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Review Article

Associations between music and the sensory system: An integrative review for child therapy

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ABSTRACT

Sensory processing disorder (SPD) is a disruption in the organization of sensory input that affects appropriate responses to the demands of the environment. The consequences of SPD in children may include a developmental lag as well as behavioral and emotional problems. Music therapy is particularly suitable for children with a sensory processing disorder because music and the sensory system are both linked to the nervous system. This suggests there is a need to better understand the relationship between the sensory system and the characteristics of music. An integrative review method was chosen here, given the small number of published articles on music and SPD. This integrative review covers 17 articles published between 1985 and 2017. A search was carried out in five major databases, eight music therapy journals, and grey literature. To assess the quality of a study, the Cochrane Collaboration tool for assessing risk of bias was used when possible. The results point to two types of associations: between music and the sensory system, and between sensation-seeking and features of music. Studies have also shown that therapeutic listening programs improved the sensory profiles of children with SPD. These findings lead to the practical conclusion that music is a suitable therapy for children with SPD. The benefits include improvement in the plasticity of the sensory system, motivation, self-confidence, communication and social skills.

Introduction

This integrative review explores the associations between music and the sensory system, and in particular the use of music in music therapy with children diagnosed with sensory processing disorder (SPD). Sensory processing refers to the way the nervous system receives messages from the senses and turns them into appropriate motor and behavioral responses. SPD is said to be present when sensory signals are either not detected or are not organized into appropriate responses (Miller, Fuller, & Roetenberg, 2014). The concept of "music" in this study draws on Sacks' description (2007): "We humans are a musical species no less than a linguistic one" (p.13). This musicality is expressed in many different forms, such as the ability to perceive music and "construct" it in our minds using different parts of the brain. In addition to this unconscious structural appreciation of music, it is often accompanied by an intense and profound emotional reaction. These reactions are not only auditory and emotional; there is a motor response as well, since "we listen to music with our muscles" (Sacks, 2007, p.13). Research in the field of neurological music therapy focuses on music as a biological language with structural elements, sensory attributes, and expressive qualities that engage the human brain comprehensively (Thaut & Hoemberg, 2014).

Dunn (2001, 2007) defined four basic patterns of sensory processing based on a person's neurological threshold and self-regulation strategies: low registration (high threshold with a passive response), sensory sensitivity (low threshold with a passive response), sensation-seeking (high threshold with an active response), and sensation avoiding (low threshold with an active response). What matters in these patterns is how they affect the person's ability to engage in everyday life. Thus, sensory processing refers to the ability of the nervous system to input, organize, and interpret incoming information through the sensory systems. Studies have emphasized that these processes directly influence the individual's responses to sensory experiences, as well as their impact on interactions with the environment, social relationships, and academic learning (Fox, Snow, & Holland, 2014). When sensory input is not processed and organized accurately, the consequences may sometimes be a developmental lag as well as behavioral and emotional problems (Dar, Kahn, & Carmeli, 2012; Gourley, Wind, Henninger, & Chinitz, 2013), social problems (Ben-Sasson, Carter, & Briggs-Gowan, 2009; Cosbey, Johnston, & Dunn, 2010), or anxiety (Engel-Yeger & Dunn, 2011; Kinnealey, Koenig, & Smith, 2011; Levit-Binnun, Szepsenwol, Stern-Ellran, & Engel-Yeger, 2014). Children with these

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conditions are referred to music therapy because both music and the sensory system are linked to the nervous system (Ellis & Thayer, 2010; Thaut, McIntosh, & Hoemberg, 2015).

There is scant literature dealing solely with music therapy for children with a SPD. Music therapy studies on children with SPD tend to have been diagnosed with other health conditions such as autistic spectrum disorders (Berger, 2002; Hooper, McManus, & McIntyre, 2004), or sensory challenges such as blindness or deafness (Gillmeister & Elwafi, 2015). There are studies dealing with music therapy in the elderly and sensory work (Clark, Baker, & Taylor, 2012). Some researchers are from the field of music education who work with children with SPD (Perry, 2015). Occupational therapists have investigated the influence of music on children with SPD (Esteves, Stein-Blum, Cohen, & Tischler, 2009). Researchers have also investigated professional musicians and their sensory systems, and have explored such factors as the way in which audio-tactile perception is integrated in the human brain, or compared musicians to non-musicians (Kuchenbuch, Paraskevopoulos, Herholz, & Pantev, 2014). However, there are few studies in the field of music therapy concentrating on children with SPD with no other comorbid diagnoses. The purpose of this review was to better understand the associations between music and the sensory system to examine the possible suitability of music therapy for children with SPD (with no other diagnoses).

