Prevalence of visual snow and relation to attentional absorption

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Abstract

Visual snow is a condition of unclear prevalence characterized by tiny flickering dots throughout the entire visual field. It appears to result from visual cortex hyperactivity and possibly correlates with propensity to be engrossed in sensory and imaginary experiences (absorption). The prevalence and correlates of visual snow, and emotional reactions to it, were explored in the general Portuguese population with three studies with online surveys. In Study 1, 564 participants were shown an animated graphic simulation of visual snow and asked to rate how frequently they see it on a scale anchored by 0% and 100% of the time. They also reported their degree of distress and fascination resulting from visual snow. Absorption was measured with the Modified Tellegen Absorption Scale. 44% of respondents reported they see visual snow at least 10% of the time, and 20% reported seeing it between 80% and 100% of the time. Similar to findings in clinical samples, the frequency of visual snow correlated with tinnitus frequency, migraine, and entoptic phenomena, but not with ophthalmologic problems. It was confirmed that visual snow is related to absorption. Although distress caused by visual snow was generally absent or minimal, a substantial minority (28%) reported moderate to high levels of distress. High fascination with visual snow was reported by 9%. In Studies 2 and 3, visual snow was measured by means of verbal descriptions without graphic simulation (“visual field full of tiny dots of light” and “world seen with many dots of light”, respectively). The results were similar to those in Study 1, but seeing visual snow 80%-100% of the time was less frequent (6.5% in Study 2 and 3.6% in Study 3). Visual snow has been insufficiently investigated. More research is needed to uncover underlying neurophysiological mechanisms and psychological and behavioral correlates.

Introduction

Visual snow refers to a visual phenomenon characterized by tiny flickering dots occupying the entire visual field. The dots are often described as bright on dark backgrounds and dark on light backgrounds. They can also be described as brighter than the background or colorful [1-3]. Visual snow has attracted much attention in recent years [1-16], often with the implication that it is a pathological and rare condition. The term “visual snow syndrome” was proposed when it occurs with other visual phenomena, like palinopsia (after-images or visual trailing), photophobia (oversensitivity to light), nyctalopia (night-blindness), and entoptic phenomena (visual phenomena arising with sources in the eye [1-3]. Visual snow appears to be unrelated to ophthalmologic problems, but co-occurs frequently with migraine and tinnitus [2-7,12].

Most research on visual snow has been conducted with clinical samples. A subgroup of persons experiencing the visual snow phenomenon may be worried about it and seek clinical assessment of potentially serious causes. Only those patients then typically enter the clinical studies. Many people experiencing visual snow may not be worried by this experience, as indicated by numerous anecdotal reports on the internet. Even some people in clinical studies are not worried about it [17]. One study examined the prevalence and correlates in the general population. In a representative British sample, 3.7% of the respondents reported seeing visual snow (CI: 2.7 – 5.2), and 2.2% fulfilled the criteria for the visual snow syndrome (CI: 1.4 – 3.3) [18]. Respondents in this nonclinical representative sample who met the criteria for the visual snow syndrome were more likely to report severe headaches, tinnitus, and mood symptoms [18], which is congruent with the studies in clinical samples. The obtained prevalence of visual snow may be underestimated, as the study asked whether respondents experience visual snow “always

or almost always”. Visual snow may be a transient experience or even a natural phenomenon which many people perceive if attention is focused on it [19]. Herein, we present the results of three studies examining the prevalence and correlates of visual snow in the general Portuguese population. We also wanted to find out to what extent visual snow causes not only distress, but also fascination, because many people are fascinated by particular peculiar visual phenomena.

Attentional absorption and visual snow

An untested possibility is that people experiencing visual snow may be more engrossed in perceptual and imaginary experiences, because visual snow seems to result from hyperexcitability of the visual cortex [4-7,9-11]. Such hyperexcitability intensifies visual perceptions and mental imagery, thereby facilitating attentional absorption in percepts and mental images. Research confirms that visual snow is associated with intensified sensory experiences [20]. Visual snow has also been associated with greater activity [5,7,9] and greater gray matter volume of the lingual gyrus [15], an area of the associative visual cortex that tends to be larger in people with greater ability to imagine [21], and that tends to be more active during tasks of internally directed attention [22] and mental imagery [23]. Such increased activity of the visual cortex is thought to facilitate the awareness of visual snow, which might result from the conscious perceptions of a particular form of sensory information that normally remains subthreshold [5].

