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The impact of functional vision changes on independent travel for individuals with adult-onset visual impairment

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Abstract

This study explored experiences with functional vision changes resulting from adult-onset vision conditions. The impact of glare, light-to-dark adaptation, depth perception, night blindness, and contrast sensitivity are examined for the way participants perceive their effects on willingness to engage in independent travel.

Two interviews were conducted with 13 participants. These consisted of structured and semi-structured, open-ended questions to determine the impact of functional vision changes on mobility and pedestrian travel. Qualitative, open and a priori coding was used to derive themes and categories for the most significant functional vision considerations among participants.

This study revealed changes in functional vision impact participants' perceived safety and were of concern when considering independent travel. Orientation and mobility (O&M) services were denied to some participants who had surrendered driving privileges and were considered vision impaired, but not legally blind, even though issues with functional vision impacted safer travel.

The impact of functional vision changes on individuals with adult-onset vision impairment was found to affect participant mobility. Agencies serving this population can provide clients with safer travel options when all functional vision changes are considered beyond acuity and field of vision loss.

The prevalence of adults diagnosed with adventitious conditions causing blindness and vision impairment is rapidly increasing. Murphy (2008) projected that by the year 2020, 50 million Americans will be diagnosed with vision impairment. Likewise, the 2010 survey conducted by the National Health Interview documented that 9% of the American population over the age of 18 has some type of vision loss, even with corrective lenses (Schiller et al., 2012).

Conditions that cause adult-onset vision loss affecting aging populations include age-related macular degeneration (AMD), which is the leading cause of vision loss in industrialized countries and in persons over age 65 (Friedman et al., 2002). Cataracts and glaucoma (CDC, 2011) are also primary and secondary conditions frequently diagnosed in the senior years. Persons in early or middle adulthood years can also experience vision loss from such genetic conditions as retinitis pigmentosa (RP) (Hamel, 2006), such health factors as diabetic retinopathy (Dhanushkodi and Manivannan, 2013), auto-immune diseases and illnesses or infections (Kestelyn and Cunningham, 2001; Schwartz, 2010), and accidents or injuries (Négrel and Thylefors, 1998).

Visual acuity and field of vision measurements are universally recognized as determining the extent of vision loss; however, multiple functional vision considerations exist that impact independent travel for those experiencing adult-onset vision loss. Changes in functional vision (Colenbrander, 2010) require attention, accommodation, and varied approaches to promote independence and safety. Geruschat and Smith (2010)

Table 1. Summary of adult adventitious vision conditions and functional vision considerations for orientation and mobility.

Diagnosis	General characteristics	Functional vision considerations for O&M documented by Geruschat and Smith (2010, p. 73)	Source
Retinitis pigmentosa	Progressive, degenerative condition; can be detected early in life. Most vision loss occurs in adulthood. Late-onset RP occurs in mid adulthood	Affects night vision, loss of visual fields, scotoma; central acuity remains intact until later stages of RP	Hamel (2006)
Diabetic retinopathy	Progressive, degenerative; can occur at any age; retinal damage and detachment, cataracts, field of vision loss with scotomas	Glare, visual field loss, scotomas, light adaptation, fluctuations, and depth perception	Scanlon et al. (2013), Schwartz (2010), Zhang et al. (2010)
Age-related macular degeneration	Progressive, central loss of vision	Glare, scotomas, vision fluctuation, depth perception	Prasad et al. (2010)
Cataracts	Clouding, blurring of vision	Glare, light adaptation, vision fluctuations, depth perception	Bruce (2004), CDC (2011)
Glaucoma	Progressive loss of peripheral field vision, blind spots	Glare, peripheral field loss, night blindness, light adaptation, fluctuating vision, depth perception	CDC (2011), Schwartz (2010)

summarized identified aspects of vision changes that affect persons with vision impairment and orientation and mobility (O&M) performance. The most common vision changes associated with the conditions previously mentioned are photophobia (glare sensitivity), variations in contrast perception, limitations with depth perception, night blindness, peripheral field changes, scotomas (blind spots), and challenges with alterations between dark and light. Table 1 summarizes conditions that cause adult-onset vision impairment and the impact they have on functional vision changes.

