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Central Field Loss in Object-System and Low-Vision Simulation

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This study examined the fidelity of low vision simulator systems, specifically for central field loss, in clinical and functional settings. The participants were 19 sighted undergraduate students who underwent clinical visual assessment (visual acuity and peripheral field examinations) and functional orientation and mobility assessment (counts of bumps, stumbles, drop-offs, false moves, and street-crossing errors as noted on Geruschat and Del'Aune's Critical Incidents Tally Sheet), while wearing two different low vision simulator goggles for central field loss.

The findings of this study indicated that while one simulator was moderately suitable for clinical purposes (it produced varied decreases in visual acuity and peripheral field results), the other was suitable for functional simulation (it produced behaviors observed in the adult population with central field loss, e.g. stumbles, false moves, slower travel time, etc.), and these two were not interchangeable. This research supports the need for outcome-based fidelity in the design and use of low- vision simulator systems in order to achieve effective simulation. Limitations of this study and suggestions for future research are provided.

Keywords: central field loss, simulator systems, object-system simulation, low-vision simulation, visual acuity testing, peripheral field testing

Vision professionals have used vision simulation systems as teaching tools since formal orientation and mobility training was initiated by Richard Hoover at Valley Forge in the 1940s (Blasch, Wiener, & Welsh, 1997; Koestler, 1976). The first vision simulator systems used by travel trainers were blindfolds that totally occluded the wearer's vision. In the 1970s, professionals in the field of vision impairment became more aware of the importance of low vision in orientation and mobility training and began to develop apparatus designed to simulate low vision conditions (Smith, De l'Aune, & Geruschat, 1992). According to Apple, Apple, & Blasch (1976), early low vision simulator systems were considered to be "a poor imitation at best" (p. 4); however, they were the only options available for professional training and directed study. Despite few changes to the original designs, low vision simulators continue to be used today (Elliott, Bullimore, Patla, & Whitaker, 1996; Morris, 1976; Walker, 1990).

Simulation Review

The use of simulation techniques has grown in popularity in many areas as well as in the field of education. In attempts to increase disability awareness and empathy, simulators designed to mimic disability conditions have been utilized in inclusion efforts (Cohen, 1982; Dittmer, 1991; Hallenbeck & McMaster, 1991; Mott, Striefel, & Quintero, 1987; Odegard-Johnson, 1984; Raines, 1987; Trent, 1993; Wesson & Mandell, 1989). However, education has been inclined to accept simulation at face value with little investigation into the characteristics of the simulation device. Also, in education, little attention has been given to the fidelity or the degree to which the simulator actually reproduces its real-life counterpart (Andrews, 1988). Therefore, opportunities to utilize simulation have emerged, as has considerable debate regarding the reliability, validity, and fidelity of simulation systems (Elliott, Bullimore, Patla, & Whitaker, 1996; Morris, 1976; Su, 1984; Walker, 1990). Considering the "anecdotal" approach used by most published educational research studies on simulation, the evidence of success of disability simulation is limited (Mott, Striefel, & Quintero, 1987).

Researchers in technical fields have identified two critical elements for effective or predictive simulation (Satava, 2004): identifying the purpose for creating the simulator and identifying the object system

(specific characteristics) required in the simulation (Collart, 1979). Collart emphasized that the object system must be compatible with the simulator for the simulation to assure the fidelity necessary to achieve effective training. Additionally, technical research has addressed assessment of the simulators in that such assessment must encompass an effective design that includes both the purpose of the simulation and the fidelity of the simulator (Su, 1984).

In keeping with suggestions presented by professionals in other fields, the fidelity of low vision simulation must be compared to the real-life counterpart to obtain the correct object system (Andrews, 1988; Collart, 1979; Su, 1984). While acknowledged that clinical visual abilities do not predict functional travel efficiency (Faye, 1984; Jose, 1983; Levack, 1991; Ludt & Goodrich, 2002), there are clinical characteristics related to certain eye conditions (Bishop, 2000; Jose, 1983). While persons who have low vision often present reduced clinical abilities, these people also demonstrate specific functional characteristics such as: increased number of critical orientation and mobility errors and increased amount of travel time, (Bishop, 2000; Jose, 1983, Levack, 1991).

