ORIGINAL INVESTIGATION

Historical Diagnostic and Chromatic Treatment in Visual Snow Syndrome: A Retrospective Analysis

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SIGNIFICANCE: Visual snow syndrome is a relatively new medical condition, with presence of visual snow as the primary visual-perceptual symptom. Information from the present study will improve future clinical diagnostic and treatment aspects in this population.

PURPOSE: This study aimed to determine the historical, diagnostic, and treatment aspects in patients with documented visual snow syndrome/visual snow in an academic, optometric setting.

METHODS: A retrospective analysis was performed in patients (N = 40, aged 12 to 55 years) with documented visual snow syndrome/visual snow examined over a 4-year period. Information was collected by a detailed case history and the Visual Snow Syndrome Symptom Survey. Treatment assessment was performed using the Intuitive Colorimeter, and a wide selection of chromatic tints was assessed under the most provocative/exacerbating and other conditions.

RESULTS: Visual snow was typically constant and monochromatic, with it being present on average 6.43 years. Bright and dark surfaces were the most provocative/exacerbating/revealing conditions, along with the viewing of computer screens. The most common etiology was mild traumatic brain injury. The most common primary and secondary symptoms were photosensitivity and tinnitus, respectively. There was a high frequency of occurrence of oculomotor deficits, especially accommodative and vergence insufficiency (~40 to 50). Eighty percent of the patients were prescribed a chromatic tint with subjective visual reduction of visual snow ranging from 15 to 100 (mean, 45).

CONCLUSIONS: The present information will help in understanding this unusual medicoperceptual condition, especially with respect to simple treatment frequently using readily available chromatic tints.

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The visual snow syndrome is a relatively new medical diagnosis.[1] It primarily refers to the presence of visual snow" across and in front of one's visual field, which is a dynamic pixelated array overlaying the visual field of either a chromatic or achromatic nature, which could be either transiently or constantly occurring, for months or years.[1–6] However, to be formally diagnosed with visual snow syndrome, one must also manifest at least two of the following primary visual symptoms[2,3]: palinopsia, nyctalopia (i.e., problems with night vision), photosensitivity/photophobia, and enhanced entoptic phenomena. In addition, individuals with visual snow syndrome typically exhibit one or more of the following secondary visual and nonvisual symptoms[2,3]: photopsia, migraine, phonophobia, hyperacusis, cutaneous allodynia, tremor, balance problems, and tinnitus.

Although considerable research has gone into the categorization and diagnostic aspects of visual snow syndrome,[2–5] the area of treatment has received relatively little attention. Some have used various prescription medications (e.g., antidepressants, antibiotics),[5] which thus far have not demonstrated effectiveness. More recently, there has been the optometric, therapeutic approach using chromatic filters to reduce the perception of the visual snow and some of the other abnormal, related perceptual phenomena (e.g., photosensitivity, palinopsia, enhanced entoptic imagery), as well as saccadic-based therapy to reduce the perceived intensity and duration of the palinopsia, all with good success.[7–11] Furthermore, most recently, there has been the new finding of general oculomotor dysfunction (e.g., saccadic dysmetria, convergence insufficiency) in the majority of patients (~60) with visual snow syndrome examined in a private optometric practice setting,[11] again with good success following conventional vision therapy.[12]

In the present study, a retrospective analysis was performed of the major historical, diagnostic, and therapeutic aspects in an academic, optometric clinical setting in patients with a documented diagnosis of visual snow syndrome. Data were obtained from both adults and children over a 4-year period.

METHODS

A retrospective analysis of all patients diagnosed with visual snow syndrome who presented to our State University New York/College of Optometry, Vision Rehabilitation Service, between January 2018 and June 2022, was performed. Ages ranged from 12.4 to 55.4 years, with a mean (standard deviation) of 28.85 (11.30) years. There were 16 males and 24 females (N = 40). The mean number of years with visual snow present was 6.43 with a range of 0.42 to 34 years. All received a comprehensive vision examination (refraction, binocular, and ocular assessment),[12] cycloplegic refraction if deemed necessary, visual fields, and a dilated fundus examination. Twenty were referred by medical specialists, six were self-referred, and the remainder was referred by optometric referral.

Clinical areas also assessed included case history/historical data; current medications; presenting visual and related nonvisual symptoms including use of the recently developed Visual Snow Syndrome Symptom Survey[7] (see Appendix 1, available at http://links.lww.com/OPX/A594), which was compiled from data of previous work[1–6]; and treatment(s). This research was reviewed by an independent ethical review board (State University New York/Optometry institutional review board), and it conforms with the principles and applicable guidelines for the protection of human subjects in biomedical research and with the human research protection tenets of the Declaration of Helsinki.

