of Dynamic Visual Assessment and Training

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Abstract: This study evaluated the ability of a dynamic visual assessment and training protocol to improve the ability of 65 persons who were legally blind to detect environmental hazards. Training improved the ability of the majority of subjects to detect hazards, and the assessments identified those who did not need training or would not benefit from it.

The profession of orientation and mobility (O&M) was developed to facilitate travel by individuals who were totally blind. In the years since its inception, the scope of O&M practice has been extended to providing training to individuals with low vision. Individuals with low vision may encounter potentially hazardous conditions in even the simplest travel paths: Undetected curbs and other drop-offs can lead to falls, objects on floors or walkways can be tripping hazards, and overhangs or protruding objects at head height can cause anything from "nasty bumps to severe injuries" (Ivers, Cumming, Mitchell, & Attebo, 1998). Studies in the medical, geriatric, and rehabilitation literatures have begun to document the extent and cost of such avoidable accidents. One area of concern they have found is that visual impairment is a risk factor for hip fractures (Dargent-Molina et al., 1996; Felson, Anderson, Hannan, & Milton, 1989; Klein, Klein, Lee, & Cruickshanks, 1998).

No environment appears to be completely safe with vision-related accidents—from structured environments, such as nursing homes (Rubenstein, Josephson, & Osterweil, 1996) to individuals' homes (Mann, Hurren, Tomita, Bengali, & Steinfeld, 1994) to the community (Ivers et al., 1998). In addition to the medical costs of these injuries, another type of cost may occur if individuals with visual impairments, especially those who are elderly, curtail their independent activities simply because they are afraid of falling (Lachman et al., 1998). This self-imposed limitation may prevent elderly people from gaining needed exercise and otherwise impair their ability to lead healthy lives, which may put them at risk for other diseases (Pukkala, Pia, Ojamo, & Rudanko, 1999). Indeed, some professionals have advocated specific interventions to ameliorate the effects of visual impairment (Horowitz, 1994; Maeda, Nakamura, Otomo, Higuchi, & Motohashi, 1998; Salive et al., 1992; Smeeth, 1998).

The authors thank Scott Johnson, Patrick Ryan, Jenny Smith, Julie Hazan, and Miriam Emanuel for their participation in the DVRA data collection, and C. T. Vasile for his help in conceptualizing the design of the project and his constructive comments during the preparation of the manuscript.

Review of the literature

Elderly people who restrict their travel because they feel they are unsafe may be making a rational decision, given the evidence that self-reported visual abilities accurately reflect objectively measured abilities (Klein et al., 1998). Many would argue that O&M services reduce fear and allow for safe travel. Yet, as Rubenstein et al. (1996) pointed out, increased activity is a two-edged sword because it both pro-motes independence and increases the opportunity for falls.

Given these risks, it seems evident that rehabilitation programs for people with low vision should assess individuals' ability to avoid hazards that may precipitate falls and, when warranted, provide rehabilitation interventions to optimize the individuals' ability to detect and avoid these hazards. But what specifically should be assessed and how should one intervene? Geruschat and Smith (1997) advocated both visual and O&M assessments and the prescription of aids and training when indicated. Training strategies to improve visually guided mobility have been developed for visually impaired children (Ambrose & Corn, 1997; Smith, Bradfield, & O'Donnell, 1990), but not specifically for elderly people with low vision.

Research on visual travel by elderly people with low vision has focused primarily on the visual characteristics of the travelers, although some studies have explored environmental variables (Kuyk, Elliott, Biehl, & Fuhr, 1996) and psychological traits (S. A. Haymes, Guest, Heyes, & Johnston, 1996). The visual characteristics that are generally considered to influence mobility performance include contrast sensitivity, extent of visual field, and visual acuity. Marron and Bailey's (1982) study, for example, of the roles of contrast sensitivity and extent of the visual field in deter-mining the ability of a person with low vision to detect and avoid obstacles in a real-world environment, suggested that, collectively, these two variables accounted for about a third of the observed variability in mobility performance. Subsequent research has generally supported the relationship of these variables to mobility performance (Brown, Brabyn, Welch, Haegerstrom-Portnoy, & Colenbrander, 1986; S. Haymes, Guest, Heyes, & Johnston, 1996; S. A. Haymes et al., 1996; Heyes, Haymes, Guest, & Johnston, 1996; Kuyk, Elliot, & Fuhr, 1998; Long, Rieser, & Hill, 1990; Lovie-Kitchin, Mainstone, Robinson, & Brown, 1990; Wilcox & Burdett, 1989).