Functional vision and mobility performance

Most O&M specialists are keenly aware of the impact functional vision changes have on independent travel, which is also documented by research. Marron and Bailey (1982) found a correlation between O&M skills and functional vision factors, such as the impact of corrected visual acuity, residual (remaining) vision, field of vision, the age in which a person lost vision, and contrast sensitivity on travel. Through dependent *t*-tests Kuyk and Elliot (1999) found 41 veterans with AMD in decreased illumination who increased mean travel time, but also increased participant collisions with route obstacles and discovered field of vision and contrast ability predict mobility performance. These results echo similar findings produced by Kuyk et al. (1996) who found in their sample of 88 veterans with vision loss, persons with decreased acuity navigate more effectively than those with peripheral loss and limited contrast detection. Additionally, the influence of glare was found to affect route traversal time and efficiency.

Researchers have examined the effects of functional vision changes resulting from RP and mobility skill. Geruschat et al. (1998) conducted a study involving 41 participants which included 25 with RP and 16 with nonimpaired vision, to determine whether or not illumination affects mobility performance for individuals with RP. Through *t*-test analysis, Geruschat et al. found

that individuals with RP walk slower than their sighted peers and are more likely to collide with obstacles. Results generated from this study documented individuals with RP travel routes more efficiently when better illumination is present. Additionally, Geruschat et al. discovered a correlation between better mobility performance and greater fields of vision. These study results corroborate findings produced by Lovie-Kitchin et al. (1996) and Haymes et al. (1996).

Some research has documented means by which functional vision changes affect individuals with varying conditions differently. However, the personal impact of functional vision changes requires an in-depth, qualitative study to elucidate the experiences of those who lose functional vision and the impact it has on independent travel and access to mobility services. Therefore, the purpose of this study was to explore the ways that noticeable changes in functional vision were discovered (e.g., increased photophobia, decreased depth perception, changes in light adaption and contrast sensitivity) by participants and the way they impact mobility. The following research questions guided this study:

1. How do changes in functional vision affect participant willingness to engage in independent pedestrian travel and perceived safety?
2. How do changes in functional vision impact participant access to O&M services?

Method

This study took place in the mid-Atlantic region of the United States, which has multiple private and state operated services for people with vision loss. Vision care professionals, for example, ophthalmologists, retinologists, optometrists, low vision specialists, government operated research agencies, and other eye care specialists are readily available. The region houses a mass public transit system with rail, bus, paratransit, taxi, and independent options for travel. Various support groups and other services are available for individuals who experience vision loss.

Permission and recruitment

The Institutional Review Board at George Mason University granted approval for this study prior to any recruitment and data collection. Permission was granted for the lead researcher to recruit participants at a network of support group meetings for persons who experience adult-onset vision impairment. Recruitment took place in person and prospective participants were provided with study related materials and consent forms in their preferred format (large print, regular print, recording, live reader, braille, and electronic format).

Participant screening

Participants eligible to contribute to this study had to be 18 years or over, able to give informed consent independently, and diagnosed with a vision condition leading to adult-onset vision loss with visual acuity or field of vision meeting the definition of vision impairment. Individuals with other impairments were accepted into this study, as long as the other conditions did not inhibit cognition or the ability to engage in mobility; persons with adaptive mobility devices, such as a support cane or wheelchair were permitted to participate.

Data sources and data collection procedures

Interviews

Qualified participants (N = 13) took part in two recorded interviews with the researcher in a private location or by phone. A structured interview questionnaire guided the first section of the interview, where participants provided personal and general information about their vision condition, functional vision changes, services received and supports/accommodations used. The second half of the first interview consisted of semi-structured, open-ended questions regarding vision loss and the impact on mobility and pedestrian travel. A second interview was conducted after all interviews were completed and an environmental mobility assessment was conducted. During the second interview, participants were asked to provide clarification and information on coded data discovered during the first round of interviews. Data were collected between February-August 2015.

Data analysis

Interview recordings were transcribed verbatim and uploaded into Nvivo for coding. Two types of coding procedures were implemented in this study. Based on methods described by Ryan and Bernard (2003), inductive, open coding was used and derived from data provided by participants. A priori coding was also integrated and consisted of set categories based on defined elements in research questions for services, supports, and devices that influence participant willingness and safety for pedestrian travel.