After all entry information and basic optometric testing, the therapeutic filter assessment was performed. This included four approaches: use of the Cerium Intuitive Colorimeter and overlays (ceriumvistech.com),[9] a range of Brain Power Incorporated filters (e.g., Omega, IR, 450, 500) (www.callbpi.com), a fluorescent light-41 rose filter (www.eschenbach.com), and a range of standard ophthalmic tints (e.g., rose, blue; https://chadwickoptical.com/). The Intuitive Colorimeter was used first, which provided the reference tint for all further testing. If no preferred tint was found, then the patient completed the other areas of tint selection, in random order. However, if the Intuitive Colorimeter revealed a preferred tint, then this provided the starting point for assessing tints using the other three approaches, in random order. All tint assessments were performed and trialed under the patient's most provocative environment(s), for example, with computer viewing, and other conditions. The final tint was then prescribed with respect to the percent overall transmission and color code/name and, frequently, a specific ophthalmic laboratory.

During the subjective chromatic tint assessment, patients estimated the percent reduction of visual snow with each filter over a range of 0 to 100 . Testing conditions were as follows: fluorescent overhead illumination (350 lux) and viewing distances of 40, 100, and 600 cm were used with distance refractive correction worn. It included walking in a clinic room and hallway, viewing a computer screen with scrolling, and viewing objects on a wall as well as their most provocative condition. This process took approximately 10 to 15 minutes to complete.

See Appendix Fig. A1 (available at http://links.lww.com/OPX/A595), which shows the spectral transmission curves for six of the most commonly used chromatic tints that have been used in these patients. Also refer to Appendix Table A1 (available at http://links.lww.com/OPX/A596) for various tint luminance transmissions per their dominant wavelength (https://www.callbpi.com/Therapeutic_Tints.html).

RESULTS

With respect to the range of patient referral sources, the majority (75) came from three: neurologists, internal State University of New York/College of Optometry faculty optometrists, and external optometrists/ophthalmologists. Six (15) were based on self-referral. The remainder (10) was referred from other medical specialists (e.g., physiatrists).

With respect to basic visual snow characteristics, for most, the visual snow was constant (90) and monochromatic (73). Visual snow of a transient (10) and/or chromatic (27) nature was less frequently reported.

There were several provocative/exacerbating conditions related to the presence of visual snow (Table 1). Common conditions included dark or light surfaces, computer screens, and printed books. One of the least was general fatigue, which was reported in only three individuals (7.5). Many reported multiple conditions (e.g., computer screens and printed books).

TABLE 1. Provocative/exacerbating conditions (some subjects had multiple conditions)

Conditions	Number
Bright surfaces	11
Dark surfaces	11
Computer screens	8
Printed books	4
Fluorescent lighting	3
Fatigue	3
Anxiety/stress	2

There was a wide range of etiologies. The most common was mild traumatic brain injury (48). Thirty-eight percent had multiple etiologies. Many were also attributed to neurological diseases (25). Interestingly, a few reported the first appearance of visual snow to be COVID-19–related (12.5). Other less frequently reported etiologies included Lyme disease, head/facial surgery, and postural orthostatic tachycardia syndrome.

Regarding prior treatments, 50 reported none. Five were unsuccessfully treated with various prescribed medications (20), such as lamotrigine and amantadine, and 12 (43) received other treatments (e.g., gray sunglasses, herbal supplements).

Their primary visual snow syndrome–related visual symptoms are presented in Table 2. All four primary symptoms were present with a high frequency, as expected per the requisite medical diagnostic criteria.[2,3] Photosensitivity and enhanced entoptic imagery were the most common (83). On average, patients reported three of the four visual symptoms.

Patients' secondary visual snow syndrome–related, visual and nonvisual symptoms are presented in Table 3. Many had more than one symptom. The two most common were tinnitus (73) and migraines (60). Presence of balance problems was also common (55), as were photopsia (55) and phonophobia (55). The least reported was tremor (23). On average, patients reported four of the eight possible symptoms.

Table 4 presents the range of sensory-motor-perceptual conditions found in the group.[12] The most common diagnoses were accommodative insufficiency (53), convergence insufficiency (38), and saccadic deficits (38). One of the least common was strabismus (7.5). Many had multiple diagnoses (e.g., accommodative and convergence insufficiency).