The present review

Given the lack of research on music therapy and children with SPD, the present integrative review includes studies on music implemented by music therapists as well as by healthcare or educational professionals who are not music therapists. Moreover, consistent with the above-mentioned theoretical framework of sensory processing (Dunn, 2001, 2007), we included studies on high *sensation-seeking*; namely, on individuals who have "high neurological thresholds and an active behavior strategy, who experience pleasure from a rich sensory environment and behaviors that create sensation; they can be considered exuberant or easily distracted" (Engel-Yeger & Dunn, 2011, p.211). This condition has been similarly conceptualized as a tendency for *experience seeking* which has been studied in different contexts including music, art, risk behavior, travel, and social nonconformity (Zuckerman, 1994). This review contributes to the literature by highlighting possible associations between music, sensation-seeking, and the sensory system, which can inform music therapists working with children with SPD.

Method

In this study we adopted the integrative review approach. Whereas a systematic review is highly selective with a focus on a particular interventions and outcomes, an integrative review takes a more comprehensive approach that encompasses all types of research on the topic, and hence presents a wider range of evidence-based practice (Whittemore & Knafl, 2005). An integrative review is the broadest type of mixed methods synthesis, in that it allows for the inclusion of experimental and non-experimental research designs. The inclusion of qualitative, quantitative, and mixed methods data from primary studies can support, reinforce, or challenge prevailing beliefs and ideas about music therapy and children with SPD through the combination, contrast and comparison of different data sources (Meadows & Wimpenny, 2016). This integrative review method was also chosen given the small number of works in the field of music and the field of SPD. This review adhered to the Whittemore and Knafl (2005) five-stage model which consists of the problem formulation, literature search, data evaluation, data analysis, and interpretation and presentation of results. The following sections describe each phase.

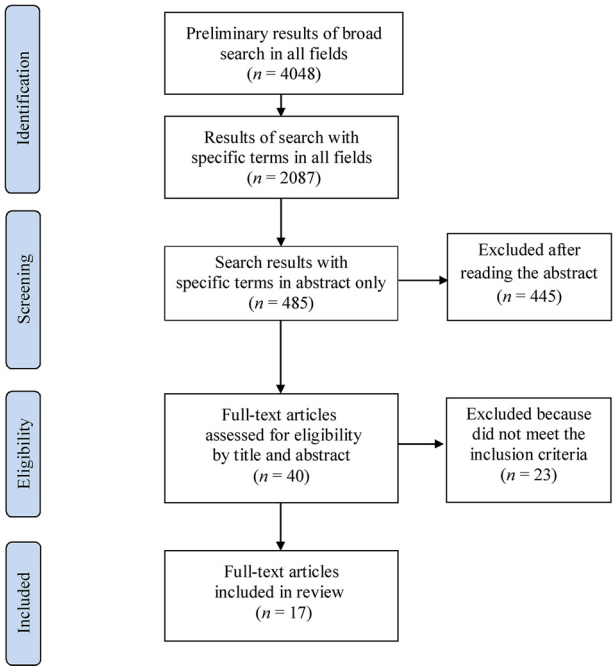

Fig. 1. Flow diagram of publications search.

Literature search

The purpose of this integrative review was to better understand the underexplored associations between music and the sensory system) the "problem" under investigation). The literature was systematically searched to include all articles, doctoral dissertations, and master's theses that appeared in the following resources from 1985 through early 2017. Six databases were searched: ERIC, PsychINFO, RILM, Medline, Academic Research Library, and Google Scholar. Additionally, nine music therapy journals were searched: Australian Journal of Music Therapy, British Journal of Music Therapy, Canadian Journal of Music Therapy, Journal of Music Therapy, Music Therapy Perspectives, Nordic Journal of Music Therapy, Voices: A World Forum for Music Therapy, New Zealand Journal of Music Therapy, Music and Medicine). The search also included several websites (i.e., grey literature): American Music Therapy Association, Association of Professional Music Therapists (UK), Canadian Association for Music Therapy, and European Music Therapy Confederation.