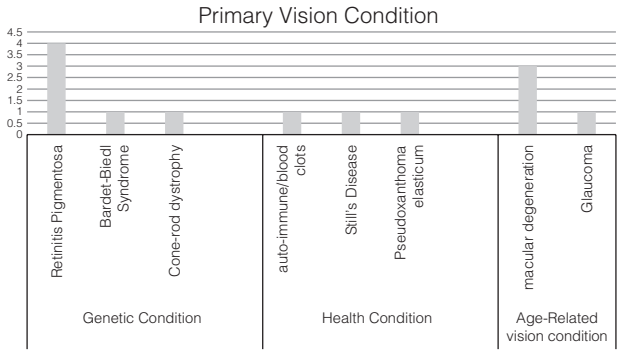

Figure 1: Participant-reported primary vision conditions.

Confidentiality

All data for this study are kept confidential in compliance with research integrity procedures at George Mason University. Pseudonyms are used in place of participant names. Specific locality information is not provided to further conceal identity.

Validity

To promote best researcher interpretation of interview data collected, participants were asked to complete a member check (Brantlinger et al., 2005), where findings and interpretations were discussed with each participant privately and participants are provided with the opportunity to clarify or correct information. Triangulation (Brantlinger et al., 2005; Cho and Trent, 2006) was used to compare data and use multiple data sources to verify findings.

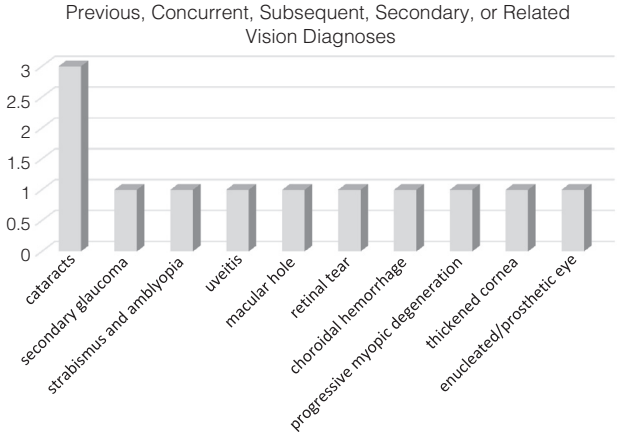

Figure 2: Participant-reported previous, concurrent, subsequent, secondary, or related vision diagnoses.

Results

This study consisted of 13 participants (three males and 10 females) with a mean age of 70 (N = 13) and a standard deviation of 15.6. Figures 1 and 2 provide information on the primary and secondary causes of vision impairment in this sample. Eight of the thirteen participants reported receiving O&M services, most of whom had significant vision loss. Five participants did not receive O&M services at all, all of whom are vision impaired with useable vision, but functional vision considerations. Table 2 provides a description of O&M services and participant reported pedestrian travel at the time of the first interview.

Functional vision

In this sample of 13, three participants reported their vision is classified as having light perception only (LPO), one reported no light perception (NLP: total blindness) and the remaining nine individuals had a wide range of vision, from fairly functional use of eyesight and impairment not requiring a white cane, to significant field and acuity loss.

Participants reported the following use of white canes or mobility devices: identification cane, n = 1; white cane for navigational, travel, and identification, n = 6; white support cane: n = 1. One participant reported using a stability cane (non-white cane) for

Table 2. Participant-reported Orientation and Mobility (O&M) services and pedestrian travel.

	Received O&M services	Did not receive O&M services
Active pedestrian traveller	6	3
Reducing or eliminating pedestrian travel due to age and related concerns	1	
Does not engage in pedestrian travel	1	2

Note: N = 13.

Table 3. Description of characteristics that affect functional vision among nine participants with useable eyesight.

Visual characteristic	Number of participants experiencing this characteristic (*n* = 9)
Glare: sensitivity to light from the sun, indoor/outdoor lighting, overall illumination, even on cloudy days, reflections, light surfaces, computer/video screens	8
Limited depth perception: challenges perceiving level changes, descending steps, the speed at which items are moving toward the individual (e.g. oncoming vehicle)	6
Night blindness: decreased functional vision in dimly lit environments	6
Changes between light and dark: prolonged periods of time for the eyes to adjust when moving from a bright to dark environment or vice versa	9
Limited contrast perception: decreased ability to perceive low contrast visual stimuli and preference for highly contrasting conditions	6
Scotoma: blind spot	4
Central vision loss: vision in the central part of the eyes	7
Field of vision loss: loss of peripheral field of vision around the perimeter in one of both eyes	9

mobility, and four participants reported no use of a white cane.

