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HYPOTHESIS PAPER

DIAGNOSIS AND TREATMENT OF MISOPHONIA AND HYPERACUSIS BASED ON THE NEUROPHYSIOLOGICAL MODEL

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Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

The complaints of patients with hyperacusis and misophonia are very similar, and frequently identical. However, there are distinctive differences between these conditions. The recognition of these differences is crucial to properly diagnose and treat hyperacusis and misophonia. Audiological evaluation, while helpful, is not sufficient for differential diagnosis. Specific patient interview is critical. The treatment for hyperacusis is based on the desensitization of auditory subconscious pathways and it is aimed at decreasing abnormally increased gain within the auditory system. For misophonia the treatment involves utilization of passive and active extinction of subconscious conditioned reflexes as well as purposefully creating and modifying complex conditioning stimuli. The treatments for both conditions include counseling and sound therapy but they are distinctively different. The treatment effective for hyperacusis is not successful for misophonia and the treatment for misophonia has limited effectiveness for hyperacusis. The treatment of Decreased Sound Tolerance (DST), based on the Neurophysiological Model of Tinnitus and Decreased Sound Tolerance, showed over 80% success rate of clinically significant improvement and can even provide a cure for hyperacusis and misophonia.

Keywords: hyperacusis • misophonia • tinnitus • diagnosis • treatment • results

DIAGNOSTYKA I LECZENIE MIZOFONII I NADWRAŻLIWOŚCI SŁUCHOWEJ Z WYKORZYSTANIEM MODELU NEUROFIZJOLOGICZNEGO

Streszczenie

Dolegliwości pacjentów z nadwrażliwością słuchową i mizofonią są bardzo podobne, a często wręcz identyczne. Istnieją jednak wyraźne różnice między tymi schorzeniami, a ich rozpoznanie jest kluczowe dla postawienia prawidłowej diagnozy i leczenia. Ocena audiologiczna, choć pomocna, nie jest wystarczająca do postawienia diagnozy różnicowej. Podstawą jest wywiad z pacjentem. Leczenie nadwrażliwości słuchowej opiera się na desensytyzacji podświadomych dróg słuchowych i ma na celu zmniejszenie nieprawidłowo zwiększonego wzmocnienia w obrębie narządu słuchu. W przypadku mizofonii leczenie obejmuje bierne i czynne wygaszanie podświadomych odruchów warunkowych, a także celowe tworzenie i modyfikowanie złożonych bodźców warunkowych. Leczenie obu schorzeń obejmuje poradnictwo i terapię dźwiękiem, ale różni się diametralnie. Leczenie skuteczne w przypadku nadwrażliwości słuchowej nie jest skuteczne w przypadku mizofonii, a leczenie mizofonii ma ograniczoną skuteczność w przypadku nadwrażliwości słuchowej. Leczenie obniżonej tolerancji na dźwięki (DST) oparte na neurofizjologicznym modelu powstawania szumów usznych i obniżonej tolerancji na dźwięki wykazało skuteczność wynoszącą ponad 80% w odniesieniu do klinicznie istotnej poprawy, a nawet może zapewnić całkowite wyleczenie nadwrażliwości słuchowej i mizofonii.

Słowa kluczowe: nadwrażliwość słuchowa • mizofonia • szumy uszne • diagnoza • leczenie • wyniki

Key to abbreviations	
DST	Decreased Sound Tolerance
LDLs	Loudness Discomfort Levels
THI	Tinnitus Handicap Inventory
TRT	Tinnitus Retraining Therapy
TTS	Tensor Tympani Syndrome
VAS	Visual Analog Scales

Introduction

We proposed to define Decreased Sound Tolerance (DST) as present when a subject exhibits negative reactions following exposure to a sound that would not evoke the same response in an average listener [1–3], and that DST consists of two components: hyperacusis and misophonia [2].

The behavioral and mechanisms-based definitions of hyperacusis and misophonia are presented in an accompanying paper [4].