As shown in Fig. 1, a preliminary search first aimed to generate a comprehensive view of the literature by searching the broad term "music AND sensory" in all search fields (i.e., title, keywords, abstracts, text), which yielded 4048 results. Next, the search in all search fields was narrowed by using three more specific terms: "music AND sensory processing (806 results), "music AND sensory integration" (496 results), "sensory AND music therapy" (785 results), yielding 2087 results. Then, the search was further narrowed by restricting the search of the same three terms only for the publication abstracts (ab) and by using exclusion criteria words (NOT children with ASD, sensory impairments, brain injured, adolescence and morbidity, psychiatric, elderly). This procedure yielded the following 485 results: "music AND sensory processing (254 results), "music AND sensory integration" (123 results), "sensory AND music therapy" (108 results). The literature was last searched in May 2017.

Data evaluation

The 485 resulting articles were further screened by title and abstract to determine their relevance for the topic of this study. If the relevance was unclear from the title or abstract, the introduction was also read to

Table 1
Inclusion and Exclusion Criteria.

	Inclusion	Exclusion
Music	Primary use	Multiple mixed interventions, including music
Sensory	Sensory processing Sensory integration Sensation-seeking	
Population	Children with SPD Sensory integration Sensory-motor difficulties	Children with ASD Sensory impairments or challenges (visual, hearing impairment) Brain injured Adolescence and morbidity Clients with psychiatric conditions The elderly
Methodologies	Quantitative studies Qualitative studies Mixed methods Case studies Pilot studies Book chapters	Conference abstracts

determine inclusion or exclusion. The remaining studies were then evaluated according to the inclusion and exclusion criteria shown in Table 1. All studies had to include the use of music, but given the limited research in music therapy, the search included the general use of music implemented by music therapists, musicians, and by non-music therapy healthcare or educational professionals. The review also included articles, quantitative and qualitative studies, case studies, pilot studies, and book chapters. The main exclusion criterion was relevance of the subject of study. The population was a major criterion for data evaluation. Studies on children with Autism Spectrum Disorder were excluded because working with this population would require more complex variables. Studies on children with sensory challenges (deafness, blindness) were also excluded in order to distinguish between SPD, which affects processing, or interpretation, and challenges caused by a disturbance in the sensory system. As mentioned above, we also included studies that examined the association between Zuckerman's sensation-seeking scale (1994) and any musical factor. This scale was reported to exhibit "validity in a wide range of contexts, far beyond the initial use of it as a method devised to predict the outcomes of sensory deprivation" (Zuckerman & Aluja, 2015, p.352).

As shown in Fig. 1, this process identified 445 papers that did not meet the inclusion criteria such that 40 papers were read in full. Of these papers, 23 did not meet the inclusion criteria, and thus were excluded, leaving 17 papers in the review, as summarized in Table 2.

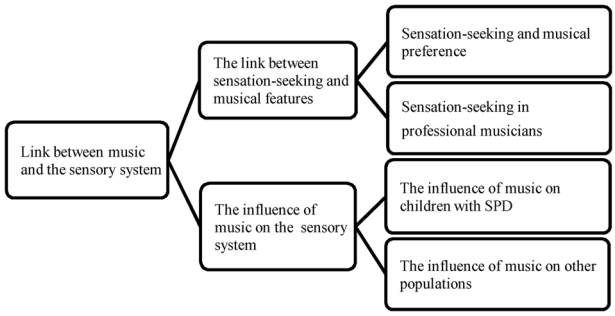

Fig. 2. Classification and categorization.

Data analysis

The data analysis stage involved an iterative process of constant comparison between publications in order to identify patterns, themes, and relationships across studies (see Whittemore, 2005, 2007; Whittemore & Knafl, 2005). Specifically, the following pre-determined parameters were considered in the publications analysis: study type and purpose, the type of music that was used, the sensory systems involved, population, and results. These parameters were used to classify each publication into one of four mutually exclusive themes. As can be seen in Fig. 2, the first overarching theme that focused on the link between sensation-seeking and musical features included the following two subthemes to differentiate between musicians and non-musicians: "sensation-seeking and musical preference" and "sensation-seeking in professional musicians." The second overarching theme that focused on the influence of music on the sensory system included the following two subthemes to differentiate between children with SPD and other populations: "the influence of music on children with SPD" and "the influence of music on other populations."

Table 2
Literature included in the Study, by Category and Date.