Participants in this study were found to have observed noticeable changes to their functional vision that extend beyond acuity and peripheral field loss. These functional vision changes were noted in the domains

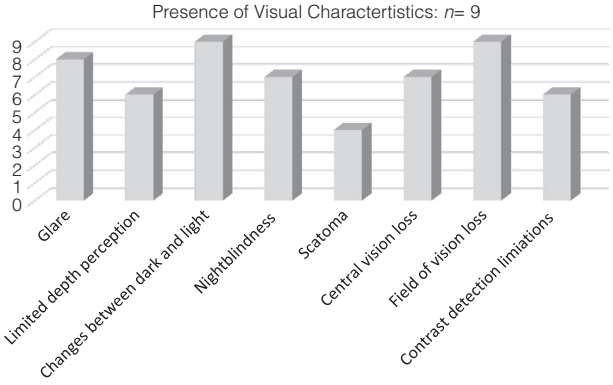

Figure 3: Visual characteristics present among the nine participants who reported functional vision.

of depth perception, photophobia, night blindness, dark-to-light adaptation, and contrast sensitivity. To further evaluate functional vision loss effects, the three participants who have LPO and one participant with NLP were removed from this segment of the data set, as these factors do not alter their use of functional vision for mobility purposes. Table 3 and Figure 3 present functional vision considerations reported by participants during this study.

Four participants who are now considered LPO or NLP reported previously having issues with glare, contrast sensitivity, and limited depth perception; Table 3 and Figure 3 represent those who were experiencing these issues at the time of the first interview. Participants provided commentary on the impact these vision changes have on mobility, willingness and safety considerations for travel, overall independence, and comfort.

Glare

Issues with glare were noted by almost every participant who has useable vision across all vision conditions represented. Glare sensitivity was so profound in some cases, that it caused pain and significant mobility concerns when travelling outdoors on bright and even overcast days. For example, Marci, who is vision impaired with an acuity of 20/160, which does not meet the legal blindness definition, did not qualify for O&M services due to acuity. However, Marci experiences significant vision changes when travelling outdoors that directly impedes her ability to travel safely.

> *I have problems with glare and that is probably the part that is the most blinding for me with everything. It's because of the thickening in my cornea. It's almost like I compare my cornea to looking through a dirty windshield,*

you know, when the sun comes through a dirty windshield, it's really tough to see out.

Greg, who is also making efforts to travel independently after surrendering his driver's license, reported significant issues with glare when travelling outside. Greg commented,

Glare is a big problem, yes. Glare especially from the sun. I mean, it could be from bright lights also. For me, more light means more glare and less ability to see.

Glare sensitivity was also found to affect indoor mobility with various lighting conditions. Jane reported the newer LED lights adversely impact her vision, while other participants, such as Hannah stated glare from large windows, atriums, or other glass enclosures impact her functioning and can cause pain or decreased travel ability. Leah, made this observation about her increasing glare sensitivity,

I notice now that it [glare] is excessively stronger than it used to be. It's absolutely blinding and I have to look away.

The impact of glare sensitivity impacts participants' decisions to travel on a daily basis.

Participants instituted methods to mitigate blinding glare and the impact it has on mobility. Eight of the nine participants who have functional vision reported using sunglasses and filters to help alleviate glare, while one participant with LPO also wears sunglasses. Participants specified various types of tinted lenses they use, including transition lenses (n = 2; one participant wears transition lenses and sunglasses together outside), wrap-around sunglasses over regular glasses (n = 1), ambient tinted (n = 1), yellow tinted (n = 1), and greenish gray wraparound ski goggle sun filters (n = 1). Two participants did not specify the type of sun filters they use, while one participant clarified that she must wear a hat and sunglasses to provide additional relief from outdoor glare. Sandy also described a pair of sun-filters that alleviate discomfort from glare that were prescribed by a low vision specialist,

I use sunglasses that my doctor, my low vision doctor at (name of hospital omitted) had suggested for me. They are much better than the drug store kind, in that they have a band across the top so that no light comes in on the forehead part.

