THE PREVALENCE OF SYMPTOMS OF SCOTOPIC SENSITIVITY/MEARES-IRLEN SYNDROME IN SUBJECTS DIAGNOSED WITH ADHD: - DOES MISDIAGNOSIS PLAY A SIGNIFICANT ROLE?

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Abstract: *Previous investigations of the visual-perception disorder scotopic sensitivity syndrome (SSS), also known as Meares-Irlen syndrome, have identified several clinical features of symptom manifestation which are strikingly similar to those found in attention deficit/ hyperactivity disorder (ADHD). We surveyed the incidences of nine widely-recognised symptoms of SSS in individuals (n = 76), of whom one sub-group (n = 12) was comprised of subjects diagnosed with ADHD by qualified healthcare providers. The prevalence of each SSS symptom in the ADHD sub-group was compared to a second sub-group of diagnosed SSS individuals (n = 18), and also to a group of appropriately matched controls (n = 46). The data showed a remarkable lack of significant variations between the ADHD-diagnosed and SSS-diagnosed groups. In contrast, highly significant variations between the ADHD-diagnosed and control groups were clearly evident. The degree of symptom overlap between the ADHD and SSS disorders may be far stronger than previously reported and it is likely that many individuals with SSS may be misdiagnosed with ADHD.*

Keywords: *attention deficit/hyperactivity disorder; scotopic-sensitivity; Meares-Irlen; learning disorders; misdiagnosis.*

INTRODUCTION

In the past two decades there has been increasing awareness of visual processing problems which affect learning. There is now wide-spread recognition of scotopic sensitivity syndrome (SSS), also known as Meares-Irlen syndrome, which reportedly affects at least 5% of the general population (Kriss and Evans, 2005; Northway, 2010). Characteristics of SSS include distortions of print when reading, such as the text appearing to move or vibrate, and these symptoms occur despite optometric or ophthalmological abnormalities having previously been ruled out (Robinson, 1994; Stein, 2003). A further hallmark of SSS is that an individual's span of word recognition (the number of words seen in one eye fixation) is significantly reduced, as is also their ability to maintain extended reading (Robinson, 1994). Although such symptoms inherently affect reading, writing, spelling and visual attention, the degree to which this occurs and the impact upon literacy and learning abilities can vary greatly amongst SSS individuals. These differences may in part be due to the condition being equally prevalent across all levels of intellectual ability, including those who are gifted and talented. Thus, SSS morbidity might often go unnoticed by parents, teachers and physicians.

Identification of SSS may be further complicated by the fact that similar symptoms have been identified in other disorders, (Richardson and Ross, 2000; Robinson et al., 2001). One such disorder is attention deficit/hyperactivity disorder (ADHD).

The reported incidence of this often comorbid condition (Thome and Reddy, 2009) has grown exponentially during the past two decades. Symptoms of ADHD are known to overlap with symptoms of SSS and/or dyslexia (Richardson and Ross, 2000; Robinson, 2002; Richardson, 2004; Taurines et al., 2010), with inattention and off-task behaviour tending to increase when children with SSS or ADHD are under fluorescent lighting (Ott, 1976; Painter, 1976; Irlen, 1994). SSS is however quite distinct from ADHD in that specific symptoms do not tend to subside in adulthood, as is the case in approximately 50% of ADHD individuals (Wilens et al., 2004).

SSS is often referred to as a sub-type of dyslexia (Sparkes et al., 2006) however, this categorisation remains highly contentious. Others describe SSS as a separate entity which can occur with or without dyslexia, albeit significantly more prevalent in the dyslexic population, with reported incidences varying from 31% to 46% (Irlen and Lass, 1989; Kruk et al., 2008). The dilemma in determining the relationship between SSS and developmental dyslexia is perhaps not aided by the absence of a clear and universally recognised definition of dyslexia itself. This deficiency may also contribute to the lack of accord that persists in explaining the high prevalence of SSS in the dyslexic population (Northway et al., 2010).

The most noticeable characteristics of SSS (in respect to literacy and learning skills) are perhaps quite difficult to distinguish from those evident in ADHD individuals. The ADHD condition is primarily characterized by a lack of ability to maintain concentration and a clear incapacity to remain focused on a given task. Other signs of ADHD include hyperactivity, inadequate organizational skills, restlessness and poor academic progress, all of which might not be unexpected of an individual with reading difficulties. ADHD reportedly affects 3 - 9% of children (Wilens et al., 2004; Cuffe et al., 2005; Froehlich et al., 2007) and 2.5 - 4.4% of the adult population (Kessler et al., 2006; Fayyad et al., 2007; Polanczyk and Rohde, 2007; Simon et al., 2009) however, the disorder has acquired a far higher profile than the more prevalent SSS condition amongst health professionals, education authorities, the media and thus, the wider community.