The individual differences in the propensity to be attentionally engrossed in sensory and imaginary experiences are reflected in the personality trait “absorption” [24-30]. This trait refers to the tendency to experience absorbed attentional states, i. e., intense states of focused, non-reflective, attention to perceptual or imaginary experiences [24-30]. Tellegen and Atkinson

(1974) reported three overlapping aspects of absorbed states: 1) a heightened sense of reality of the attentional object that to some extent excludes metacognitions (thinking about the attentional object), 2) imperviousness to normally distracting events as individuals become less aware of the surrounding space, and 3) an altered sense of reality. The experience of one part of reality is amplified, while the presence of other aspects, not only the environment, but also thoughts and characteristics of the self, retreat in consciousness. In retrospect, the experience might be remembered as fascinatingly strange or intriguing, or even as a discontinuity of the usual awareness of self and the world. A great sense of proximity to the attentional object is felt. The type of focused attention that characterizes absorption is not the result of sustaining attention actively and with conscious effort; instead, absorbed states “have the quality of effortlessness, as if they happened by themselves, and in that sense, of involuntariness” (p. 222) [27]. Fascination is another term for the experience of absorption [24].

Higher propensity to experience absorbed states has been associated with openness to experience [28,31-33], appreciation of arts [33], rich and vivid imaginary [34,35], daydreaming as means to problem solving [36], greater hypnotic susceptibility [24-26,32,34,36], higher sexual desire [28,31], and mystical experiences [25,37]. People with the propensity for absorption are more prone to unusual perceptual experiences [29]. Also, the scales commonly used to measure trait absorption have an item that taps into whether people experience after-images [24, 26], which is a criterion for the proposed visual snow syndrome [1-3]. The experience of visual snow may well be related to the personality trait of absorption, but the possibility of such relationship was never examined.

To summarize, in the present study, we explored how frequently visual snow occurs in an unselected nonclinical group, and how frequently visual snow causes distress and fascination in

this group. We also explored correlations between the frequency of seeing visual snow and tinnitus, migraine, and trait absorption.

Method

Procedure

Three studies on these research questions were performed in Portugal with online surveys advertised on social media between 2017 and 2021. These were part of a series of studies on correlates of attentional absorption. All studies received ethical approval from the local Ethics Committee. We will refer to the three studies as Study 1, Study 2, and Study 3. As described below, measures of visual snow differed across the studies because we were interested in comparing the prevalence of visual snow when visual snow is measured with the aid of an animated graphic simulation or by mere verbal descriptions. Table 1 illustrates the variables assessed in the three studies. Measures are described in the next subsection.

Table 1. Measures used in Studies 1, 2, and 3.

	Study 1	Study 2	Study 3
Visual snow assessed with the aid of animated graphic simulation (seen with open eyes)	X		
Visual snow assessed with the aid of animated graphic simulation (seen with closed eyes)	X		
Visual snow described as a visual field full of tiny dots of light (seen with open eyes)		X	
Visual snow described as a visual field full of		X	

tiny dots of light (seen with closed eyes)			
Visual snow described as the world seen with many dots of light (seen with open eyes)			X
Absorption	X	X	X
Blue field entoptic phenomena assessed with the aid of animated graphic simulation	X		
Floaters assessed with the aid of pictures	X		
Distress caused by visual snow	X	X	
Fascination with visual snow	X	X	
Tinnitus	X	X	
Distress caused by tinnitus	X	X	
Fascination with tinnitus	X	X	
Situations triggering visual snow	X	X	
Life events associated with the first-time appearance of visual snow	X	X	
Analogies of visual snow	X	X	
Time of visual snow first appearance	X	X	
Intensification of visual snow over time	X	X	
Computer-screen time	X	X	
Migraine	X	X	
Ophthalmological problems	X	X	
Low blood pressure	X		
Blood-pressure drops	X		

Measures

Measures of Study 1

We showed animated simulations of visual snow and of a blue field entoptic phenomenon for 10 seconds. The simulations were taken from VisionSimulations.com. Participants were instructed to pay attention to the dots of light and to replay the video as often as they wanted. They were then asked how frequently they see similar dots of light occupying their entire visual field with their eyes open in everyday life and instructed to rate the frequency on a visual analogue scale by positioning a cursor on a line anchored by 0% (Never) and 100% (All the time). The line had 101 possible positions and responses were rounded to fit percentages from 0% to 100% in 11 steps (0%, 10%, 20%, ..., 100%). The simulation of visual snow can be found at <https://visionsimulations.com/visual-snow.htm?background=restaurant.jpg>. The simulation of the blue field entoptic phenomenon can be found at <https://visionsimulations.com/blue-field-phenomena.htm>.

Participants were also asked to report how frequently they see the dots of light representing visual snow when their eyes are closed using the same visual analogue scale.

Participants were shown a graphic representation of floaters (also known as *muscae volitantes*) and instructed to look at the appearing floater forms. They were then asked to rate how frequently they see similar forms in daily life using the same visual analogue scale.