To achieve a compatible object system, attention must be given to the fidelity needed in a given simulation. Clinical simulations must have clinical object systems and be assessed in static environments (Collart, 1979). Consequently, if functional fidelity is desired, those elements related to functional performance assessed in dynamic situations should be considered (Bozeman, 1998; Walker, 1990).

Toward this goal, this study examined simulators from two different low vision simulator systems: one that was commercially-available (without discussion of object system) and one that was designed with a functional object system; to produce behaviors consistent with central opacity, e.g. reduced orientation and mobility performance, problems discerning surface changes, the need for increased scanning and travel time (Bishop, 2000; Smith & Geruschat, 2000).

The researchers hoped to determine if significant differences existed in the mean frequencies of observed critical orientation and mobility errors and the means of route completion times while traveling outdoor and indoor routes between the commercially-available simulator (Simulator 1), the simulator designed with a functional object system (Simulator 2), and the

Control (No Simulator) as recorded on the Critical Incidents Tally Sheet (Geruschat & De l'Aune, 1990). Based upon functional procedures typically administered during orientation and mobility assessments of individuals who have low vision, this question was used to determine if the simulators elicited the anticipated effects, both clinically and functionally.

Methodology

The effects of central field loss simulators on static and dynamic behaviors of participants were evaluated in clinical and functional settings. Clinically, volunteers were assessed and data reported for distance visual acuity and for visual fields. Functional data were gathered and analyzed regarding critical orientation and mobility errors and time required to travel the assigned routes.

Participants

Nineteen, sighted participants ages 20-22, who were students in the Taiwan University System, completed this study. Participants had no mental or physical disabilities per self-report and no prior experience with low vision simulation or orientation and mobility.

Subjects who volunteered and who qualified for inclusion were screened and had measured distance acuities of at least 20/40 (standard testing threshold) without spectacle correction in the better eye as measured by the Snellen Tumbling E Chart (the Snellen Tumbling E is traditionally used in Taiwan culture for distance visual acuity assessment). Study participants had monocular visual fields of at least 60 degrees in diameter as measured by tangent screen. Correction of refractive errors by the use of contact lenses was acceptable; however, correction via eyeglasses excluded the volunteer due to the physical construction of the simulator systems used in this study.

Procedure

The participant's better eye, determined by visual acuity and peripheral field screening, wore the low vision simulation device. Each participant was assessed one time wearing a commercially available simulation for central field restriction (Simulator 1), which included instruction to hold the head and eyes still while wearing the device. While not typical in low-vision acuity testing, the manufacturer's recommendations were followed. Simulator 1 consisted of a welder's goggle with an opaque dot that measured 15mm in diameter and placed in the middle of one

goggle to restrict the wearer's vision in the central area. Participants were then assessed while wearing Simulator 2, designed to produce behaviors consistent with functional central field restriction e.g. increased scanning and use of eccentric viewing; problems with glare, orientation and color discrimination; slower travel time; and difficulty discerning surface changes (Bishop, 2000) and instructed to use whatever movement necessary to utilize remaining vision. This simulator was a swim goggle adapted using electrical tape to block out all central visual stimulation leaving only a small amount (0.5mm) of the periphery clear. This simulator was designed to restrict central visual abilities even with eye movement. Both simulators had one lens completely occluded per Jose's (1983) recommendations. To determine the effect of the simulations, each participant was assessed with No Simulation to serve as a control.

Clinical assessments of distance visual acuity and peripheral fields were obtained using the Feinbloom (Original) Distance Test Chart for the Partially Sighted and tangent screen, respectively. These accepted measures were scored using standard procedures for assessment of people with low vision with the exception of the manufacturer's recommendation for Simulator 1.