Nevertheless, visual sensory variables do not seem to offer a complete explanation for the variability in low vision mobility, and both clinicians and researchers have sought better explanations of intersubject variability in mobility performance. As S. A. Haymes et al. (1996, p. 314) noted, "The relationship between orientation and mobility (O&M) performance and residual vision is not clearly understood." These researchers have even explored the potential role of personality factors (S. Haymes et al., 1996), although their most recent studies found a limited relationship between mobility performance and personality, at least for the populations studied (Heyes et al., 1996). It is also possible that the lack of explanatory power of visual variables for mobility performance stems from the fact that the variables are tested using one-dimensional assessments (visual acuity, contrast sensitivity), whereas

mobility performance is governed by multidimensional factors.

Another aspect of such studies is that they have not tended to account for the clinically observed intrasubject variability. One source of intrasubject variability may be that imposed by the environment. It is known that reducing illumination, for example, adversely affects an individual's ability to travel (Kuyk et al., 1998). Although such laboratory results coincide with clinical observations in real-world situations, the variables studied account for only about 50% of the variability in mobility performance and do not account for the other 50% (Kuyk et al., 1998).

A possible source of variability may be the visual perceptual capabilities of the individuals being studied. Rieser, Hill, Taylor, Bradfield, and Rosen (1992) noted that people with prior visual experience, particularly of broad-field vision, have advantages in learning environments over those who do not have prior visual experience and that differences in the perception of walking lead to observed differences in sensitivity to spatial structure.

Dodds and Davis (1989, p. 439) advocated the "need to develop ecologically valid measures of visual functioning and mobility performance in the context of cur-rent theories of perceptual functioning and learning," and Goodrich (1994) postulated that assessment and training techniques could be improved by incorporating evaluations of individuals' perceptual abilities. Dodds and Davis devised four tasks, which they found to be better predictors of mobility performance than existing clinical measures. Their assessment tool consisted of four programs displayed on a computer monitor: textural shearing, degraded fig ures, embedded figures, and peripheral attention. Dodds and Davis found that artificial tasks could be useful predictors of mobility performance and that practice tasks improved mobility performance. Their findings also lend credence to the view that the best assessment tools for visually guided mobility may be multidimensional.

Low vision mobility program

The Western Blind Rehabilitation Center (WBRC), in Palo Alto, California, developed a unique O&M program—the Verification Technique (V-Tech)---that integrates elements of traditional O&M low vision training with perceptual teaching strategies. With V-Tech, the traveler uses an individually tailored visual scanning pattern to preview the travel environment, combined with adaptive long cane and auditory-awareness techniques. V-Tech, when applied to low vision individuals, is one example of dynamic visual assessment and training (DVAT) therapies that are designed to capitalize on an individual's visual abilities, typically in conjunction with the long cane.

DVAT therapy can be defined as therapy that incorporates clinical measures of visual function (visual acuity, diagnosis, visual field, and contrast sensitivity) and uses low vision O&M assessments that take place in ecologically relevant (real-world) environments. Other examples of DVAT include training to travel safely and effectively in urban settings, in stores and malls, on public transportation, and in other perceptually challenging environments. In large part, V-Tech originated from clinical observations that many people with low vision selectively used their canes during travel

and seemed to rely primarily on their visual abilities for safe and efficient travel. In familiar environments, for example, the cane was either not used or used as if it were confirming what the individual saw. In unfamiliar environments, the cane might be more extensively used, but vision was still the predominantly employed sense.