The degrees of distress and fascination caused by visual snow were measured on a 7-point Likert scale ranging from 1 (absolutely nothing) to 7 (extremely).

Two open-ended questions were included asking about situations that commonly trigger the appearance of visual snow and if there was a life event that could be associated with the first-

time appearance of visual snow. If such triggering situations and life events existed, respondents were asked to describe them in their own words.

Participants were requested to tick options indicating analogies for their experience of visual snow (they could tick more than one option). Options were: a) static of an analog television, b) snowfall, c) uncertain, d) other analogies. If they chose “other analogies”, they were asked to describe them.

We inquired since when visual snow had been seen. Options of answers were: a) since childhood, b) since some years ago, and c) since very recently. Answers b and c were collapsed into a category “since after childhood”.

We asked about the intensification of visual snow with time. Options of answers were: a) the intensity has been increasing with time, b) the intensity has been decreasing with time, and c) the intensity has remained the same.

The computer-screen time was assessed by asking participants to estimate the number of hours per day they spend looking at a computer screen.

The frequency of tinnitus was assessed by asking participants about the amount of time they hear a ringing, buzzing, hissing, or other sounds that do not come from the external world. Answers were given on the same scales used to assess visual snow frequency, i. e., the frequency of experienced tinnitus was reported on a scale from 0% (Never) to 100% (All the time) with intervals of 10.

The levels of distress and fascination caused by tinnitus were measured on a 7-point Likert scale from 1 (absolutely nothing) to 7 (extremely).

Participants were asked if they have migraine, ophthalmological problems, low blood pressure, and episodes of blood pressure drops.

The propensity for attentional absorption was measured with the Modified Tellegen Absorption Scale (MODTAS) [26], which is composed of 34 self-descriptive items to be rated on a 5-point scale from 1 (I totally disagree) to 5 (I totally agree), which are assigned to the following five subscales [26]:

1) Imaginative Involvement: propensity to be attentionally absorbed in imagination. Examples of items: “If I wish I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does.”; “I can sometimes recollect certain past experiences in my life with such clarity and vividness that is like living them again or almost so”.

2) Esthetic Involvement in Nature: propensity to be attentionally absorbed in external events. Examples of items: “It is sometimes possible for me to be completely immersed in nature or in art and feel as if my whole state of consciousness has somehow been temporarily altered”; “When I listen to organ or other powerful music, I sometimes feel as if I am being lifted into the air”.

3) Altered States of Consciousness: tendency to experience psychological states that deviate markedly from the usual waking consciousness. Examples of items: “I think I really know what some people mean when they talk about mystical experiences”; “Sometimes I experience things as if they were doubly real”.

4) Synesthesias: proneness to experience associative synesthesias [38], i. e., when sensations in one particular sensory modality elicit mental associations in a different sensory modality, normally visual. Examples of items: “I find that different odors have different colors”; “Some music reminds me of pictures or changing color patterns”.

5) Extrasensory Perception (ESP): tendency to be impressed by events that are intriguing because they apparently defy known physical laws. Examples of items: “I can often somehow

sense the presence of another person before I actually see her/him”; “I often know what someone is going to say before he or she says it”.

Measures of Study 2

Visual snow was assessed by asking participants to report the amount of time their visual field is full of tiny dots of light when their eyes are open (here we did not use visual simulations). Answers were given on an 11-point scale with options 0% (Never), 10%, 20%, ... 100% (All the time). We repeated the same question with the same scale to assess the frequency of visual snow with the eyes closed. We described visual snow as “dots of light” because that description is what is actually seen in most graphic simulations. As we will show in the Results section, not all people associate their experience of visual snow with static of analog television.

Measures similar to those in Study 1 were used to assess absorption, tinnitus frequency, tinnitus distress, tinnitus fascination, situations triggering visual snow, life events associated with the first appearance of visual snow, analogies of visual snow, intensification of visual snow over time, time of first-time appearance of visual snow, migraine, ophthalmological problems, and computer-screen time.

Measures of Study 3

Visual snow frequency was assessed as the amount of time the world was seen with many dots of light. Answers were given on an 11-point scale with options 0% (Never), 10%, 20%, ... 100% (All the time).

Absorption was measured like in Studies 1 and 2.

Results and discussion

Prevalence of visual snow

Sample characteristics and the prevalence of visual snow across studies are reported in Table 2 and graphically depicted in Figure 1. Information regarding other variables of interest can be found in the Appendix.

Table 2. Sample characteristics and frequency of visual snow.