Estimations of the prevalence of SSS in the population vary between 5% using strict criteria, such as an immediate improvement in reading speed ≥ 25% when reading through coloured transparencies placed over text (Kriss and Evans, 2005), and 20 to 25% when reported symptoms of visual discomfort and print distortions form the basis of diagnosis (Robinson et al., 1995; Allen and Hollis, 2008). However, there appears to be general consensus that estimations of SSS prevalence in the vicinity of 12% are reasonable (Jeanes et al., 1997; Northway et al., 2010). With respect to the prevalence of dyslexia, in a recent review commissioned by the British Government dyslexia was reported to affect 4 to 8% of the U.K. population (Rose, 2009).

To date, most estimations of SSS prevalence have either been based upon observable improvements in reading speed when a trial subject views text through coloured overlays or lenses, or the subject's own reporting of reduced levels of visual stress due to glare or print distortions when reading under such conditions (Hollis and Allen, 2006). However, these traditional methodologies may be vulnerable to subjectivity both on the part of the subject, and possibly also the assessor. Moreover, as individuals with SSS are known to be highly sensitive to certain forms of lighting, especially fluorescent lighting (Wilkins and Wilkinson, 1991; Whiting et al., 1994), unless the lighting conditions are controlled for when carrying out either of the above screening methods, the results and therefore diagnosis could potentially vary from one screening room to another.

Although studies such as those cited above have reported a substantial degree of symptom overlap between the ADHD and SSS conditions, to our knowledge this study is the first to specifically measure the prevalence of individual symptoms pertaining to either one of these disorders in individuals diagnosed with the opposing disorder. In view of the likelihood that distinguishing between the two conditions may be problematic, the possibility that many individuals with SSS may have been misdiagnosed with ADHD is also considered.

METHODS

A questionnaire designed to survey the incidences of nine diagnostic symptoms of SSS (listed in Tables 1 and 2), as per those described by Irlen

(1994), Whiting (1994) and Evans (2005), was completed by a group of individuals (n = 12) with prior diagnoses of ADHD. All participants in this group had been clinically diagnosed with ADHD by medical practitioners or clinical psychologists in the Australian healthcare system, thus all had met ADHD diagnostic criteria as described in the DSM-IV (Diagnostic and Statistical Manual of Mental Disorders, 4th edition, American Psychiatric Association, 2000). None of the ADHD individuals had previously been diagnosed with SSS or any other visual-perception deficit.

A second group of participants (n = 18) with prior diagnoses of SSS, attained from certified Irlen/SSS screeners or optometrists trained in SSS diagnosis, were also recruited to take part in the study. Only those SSS participants who in their pre-trial interview had further confirmed; a long-term history of deficient reading, distortions of text which increase with extended reading, excessive sensitivity to fluorescent lighting, and the continued use (> 1 yr) of coloured lenses or coloured paper were subsequently included in the study.

An additional group of age and sex-matched control subjects (n = 46) participated in the survey. These individuals declared having no prior diagnosis of SSS, nor any reading deficits or visual-perception problems. The control participants also reported to not have a prior diagnosis of ADHD, nor a history of inattention or hyperactivity symptoms of a type described in the DSM-IV guidelines pertaining to ADHD diagnosis. This was confirmed during a pre-trial interview designed to identify characteristics of either SSS or ADHD. During the recruitment of all three groups, individuals with ophthalmological conditions, or optometric problems which had not recently been corrected were excluded from the study.

Each participant in the study (n = 76) had signed a personal consent form verifying that their consent was given after being duly informed in writing of the aims and procedures of the study prior to its commencement. Ethics approval was obtained from the University of New England Human Research Ethics Committee (approval number: HEO9/018). All of the participants were recruited by means of notices posted on the university campus and website in accordance with Human Research Ethics Committee guidelines. There was no statistically significant difference between the mean age of the morbid participants (M = 35.78, SD = 12.37 years) and the control group (M = 31, SD = 10.19 years), $t(94) = 2.06$, $p > 0.05$. Similarly, there was no significant difference between these groups in gender composition, with the morbid participants consisting of 68% female and the control participants consisting of 74% female ($X^2 = 0.41$, $p > 0.05$). The participants in each group were also drawn from similar socio-economic and academic backgrounds.