Functional observation of critical orientation and mobility errors observed while traveling outdoor and indoor routes as well as time required for route completion were recorded by Certified O&M Specialists (COMS) on the Critical Incidents Tally Sheet, developed by Geruschat, et al (1990). Geruschat and De l'Aune identified six critical incidents in orientation and mobility: **bump errors -** body contact (except hands) with any person or object; **stumble errors -** a change in posture or gait as a result of contact with an object below the knee; **drop-off errors -** a change in posture or gait as a result of an unexpected surface change; **orientation errors -** a change in direction which is not consistent with the directions provided by the observer or verbal indication of an inability to complete that portion of the route; **false move errors -** a reaching or groping with the hands toward an object without making contact with the desired object; **street crossing errors -** crossing a street in an unsafe manner (requiring intervention from the observer) or crossing to an inappropriate area. The Critical Incidents Tally Sheet also provided an area for observer comments regarding the performance of the

subject and/or unusual environmental occurrences. Both of the routes were traveled within a specific time of the day to control for lighting changes and environmental fluctuations (outdoor) and the effects of pedestrian traffic, natural, and indoor lighting conditions on the travel abilities of the participant (indoors).

Clinical assessment data were descriptive in nature. A randomized, block factorial, within subject model was used as the design. The quantitative ANOVA examined the number of critical orientation and mobility errors and the time required for route completion across the simulator and control groups. Post hoc testing was done using the Scheffe Post Hoc Comparison method.

Results

Clinical Results (Table 1)

With Simulator 1, distance visual acuities ranged from 20/25 to 20/100 (with 2 participants unable to respond to the test at all). These results were affected by where the black dot on the goggle corresponded with the participant's pupil. Differing facial structures affected the amount of central vision available to the subject. With Simulator 2, all 19 subjects reported problems seeing the chart and acuities ere unobtainable at the 10' distance. With No Simulation, distance acuities ranged from 20/20 to 20/30.

With Simulator 1, tangent screen results indicated a scotoma size that ranged from 15-30 degrees in diameter. This variance appeared to again be related to simulator fit and the position of the dot in relation to the participant's pupil. None of the subjects could respond to the 5/100W tangent testing target while wearing Simulator 2. With No Simulation, all participants' tangent screen results were within normal limits.

Table 1 Clinical Measures

Participant ID	Distance Vision: S1	Distance Vision: S2	NS	Scotoma		
				S1	S2	NS
1	20/40	XX	20/20	~ 20 degrees	XX	WNL
2	20/40	XX	20/20	~ 20 degrees	XX	WNL
3	20/60	XX	20/20	~ 20 degrees	XX	WNL
4	20/60	XX	20/20	~ 25 degrees	XX	WNL
5	20/40	XX	20/20	~ 25 degrees	XX	WNL
6	20/100	XX	20/30	~ 25 degrees	XX	WNL
7	20/40	XX	20/25	~ 20 degrees	XX	WNL
8	20/30	XX	20/20	~ 25 degrees	XX	WNL
9	20/25	XX	20/20	~ 15 degrees	XX	WNL
10	20/60	XX	20/25	~ 15 degrees	XX	WNL
11	20/80	XX	20/20	~ 25 degrees	XX	WNL
12	20/40	XX	20/20	~ 20 degrees	XX	WNL
13	20/100	XX	20/25	~ 25 degrees	XX	WNL
14	20/30	XX	20/20	~ 25 degrees	XX	WNL
15	20/60	XX	20/25	~ 20 degrees	XX	WNL
16	20/60	XX	20/30	~ 25 degrees	XX	WNL
17	XX	XX	20/25	~ 20 degrees	XX	WNL
18	20/80	XX	20/30	~ 30 degrees	XX	WNL
19	XX	XX	20/20	~ 30 degrees	XX	WNL

S 1 = with Simulator 1 S 2 = with Simulator 2 NS = no simulator (control)
WNL = within normal limits XX = unable to respond

Functional Results: Outdoor and Indoor Routes(Table 2)

With Simulator 1, there were few mobility errors observed when the participants were traveling outdoor and indoor routes (2 errors outdoors; 2 errors indoors). The O&M Specialists noted that participants looked "around" the opaque dot in Simulator 1 while moving through the environment.

Simulator 2 produced many more errors. A total of 85 errors (outdoors) and 33 errors (indoors) occurred across the nineteen routes respectively.

With No Simulation, two outdoor and no indoor errors were observed during the 19 trials. When participants wore no simulation (the control), the results were almost identical to wearing Simulator 1 across functional settings.

The mean time for outdoor route completion using Simulator 2 (292 seconds) was considerably longer than with Simulator 1 (161 seconds) or with No Simulation (140 seconds). For indoor route completion, the mean times were the same (47seconds) for Simulator 1 as for No Simulation. Simulator 2 produced a mean time of 69 seconds.