	Study 1 ^a	Study 2 ^b	Study 3 ^c
<i>N</i>	564	310	368
Women	332	240	250
Men	232	70	118
<i>Age</i>			
Mean (<i>SD</i>)	32.43 (16.68)	30.77 (11.57)	27.18 (8.53)
Range	18 – 75	18 – 67	18 – 75
Interquartile range	18	17	6
<i>Measure of visual snow</i>	% of time the visual field looks like an animated simulation of visual snow	% of time the visual field is full of tiny dots of light	% of time the world is seen with many dots of light
<i>Estimated percentage of time seeing visual snow</i>			
0%	55.9	54.5	56.0
10%	7.6	9.0	15.2
20%	4.3	6.8	6.3
30%	3.9	5.2	6.5
40%	2.0	2.3	3.5
50%	3.7	6.5	3.8
60%	1.6	5.2	2.7

70%	1.4	4.2	2.4
80%	3.2	2.3	1.4
90%	2.1	1.6	.8
100%	14.4	2.6	1.4
<i>Percentage of time seeing visual snow with closed eyes</i>			
0%	30.2	29.7	
10%	13.4	11.7	
20%	12.0	5.9	
30%	8.7	9.7	
40%	6.8	7.6	
50%	9.1	10.3	
60%	5.2	5.9	
70%	5.2	4.8	
80%	3.1	5.2	
90%	3.1	3.4	
100%	3.1	5.9	
Visual snow present since childhood (subsample of those with visual snow)			
	47.4	50.5	
<i>Progression of visual snow (subsample of those with visual snow)</i>			
It has been increasing with time	7.7	15.3	
It has been decreasing with time	12.2	6.1	
It has remained constant	75.1	78.6	

^a collected in 2020-2021; ^b collected in 2018-2019; ^c collected in 2017

¹ In the group of those not seeing visual snow, a small proportion (N = 13; 2.4% of the total sample in Study 1) reported seeing it very occasionally.

Insert Figure 1. Frequency of visual snow

The prevalence of those experiencing visual snow was remarkably similar regardless of whether the assessment was performed with the aid of animated graphic simulations or participants were simply asked about the frequency of seeing “dots of light”. Roughly 45% of the respondents reported some visual experience of snow with varying degrees of frequency. In Study 1, 14% [95% CI: 11% - 17%] of the respondents reported seeing visual snow permanently (100% of the time). The percentage of those who always or nearly always see visual dots (between 80% and 100% of the time) was about 20% (95% CI: 16% - 23%). Study 1 used animated graphic simulations of visual snow. When participants were asked about the frequency of seeing visual snow without the aid of graphic simulations, the proportion of those reporting seeing “dots of light” always or nearly always (between 80% and 100% of the time) was lower: 6.5% (95% CI: 4% - 10%) in Study 2 and 3.6% (95% CI: 2% - 6%) in Study 3. Visual snow may be a rather common phenomenon, but some people only notice it when instructed to pay attention to it, and the graphic simulation may have been more effective in calling attention to the fact that visual snow is “permanently or usually there”. A similar thing happens with entoptic phenomena, which may only become visible after attention has been called to them. The use of graphic simulations is likely a more reliable method because it does not depend on descriptions of particular analogies. Therefore, it is possible that the results of Studies 2 and 3 are underestimations.

In a study with a representative British sample, the prevalence of visual snow occurring always or nearly always was estimated at 3.7% (CI: 2.7 – 5.2) [18], which is similar to the results obtained in Studies 2 and 3. The British study did not use a graphic representation, but simply

asked, “Do you have visual symptoms that can be described like this: ‘tiny dots, continuously occurring in the entire visual field? The dots are usually black/grey on white background or grey/white on a black background, but they can also be transparent, white flashing or colored” [18]. As noted above, when graphic simulations are not employed, many respondents might not associate their experience with the verbal descriptions offered. As shown in Table 3, only 67% of the respondents in Study 1 who experience visual snow reported that it resembled the static of analog television, which is the analogy most commonly given. One third of the sample did not make the association with static. One quarter was uncertain about what analogy to use (see Table 3).

Table 3. Analogies of visual snow (Study 1; N = 209).

Static of an analog television	67% ¹
Snowfall	7.7% ¹
Uncertain	24.9% ¹
Other analogies	6.2% ¹
<i>Description of the other analogies</i>	
Grain in photos (not static from analog television)	.2 ²
Dark moving dots (in addition to luminous static)	.2 ²
Non-luminous static with moving spots (in addition to luminous static)	.2 ²
Out-of-focus image	.2 ²

Tiny colorful dots	.2 ²
Dust particles	.2 ²
Rounded clouds	.2 ²
As if seeing the wind	.2 ²
Fireflies	.2 ²
Falling purpurins	.2 ²
Sparks of the reflection of sunlight on water	.2 ²
As if cells falling from heaven	.2 ²
Angels ²	.2 ^{2,3}

¹ Sum of percentages is more than 100% because some respondents ticked more than one option.