The questionnaire requested participants to acknowledge the occurrence or absence of nine individual symptoms of SSS utilising a simple box-ticking method, within which 'Yes', 'No' and 'Sometimes' were the only possible answers. Analytical processing of the data acquired was by design conservative, as this was intended to mitigate potential ambiguity in the responses of the trial participants. The conservative bias lay within the weighting attributed to each of only three possible responses an SSS symptom, as the responses 'Sometimes' and 'No' were both deemed to equal zero and, thus, only the response 'Yes' was viewed as positive confirmation of a symptom. Age and gender differences between the groups were measured utilising SPSS version 14.0, (t-Test). Probability calculations of between-group variances in symptom incidences were carried out using GenStat version 10.1, (ANOVA, One-way design).

RESULTS

SSS symptom prevalence: ADHD-diagnosed group compared to the Control group

Of the nine symptoms of SSS surveyed, the incidences of seven of the symptoms were clearly far more prevalent in the ADHD-diagnosed group, as compared to the control group (Figure 1). Statistical analysis (provided in Table 1) confirmed that these substantial between-group variations were in fact highly significant ($p < 0.001$). Further analysis of the data also indicated that six of the nine SSS symptoms that were surveyed showed prevalence rates ranging between 50% and 83% in the ADHD subjects.

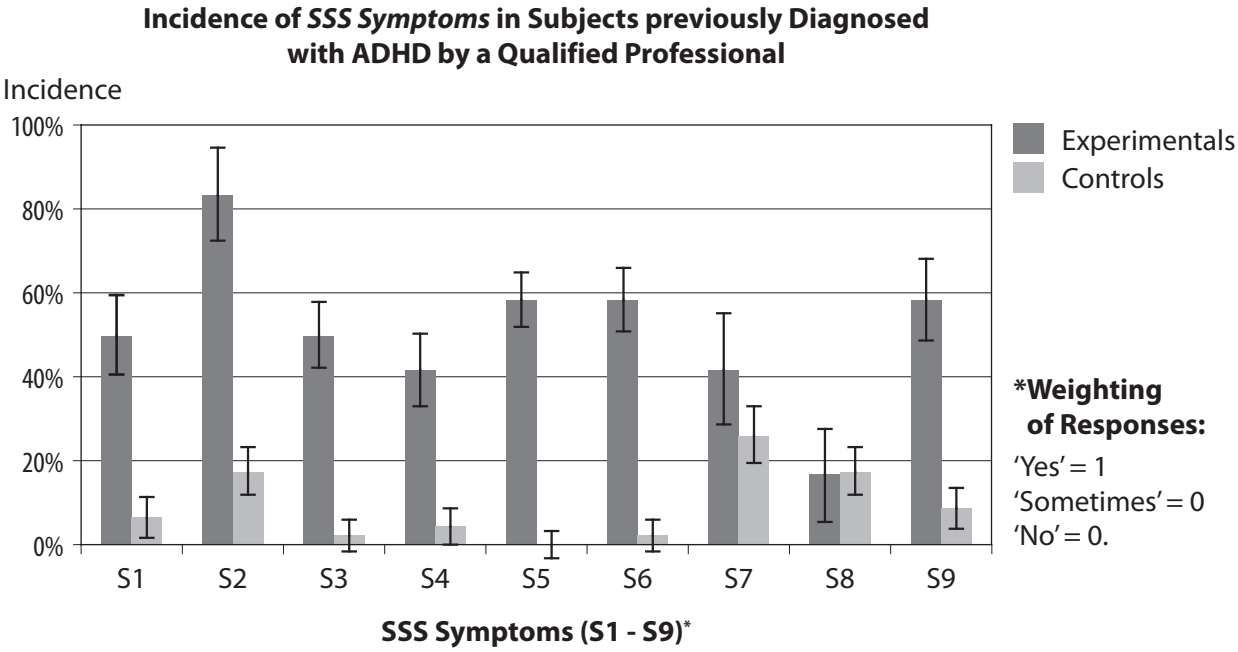

Figure 1. *Increased incidences in seven of nine SSS symptoms in the ADHD-diagnosed group (n = 12) compared to controls (n = 46) were highly significant.*

Table 1. *Mean incidences of SSS symptoms in the ADHD-diagnosed group compared to control group means with results of one-way ANOVA.*