Glare sensitivity is a significant concern expressed by participants that impacts their willingness to engage in travel and is a cause for safety concerns. However, participants reported in order to get O&M services, their acuity of field of vision had to meet certain criteria and issues with travelling outdoors or in bright buildings were not offered. No two participants shared using the same shade or device, except for transition lenses. No participants reported receiving glare reducing options from an O&M specialist.

Depth perception

Depth perception is a vital function of vision for travel and mobility. Six of the nine participants with functional vision reported serious issues with decreasing depth perception that caused significant concern regarding travel. The most prevalent factors were descending steps and curb cuts. Cheryl reported with her changing vision, depth perception,

has become less accurate [and that] steps always present a problem for someone with eye problems, and, I've noticed that the problem has increased.

Challenges with navigating descending steps and curb cuts were also clearly specified by Hannah, Leah, Marci, and Sandy. Hannah clarified,

I think [my depth perception] it is not good because with my [support] cane, I have to—curbs are ridiculously difficult for me. I go to the curb, and especially if it is not marked, I am in trouble. I take baby, tiny steps in places that I do not see anything in case there is a bump. If I come to a curb, I stick my cane down to see how deep it is. And with steps.

Leah stated,

Oh, depth perception yeah, I am beginning to notice it with things like curbs. I first of all stand on the curb and I measure the depth with my [support] cane and I won't get into a car unless I have somebody who will hold my hand as I get off the curb.

Marci further explained,

It's the steps going down that are terrifying. And those steps don't have strips that like different contrasting colored strips that you really can't tell the edges of the steps.

Sandy discussed the way her loss of depth perception had been one of the most frustrating aspects of her progressive vision changes. She described her depth perception is now *terrible* and went on to clarify,

Yeah. I do not think there is any solution. I mean, there are lots of issues that I have to deal with. But one of the things that are the most frustrating to me is the depth perception, and the loss of that. Because I have to be

careful where there is a step or curb and how many steps there are, and where the landing is.

Clara shared her depth perception is still intact, but she has some issues with noting what might be depth perception issues or overall vision loss:

Depth perception is pretty good. I'm very glad for that; I didn't seem to have the problem where everything seems flat to me. It isn't as great as it was; I'm more clumsy with things around the house but I know—well it's probably—if it's not depth perception then it's actually defining the edge of the things. I don't see them as clearly as I used to with my peripheral vision is a little bit fuzzy so I have to be very careful when I'm putting something on the table that I don't misjudge and hit the edge of the table.

Limitations with depth perception can lead to falls or other serious issues and impacts participant willingness to travel independently and perceived safety. These several themes were abundantly clear in coded data from this research.

Contrast

Six of the nine participants with useable vision reported issues with contrast sensitivity. Contrast vision is important to mobility, as limits with detection can result in missing descending steps, curbs, or other obstacles. Six participants remarked that they prefer contrasting strips to be placed on curb cuts, steps, and other level changes, and four participants discussed the way they had advocated for high contrast strips to be placed in their environments where they frequently travel (such as outdoors, at their churches or work).

Night blindness

Night blindness was reported by seven out of nine participants with functional vision as an issue. Two participants reported that at night, functional vision is almost completely gone, and this affects willingness to travel during certain times of day, as Don, who has RP, stated:

[If it's] really gloomy or toward the end of the day, I do not go out… because it is darker and even with my cane, I still need to see…When it is too gloomy I cannot even see where the cars are and stuff like that. I need to have some vision to go out even if I am using my cane to make sure that I do not run into the curbs.

Similarly, Hannah stated,

When the sun goes down, or at night—if they dim the light, I cannot see.

Leah will request assistance in the event she needs to be out later to accommodate her night blindness,

I don't like to stay out late and if I do I generally have somebody walk me from the car to my front door because I feel much more insecure in the dark after the sun has set.

Leah and five other participants also clarified that night blindness does not just affect them in the evening hours. The region's transit system, which has above-and below-ground rail with dimly lit subway stations, has caused her to stop using this form of transportation,

I walk into the tunnel [station] of the subway and it's black. I have to stand there and wait—well I don't have to do it anymore because it was at that point that I bowed out of subway riding.