² Percentages of .2 refer to one single participant for each description.

³ This respondent reported that visual snow appeared during a process of religious transformation. This is more accurately described as a subjective interpretation than an analogy.

The results of the present study must be interpreted with caution. Our samples were not representative of the Portuguese population, although in comparison with other studies, the total number of respondents was large ($N = 1,242$). Future studies with more representative samples and stratified according to gender, education, and age are needed. The results still suggest a higher prevalence of visual snow in the general population than is often assumed and also indicate that visual snow is not an all-or-nothing phenomenon, i. e., it is not permanently present in the visual field of those who experience it. Visual snow appears to be more frequently seen with closed eyes. In Studies 1 and 2, around 70% reported seeing visual snow with closed eyes (see Table 2 and Figure 1).

Visual snow and tinnitus

In clinical groups, tinnitus is a consistent correlate of visual snow, and the two conditions may share common etiologies. This was replicated in the nonclinical groups in the present investigation. Table 4 shows a significant positive correlation between visual snow frequency and tinnitus frequency in Studies 1 and 2. There exists a wide variability in the frequency of both tinnitus and visual snow (see Figure 2), but tinnitus was experienced by a larger proportion of respondents than visual snow.

Table 4. Correlates of visual snow (Pearson correlation coefficients).

	Study 1	Study 2	Study 3
Sex (women = 1, men = 2)	.08	-.05	.14*
Age	.01	.01	.09
Migraine	.11*	.13*	
Tinnitus	.23***	.37***	
Blue-field entoptic phenomenon	.39***		
Floaters	.21***		
Visual snow since childhood ¹	.02	-.06	
Distress caused by visual snow	.37***	.03	
Fascination with visual snow	.18*	.32***	
Absorption (MODTAS total score ²)	.17***	.21***	.34***
MODTAS Imaginative involvement ²	.13**	.18**	.28***
MODTAS Esthetic involvement in	.11*	.16**	.26***

nature ²			
MODTAS Altered states of consciousness ²	.24***	.29***	.35***
MODTAS Synesthesias ²	.13**	.17**	.28***
MODTAS Extrasensory Perception ²	.15**	.19**	.35***
Ophthalmological problems	.02	.05	
Computer-screen time	-.04	-.03	
Low blood pressure	.01		
Blood-pressure drops	.07		
Lifetime use of cannabis	.02		
Lifetime use of psychedelics	.02		
Lifetime use of MDMA	-.001		
Lifetime use of cocaine/stimulants	.03		
Lifetime use of any the psychoactive substances listed above	.02		

¹ 0 = visual snow present since after childhood: 1 = visual snow present since childhood

² MODTAS = Modified Tellegen Absorption Scale

* $p < .05$; ** $p < .01$; *** $p < .001$

Insert Figure 2. Frequency of tinnitus

Reactions to visual snow and tinnitus

The emotional responses (distress and fascination) provoked by visual snow were quite similar regardless of whether visual snow had been assessed with the aid of animated graphic

simulations or not. In Studies 1 and 2, the levels of distress resulting from visual snow varied considerably (see Figure 3), but most respondents (between 63% and 69%) do not feel distressed, and if they do, the distress is minimal. Between 30% and 32% of those seeing visual snow reported absolutely no distress (scoring 1 point on the 7-point distress scale). Between 37% and 38% reported minimal or little distress (scoring 2 and 3 points). Between 10% and 19% reported moderate distress (scoring 4 points). Between 18% and 20% complained of higher levels of distress (scoring between 5 and 7 points). Although many people are not distressed by their visual snow, there appears to be a substantial proportion that could possibly benefit from clinical attention. As with tinnitus, pharmacologic interventions for visual snow are largely ineffective. Possible strategies to help people who are distressed by visual snow are cognitive-behavioral therapies like those used for tinnitus distress. The objective would not be to eliminate visual snow, but to eliminate the associated distress [39].

Insert Figure 3. Distress and fascination with visual snow.

The distribution of distress caused by visual snow is similar to that of tinnitus (see Figure 4). Most respondents with tinnitus were not distressed at all, and if they were, distress was minor. Between 22% and 30% reported higher levels of distress with tinnitus (scoring between 5 and 7 points on the 7-point distress scale). It is well known that many people are not distressed by tinnitus [40,41].

Insert Figure 4. Distress and fascination with tinnitus

Because sometimes unusual visual phenomena cause fascination, we investigated whether visual snow also evokes this positive reaction. Some participants reported higher degrees of fascination with visual snow; 9% in Study 1 and 24% in Study 2 scored between 5 and 7 on the 7-point fascination scale (see Figure 3). Fewer people reported fascination with tinnitus (see Figure 4).