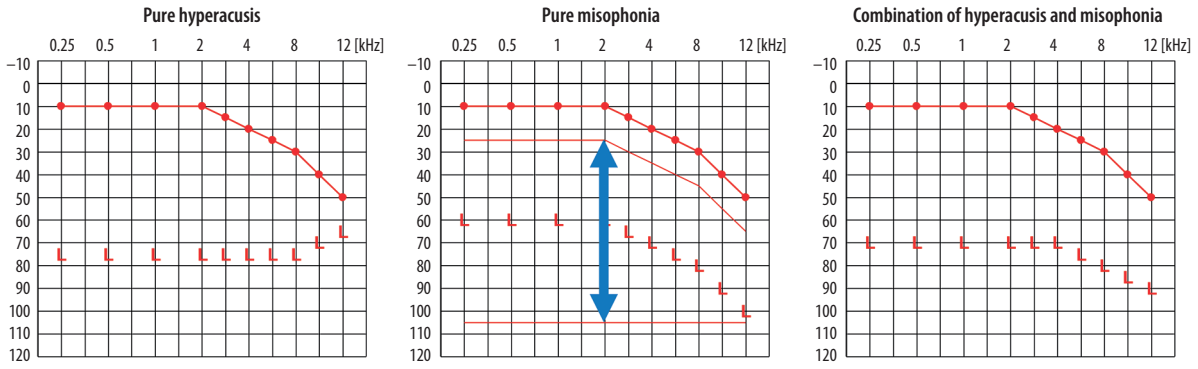

Figure 1. Comparison of shapes of audiogram and LDLs in patients with DST. For pure hyperacusis LDLs are flat with tendency of lower values for higher frequency (left panel). In case of pure misophonia LDLs follow the shape of audiogram (center panel). Note that they may have any values from very low to very high. Frequently both hyperacusis and misophonia are present together resulting in combination of these two graphs (right panel)

Note, that the proposed behavioral definitions, based on observation of patients with DST, are independent of etiology or potential theoretical mechanisms: Hyperacusis – negative reactions to a sound which depend only on its physical characteristics (i.e., spectrum, intensity). Time course (coded in the phase of spectrum) and meaning of the sound are irrelevant. Misophonia – negative reactions to sounds with specific patterns and/or meaning to a patient with physical characteristics being secondary. The reaction to a misophonic trigger can also vary significantly based on the specific person making the sound or the location where the sound occurs. Notably, reactions to bothersome sounds are remarkably similar, even identical on hyperacusis and misophonic patients, and cannot be used to distinguish between these disorders. Furthermore, audiological evaluation alone is not enough, as misophonia triggers negative reactions to sounds with specific patterns and/or meaning to a given patient.

Methods

To assess the presence of hyperacusis most commonly Loudness Discomfort Levels (LDLs) are used [5]. LDL testing aims to identify the maximum sound intensity a person can tolerate before it becomes uncomfortably loud. A series of pure tones are presented at increasing intensities, and the individual indicates when the sound becomes uncomfortably loud. LDLs reflect the combination of effects of hyperacusis and misophonia.

In case of pure hyperacusis the LDLs will always have lower values as in hyperacusis the *level* of any sound is the determining factor. Therefore, normal values of LDLs preclude the presence of hyperacusis. Comparing Loudness Discomfort Levels (LDLs) to speech uncomfortable levels can offer some insight into misophonia for patients whose misophonic triggers are voices. These patients might exhibit normal LDLs when tested with pure tones, yet still experience a reduced uncomfortable level specifically for speech. This highlights that misophonia is sound-specific, even if general loudness tolerance (measured by pure tones) remains unaffected.

In case of pure misophonia, if the sound of pure tones (resembling sounds of flute) is not within range of patient's misophonic triggers, the LDLs will be normal (around 100 dB HL), even if patients have very strong reactions to other even soft sounds of, e.g., eating or speech. In this case the contribution of misophonia to LDLs values, even strong, is not existing, and since there is no hyperacusis the LDLs have normal values. However, if pure tones are within the range of misophonic triggers, then LDLs values will be lower than normal.