Observations also indicated that individuals might inadvertently misidentify objects or place themselves in potentially dangerous situations because they could not see potential hazards. The fact that their visual abilities were "usually" sufficient for effective travel seemed to generate sufficient self-confidence that they continued to rely on it, even when doing so led to occasional collisions with objects in the' environment or even falls. From the O&M specialist's point of view, the person was engaging in unsafe travel. From the person's point of view, he or she was engaged in effective, if occasionally painful, travel. Given that people with low vision were reluctant to give up their use of vision and that their vision was, for the most part, extremely useful, the solution seemed to be to optimize a person's visual abilities and to rein-force the use of the long cane to supplement limited visual ability. This technique provides quantified information that can be given to the individual to help emphasize the need for low vision O&M training.

Although V-Tech has been used extensively at the WBRC, its efficacy has not been formally evaluated, and the study presented here was designed as a starting point to provide formal documentation of the technique. Since V-Tech is a comprehensive O&M technique, it was not practical to assess its efficacy in a single study. Therefore, the authors first assessed one of its primary components, the Distance Vision Recognition Assessment (DVRA), and will evaluate other aspects in future studies. DVRA has three main objectives: to quantify (1) the pretraining distance at which an individual with low vision can visually identify such potential hazards as curbs, obstacles, or overhangs; (2) any potential (pre-O&M training) ability the individual may have to increase his or her ability to identify curbs, obstacles, or over-hangs visually; and (3) gains in visual-identification ability following training.

DVRA is designed as a component of a comprehensive low vision O&M assessment and training regimen. An individual is considered to be a candidate for DVRA if, during the initial assessment, the O&M specialist observes an ability to relate visually to the travel environment (by demonstrating visual-spatial orientation abilities).

Once a candidate is identified, the DVRA is initiated. In practice, there are three components of the DVRA: the pretraining assessment, the visual perceptual training regimen, and the posttraining assessment. The training regimen includes training the individual to use visual perceptual cues better in identifying common environmental obstacles and may include techniques to control glare effectively (Ludt, 1997).

DVRA is viewed as a means to improve the travel abilities of a person with low vision by improving his or her ability to detect visually some common environmental hazards. Although it is reasonable to assume that a significant improvement in the detection of commonly occurring environmental hazards will improve travel efficiency and reduce accidents, it is beyond the scope of this article explicitly to draw

such a linkage. Rather, in the study, the authors sought to determine if an assessment of an individual's abilities to detect three types of hazards visually could be accomplished and, if so, whether these abilities could be improved through a systematic training program. Furthermore, the authors wondered if the assessment procedure could be used to predict the amount of improvement an individual might experience from the training procedure.

Method

SUBJECTS

The subjects were 65 patients (63 men and 2 women) who were admitted to the WBRC for comprehensive vision rehabilitation. Criteria for inclusion in the study were a demonstrable ability to use distance vision, no cognitive or emotional impairment that would prevent the individual from understanding and following instructions, and the ability to complete the DVRA program. Most subjects were able to walk the course unassisted, but 11 used support canes, 2 used electric scooters, and 1 each used a walker or manual wheelchair.

The average age of the subjects was 72.4 (SD = 11.9 years). The subjects' average visual acuity, measured in logMAR units, was 0.96 (SD = 0.29), and their contrast sensitivity, measured using a Pelli-Robson chart, was 0.89 (SD = 0.35). These visual acuities and contrast sensitivities were measured using best-practice low vision techniques and correspond to a Snellen acuity of approximately 20/200 with a severe loss in contrast sensitivity. The primary visual pathologies of the 65 subjects were age-related maculopathy (42 subjects), diabetic retinopathy (9 subjects), glaucoma (3 subjects), and other (11 subjects).

PROCEDURE

Each subject received a comprehensive assessment (including visual acuity, visual field, contrast sensitivity, and other clinical measures) by an experienced optometrist prior to his or her participation. The subjects were grouped according to the visual field characteristics of central field loss, peripheral field loss, or mixed central and peripheral loss. The protocol began with each subject being interviewed by an O&M specialist to determine his or her travel goals.

All the O&M specialists were trained in V-Tech and initially practiced the technique under supervision. Although a formal inter-rater reliability study was not conducted, all the O&M specialists demonstrated their competence with the V-Tech procedure to the first author before they were allowed to assess and instruct the subjects. In addition, they were observed during at least one pre–posttest sequence to ensure the comparability of methods and procedures.