Sensation-seeking and music preference	Sensation-seeking in professional musicians	The influence of music on children with a SPD	The influence of music on other populations
Glasgow et al. (1985). Conservatism, sensation-seeking and music preferences. (Article) Litle and Zuckerman (1986). Sensation seeking and music preferences. (Article) McNamara and Ballard (1999). Resting arousal, sensation seeking, and music preference. (Article) Nater et al. (2005). Sensation seeking, music preference, and psychophysiological reactivity to music. (Article) Heydari et al. (2013). Analyzing the relationship between sensation seeking and preference of type of music in college students. (Article)	Vuust et al. (2010). Personality influences career choice: Sensation seeking in professional musicians. (Article)	Rose (2004). Tapping into the spirit of the sensitive child: A foundation for understanding and bringing the joy of music to children who have sensory integration challenges. (Article) Hall and Case-Smith (2007). The effect of sound-based intervention on children with sensory processing disorders and visual–motor delays. (Article) Esteves et al. (2009). Identifying the effectiveness of a music-based auditory stimulation method, on children with sensory integration and auditory processing concerns: a pilot study. (Book chapter) Perry (2015). Musical engagement of children with sensory processing disorder: A multiple case study (Doctoral dissertation) Schoen et al. (2015). A pilot study of integrated listening systems for children with sensory processing problems. (Article)	Eitan and Rothschild (2011). How music touches: Musical parameters and listeners' audio-tactile metaphorical mappings. (Article) Zimmerman and Lahav (2012). The multisensory brain and its ability to learn music. (Article) Gebel et al. (2013). Instrument specific brain activation in sensorimotor and auditory representation in musicians. (Article). Kuchenbuch et al. (2014). Audio-tactile integration and the influence of musical training. (Conference presentation) Kantono et al. (2016). Listening to music can influence hedonic and sensory perceptions of gelati. (Article) Landry and Champoux (2017). Musicians react faster and are better multisensory integrators. (Article)

Table 3
Sensation Seeking and Music Preferences.

Author(s)	Study purpose	Design and measures	*N*	Sensory system	Music type	Results
Litle and Zuckerman (1986)	Examined musical preference and its correlations with preferences rated according to the SSS.	Quantitative correlational; MPS, SSS scales	82 Gender and age N/A	Sensation seeking	Varied	Total sensation seeking correlated positively with liking rock music. TAS and ES subscales linked folk and classical music.
Glasgow, Cartier and Wilson (1985)	Examined personal conservatism range, musical preference and sensation-seeking level.	Quantitative correlational; WPAI, SSS. scales	42 males (16) females (26) aged 18- 69	Sensation seeking	Classical	Conservatives prefer simple, familiar and "safe" stimuli. Sensation-seeking was a less powerful predictor of musical preferences.
McNamara and Ballard (1999)	Examined music preference, sensation seeking, and resting arousal in male and female college students.	Quantitative correlational; SSS, MMPI-2 scales	96 males (49) females (47) age $M = 19$	Sensation seeking Resting arousal	Varied	Men showed a preference for arousing music, which was linked to behavior via resting arousal. Women showed a correlation between a preference for arousing music and cardiovascular measures.
Nater, Krebs and Ehlert (2005)	Examined the link between sensation seeking and musical preference, including psychological and physiological parameters.	Quantitative correlational; MEQ, SSS scales	53 males (26) females (27) age $M = 26$	Sensation seeking	Classical vs. heavy metal	Sensation seeking was associated with the psychological experience of aggressive arousing music, no physiological correlation.
Heydari, Mohammadi, and Rostami (2013)	Analyzed the relationship between sensation seeking and music preference.	Quantitative prospective; SSS scale	100 males (50) females (50) age N/A	Sensation seeking	Pop, classical	Positive relationship between high sensation seeking and pop, and low sensation seeking and classical. Difference was significant between the two sexes.

Note: SSS: The Zuckerman Sensation Seeking Scale; MPS: Musical Preference Scale; WPAI: The Wilson-Patterson Attitude Inventory; MMPI-2 Minnesota Multiphasic Personality Inventory2; MEQ: Music Evaluation Questionnaire; TAS: Thrill and adventure seeking; ES: Experience Seeking.

Table 4
Sensation Seeking in Professional Musicians.

Author(s)	Study purpose	Design and measures	*N*	Sensory system	Music type	Results
Vuust et al. (2010)	Investigated the relationship between sensation seeking and musical career choice.	Quantitative, nonrandomized group comparison; SSS, STAI scales	95 males (48) females (47) aged 18–31	Sensation seeking	Classical, rhythmic	Students playing rhythmic music had significantly higher sensation seeking scores than classical music students, who were predominantly driven by higher boredom susceptibility.