Nevertheless, certain audiological indicators are useful in detecting misophonia and distinguishing it from hyperacusis. Our clinical observation pointed out that in the majority of cases there is a relation between shape of audiogram and LDLs in pure misophonia which is absent in case of pure hyperacusis (**Figure 1**). In cases where there is pure hyperacusis the LDLs are flat, with values typically below 80 dB HL, with some tendency to decrease for high frequency (**Figure 1**, left panel). For pure misophonia LDLs follow the shape of audiogram keeping approximately the same distance between audiogram and LDLs and all values, form very low (e.g., 25 dB HL) to over 100 dB HL, are observed (**Figure 1**, center). This phenomenon exists not only for high frequency hearing loss, but also for any other types of hearing loss (e.g., "cookie-bite audiogram" or low frequency hearing loss).

For majority of DST cases both hyperacusis and misophonia are present, yielding LDLs which are initially flat and only when there is larger hearing loss, they start to increase in value (**Figure 1**, right panel). As the majority of misophonic patients have normal hearing up to 8 kHz, it is recommended to do audiogram and LDLs evaluation for frequency range at least up to 12 kHz where majority of patients have some hearing loss. Preferably, the measurements should be done up to 20 kHz as many misophonic patients, particularly children, have excellent hearing even up to 12 kHz. Evaluating audiogram and pure tone Loudness Discomfort Levels assessed for all frequencies measured at audiogram is helpful.

Therefore, to accurately diagnose and distinguish between hyperacusis and misophonia, a specific and detailed

SOUND TOLERANCE

DST Y / N First noticed_____ Physical discomfort
Description of troublesome sounds
Are you bothered by: all loud sounds Y / N e.g.,
specific sounds Y / N e.g.,
only in specific situations Y / N e.g.,
only prodcuced by specific person(s) Y / N e.g.,
Reactions to bothersome sounds
Favorite sounds
Effect of short loud snd: No / Bt / Wrs Persists for: m / h / d
Ear overprotection Y / N ___ % of time In quiet Y / N
Changes of DST with time: None / Better / Worse
Why is DST a problem
Activities prevented or affected by DST:

0 1 2 3 4 - *High pitch sounds*	0 1 2 3 4 - *Work*
0 1 2 3 4 - *Loud events*	0 1 2 3 4 - *Social*
0 1 2 3 4 - *Restaurants*	0 1 2 3 4 - *Childcare*
0 1 2 3 4 - *Housekeeping*	0 1 2 3 4 - *Shopping*
0 1 2 3 4 - *Kitchen sounds*	0 1 2 3 4 - *Church*
0 1 2 3 4 - *Movie theater*	0 1 2 3 4 - *Other*

0 1 2 3 4 5 6 7 8 9 10 *Loudness*
0 1 2 3 4 5 6 7 8 9 10 *Annoyance*
0 1 2 3 4 5 6 7 8 9 10 *Effect of life*
Past & current treatments for DST

Figure 2. Part of the Structured Interview Form related to hyperacusis and misophonia [19,21]

interview is essential. During this interview, an assessment of the relation of severity of sound-evoked reactions on physical parameters of the sound is crucial (**Figure 2**) as in the case of hyperacusis the level of a sound is dominant factor, while in the case of misophonia the meaning and association of a sound are crucial. For example, if for a patient the sound of person voice, or the sound of eating are evoking negative reactions then, performing spectral analysis of these sound (e.g., by Fast Fourier Transform, FFT) provides detailed information about spectrum and phase relation of its components and allows for full reconstruction of the original sound. If, however, reconstruction is performed but with removing all phase information, these sound will have exactly the same spectrum but will be perceived as meaningless noise.

Hyperacusis patient will be responding to both, the original sounds and reconstructed from them noise in the same manner as in hyperacusis the crucial factor is physical characteristics of the sound (i.e., level, spectrum, total energy) and meaning is irrelevant. On the other hand, a misophonic patient who had negative reactions to the original sounds will not react to reconstructed sounds, in spite that this sound has the same physical characteristics as original, but reconstructed sounds have no meaning. This method may serve as a diagnostic approach for identifying the presence of misophonia.