Table 2 Routes: Errors and Mean Times

Errors Outdoor	S1	S2	NS
Bumps	0	9	0
Stumbles	0	20	0
Drop offs	1	6	0
Orientation	1	7	1
False moves	0	42	1
Unsafe street crossing	0	1	0
Mean Time (in seconds)	161	292	140
Errors Indoor	S1	S2	NS
Bumps	0	0	0
Stumbles	1	21	0
Drop offs	0	0	0
Orientation	0	0	0
False moves	1	12	0
Street crossing	N/A	N/A	N/A
Mean Time (in seconds)	47	69	47

S 1 = with Simulator 1 S2 = with Simulator 2 NS = no simulator (control)

Table 3 illustrates that significant differences in the mean frequency of critical orientation and mobility errors while traveling the indoor and outdoor routes only occurred when the participant was wearing Simulator 2. There were no significant differences in the participants' functional performance when wearing Simulator 1 and results were essentially the same when wearing Simulator 1 as when wearing no simulation at all.

Table 3 ANOVA of Frequency of Error by Types of Simulators

O=Outdoor Route I=Indoor Route #1=Simulator 1 #2=Simulator 2 #3=No Simulator

Source	Mean	SD	F	Scheffe
O_1	.11	.46	57.339***	**O**_#2 > **O**_#1 **O**_#2 > **O**_#3 **O**_#2 > **I**_#1 **O**_#2 > **I**_#2 **O**_#2 > **I**_#3 **I**_#2 > **O**_#1 **I**_#2 > **O**_#3 **I**_#2 > **I**_#1 **I**_#2 > **I**_#3
O_2	5.05	2.57		
O_3	0.0526	.23		
I_1	.11	.32		
I_2	1.74	1.05		
I_3	.00	.00		

***p<0.001

There were also significant differences in the time required for outdoor and indoor route completion when wearing Simulator 2. As noted in Table 4, the significance scores were less than .001; therefore, Simulator 2 did produce the need for more time to complete the outdoor and indoor routes, respectively, whereas travel time with Simulator 1 was essentially the same as with No Simulation.

Table 4 Significance of Times

Outdoor	Mean	Std.	F	Scheffe
#1	161.1579	27.8553		#2>#1
#2	292.1579	155.7163	25.090***	
#3	140.1053	35.4023		#2>#3
Indoor	Mean	Std.	**F**	Scheffe
#1	47.4737	6.2926		#2>#1
#2	69.3684	23.3957	13.716***	
#3	47.6842	8.4133		#2>#3

#1=Simulator1 #2=Simulator2 #3=No Simulator
*p<0.05; **p<0.01; ***p<0.001

Discussion

The purpose of this study was to determine if low vision simulators for central field restriction would generate consistent clinical results as well as specific functional behaviors typically observed in their real-life counterpart. Simulator 1 did exhibit a clinical fidelity with the few variances noted due to fit and differences in facial structure. Simulator 1, however, did not produce the functional behaviors and demonstrated no significant differences than with no simulation in functional settings. Directions accompanying Simulator 1 noted for the user to be cautious about eye movement during the simulation. These instructions were effective in the static, clinical, setting; however, adherence was difficult when the participants moved through the changing, environmental conditions. While moving, participants were apparently unable to control intuitive eye movements and received visual input from parts of the goggles that had little, if any, distortion. The ability to easily see “around” the opaque dot may be viewed as a major deficit in the fidelity of the commercially available simulator (Simulator 1) if used in functional environments. Conversely, while wearing the simulator designed with

the functional object system (Simulator 2) participants were unable to respond to measures in the clinical setting. This result was anticipated as Simulator 2 was designed to elicit the functional characteristics observed in a person with low vision due to central field restriction and, therefore, this simulator did not have a clinical object system.