Once the subject's goals were deter-mined, comprehensive pretraining outcome assessments were made (see Babcock, Goodrich, Head, & Boyless, 2000). DVRA assessments were made after the pretraining outcome. During the DVRA pretest, the subjects traveled on a route that they were not likely to have previously used. The pre-and posttraining assessments were done using two "I" routes, which were approximately 250 feet long. The instructors ensured that no other pedestrians were traveling at the same time the assessments were conducted. The first half of each route had naturally occurring drop-offs (curbs) and

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obstacles (a gray waste basket, 13 inches in diameter, and 16 inches high and 11 inches deep). The overhang was a three-foot-long by 0.5-inch-diameter black foam tube that was suspended from a tree. The height of the overhang was adjusted to be at the head height of each subject.

The subjects were oriented so they faced north at the beginning of the assessment and were informed that there were multiple drop-offs, obstacles, and overhangs, thus ensuring that they would continuously search for all three types of hazards throughout the assessment. In practice, there was a quasi-

random distribution of hazards. The subjects were instructed to stop and point to a hazard directly in their path as soon as they saw it. At each point at which they correctly identified a hazard, the O&M specialist marked the spot with chalk for later measurement and recording on the data sheet. False positive reports were ignored. As each hazard was identified, the O&M specialist also asked the subjects a series of questions to determine the cue (e.g., contrast or change in the shoreline) that was used in detecting the hazard. If the subjects did not identify a target, the distance was recorded as zero. Six O&M specialists provided subject training and collected data for the study. The O&M specialists walked beside each subject in a position to observe direction of gaze and scanning patterns and to ensure that the subject was not at risk of falling during the assessment.

Once the initial assessment was completed and all measurements were made, the DVRA potential detection distances were determined using a route that was judged to be equivalent to the pretest route. This judgment was based on extensive analysis of the geographic orientation of the route (including the position of the sun), similarity of the type and location of obstacles, absence of distracting conditions or obstacles, length, and similar concerns. The O&M specialists varied the order of presentation of hazards so the subjects could not anticipate the order. The subjects were told that the objective of the assessment was to determine if they had the potential, with O&M instruction, to increase the distance at which they could visually detect hazards. To ensure that the subjects were confident of their safety, each assessment was con-ducted with the O&M specialist using a human guide technique. The subjects with central field losses were instructed to use their preferred retinal locus.

The subjects were then instructed to "scan the sidewalk, head to toe, for any-thing that's in your way"—a technique referred to as the dynamic scanning method (DSM). It had been observed that most people with low vision who are admitted to the WBRC traveled with a head-down posture, looking just in front of their feet, and used quick, random upward scans or other ineffective scanning patterns. It was thought that DSM was a better technique that gave the subjects the opportunity to detect hazards earlier. It was suggested to the subjects that eye scanning (rather than head scanning) would be the most effective. The recommended DSM was to scan (or preview) the environment with a vertical (scanning up and down) pattern at each of three levels: head level, street-obstacle level, and drop-off. The subjects were further instructed to pause at each of the three viewing levels and identify the absence or presence of the best visual cue per the assessed pretest. This was an important ele-

ment in the instruction process, since it was essential that the O&M specialist ensured that each subject followed the viewing strategy just described. Generally, this procedure took only five to eight minutes.

Once the subjects were familiar with DSM, the potential DVRA was assessed. The subjects were instructed to use the DSM and mentally preview the targets they had encountered in the preassessment and during DSM training. The O&M specialist also described the obstacles and potential cues that were identified in the preassessment. (e.g., "I want you to look for a sharp drop in the sidewalk, such as the down slope of a ramp, curb, or stairway"). The specialist then guided the subjects through the DVRA potential route, asking them to detect visually and point out any of the three hazards they encountered. As each hazard was identified, the specialist again marked the spot with chalk for later measurement. These distances were used as the estimate of each subject's potential visual detection distance.

During the potential assessments, the O&M specialist ensured that the subjects used their best viewing angle, DSM, and visual cues. If necessary, the specialist reviewed the instructions to help the subjects use the most appropriate eccentric viewing angle or scanning pattern. The data recorded included the potential distance and the visual cue or cues (contrast, figure-ground, shape, color, motion, change in the shoreline, and/or depth perception) used by each subject for each hazard.