During the interview, the goal is the assessment whether physical characteristics or meaning of bothersome sounds are crucial and to which extent the loudness of these sound affects their severity. In hyperacusis all sound "louder than" will evoke negative reaction and increase of the level of these sounds will results in proportional increase of their severity. In misophonia the level of the sound inducing reactions will be different for different misophonic triggers, e.g., a very soft sound (e.g., chewing) can evoke strong reaction, while it will be necessary to present a less bothersome trigger, e.g., voice, at a higher level to evoke similar reactions). Furthermore, the extent of reaction will be only weakly dependent on the level of a given trigger.

The important question, from the perspective of patients, is what should be considered an effective treatment? For patients, effective treatment means that negative reactions evoked by sound are eliminated or they are decreased to such an extent that they have a low-level impact on their lives. If pain induced by sound is one of the reactions it has to be significantly attenuated, preferably totally removed as pain has a special meaning, warning about problems and is difficult to habituate. To determine if a treatment has led to a clinically significant improvement, it is essential to look at the patient's final severity score. A change that is statistically significant – or a drop by a certain number of points – is not enough on its own and can be misleading. The key is whether the treatment brings the patient's condition to a low level of severity. Note that reactions to sounds cannot be used to differentiate hyperacusis and misophonia as for both phenomena they are very similar, and even identical.

Both our clinical experiences as well the predictions from the neurophysiological model show that treatments for hyperacusis and misophonia are different (**Figure 3**) [3,6]. Treatment for hyperacusis is aimed at a decrease of abnormally increased gain in the auditory system. Counseling aims at describing to a patient the mechanisms of hyperacusis, particularly the decrease of abnormally increased gain in subconscious parts of the auditory system; it is not aimed at habituation of reactions evoked by sound. Sound therapy is based on desensitization of the auditory system by consistent, day and night exposure to neutral external sounds. This treatment is not effective for misophonia.

Treatment for misophonia involves passive and active extinction of subconscious conditioned reflexes, furthermore, purposefully creating complex conditioned stimuli (which includes misophonic triggers and other positive, multisensory components), and principle of generalization [3,6] and description of protocol [4] explained below. Counseling is extensive and involves an explanation of all mentioned mechanisms and teaching patient's basis of using complex conditioned stimuli in treatment.

Sound therapy for misophonia involves four protocols, which are applied depending on the stage of treatment and specifics of a given patient. The first three protocols aim at increasing the 'likability' of sounds. In protocol (1) the type of sound, its level and duration are totally under patient's control, therefore this protocol can be used by all patients with DST, even in patients with high severity of hyperacusis or misophonia. Typically, music, most liked at the given moment, is used.