Information related to the chromatic tints prescribed is presented in Table 5. The two most common were the therapeutic and standard ophthalmic tints (combined 45) of the Brain Power Incorporated. Transmissions ranged from 10 to 90 but were most frequently 40 to 50 . Rose tint was a common preference. The subjective rating with respect to reduction of the visual snow and at times other related symptoms (e.g., photosensitivity) ranged from 15 to 100 (mean, 45). There were eight patients (20) for whom none of the tints produced any noticeable subjective visual gain. None of the tints worsened the patients' symptoms related to visual snow/syndrome.

TABLE 2. Primary VSS symptoms (many subjects had multiple conditions)

VSS symptom	Number
Photosensitivity	33
Enhanced entoptic imagery	33
Palinopsia	27
Impaired night vision (nyctalopia")	22

VSS = visual snow syndrome.

Regarding refractive error, most were myopic (48). Thirty percent were hyperopic, and 22 were emmetropic.

DISCUSSION

The results of the present investigation reveal that most patients with visual snow syndrome who presented to our clinic with a visual symptom of visual snow received a chromatic tint that reduced this disturbing perceptual phenomenon. This included 80 of the individuals overall and patients of all ages, sexes, and provocative conditions. They reported reduced perceived intensity and duration, and, in many cases, reduced frequency, of the visual snow. The same was true for the related visual symptom of palinopsia. The successful tints typically reduced transmission in the blue end of the visible spectrum. The Intuitive Colorimeter was critical in the present study, as it provided the baseline precision tint for all subsequent testing sequences for viewing by the patients, and it has a well-established protocol.[9]

A range of chromatic tints was found to be helpful to reduce the perception of visual snow. In a few cases, two different tints were required based on the individual's multiple provocative conditions. For example, the patient might require one under fluorescent illumination and a different one at nightfall. Furthermore, specifically for the palinopsia, which was especially disturbing during reading because they made rapid sequences of saccades across the line of print, a different tint might be required. With that specific tint, the palinopsic-based, perceived afterimages and frequent comet-like trailing were reduced and thus less visually disturbing and disruptive to the reading process. The therapeutic tints could be incorporated either into the spectacle refractive correction or in the form of a clip-on" over the spectacles to be conveniently used as needed for a particular provocative situation.

TABLE 3. Secondary VSS symptoms (many subjects had multiple conditions)

Secondary VSS symptom	Number
Tinnitus	29
Migraine	24
Balance problems	22
Photopsia	22
Phonophobia	22
Hyperacusis	16
Cutaneous allodynia	15
Tremor	9

VSS = visual snow syndrome.

TABLE 4. Sensory-motor/perceptual problems (some subjects had multiple conditions)

Problems	Number
Accommodative insufficiency	21
Convergence insufficiency	15
Saccadic deficits (e.g., hypometric)	15
Accommodative infacility	8
Binocular instability	6
Visual perceptual deficits (e.g., figure-ground disambiguation)	6
Convergence excess	4
Strabismus	3
Accommodative excess	2
Divergence insufficiency	2

The strabismus was consisted of intermittent alternating exotropia due to ocular myasthenia gravis, constant right exotropia due to mild refractive amblyopia, and childhood intermittent, alternating esotropia. None were of traumatic etiology. All were present before the visual snow syndrome was first noticed.

It is of interest that the chromatic tints could also function to reduce other related visual symptoms in those with visual snow syndrome. For example, the fluorescent light 41 and Brain Power Incorporated Omega tints have been found to reduce, to some extent, the common symptom of palinopsia, presumably by reducing the luminous intensity of the offensive afterimage and trailing.[11] These tints may also reduce some of the other visual symptoms commonly found in those with visual snow syndrome and mild traumatic brain injury as an etiology, which constituted the majority of patients in the present investigation and recently elsewhere.[11] For example, they may reduce the degree of photosensitivity and abnormal visual motion sensitivity by reducing the luminous intensity of the offensive stimuli,[10,13] although other yet unknown mechanisms (e.g., chromatic bias and/or adaptation) may be involved.[14,15] This warrants further investigation. Thus, the judicious application of chromatic tints had manifold, helpful visual dimensions.