After the assessments, all the subjects began their formal O&M training programs, which consisted of V-Tech therapy, which is based on a person's goals and incorporates the O&M specialist's assessment of the person's visual and other sensory abilities and hence is an individualized therapy pro-gram. For travelers with low vision, the role of the long cane may be that of a tool to ensure safety, with the traveler's vision the primary sensory aid. That is, once the hazard is visually detected, the long cane may then be used to navigate obstacles and/or as a forearm protective technique for overhangs, so the person's vision is left free to look for additional hazards, travel cues, and the like. For travelers who are totally blind or have severe low vision, the long cane is the primary mobility tool for both the detection and avoidance of obstacles.

V-Tech therapy, as applied in this study, required 10—15 hours of assessment and training. Each subject's pretest results were incorporated into the V-Tech instruction so that the training was individualized. The posttraining assessment was conducted on an unfamiliar route that was also judged to be equivalent to the pretraining route, and the instructions were similar to those given before the pretraining assessment. Data points were again marked at the spots at which the subjects visually identified the hazards, and the distance to the actual hazards was measured after each trial was completed. In addition, the subjects were asked to identify the visual cue used in identifying each type of hazard.

DATA ANALYSIS

The data analysis used the results of the clinical low vision examinations and the subjects' demographic data, as well as the data collected during the pre-, potential, and posttraining DVRA assessments. In addition, the O&M specialist recorded the type of mobility aids used by each subject prior to admission (e.g., a long cane, sun-

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glasses/tints, walkers, or wheelchairs) and those issued on completion of the training. Correlations were performed to examine the relationship between the clinical variables (visual acuity and contrast sensitivity) and visual detection distances. A one-way analysis of variance (ANOVA) was used to examine the effect of visual field loss (central loss, peripheral loss, or mixed central and peripheral losses) on visual detection distances. The statistical significance of the pretraining assessments, predicted visual detection distances, and posttraining assessments were assessed using t-tests. The clinical effect size was estimated using the procedure for determining d advanced by Cohen (1988).

Results

The posttraining visual detection distances for each of the three types of hazards increased significantly over the pretraining assessments (see Table 1): for drop-offs, from 4.3 feet to 20.9 feet; for obstacles, 23.1 feet to 61.3 feet; and for overhangs, 10 feet to 23.9 feet. In the study, the average pretraining detection distances understate the degree of the problem most subjects had in visually detecting the hazards. For example, some subjects were able to detect the hazards at relatively long distances, but many others were unable to do so until they were literally on top of the hazards.

Table 2 presents the percentage data for all the subjects by the distances at which they were able to detect visually each of the three types of hazards. It shows that prior to training, 55.4% of the subjects could not visually detect drop-offs and an additional 23.1% could visually detect them only at a distance of 5 feet or less. Thus, before training, 78.5% of the subjects were visually unable to detect drop-offs from a distance sufficient to ensure their ability to avoid them, whereas after training, 87.7% had a visual detection distance for drop-offs of more than 5 feet. Similarly, although only 9.2% could visually detect obstacles at 5 or more feet before training, after training, all the subjects could. In addition, before training, overhanging hazards were visually undetectable at any distance by 12.3% of the subjects, and an additional 27.7% could detect them at 5 or more feet, but after training, all the subjects could visually detect overhangs at 2 feet, and 97% could detect them at 5 or more feet.

The predicted visual detection distances were in good agreement with the actual visual detection distances for all three types of hazards, although the predictions significantly underestimated the actual visual detection distances for drop-offs (18.5 feet versus 20.9 feet). The pretraining visual detection distances for all three types of hazards were statistically significantly different from both the predicted and post-

Table 1
Average visual detection distances for each of the three types of hazards (N = **65; standard deviations in parentheses).**

Hazard	Pretraining assessment	Predicted potential	Posttraining assessment
Drop-off	4.3 feet (7.4)	18.5 feet (12.9)	20.9 feet (14.4)
Obstacle	23.1 feet (19.0)	54.7 feet (36.6)	61.3 feet (32.2)
Overhang	10.0 feet (10.1)	21.2 feet (13.4)	23.9 feet (19.3)

Table 2
Pre- and posttraining visual detection distances, by maximum detection distance and percentage of subjects.