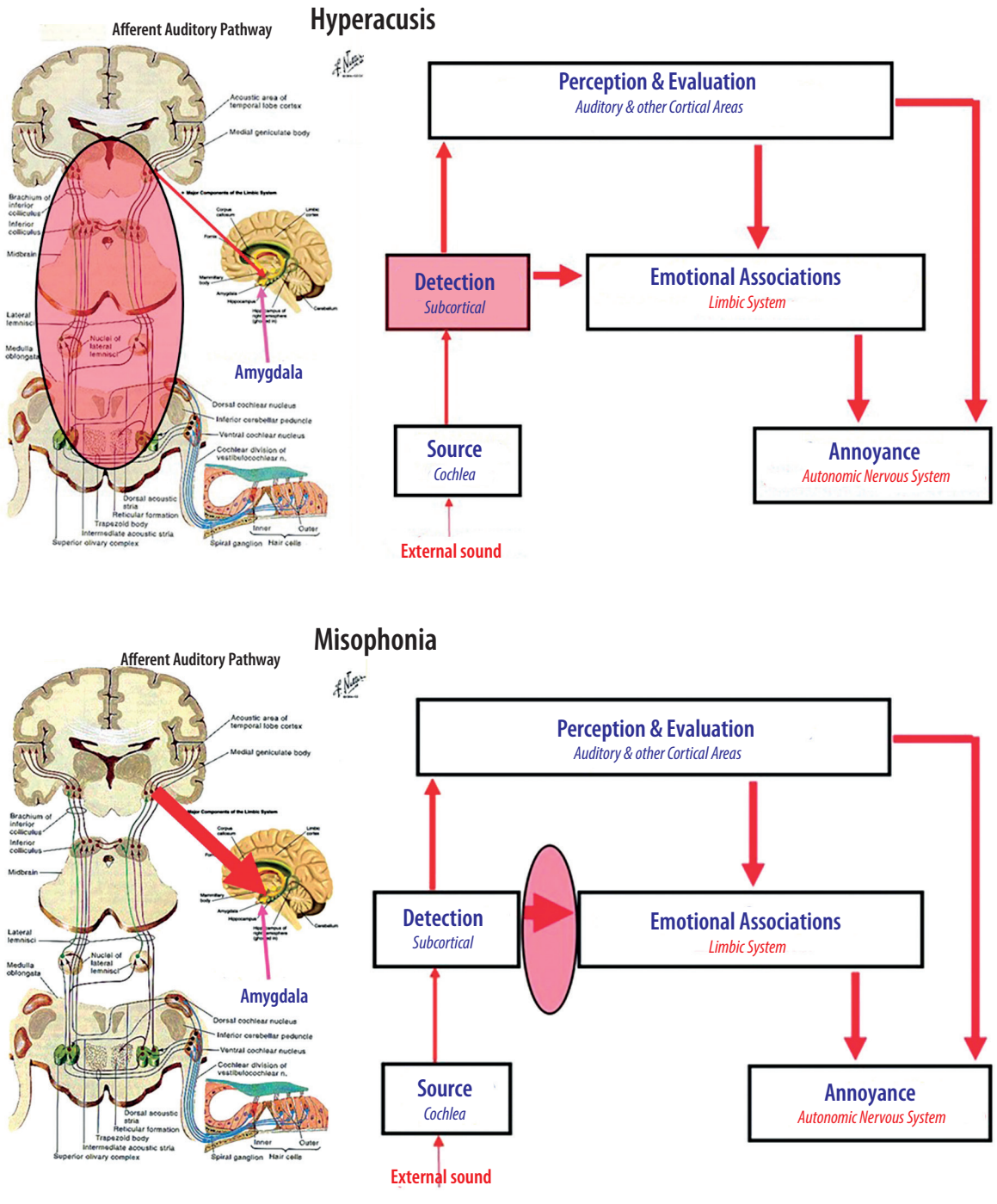

Figure 3. Comparison of postulated mechanisms for hyperacusis and for misophonia

In protocol (2), the sound level is set by someone familiar with the patient and her/his preferences. This person adjusts the sound to what they believe is optimal, then fine-tunes it for subsequent sessions based on the patient's feedback. Thus, a patient has indirect control of the sound level while she/he has full control of its type. This protocol combines auditory and visual stimuli with aim that achieved combination is pleasant to patients, e.g., watching a favorite movie at home.

In the protocol (3) patients have no control over sound level but have full control of its type; level fluctuates in an unpredictable manner (e.g., going to a movie theater to watch their favorite movie).

Protocol (4) is based on the concept of complex conditioned stimulus – creating such stimulus by combining misophonic trigger with positive sounds and other positive elements from different sensory modalities

(e.g., visual, smell, taste, surrounding), combination of which have a positive connotation [6]. Then, over a period of time the level of positive components gradually decreased. This protocol is typically used together with protocols (1) and/or (3).

Tensor Tympani Syndrome (i.e., fullness in the ear, ear pain, dysacusis consisting of various abnormal acoustic sensations, e.g., murmurs, clicks, tickling sensations, sound distortion) is often observed in patients with DST [7–9]. It is especially troubling when pain is involved, whether it is triggered by a sound or appears without an obvious cause. It has been proposed that it is facilitated by hyperacusis [8]. In our experience it is rather linked to the presence of misophonia. The treatment is focused on removing DST combined with exercises aimed at activation of Eustachian tube (tensor tympani muscle is part of network cleaning middle ear and is contracting when Eustachian tube is opening). Once this is achieved, in the majority of cases the Tensor Tympani Syndrome disappears.