Visual snow and entoptic phenomena

Study 1 demonstrated that visual snow frequency correlated directly with the frequency of two entoptic phenomena: floaters and blue field entoptic phenomenon (see Table 4). This coincides with research in clinical samples in which visual snow and entoptic phenomena often occur together. Entoptic phenomena are among the additional visual phenomena required to diagnose the visual snow syndrome [1-3]. More people apparently report visual snow with additional visual phenomena than without [3,18].

Visual snow and migraine

Table 4 shows weak but significant associations between migraine and visual snow frequency, whether visual snow was measured with animated graphic simulations or by mere verbal description. This coincides with studies in clinical samples showing that migraine is a correlate of visual snow. The study with a British representative sample [18] demonstrated a marginal association between the visual snow syndrome and migraine, which disappeared in a multiple regression in which tinnitus was the only significant predictor. The question whether visual snow is more strongly associated with migraine in clinical groups deserves further investigation.

Triggers of visual snow

Because many people who see visual snow do not see it all the time, it is important to ascertain if there are situations that trigger short-term appearances of visual snow. Only some respondents with visual snow reported such triggers (31% in Study 1 and 26% in Study 2 among those seeing visual snow). As shown in Tables 5 and 6, we detected eight types of triggers: light-related, attention-related, tiredness-related, blood pressure-related, mood-related, eye-related, migraine-related, and pain-related. For those reporting light-related triggers, visual snow appears when looking at intense lights, when changing from dark to bright environments or when being in dark surroundings. Attention-related triggers refer to situations in which visual snow appears as a result of highly focused attention on something, but “vague thoughts” or “looking at the void” can also trigger visual snow, which indicates rather dispersed attention. Attention-related and light-related triggers can overlap, as visual snow can appear when focusing attention on lights. Visual snow can also appear when one is tired. Visual snow can become visible when drops in blood pressure are felt or as a consequence of movements that lower blood pressure. Mood-related triggers are more common with negative mood changes. Eye-related triggers are the result of a variety of physiological processes in the eyes, such as making pressure on the eyes or feeling “tired eyes”. All these six types of triggers were equally observed in Studies 1 and 2, regardless of whether animated simulations of visual snow were presented or not (see Tables 5 and 6). Although migraine was related to visual snow in the present investigation, only two participants in Study 1 associated migraine attacks with the appearance of visual snow. Four additional participants in Study 1 reported visual snow triggered by pain (headache in one case, back pain in one, and unspecified in the two others).

Table 5. Triggers of visual snow (Study 1; N = 78): number of participants reporting particular types of triggers are indicated in parentheses (some participants reported more than one type)¹.

Light-related² Intense lights (8) Sunlight (5) Focusing attention on lights ² (4) Light foci ² (2) Looking at tv or computer for a long time ² (4) Darkness/dim light (7) Passing from dark to bright environment (5) Changes in luminosity (7)	Attention-related Focusing visual attention on something (6) Turning the attention to the visual snow (2) ³ Changing attentional focus (1) Introspection (1) Doing nothing (1) Tiredness-related Feeling tired (21)
Mood-related Anxiety (7) Stress (3) Strong emotions (1)	Migraine-related Migraine attacks (2) Pain-related When in pain (4)
Blood pressure-related Blood-pressure drops (1) Raising quickly (4) Sudden movements (2) Feeling dizzy (1)	Eye-related Pressure on the eyes (2) Tired eyes (3) Not wearing glasses (1) Unfocusing the eyes (1)

¹ Other reported triggers were hot environments and when awakening.

²Some light-related triggers are also attention-related.

³One respondent reported that paying attention to visual snow is easier in nature.

Table 6. Triggers of visual snow (Study 2; N = 35): number of participants reporting particular types of triggers is indicated in parentheses (some participants reported more than one type).

Light-related Intense lights (9) Sunlight (5) Focusing attention on lights ¹ (4) Watching television in the dark ¹ (1) Looking at television or computer screens for a long time ¹ (1) Night darkness (1) Passing from dark to bright environment (1)	Attention-related¹ Focusing visual attention on something (4) Looking at the sky (1) Vague thought (1) “Looking at the void” (1) Evoking memories/talking about something in the past (2)
Mood-related Relaxation (1) Stress (1)	Tiredness-related Feeling tired (1)
Blood pressure-related Blood pressure drops (2) Raising the head quickly (4) Sudden movements (2) After sudden physical efforts (1) After physical efforts (1)	Eye-related Pressure on the eyes (1)

¹Some attention-related triggers are also light-related.

Although reductions in blood pressure were a relatively common trigger, visual snow frequency was unrelated to self-reported low blood pressure and drops in blood pressure.

Tiredness was a common trigger, especially in Study 1. Because fatigue has been associated with hypotension [42,43], future research is needed to ascertain the interrelationships between visual snow and fatigue and low blood pressure.