Visual detection distance	Pretraining drop-off	Posttraining drop-off
Could not detect visually	55.4	1.5
0.1 to 2 feet	10.8	0.0
2.1 to 5 feet	12.3	10.8
Greater than 5 feet	21.5	87.7
	Pretraining obstacle	Posttraining obstacle
3 feet or less	4.6	0.0
3.1 to 5 feet	4.6	0.0
Greater than 5 feet	90.8	100
	Pretraining overhang	Posttraining overhang
Could not detect visually	12.3	0.0
0.1 to 2 feet	6.1	0.0
2.1 to 5 feet	[illegible]	3.0
Greater than 5 feet	[illegible]	[illegible]

training visual detection distances. This finding was demonstrated with t-tests, except for the pretraining drop-off data. A Kolmogorov-Smirnov Test indicated the pretraining drop-off data were not normally distributed (K-S = 2.285, $p < .000$); therefore, chi-square tests were computed to determine that the pretraining distance was significantly different from both the predicted and posttraining distances. The data for the remaining conditions were normally distributed. The predicted and posttraining distances for obstacles and overhangs were not statistically different from each other, indicating that the predicted distances were in general agreement with the distances

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assessed after training. Table 3 presents the t-test and chi-square statistics.

Visual acuity was not significantly correlated with posttraining visual detection distances for either drop-offs (r = - 0.177, n.s.) or obstacles (r = - 0.231, n.$), but was modestly correlated with visual detection distances for overhangs (r = - 0.271, p < .03). Contrast sensitivity was modestly correlated with all three types of hazards (posttraining): drop-offs, r = 0.3254; obstacles, r = 0.321; and overhangs, r = 0.343. Age was not correlated with any measured posttraining visual detection distances. The posttraining visual detection distances for all three hazards had moderate to large correlations with themselves: drop-offs and

Table 3
t-tests of pretraining, potential, and posttraining visual detection distances for the three hazards assessed.

Hazard	Variable pair	Test statistic	Significance (two-tailed)
Drop-off	Pretraining-predicted	XZ = 274.5	.000
	Pretraining-posttraining	XZ=101.8	.000
	Predicted-posttraining	t = -2.301	.025
Obstacle	Pre-training-predicted	t = -9.585	.00
	Pretraining-posttraining	t= -10.152	.00
	Predicted-posttraining	t = -1.674	NS
Overhang	Pretraining-predicted	t = -11.634	.00
	Pretraining-posttraining	t = -8.244	0.00
	Predicted-posttraining	t=-1.706	NS

obstacles, r = 0.431; drop-offs and overhangs, r = 0.748; obstacles and overhangs, r = 0.488. The measure of visual field (central loss, peripheral loss, or mixed central and peripheral loss) did not have a significant effect on visual detection distance for any of the three variables, as measured by a one-way ANOVA (for drop-offs, f = 1.742, n.s.; for obstacles, f = 2.027, n.s.; and for drop-offs, f = 1.731, n.s.). (see Table 4).

The predicted visual detection distances correlated highly with the actual visual detection distances: for drop-offs, r = 0.821, p < .000; for obstacles, r = 0.575, p < .000); and for overhangs, r = 0.764, p < .000. The intersubject variance accounted for by these correlations was 67% for drop-offs, 33% for obstacles, and 58% for overhangs.

In light of previous studies that found correlations between visual acuity and contrast sensitivity and the current findings that these variables correlated less well with visual detection distances than did the prediction technique, stepwise linear regressions were conducted. A regression model was used for each of the three hazards as the dependent variable and visual acuity, contrast sensitivity, and the predicted visual detection distances as the independent variables. In all cases, the model excluded both visual acuity and contrast sensitivity, since they did not add to the descriptive power of the model. Thus, only the predicted visual

detection distance was significant (drop-off beta = 0.822, $t = 11.377$, $p < .000$; obstacle beta = 0.575, $t = 5.532$, $p < .000$; and overhang beta = 0.763, $t = 9.283$, $p < .000$).