Note: SSS = Sensation Seeking Scale; STAI = Spielberger State Trait Anxiety Inventory.

Table 5
The Influence of Music on Children with SPD.

Author(s)	Study purpose	Design and measures	*N*	Sensory system	Music type	Results
Esteves, Stein-Blum, Cohen and Tischle (2009)	Evaluated the efficacy of TLP on children with SPD and auditory processing concerns.	Pilot study; pre/post developmental motor scales and a writing speech/language assessment	6 Gender N/A aged 3–11	Sensory processing	Classical	Improvement by all children compared to therapy alone.
Schoen, Miller and Sullivan (2015)	Explored the effects of ILS on children with SPD.	Pilot study; Single-subject, AB design, repeated measure; multiple sensory, physiologic and behavioral scales.	7 males (4) females (3) aged 5–12	Sensory processing	Classical	Improvement in home and educational goals. Partial support for effectiveness on behavioral and physiological goals.
Hall and Case-Smith (2007)	Investigated the effects of sensory diet and a therapeutic listening program on children with SPD and visual–motor delays.	Single-subject design; repeated measure; sensory profile; DAM, VMI, ETCH.	10 males (9) females (1) aged 5–11	Sensory processing	CDs selected for the child	Improvement on sensory profile. Therapeutic listening combined with a sensory diet improves behavioral problems.
Rose (2004)	Understand and adapt a music class to children with SPD.	Theoretical case study	N/A	Sensory integration	Music classroom	Music teachers provide a classroom where a child with sensory challenges can thrive.
Perry (2015)	Gain an under-standing of children with SPD, their musical engagement, and ability to self-regulate in music.	Qualitative; collective case study followed by cross-case analysis; school and OT reports, interviews, and observation	3 males (2) females (1) aged 8–10	Self-regulation	Music classroom	Engaged and experienced flow in music activities while demonstrating the ability to self-regulate in music classes.

Note: TLP: The Listening Program; ILS: Integrated Listening Systems; VMI: Visual Motor Integration; DAM: Draw-A-Person test; ETCH: Evaluation Tool of Children's Handwriting; OT: occupational therapist.

Results

Sensation-seeking and music preference

All five publications included in Table 3 were quantitative studies that examined the relationship between sensation-seeking and musical preference in different areas, aside from one, which examined other sensory processes, such as resting arousal (McNamara & Ballard, 1999). The literature included studies that aimed to replicate findings from previous studies that reported positive correlations between sensation-seeking and musical preference (Litle & Zuckerman, 1986). Other studies specified that there were significant differences between men and women in sensation-seeking and musical preference (Heydari, Mohammadi, & Rostami, 2013; McNamara & Ballard, 1999) or the preferences of people with conservative attitudes (Glasgow, Cartier, & Wilson, 1985). One key argument often stated was that physiological and psychological factors must also be taken into consideration (McNamara & Ballard, 1999; Nater, Krebs, & Ehlert, 2005).

The participants in all five studies were students, therefore limiting the ability to generalize findings to the general population. Furthermore, participants could differentially classify types of music or as a function of their familiarity with music. All the studies used Zuckerman's Sensation-seeking Scale (SSS) as an explanation for behavioral phenomena (Zuckerman, 1994). The SSS consists of four subscales: Thrill and adventure seeking, or the effort to seek arousal by engaging in risky behavior (e.g., skydiving), Disinhibition, or seeking arousal by experimenting with drugs or alcohol, Experience Seeking, or being open to new experiences, and Boredom Susceptibility, the avoidance of boring or low arousal situations. Zuckerman (1994) stressed, however, that these traits arise from psycho-biological interactions, and are not merely biological. The results indicated that questionnaire measures of musical preference fell into several categories on the Sensation-seeking Scale. In particular, the Experience Seeking sub-scale was associated with types of rock music, hard rock and classical music.

Sensation-seeking in professional musicians

The single article in Table 4 dealt with the sensory system and professional musicians (Vuust et al., 2010, p. 216) as defined in the Zuckerman sensation-seeking scale as a "test [of the] subject's optimal level of sensory stimulation and preference for new experiences and novelty in general." This study reported that individual sensation-seeking levels differed between classical and "rhythmic" students, thus suggesting an influence of personality on career choice. The risk of bias in reporting draws attention to the limitation of this study, in that musicians may represent a special population, and a career choice to be a musician differs from other professions because of the dedication to music from early childhood.