Intense light was a common trigger, and some participants specifically indicated that looking at television or computer screens elicited visual snow. We tested whether computer-screen time correlated with visual snow frequency, but found no supportive evidence. In Studies 1 and 2, computer-screen time was uncorrelated with visual snow frequency (see Table 4).

We inquired about events that respondents associated with the first appearance of visual snow. Very few reported any such event, and the answers were very heterogeneous, as shown in Table 7. Some individuals may have reported non-causative, coincidental events. Only one respondent associated the use of substances (cannabis and synthetic cannabinoids) with the first-time appearance of visual snow. Table 4 indicates that lifetime use of a variety of psychoactive substances was unrelated to visual snow frequency. We also found visual snow to be unrelated to ophthalmological problems (see Table 5), which is consistent with the extant research. Since three participants associated the first appearance of visual snow with ophthalmological problems, some etiologies of visual snow might be related to eye disorders.

Table 7. Events associated with the first appearance of visual snow: numbers of participants reporting a particular event are indicated in parentheses.

<p>Study 1 (N = 12)</p> <p>Ophthalmological problems (3)</p> <p>Migraine (2)</p> <p>Panic attacks (4)</p> <p>“Waking in the direction of the sunset, as a child” (1)</p> <p>Watching the sea (1)</p> <p>Religious conversion to Christ (1)¹</p>
<p>Study 2 (N = 6)</p> <p>Use of cannabis and synthetic cannabinoids (1)</p> <p>Intensive practice of sports (1)</p> <p>Loss of family member (1)</p> <p>Change to vegan diet (1)</p> <p>During a hospital stay in childhood, when walking at night in the hospital corridors (1)</p> <p>In childhood, dots of light appeared associated with fear of dark, and were imagined to be witches. They disappeared and reappeared later during university classes when attention was very focused on teachers to the point that it was like surrounding space did not exist (1)</p>

¹ This respondent associated visual snow with angels as an analogy (see Table 5).

The finding that very few participants could remember any event associated with the origin of visual snow corresponds with the study by Puledda and colleagues, in which 40% - 46% reported seeing visual snow since childhood (for as long as they could recall). The majority of those in whom it started after childhood could not recall any associated event [3]. The associated events, when recalled, varied [3]. Many participants in Study 1 (47%) and Study 2

(51%) reported that they have visual snow since childhood, as depicted in Table 2. These figures were similar to those obtained by Puledda and colleagues. Table 4 shows that visual snow frequency was uncorrelated with seeing visual snow since childhood.

Table 2 demonstrates that visual snow intensity usually remains stable. In a study by Schankin and colleagues, 41% of participants reported that their visual snow intensity had been stable from the start [2]. Among those with an initial phase of progressive intensification, 48% reported a later stabilization. Among those with a stepwise beginning, 100% reported that stabilization followed [2].

Visual snow and absorption

Table 7 shows that the frequency of visual snow correlated positively with trait absorption, as well as with all the five dimensions: imaginary involvement, synesthesias, sensory involvement, extrasensory perception, and altered states of consciousness. This was found in all three studies, regardless of how visual snow was assessed. More frequent visual snow was associated with a greater capacity to be engrossed in sensory and imaginary experiences that are perceived as fascinating. The correlation with the dimension “altered states of consciousness” was always the strongest in the three studies, raising the possibility that people with visual snow might be more susceptible to hypnosis [24-26,32,34,36], more open to enrapturing esthetic experiences, feel the effects of psychoactive substances more intensely, have more blissful sexual experiences [44], and be more prone to mystical-type experiences [25,37], which have recently become a topic of growing scientific interest [25,37,45-49]. These are important issues for future research, especially because some altered states of consciousness can be very enriching [48].

A possible explanation for the relationship between absorption and visual snow is that visual cortex hyperexcitability facilitates visual snow and intensifies perceptual and imaginary experiences to the extent that they absorb attention to a high degree. Possible brain areas that may be involved in visual snow experiences are the associative visual cortex and the thalamus [5]. A possible next step could be to study the general excitability of the associative visual cortex and the activity of the thalamus in participants experiencing visual snow and showing a greater capacity to be engrossed in visual experiences and imagination. Visual receptors and neurons demonstrate continuous activity with or without sensory information on the retinae. Neural activity in visual areas without sensory stimulation is typically labeled visual noise. Such lower-level noise activity may be suppressed by certain brain areas, possibly including the thalamus, and not enter awareness. One possible explanation for visual snow experiences may be less suppression or lower consciousness thresholds in observers with hyperexcitability of the visual cortex.