As was previously noted, the pre—post-training changes for all three hazards were statistically significant, but the test for statistical significance only determines the probability that these were chance occurrences. Stated more formally, it is a test of whether the null hypothesis is true or false. Although important in research, statistical significance does not indicate whether the finding is clinically significant. That is, is it sufficiently robust to warrant a change in a clinical program or, put another way, does it make a meaningful improvement in a client's abilities? Clinical significance can be estimated using a measure of effect size symbolized by d (Cohen, 1988). Effect sizes indicate the "degree to which the phenomenon under study is manifested" (Cohen, p. 10), which can be estimated from the difference between two mean scores divided by the standard deviation of the change score. An effect size $d = 0.2$ is considered small, $d = 0.5$ is medium, and $d = 1.0$ is large. In the study, the effect size for the increase in visual detection distances for drop-offs was $d = 1.5$; for obstacles, $d = 1.26$; and for overhangs, $d = 1.02$. Thus, for all three types of hazards, the

Table 4

Correlation of the posttraining visual detection distances with the subjects' visual acuity, contrast sensitivity, age, and predicted visual detection distance.

	Visual acuity	Contrast sensitivity	Age	Predicted visual detection distance
Drop-offs	-0.177	0.325	0.049	0.821**
Obstacles	-0.231	0.321**	-0.189	0.575**
Overhangs	-0.271 *	0.343	-0.193	0.764**

* p < .05, ** p < .01.

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DVAT resulted in clinically meaningful improvements.

Discussion

Falls are a substantial health threat for elderly people with visual impairments, and even the fear of falls may curtail travel. Reduced travel limits one's quality of life and may, in itself, be a health threat by reducing exercise. O&M specialists use a highly effective technique, the long cane, to facilitate independent travel by people who are blind. Clinical observation indicates that a similar long cane technique is beneficial to many travelers with low vision, but many of these individuals choose not to use the cane, use it inappropriately, or use it inconsistently. In any event, the ability of a long cane to detect drop-offs and obstacles is limited by the length of the cane and the skill and technique of the traveler (Blasch & de l'Aune, 1994, 1996; Johnson, Johnson, Blasch, & de l'Aune, 1998), and the long cane does not offer protection from over-hanging obstacles. Thus, in itself, it is unlikely to be the primary mobility aid used by the majority of people with low vision.

The pretraining assessments found that most of the subjects were visually unable to detect one or more of the hazards at a safe distance. The measured (one-dimensional) variables of visual acuity and contrast sensitivity explained little of the variability for visual detection distances of any of the hazards studied. This finding is only in general agreement with prior studies in that these studies found a greater relationship between acuity and contrast and mobility performance than was found in this study. These differences may be due to the mobility measures used in this study versus prior studies and/or the use of an outdoor environment in the current study versus controlled, laboratory environments in most previous studies. The differences also may be due to differences in the subjects (the subjects in the current study had a variety of visual pathologies, whereas previous studies often focused on a specific pathology, such as retinitis pigmentosa). The current findings may add credence to the notion advocated by Dodds and Davis (1989) that it would be profitable to pay more attention to ecologically valid assessments and training paradigms that incorporate perceptual training.

Substantial improvement in the visual detection distances for all three types of hazards studied were found as a result of the training that was provided. These improvements were both statistically and clinically meaningful. The authors also found that DVRA, a multidimensional assessment of visual detection abilities, was a better predictor of the rehabilitation outcome (improvement in the visual detection distances for all three types of hazards) than were the traditional one-dimensional assessments of visual acuity and contrast sensitivity. The stepwise linear regression analysis indicated that these clinical variables did not meaningfully add to the predictive ability of DVRA. DVRA, unlike traditional clinical measures, assesses the individual's scanning and perceptual abilities, as well as the person's ability to integrate visual stimuli into the decision-making process used during travel.