The influence of music on children with SPD

Table 5 has the largest number of studies (five) in music and sensory research because of the extensive use of music therapy in the field of special education. All participants in this section were children aged 3-12. Three studies investigated the influence of therapeutic listening intervention on children with SPD (Esteves et al., 2009; Hall & Case-Smith, 2007; Schoen, Miller, & Sullivan, 2015). All the studies reported significant improvement in progress made by the children after the completion of the therapeutic listening program. However, as a pilot study designed for only a few participants, there is a high risk of bias since the results cannot be generalized, and were based on parental rather than children's reports. One article with low credibility is a hypothetical case study (Rose, 2004). Only one doctoral dissertation examined three third grade students diagnosed with SPD in their regular musical classes (Perry, 2015). The researcher did not intend to

Table 6
The Influence of Music on Other Populations.

Author(s)	Study purpose	Design and measures	*N*	Sensory system	Music type	Results
Eitan and Rothschild (2011)	Examine the effects of musical variables on ratings of tactile metaphors.	Quantitative; nonrandomized group comparison; repeated measures; participants rated adjective scales	40 males (19) females (21) aged 18–60	Audio, tactile	musical variables	Tactile metaphors applied to sound were affected by musical variables.
Kantono et al. (2016)	Show that taste perceptions of different flavored gelato change with music.	Quantitative; single group; TDS; application of food-related emotional attributes scales	45 males (20), females (25) aged 21–41	Taste, audio	14 musical genres	Listening to music influenced the hedonic and sensory impressions of the gelato.
Kuchenbuch, Paraskevopoulos, Herholz, and Pantev (2014)	Test the influence of musical training on audio-tactile processing.	Quantitative; nonrandomized group comparison; stimulus sequences were presented and signified if the trial was congruent, incongruent, tactile or auditory deviant	30 males (11) females (19) age $M = 25$	Audio-tactile	Short melodies	Musicians showed an enhanced multisensory incongruence response.
Landry and Champoux (2017)	Test whether musical training enhances multisensory processes.	Quantitative; nonrandomized group comparison; a non-musical audio-tactile reaction-time task	35 males (10) females (25) aged 19–34	Audio, tactile, and audio-tactile.	Auditory stimulation	Faster reaction times by musicians for auditory, tactile, and audio-tactile stimulations.
Gebel et al. (2013)	Examine cortical representation sites and motor performance associated with auditory feed-back subject to instrument-specific training.	Quantitative; nonrandomized group comparison; fMRI (functional magnetic resonance imaging) in two groups of instrumentalists with different instrumental training	29 males (16) females (13). age $M = 25$	Sensory-motor feedback	Playing an instrument	Trumpeters had greater functional activation in the cerebellum, sensory-motor cortex, and auditory cortex than pianists when performing trumpet activities.
Zimmerman and Lahav (2012)	Discusses multisensory regions within the brain and their role in music learning and rehabilitation.	Theoretical article	N/A	N/A	N/A	Multisensory cortical brain regions are associated with music learning and enable music-induced brain plasticity.

Note. TDS: Temporal Dominance of Sensations procedure; fMRI: functional magnetic resonance imaging. N/A = not available.

represent or generalize the findings; therefore, results have a low risk of bias.

The influence of music on other populations

Table 6 presents six publications the majority of which focus on how musical training or experience may lead to sensory and motor neuroplasticity changes in the human brain due to the strong association between multiple sensory inputs. In this case, articles examining brain neuroplasticity, or how the process of listening or performing music modifies the sensory system were included. Although music listening is related to audio-sensory concepts, and playing music involves auditory-tactile integration, only a few empirical studies systematically investigated how music affects these specific sensory systems. One article investigated the representation of musical terms as tactile metaphors (Eitan & Rothschild, 2011). Four studies examined the link between music and its sensory influence, and in particular between playing music and the tactile system. Of these four, two studies examined how listening to music can influence sensory perceptions (Gebel, Braun, Kaza, Altenmüller, & Lotze, 2013; Kantono et al., 2016) and two systematically investigated how music affects the auditory-tactile system (Kuchenbuch et al., 2014; Landry & Champoux, 2017). In addition, a distinction is made between musicians or musical training versus non-musicians (Gebel et al., 2013; Kuchenbuch et al., 2014; Landry & Champoux, 2017). An article with a focus on taste as a sensory system appears here as well (Kantono et al., 2016). One article was theoretical and applied the other findings by arguing that the use of multisensory feedback during musical training should be emphasized, since music induces brain plasticity (Zimmerman & Lahav, 2012).