DIAGNOSTIC SYMPTOM OF SSS:	ADHD group	Control group	Variation		
			d.f.	F	*p*
1. Slow reading:	50.00%	6.52%	1	17.36	< 0.001*
2. Strain & fatigue with extended reading:	83.33%	17.39%	1	28.01	< 0.001*
3. Print distortions, esp. black print on white paper:	50.00%	2.17%	1	30.64	< 0.001*
4. Prefer reading text on coloured or off-white paper:	41.67%	4.35%	1	15.37	< 0.001*
5. Lack of depth perception, difficulty catching a ball:	58.33%	0.00%	1	62.18	< 0.001*
6. Clumsiness when walking on uneven ground:	58.33%	2.17%	1	43.16	< 0.001*
7. Dislike of bright light or glare (photophobia):	41.67%	26.09%	1	1.10	0.299
8. Dislike of reading/writing under fluorescent lighting:	16.67%	17.39%	1	0.00	0.954
9. Difficulty keeping train of thought in a conversation:	58.33%	8.70%	1	19.99	< 0.001*

d.f. = degrees of freedom; F = variance ratio; p = probability

SSS symptom prevalence: ADHD-diagnosed group compared to SSS-diagnosed group

The incidences of SSS symptoms reported by the ADHD-diagnosed subjects were subsequently compared with those reported by the sub-group actually expected to experience such symptoms, namely, the SSS-diagnosed subjects. The results (illustrated in Figure 2) showed an extraordinary lack of significant variations, with the only exceptions to this relating to Symptom: 3 ($p = 0.017$) and Symptom: 8 ($p = 0.015$). Statistical analysis of the data (Table 2) not only indicated that the incidences of the seven of the nine SSS symptoms surveyed were remarkably similar in both groups, but moreover, there were no statistically significant between-group variations pertaining to these symptoms.

DISCUSSION

The purpose of the study was to test the hypothesis that many characteristics of SSS might be misinterpreted as signs of ADHD. It was further hypothesized that if misdiagnosis were to be indeed com-

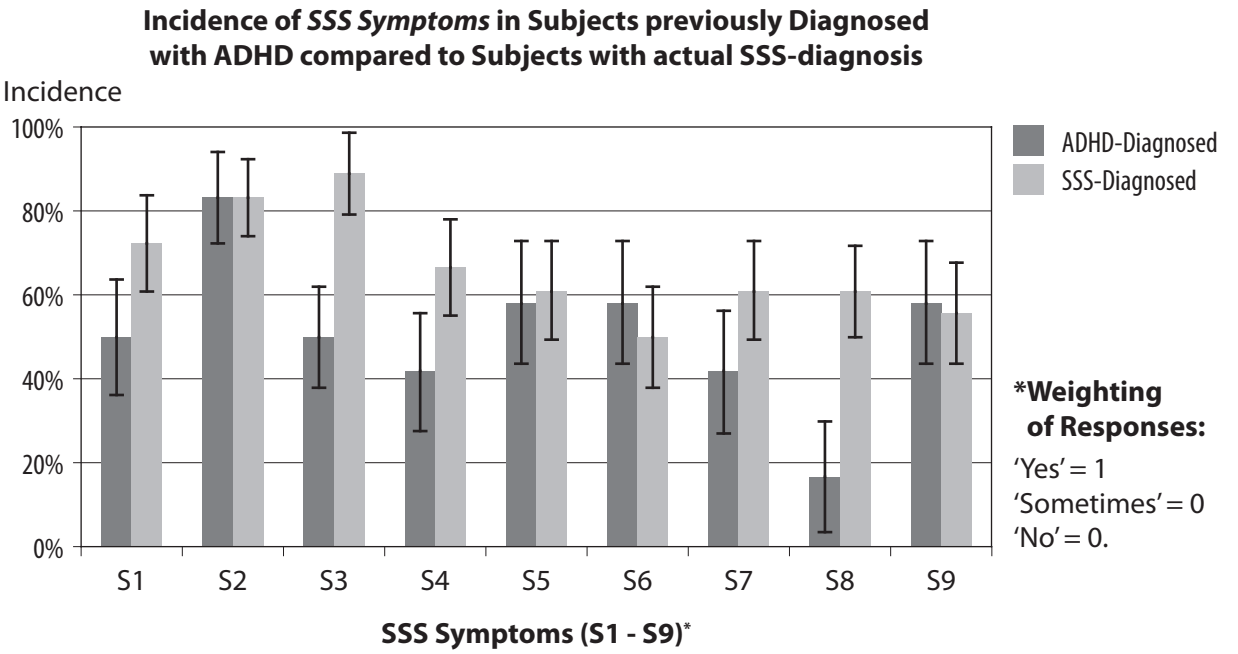

Figure 2. *No significant variation in incidences of seven of nine SSS symptoms observed between the ADHD-diagnosed group (n = 12) and the SSS-diagnosed group (n = 18)*