Were positive tint acceptance and related self-reported reduction of specific visual symptoms simply due to a placebo effect? There are three reasons why this may not be the case. First, 20 of the sample population did not select any chromatic tint, despite the strong desire to reduce their troublesome visual symptomatology. This agrees reasonably well with a recent similar retrospective study (10).[11] Second, some of those who did select a tint reported a considerable degree of symptom reduction, up to 100 . Such dramatic effects are unlikely placebo related. Third, patients were highly selective and careful in deciding the best tint. If it were simply a placebo, one would expect that many or all the tints available would appear to have some degree of positive effect. This was not the case. However, we cannot exclude a placebo component to the overall perceived effect as a contributor to the outcome, as a randomized prospective study was not conducted.

Although conducted in somewhat different clinical settings (i.e., academic versus private practice), the results of the present study (n = 40) are in good agreement with those of the Tannen group (n = 27).[11] Both used the recently developed Visual Snow Syndrome Symptom Questionnaire,[7] as well as a thorough general case history, so this consistency was a likely factor to aid in

TABLE 5. Specific tints prescribed and their frequency

Type of tint	Tint characteristics (transmission)	Frequency
BPI therapeutic tints (part of the BPI Dyslexia Research Lorgnette Set)	BPI Omega (40 , 50)	4
n = 10	BPI Mu	2
	BPI FL-41 (80)	1
	BPI 450 nm	1
	BPI IR 40	1
	BPI 500 Delta	1
BPI standard tints	BPI R/S rose (55 , 75 , 85 , 90)	7
Total n = 8	BPI blue (50)	1
Cerium	Green/turquoise (hue, 190; saturation, 30)	1
n = 6	Blue/purple (hue, 270; saturation, 30)	1
	Green/turquoise (hue, 180; saturation, 20)	1
	Green/turquoise (hue, 180; saturation, 50)	1
	Purple-rose (hue, 330; saturation, 35)	1
	Rose overlay (80)	1
Eschenbach (fitovers)	FL-41 dark rose filter—meridian (25)	2
n = 4	FL-41 light rose filter—meridian (50)	2

BPI = Brain Power Incorporated.

comparing the findings. In both studies: (1) visual snow was typically constant and monochromatic; (2) mild traumatic brain injury was the most common etiology; (3) the secondary visual snow syndrome symptoms occurred with a similar frequency; (4) the oculomotor diagnoses were of similar high frequency; and (5) the most prescribed tint was of the Brain Power Incorporated family. The primary difference was that palinopsia was the most common primary visual symptom in the study by Tannen et al.,[11] whereas it was three of four in our investigation but still very common.[11] These findings provide a good platform for comparison with future studies involving diagnostic and therapeutic aspects in the visual snow syndrome population.

An interesting primary visual symptom in those with visual snow syndrome is nyctalopia" or night vision difficulty (i.e., not retinal night blindness per se). What factors may contribute to this problem? Based on clinical case history and careful vision testing in the present study, there did not appear to be either a predisposing genetic or abnormal retinal factor. However, there are two other distinct possibilities. First, having a foreground of pixilation (i.e., dynamic visual noise) can produce a general visual disturbance or interference of one's visual perception,[16,17] with overlap onto the background scene of interest, such as a car on the highway at night. Thus, there are now two potential, conflicting and competing, depth-related frames of reference created. Second and possibly related to the previous statements, it may be due to the Mandelbaum effect,[18] in the pre-presbyopic, visual snow syndrome population. Mandelbaum reported that, if a semitransparent object, such as a window screen, was positioned in the facial plane, there was difficulty focusing upon the distant object. Their accommodative system tended to focus upon an intermediate, rather than far distance, depth plane. This small degree of myopic defocus (<0.6 D) also results in slightly reduced visual acuity.[19] Furthermore, it might slightly impair global visual perception under dynamic viewing conditions. These ideas should be explored in the laboratory to understand better the related visual consequences and possible localization of the responsible neural site/pathway.

Strabismus was found in 7.5 of the present visual snow syndrome sample population. This is similar to that found in the general population (~5),[20] as well as in a recent optometric, practice-based setting (~4) in patients with documented visual snow syndrome.[11] Thus, despite the very high frequency of occurrence (~40 to 50) of non–strabismic-related versional, vergence, and accommodative deficits found in the present study and recently elsewhere in the visual snow syndrome population,[11] a total breakdown of motor binocularity, namely, strabismus, did not occur. The effective functional vision impact was more subtle (e.g., convergence insufficiency versus strabismus) but more common in those with visual snow syndrome versus the general population.[12] In contrast, in individuals with concussion/mild traumatic brain injury, strabismus was present in 26 of the sample population, in addition to the high prevalence of nonstrabismic oculomotor dysfunctions as described previously (40 to 50).[21] In the future, brain imaging (e.g., functional MRI, blood oxygenation level dependent imaging) should be performed to determine the neural sites that may account for this strabismus-related difference (i.e., 4 to 7.5 vs. 26).