Conclusions

The results of this study indicate that these low vision simulators did appear to elicit some clinical and functional low vision behaviors; however, the two simulators/environments were not interchangeable. The data indicated that the value of a simulator may be directly determined by the way it is used. By considering the object system (specific clinical and functional characteristics) needed for the task, professionals using low vision simulator systems can better choose/design the precise type of simulation that will create the desired training outcome or experience. Through the identification of specific clinical and functional characteristics induced by the low vision simulation, Orientation and Mobility Specialist may be able to develop better methods for utilizing low vision simulation systems. From this information, vision professionals may be able to better select the clinical and functional environments in which to use the simulations and exercise some control over confounding variables that may be elicited by the low vision simulators.

Also, in education, more attention should be given to the fidelity or the degree to which the simulator actually reproduces its real-life counterpart. To achieve a compatible object system, attention must be given to the fidelity needed in a given simulation. Clinical simulations must have clinical object systems and be assessed in static environments. Consequently, if functional fidelity is desired, those elements related to functional performance assessed in dynamic situations should be considered. Therefore, orientation and mobility specialists should assess the clients' use of residual vision in a functional setting.

Regarding the limitations of this study, the following matters should be considered when interpreting the results of this study. First, there were 19 participants in this study. Substantial differences were needed for significant results. The sample was limited to students in universities in Taipei, Taiwan.

Therefore, there may be an intellectual bias and/or a geographical bias. While care was taken to assure consistent environments for the outdoor and indoor routes, randomly occurring environmental influences such as pedestrian traffic, vehicular traffic, weather variations, traffic signal cycles, may also have generated random errors. Physical and emotional well being, not specifically addressed in this study, may have contributed to travel efficiency, which was defined only by specific critical errors and by route travel time. Varying physical characteristics of the participants and resulting fogging may have caused some inconsistent results. The goggles did not fog on every participant.

As far as further research is concerned, it is necessary to explore how low vision simulators affect the visual abilities of the wearer under night and low lighting conditions. In addition, future researchers can invite adults with central vision loss to participate in a similar study so that the researchers can compare their experiences with sighted persons who wear simulation systems. Finally, future research can also examine the psychological aspects of low vision simulation.

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兩種中心視野缺陷模擬系統之應用成效研究

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本研究旨在探討兩種中心視野缺陷模擬系統之應用成效。受試者為 19 位明眼的大學生，這些學生沒有任何的身心障礙狀況。在研究中，研究者請這 19 位明眼大學生分別戴著兩種不同缺陷程度的中心視野缺陷模擬系統並參與功能性的定向行動能力評估。同時，研究者記錄每一位受試者在 GDCITS 評量表(Geruschat and Del' Aune's Critical Incidents Tally Sheet)上的行為次數。GDCITS 評量表共有六個行為項目：一、bump errors 表示「碰撞到任何物品或人」；二、stumble errors 表示「膝蓋以下的身體部位碰撞到任何物品或人而改變步態或身體姿勢」；三、drop-off errors 表示「未察覺地面高度之差異而改變行走步態或身體姿勢」；四、orientation errors 表示「未朝著指定之目的地方向前進或無法完成指定之行走動線」；五、false move errors 表示「伸出手想要抓取或摸索物品」；六、street crossing errors 表示「以危險的方式過馬路」。

本研究發現，戴著第一種中心視野缺陷模擬系統的受試者於日常情境中行走時並未產生功能性的行為變化（亦即，上段所提之六種行為項目），其行為表現反而跟未配戴模擬系統時的表現很相近。然而，當受試者戴上第二種中心視野缺陷模擬系統並於日常情境中行走時，卻表現出上述的六種行為；此種功能性行為表現與文獻所言之中心視野缺陷視障者的經驗非常雷同。由本研究發現可知，第一種中心視野缺陷模擬系統比較適合於臨床上（亦即，受控制的靜態環境）使用；而第二種中心視野缺陷模擬系統則比較適合用於日常情境中之訓練。因此這兩種中心視野缺陷模擬系統之訓練功能是無法互相交換的。本研究結果亦認為，為了比較有效地瞭解中心視野缺陷患者之經驗，在設計與使用類似的視野缺陷模擬系統時，需要考量該設計是否能夠幫助使用者體驗出真正患者之實際經驗。本文文末亦提出研究限制與未來研究之方向。

中文關鍵字：中心視野缺陷，功能性的定向行動能力評估，視覺模擬系統，弱視模擬，視覺敏銳度測試，周圍視野測試。