Discussion

This integrative review covered 17 studies that explored associations between music and the sensory system. The results point to two types of associations: between music and the sensory system and between sensation-seeking and musical aspects. Some studies reported a positive correlation between sensation-seeking and a preference for rhythmic music such as rock, hip-hop, and the like (Litle & Zuckerman, 1986), which could have mainly been driven by higher boredom susceptibility (Vuust et al., 2010). This link was suggested to be stronger for men than for women, with significant gender differences (Heydari et al., 2013; McNamara & Ballard, 1999).

Another important finding that may have meaningful clinical implications is the reduction in behavioral problems and improvement in self-regulation. For children who need self-regulation, some studies reported a positive influence of music, especially listening programs (Esteves et al., 2009; Schoen et al., 2015), where there was a significant improvement in sensory profile. Therapeutic listening combined with a sensory diet appeared to be effective in improving behavioral problems (Hall & Case-Smith, 2007). This contributes to a better understanding of the relationship between the sensory and emotional systems, which is vital for music therapists to take into consideration when working with children with SPD. One study showed the extent to which music listening influences the senses, in that even the sense of taste can be influenced by listening to music. Kantono et al. (2016) showed that sweetness is perceived as more dominant when listening to liked music, while bitterness seems to be enhanced when listening to disliked music. This may suggest that the affective emotional connotation that people attribute to music may affect multiple sensory functions.

The studies also point to the potential effect of musical training on auditory, tactile and audio-tactile functions (Kuchenbuch et al., 2014; Landry & Champoux, 2017). Here, the results showed that musicians were better at identifying auditory and tactile incongruences. Many of these processes are specific to the instrument played; in particular trumpeters had greater functional activation in the cerebellum, as well as a more dominant sensorimotor cortex and left auditory cortex than pianists when performing trumpet-related activities (Gebel et al., 2013). This may lead to interpretational biases that are likely to have a significant impact on results when using the term “musicians” globally.

Whether focusing on musical training (Kuchenbuch et al., 2014; Landry & Champoux, 2017), active music making (Perry, 2015), or passive listening (Esteves et al., 2009; Hall & Case-Smith, 2007; Kantono et al., 2016; Schoen et al., 2015), the studies reviewed here also suggest that both playing or listening to music had a significant influence on the sensory system. Both children and adults manifesting arousal through sensation-seeking showed specific musical preferences (Glasgow et al., 1985; Heydari et al., 2013; Litle & Zuckerman, 1986; McNamara & Ballard, 1999; Nater et al., 2005) which may also affect musical career choice (Vuust et al., 2010). All of the above is indicative of the influence of the sensory system on musical factors. This may lead to the practical conclusion that music therapy can be a suitable medium for children with SPD, and can help improve the plasticity of the sensory system (Zimmerman & Lahav, 2012), learning and engaging in music classes (Perry, 2015), communication, social skills, self-confidence, and motivation (Esteves et al., 2009).

Overall, the search process indicated that scant research has been conducted in the field of music therapy that focuses on children with SPD. To the best of our knowledge, this is the first review of studies in the field of music combined with the field of sensory integration. The method used in this study is the broadest type of mixed methods synthesis, which allows for the inclusion of experimental and non-experimental data. While the small number of studies and methods could be construed as a weakness of the review, it may nevertheless lead to a better understanding of the association between music and the sensory system and can be a basis for further research.

Conclusion

The purpose of this study was to better understand the associations between music and the sensory system to examine the suitability of treating children diagnosed with SPD through music therapy. The review revealed that there is a small but interesting body of research on the topic of the sensory system and music, and points to the possible association between the two. However, these findings should be viewed with caution due to the small sample sizes and participants’ differences in age. Another caveat is the potential risk of bias which in most of the studies was high or unclear, because they were nonrandomized group comparisons or single group studies that did not include a control group. Therefore, few firm conclusions can be drawn from this review. There is a need for more research on this topic, and especially on the effects of music therapy on children with SPD. It is hoped that this study will promote more work in this expanding area of interest.

Declarations of interest

None.

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