Table 2. *Mean incidences of SSS symptoms in the ADHD-diagnosed group compared to SSS-diagnosed group means with results of one-way ANOVA.*

DIAGNOSTIC SYMPTOM OF SSS:	ADHD group	Control group	Variation		
			d.f.	F	*p*
1. Slow reading:	50.00%	72.22%	1	1.51	0.230
2. Strain & fatigue with extended reading:	83.33%	83.33%	1	0.00	1.000
3. Print distortions, esp. black print on white paper:	50.00%	88.89%	1	6.38	0.017*
4. Prefer reading text on coloured or off-white paper:	41.67%	66.67%	1	1.82	0.188
5. Lack of depth perception, difficulty catching a ball:	58.33%	61.11%	1	0.02	0.884
6. Clumsiness when walking on uneven ground:	58.33%	50.00%	1	0.19	0.667
7. Dislike of bright light or glare (photophobia):	41.67%	61.11%	1	1.06	0.312
8. Dislike of reading/writing under fluorescent lighting:	16.67%	17.39%	1	6.70	0.015*
9. Difficulty keeping train of thought in a conversation:	58.33%	8.70%	1	0.02	0.885

d.f. = degrees of freedom; F = variance ratio; p = probability

mon, it would likely occur due to the high degree of symptom overlap between the two disorders which, in turn, may be suggestive of common biological factors. Our results showed that substantially increased incidences of seven of the nine symptoms of SSS surveyed were present in the ADHD-diagnosed group as compared to the control group and, statistically, these variations were highly significant.

The data acquired in the study thus indicated that either unusual rates of comorbidity were applicable to the ADHD-diagnosed group, or that many of the individuals in that group had previously been misdiagnosed. The latter prospect appeared to gain plausibility when the incidences of the individual SSS symptoms reported by the ADHD-diagnosed group were subsequently contrasted against those reported by the study's SSS-diagnosed group. In that comparison, the results (provided in Table 2) suggested that the most significant finding may indeed have been the noticeable *lack* of significant differences that were detected.

The only statistically significant variations found between the SSS and ADHD-diagnosed groups were related to Symptom: 3 ('*Print distor-*

tions, particularly with black print on white paper') and Symptom: 8 (*'Dislike of reading/writing under fluorescent lighting*'). However, the data pertaining to these two symptoms may possibly have been skewed by the fact that, upon diagnosis, individuals with SSS are routinely advised that avoiding fluorescent lighting and the use of white paper when reading can greatly reduce the intensity of their symptoms. (Irlen, 1994; Wilkins et al., 2004). In other words, it has long been recognised that many undiagnosed SSS individuals may not necessarily associate the lighting and ultra-white paper in office and classroom situations with the levels of reading and visual discomfort they experience when in such environments.

Until future research reveals the fundamental causes of these conditions, a number of explanations might equally account for the high degree of overlap observed between the SSS and ADHD disorders and further evidenced in this study. However, each cause and effect scenario presented below cannot truly be assessed until the question it entails is first resolved.

1) Are the SSS and ADHD disorders actually separate entities, or simply differing manifestations of the same underlying neurobiological condition?
2) Could the significant degree of symptom overlap between these disorders merely be the consequence of an unusually high incidence of SSS-ADHD comorbidity?
3) Does misdiagnosis of SSS, or ADHD, occur far more commonly than previously reported and, if so, did it perhaps substantially contribute to the highly significant degree of symptom overlap observed in the present study?
4) Are the primary symptom manifestations of SSS and ADHD capable of causing secondary phenotypic effects which emulate the symptoms of the opposing disorder?

In respect to scenario 1, it might reasonably be argued that the vastly dissimilar methods of treatment for SSS and ADHD suggest that these disorders are unlikely to be different manifestations of the same underlying condition, if only because certain stimulant medications known to effectively treat two thirds of ADHD cases (Quintero, et al., 2010) are not suggested or medically-indicated as a prescribed treatment for SSS. Moreover, in approximately 50% of children and adolescents with ADHD, specific symptoms such as hyperactivity are known to subside in adulthood (Wilens et al., 2004). In contrast, SSS is a non-abating lifelong condition which does not moderate with age or maturity. Thus, despite several associating factors, these disorders indeed appear to be separate entities.