What neurological scenario might give rise to visual snow? Many possibilities have been suggested[6,22,23] (e.g., hyperexcitability of the angular gyrus).[6] However, there is another possibility, namely, extrastriate visual area in the middle temporal area.[24,25] The middle temporal area is involved in the generation and perception of visual motion. Although the middle temporal area has poor retinotopic representation, stimulation of very small clusters of its cells is highly directionally specific. If the middle temporal area becomes injured, however, for example, by a mild traumatic brain injury, this will result in increased spontaneous activity and hyperexcitability of its cells. Such increased and sustained activity would produce current spread, therefore now stimulating a very large population of middle temporal area cells having multidirectional signals. This would give rise to the perception of visual motion in all directions, thereby producing dynamic visual noise, that is, visual snow. Interestingly, the middle temporal area also has a weak

chromatic input, which could account for the less frequent occurrence of chromatic visual snow.[26] Assuming the aforementioned statements, the therapeutic application of chromatic filters may have a twofold effect: (1) reduce the overall luminance intensity of the visual scene and related neural activity (i.e., hyperexcitability cell firing rate)[27] and (2) further luminance intensity reduction per the specific filter's chromatic bias (e.g., filtering out light more in the blue region of the visible spectrum).[6,28] This speculation should be tested in the laboratory setting.

There were three primary study limitations. First, the sample size was relatively small. Second, a formal protocol for visual snow syndrome clinical therapeutic intervention has yet to be developed. This would provide increased consistency across all future studies in this population. Third, there was no control for a possible placebo contribution to the perceived changes in visual snow.

There are three possible future directions. First, there is the need for long-term clinical follow-up to assess for continued satisfaction, as well as any chromatic adaptive phenomenon that might alter their perceptual state and hence long-term efficacy of the tint.[14,15] Second, there is a need to develop a specific, detailed, standardized protocol for the testing and prescribing of a chromatic tint in this population that extends beyond the well-established intuitive colorimeter protocol. Currently, one does not exist. However, in the present study and in a related, recently completed one,[11] a common theme was to assess the efficacy of a chromatic tint under the most provocative/exacerbating condition(s), which allows for better direct comparison of the respective findings. Although this approach is logical, it is limiting. A wider array of problematic, naturally occurring conditions should be probed. For example, the protocol might include the use of a computer-based, simulator program for readily testing the various possible tints (visionsimulations.com). This program includes a wide range of relevant visual scenarios (e.g., night driving, indoor room, road sign), with the capability to control the visual snow density, speed, and grain. Third and related to the previous statements, there is a need for a randomized clinical trial to assess for efficacy of this treatment approach for both the visual snow and palinopsia, as well as related perceptual phenomena such as enhanced entoptic imagery and photosensitivity. This might include functional MRI or blood oxygenation level brain imaging to determine objectively the affected neural sites with and without the prescribed chromatic tint.[22,23] In conclusion, the present findings reveal the complexity of the abnormal sensory-motor-perceptual dysfunctions found in those with visual snow syndrome. A careful case history and comprehensive vision examination are required to ascertain the basic symptoms and signs as well as functional ramifications. A chromatic tint was found to reduce the perceived intensity of the visual snow in the majority of individuals (80). However, further studies (e.g., a randomized clinical trial) will be required to disambiguate any effect of a chromatic tint per se from a possible placebo contribution.

ARTICLE INFORMATION

Supplemental Digital Content: Appendix 1, available at http://links.lww.com/OPX/A594: Visual Snow Syndrome (VSS) Symptom Survey.

Appendix Table A1, available at http://links.lww.com/OPX/A596: Density for BPI Specialty Tints (available at: https://www.callbpi.com/Therapeutic_Tints.html).

Appendix Figure A1, available at http://links.lww.com/OPX/A595: Chadwick Optical Spectrophotometry of Common Tints Used in the Vision Rehabilitation Service. Percentages reflect lens chromatic filters transmission. Top (left to right): BPI FL-41 (25), BPI FL-41 (50), and BPI FL-41 (75). Bottom (left to right): BPI R/S Rose (75), BPI Omega (50), and BPI Mu (70)

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