Her concerns about the rail station lighting were echoed by five other participants in this study.

Participants who expressed difficulty with night blindness also reported issues with glare. Therefore, all times of day can present different types of challenges for visual functioning that relate to mobility and daily living tasks. Marci discussed the convergence of issues with glare sensitivity and night blindness,

I think when you're talking about night time vision there's a lot of peripheral light so when it's a dark room and you've got peripheral light all around it's a really bad combination.

Through qualitative data, night blindness was found to affect both perceived safety and willingness to travel in regard to time of day and in the region's subway stations.

Light and dark adaptation

All participants with some degree of visual functioning reported varying issues with their eyes adapting from bright light to dark situations and vice versa. Five participants specifically noted challenges navigating movie theaters due to light to dark adaptation. Clara remarked the progressive change in her vision that affects light to dark adaptation extends to leisure and social activities,

Yes and that [light to dark adaptation] has gotten worse as the years have gone by, just going to the theater I mean I have to wait quite some time before I can adjust to the amount of light that's in a theater.

Hannah further clarified how long it takes her eyes to adjust in a dark movie theater,

> *I did not know what it was from, but I found out—I think it was when I was in my 50s. I would go into a movie theater, I could not find a way to find a seat until I waited for 10 or 15 minutes for my eyes to adjust a little bit better. To me it was weird. I thought what in the world is going on. I had no idea it was from this.*

Leah remarked,

> *I know that if I go to do something like go to the movies, it's darker to me than it is to anybody else and it limits my vision.*

Sandy reported,

> *If I go into the movie theater from the lights in the lobby, I cannot see a thing.*

Access to movie theatres and various auditoriums in the region was a priority for participants. Yet, features, such as stadium seating, ramps, small steps, locating seats, and other navigation tasks were of concern. Similarly, navigating between dark and light areas of buildings, shaded and bright walking routes, and moving in and out of stores or medical offices to brighter or darker environments were present among participants with light to dark adaptation considerations.

Conclusion

Adult-onset vision conditions affect more than acuity and peripheral vision. Glare, depth perception, light to dark adaptation, night blindness, and contrast perception impact participants' willingness to engage in mobility and independent travel. O&M service providers are skilled in addressing functional vision considerations for these populations, however, limitations exist when certain agencies require specific acuities or field of vision loss in degrees to qualify for services. Individuals who experience changes in functional vision, in addition to or aside from acuity and field of vision, can benefit from O&M services and instruction or recommendations for specific devices and accommodations.

Discussion

This study revealed functional vision factors that can affect individuals who have adult-onset vision conditions. All aspects of a person's life must be considered as he or she negotiates the process of changing vision, especially as it impacts mobility. Vision loss does not necessarily entail complete blindness for those affected by adventitious vision impairment. Functional vision and changes to eyesight require specialized services, supports, techniques, and technologies to promote the most effective outcomes and mobility methods for these populations.

Agencies that serve individuals with adult-onset vision conditions can best meet their clients' needs by reconsidering criteria to qualify individuals for services. Gordon (2009) asserted that service delivery models will need to be reconsidered as the aging population continues to experience vision changes. The current study provides a framework for evaluating the need for vision services based on functional vision changes that extend beyond acuity and field of vision measurements. Ballemans et al. (2011) concluded that O&M services for this population need to include an approach that supports functional and independence goals. Participants in the current study sought to maintain independence as much as possible in their home neighborhoods and access to community resources. The profession of O&M provides instruction in methods to address functional vision changes associated with adult-onset conditions. Access to these instructional methods, and specialized devices can provide individuals with safer and more effective means for independence and travel.

Limitations and future research

This study consisted of a small sample size of 13, with nine participants reporting functional vision considerations. A larger sample would most likely provide more data on the continual impact of functional vision changes that could be generalized to the overall population. This research provides multiple opportunities for future study. No participants in this study received or were offered services under the grants for older individuals. Another research study might determine whether or not individuals who receive those services have better access to O&M. Interventions that study the effects of mobility training for individuals with functional vision changes can be conducted to determine whether or not certain methods promote safer and more independent travel. Finally, device and accommodation use (e.g. sun-filters, low vision aids, and technologies) can be tested to determine methods to deflect glare sensitivity, increase contrast, and aid with depth perception and night blindness.

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