Similarly, the prospect that comorbidity could explain the remarkable degree of symptom overlap observed in the present study (scenario 2) also appears unlikely, as this would call for the majority of the ADHD participants to have been comorbid. If, however, future research reveals that the incidence of SSS-ADHD comorbidity is indeed exceptionally high, then the lifetime duration and higher prevalence of SSS would perhaps infer that the underlying causes of that disorder may predispose certain individuals to the subsequent development ADHD morbidity, or at least the manifestation of similar symptoms.

Conversely, misinterpretation of SSS as being symptomatic of ADHD (scenario 3) could quite plausibly be a common occurrence and, in that way, substantially contribute to the extent of symptom overlap reported in these disorders and observed in this study also. When this possibility (scenario 3) is considered together with the similar phenotypic manifestations of both conditions in relation to literacy and learning skills (scenario 4), it seems not implausible that there may be a dualistic effect which at least contributes in part to the incidence of individuals diagnosed with ADHD who nonetheless have symptoms of SSS.

Moreover, the propensity for educators to suggest that a child with reading, learning or behavioural problems should first be assessed for ADHD (Graham, 2008) can only but enhance the potential for over-diagnosis of ADHD in children. In contemplating such a proposition, one might again consider that symptoms of ADHD such as restlessness, disorganisation, lack of focus and an inability to maintain concentration could quite conceivably be experienced as secondary effects of SSS, especially when an individual with SSS is required to maintain reading and writing under bright fluorescent lighting, as is the case in a typical classroom environment.

Also worthy of consideration are the currently reported incidences of ADHD in childhood and adolescent populations, which are approximately double of that reported in adult populations. Misdiagnosis may to some extent account for this discrepancy, and also offer an explanation for the poor stimulant-based treatment efficacy observed in up to 30% of ADHD individuals who receive such medication (Graham, 2008; Quintero, et al., 2010). Such individuals consequently become categorized as "non-responders" and thereafter tend to be excluded from subsequent treatment trials involving stimulants such as Ritalin (Graham, 2008), although they still carry their ADHD diagnosis throughout life. As initiation of the process leading to a child being diagnosed with ADHD may also be influenced by teacher subjectiveness, the reality that it may be far easier to convince a child (and their parents) of ADHD morbidity than it would be an adult could potentially be a factor which contributes to the yet unexplained variance between childhood and adult ADHD epidemiology.

CONCLUSION

SSS is a visual-perception deficit which primarily affects reading and writing, and it is thus likely to have secondary effects upon attention and concentration skills that are difficult to distinguish from the more publicised ADHD condition. Conversely, certain features of ADHD may perhaps exhibit secondary effects which mimic the dyslexic characteristics of SSS, such as impaired reading and writing. Indeed, Taurines et al. (2010) describe just such a "phenocopy hypothesis". Both disorders can lead to disruptive classroom behaviour and poor academic performance and both can be exacerbated by fluorescent lighting. Moreover, this now standard form of illumination in school classrooms is typically installed in far greater excess than that recommended by most recognised illumination guidelines (Winterbottom and Wilkins, 2009), other than those proposed by the lighting industry itself.

In summary, our data showed that several key diagnostic symptoms of SSS were far more frequent in ADHD subjects in comparison to control subjects and that these group variations were highly significant. In marked contrast, when the reported incidences of SSS symptoms in the ADHD-diagnosed group were compared to those reported by the group diagnosed with SSS, the most notable finding was the surprising lack of significant variation. Our results therefore suggest that either an exceptional degree of symptom overlap and/or comorbidity exists between these poorly understood conditions, or that many individuals with SSS may have been incorrectly diagnosed with ADHD. In regard to future directions in this area, follow-up research is needed to substantiate the findings of the pilot research presented here. If subsequent studies show that misdiagnosis does not significantly contribute to the degree of symptom overlap evidenced here, then such a finding may actually support the alternative hypothesis that common neurobiological factors may underlie both disorders. Thus, any contemplation of expanded research in this area should perhaps consider the added incentive of a potential win-win situation in regard to outcomes.

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Conflict Of Interest

The authors declare that they have no conflict of interest.

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