Results

To assess the severity of DST and evaluation of results of the treatment patients were asked to judge the severity of their DST, the annoyance induced by it, the effect of DST on their lives, and to rate DST as a problem on a scale from 0 to 10 (where 0 corresponded to an absence of DST and 10 indicated that DST was as big of a problem as they could imagine). Patients were asked to consider an average over the last month in their responses. The levels of "Annoyance" and "Effect on Life" "DST as a problem" are main parameters to determine severity of DST (**Figure 2**). Treatment has been considered to be clinically effective when all these measures decreased by at least two and final scores were not greater than 2. Furthermore, for patients diagnosed with hyperacusis it was requested that their average LDLs were in normal range (around 100 dB HL). Our results indicate 83% effectiveness in treating DST to a clinically significant extent. In many cases it is possible to achieve a cure [3].

Ongoing discussion on how to evaluate severity of hyperacusis and misophonia have not produced consensus. There is lack of randomized clinical trials, with the exception of one trial on misophonia which shows 48% of success rate of significantly improving misophonia [10]. A number of reviews delineate situation with determining severity of hyperacusis and misophonia describing wide variety of approaches and results, without presenting consensus [11–18].

Conclusions

There is fundamental difference in mechanisms of hyperacusis and misophonia, which necessitates careful differential diagnosis and different treatment approaches to these disorders. Analysis of sound induced reactions cannot be used to differentiate hyperacusis and misophonia. Audiological evaluation (audiogram, LDLs, speech discomfort level), while needed and providing useful information in diagnosis, offers only a partial indication and alone cannot be used for diagnosis. Normal values of LDLs, however, preclude the presence of hyperacusis. Therefore, a detailed interview is crucial, with audiological evaluation providing only some help in diagnosis (**Figure 2**) [19]. Proper criteria allowing to determine achieving clinically significant improvement are essential.

We argue that the extent of decrease in severity measured by Visual Analog Scales (VAS) or specific questionnaires is not sufficient as well as achieving statistically significant decrease of severity on these measures. For example, in the field of tinnitus, Tinnitus Handicap Inventory (THI) is a validated questionnaire for tinnitus and specific studies determined that decrease of total score by 20 points document clinically significant improvement [20]. The maximal score in THI is 100 and the range from 80 to 100 is considered Catastrophic; the level below 18 is considered non-significant tinnitus. If a patient has an initial score e.g., 90 the decrease by 20 points means that the score is now 70 (i.e., in the range of severe tinnitus 58–76). From a practical standpoint, this patient will continue to experience significant suffering and may not even notice any improvement. Even if the initial score is 50 or 60 (frequently observed in clinical practice), decrease of these scores by 20 will not remove tinnitus as a problem and life of a patient will still be negatively affected by tinnitus. Therefore, we are postulating that to declare clinically significant improvement, in addition to decrease of the initial score, there is a requirement that THI score is below 20.

Given the lack of consensus on a standardized questionnaire for DST and even less agreement on how to distinguish misophonia from hyperacusis, we opted to use our own forms for Structural Initial and Follow-up interviews [19,21] to evaluate the severity of both tinnitus and DST in our study and require that all scores of "Annoyance" and "Effect on Life" and "DST as a problem" decrease by at least 2 points, and that their final scores are not larger than 2. Use of proper criteria for declaring improvement is essential and we are concerned that currently used approaches may provide misleading results.

The TRT (Tinnitus Retraining Therapy) approach, based on the neurophysiological model of tinnitus, hyperacusis and misophonia, which we have been using for over 25 years, is very effective, even providing cure in many cases [3]. Diagnosis and treatments are presented in more detail in Jastreboff PJ and Jastreboff MM (2023) [6].

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