An additional explanation for the link between visual snow and absorption is that both might be influenced by patterns of serotonergic activity, particularly at the 5HT_{2a} receptors [50-52]. The serotonergic agonist lysergic acid diethylamide (LSD) increases visual cortex activity and induces the so-called *ego dissolution* [53], i. e., loss of the usual perception of the limits between the self and the external world, which is a characteristic of states of absorbed attention [24]. The psychoactive effects of LSD and psilocybin are thought to be largely mediated by agonist activity on the 5HT_{2a} receptors [53].

Final remarks

Visual snow seems to be a relatively common phenomenon with many people experiencing it always or nearly always. Many people are not distressed, implying that it is not a distressing phenomenon *per se*. In the nonclinical group in the present investigation, we found visual snow correlates similar to those that have already been observed in clinical groups: tinnitus, entoptic phenomena, and migraine. We also confirmed that visual snow is associated with a greater capacity to be attentionally absorbed, i. e., the capacity to be fascinated.

Could clinical cases be characterized by more intense visual snow? It is possible, but difficult to confirm. Visual snow is an inherently subjective experience. An intensity that is comfortable for one person could be excessive and distressful for another. If one is anxious about the experience of visual snow or desires to conform to what is perceived to be “normal visual perception”, this person might seek clinical advice. These aspects deserve to be addressed by clinicians. Cognitive-behavioral therapies might offer a possible intervention to reduce distress related to visual snow. In some cases, reassuring distressed people that visual snow can be a normal experience may already be an effective intervention.

There exist anecdotal reports of people who talked to their parents about the visual snow when they were children and were shocked by their parents’ lack of understanding (e. g. [54]). Parental education in this regard seems important. As shown in Table 7, one respondent interpreted visual snow as terrifying witches when she was child. It is important to raise attention to visual snow in pediatric care.

An important question still needs be asked. If there are so many people who are not distressed and even enjoy visual snow, why has scientific attention been so focused on people who are distressed? A possible answer lies in the difficulties that many people have relating their subjective experiences, fearing being misunderstood. An example is provided by a study of

women with visual synesthesias during sexual activity, i. e, women who see colorful forms while experiencing sexual desire, arousal, or orgasm. These experiences are pleasant and enriching and are associated with greater sensory and emotional involvement (absorption) in sexual intercourse. Nevertheless, many of these women felt dissatisfied because they had difficulties sharing their synesthetic experiences with their partners [55]. Perhaps it is time to be more open and accepting of these possibly fascinating and intriguing aspects of human experience. Increasing awareness of visual snow by talking about it is one important step. To extend understanding to many other intriguing phenomena in visual or other sensory modalities, experienced as pleasant or not, will be another step. Conducting research like ours could help foster awareness of these phenomena.

More research is needed to establish the prevalence of visual snow and its underlying neurophysiological determinants, to better understand its psychological and behavioral correlates, and to characterize in greater detail emotional reactions to it.

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Figure 1. Frequency of visual snow.

Figure 2. Frequency of tinnitus.

Figure 3. Distress and fascination with visual snow.

Figure 4. Distress and fascination with tinnitus.

Appendix

Descriptive statistics for migraine, low blood pressure, blood pressure drops, ophthalmological problems, screen time and lifetime use of psychoactive substances.

	%
Migraine (Study 1)	29.8
Migraine (Study 2)	33.7
Ophthalmological problems (Study 1)	53.1
Ophthalmological problems (Study 2)	57.0
Low blood pressure	24.2
Blood pressure drops	23.5
Lifetime use of cannabis.	45.4
Lifetime use of psychedelics	9.6
Lifetime use of MDMA	13.1
Lifetime use of cocaine/stimulants	12.7
Lifetime use of any the psychoactive substances listed above	45.8

Frequency of tinnitus.

	Study 1	Study 2
<i>Estimated percentage of time with tinnitus</i>	N = 482	N = 277
0%	41.9	52.0
10%	18.3	10.5
20%	9.1	9.0
30%	7.1	4.3
40%	3.7	6.1
50%	5.0	3.2
60%	3.1	4.0
70%	2.1	4.0
80%	2.5	2.9
90%	3.1	1.1
100%	4.1	2.9

Frequency of floaters and blue field entoptic phenomena.

	Study 1		Study 1
<i>Estimated percentage of time seeing floaters</i>	N = 450	<i>Estimated percentage of time seeing blue field entoptic phenomenon</i>	N = 456
0%	46.7	0%	66.4
10%	18.2	10%	12.1
20%	8.2	20%	4.4
30%	4.7	30%	3.9
40%	4.7	40%	1.3
50%	5.3	50%	2.4
60%	2.7	60%	1.1
70%	1.8	70%	1.3
80%	1.8	80%	.9
90%	.4	90%	1.1
100%	5.6	100%	5.0