It is important to note that data from this study indicate that DVRA can allow O&M specialists to target low vision mobility appropriately. For example, less than 10% of the subjects were assessed as lacking the visual ability to make significant improvements in their visual detection distances (to

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detect hazards visually at a distance greater than can be detected by a long cane). Since extensive training in visual detection did not improve these subjects' abilities, DVRA seems to offer promise in eliminating visual detection training for such persons. At the other extreme, about 10% of the subjects were assessed as having good visual detection abilities (they could visually detect hazards at a distance of at least 15 feet). It can be debated whether there is value in providing training to individuals who already have good abilities, and for some subjects, the study found it to be a moot point, since they could not improve their visual detection abilities even with further training.

Implementing the V-Tech procedures is not simply a matter of generally following the guidelines presented here. In training the participating instructors before the study began, the authors found that some used other techniques to train clients in scanning and viewing the environment, specifically some scanning patterns (such as looking up and forward or a center-leftcenter-right-center pattern, similar to the motion of a windshield wiper) that were ineffective in improving the clients' visual detection abilities. It seems, therefore, that not all training techniques are effective, which reinforces the need to do systematic, measurable assessments, like DVRA. It is only through such documentation that effective training techniques can be promoted and ineffective ones eliminated.

Benefits of DVRA training

The benefits of implementing the systematic assessment and training methodology of DVRA are manifold. First, DVRA appears to offer a more effective assessment tool for an important subset of mobility training than do current clinical measures. Second, DVRA allows O&M specialists to identify clients who are unlikely to benefit (or to benefit marginally) from the training because their visual impairment prevents them from effectively using visual environmental information even with additional training. Third, DVRA allows O&M specialists to identify clients who have sufficiently good visual detection abilities that training in visually detecting the identified hazards is unlikely to improve their existing abilities as defined in this study. Both the second and third benefits can help O&M therapists provide cost-effective services without sacrificing the quality of care.

Fourth, DVRA allows for systematic data collection on the type and amount of training provided in relation to the assessment of clients' needs. This documentation is meaningful for specialists or agencies that must document the time and outcomes of interventions for internal or external (third-party) reimbursement. Finally, DVRA offers a direct benefit in improving the care of people with low vision who do not want to use a long cane, but who need it to travel safely and efficiently. DVRA allows an O&M specialist to measure a client's existing and potential abilities and to document them clearly and precisely. This documentation should be shared with the client so that he or she has a clear under-standing of his or her strengths and limitations. The authors have found that being able to tell a person that he or she was unable to detect a hazard visually, even 2 feet away from it, was a convincing argument and helped the person acknowledge and accept the need for a long cane.

Conclusion

In summary, the authors found that DVRA is an effective visual assessment tool that complements the information provided by existing clinical vision assessments. They also found that DVRA allowed them to identify clients who could not improve their visual detection abilities, those who could and needed to improve their visual detection abilities, and those who did not need (and were unlikely to benefit from) visual detection training. These results were both statistically significant and clinically meaningful.

It is important to recognize that there are limitations to this study. The methodology employed a quasi-experimental design and lacked a control group that would have allowed a less equivocal demonstration of the effectiveness of training. The authors did not include a control group for two reasons: First, there was no readily available group of persons who did not want rehabilitation training and who were similar to the client population. Second, the authors believe that training is important and thus to withhold such training would be unethical. A compromise would have been to delay training, but it was not possible to justify the additional cost that such a strategy would entail (an added length of stay of one to two weeks).

The authors do not advocate abandoning visual acuity and contrast sensitivity measures. These are tried and true assessments that provide the clinician and O&M specialist with valuable information and the ability to prescribe appropriate low vision devices. They are also valuable tools for virtually all research projects, if for no other reason than they allow one to group subjects meaningfully. The authors do believe, however, that it is possible and necessary to develop other assessment tools, such as DVRA, that provide meaningful information that existing clinical measures do not provide. Indeed, it seems that a great deal more work could profitably be done in this regard.

This study used a novel methodology, a first-of-a-kind if you will, and it is always beneficial to have any such study replicated by others. The authors believe that the findings are creditable and hope that they will spur others to consider replicating the study and/or developing alternatives, which may ultimately prove superior to the current design. That having been said, the authors believe they have demonstrated that the DVAT methodology provides clinically valid and documented results that cannot be obtained through any other assessment and training paradigm.

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