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Development Of Source-Contextual Memory Through Musical Activities in People with Autism

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ABSTRACT

A total of 28 participants with autism spectrum disorder (ASD) were included in this study. The participants were divided into three experimental groups, each corresponding to one of three types of intervention:

1. One group undertook text comprehension with simultaneous background music;
2. A second group undertook text comprehension of the same text, but without simultaneous music, although they attend music-based support sessions at other weekly times, and
3. A third group reading the text, without any form of musical intervention. After one week, they were asked what they could remember about the text they had read or listened to. Other variables were also examined, such as the participants' level, age and gender.

Data were analysed through non-parametric statistical tests, such as ANOVA with Cochran's Test and the Kruskal-Wallis Test, together with the corresponding descriptive statistics. The results of the ANOVA with Cochran's Test showed there were significant differences between the three experimental groups (sig: .00), a finding confirmed by the independent Kruskal–Wallis Test, the results of which indicated significantly different scores between the three experimental groups for the text comprehension variable (sig: .00), whilst there are no differences for the other variables in the analysis: level of ASD, age and gender. The t-Tst for Equality of Means was used to compare the non-parametric data; this resulted in findings similar to those of the non-parametric tests, showing a significant level for the 'understanding' variable (t: 3.66, df: 17, sig: .00), whereas the the other variables didn't show significant levels of differential variance between the three experimental groups.

Keywords: Music; Music Therapy; Autism Spectrum Disorder; Learning; Sensory Memory; Information Neuroprocessing

Introduction

Based on the International Classification of Disabilities [DSM-V] of the American Psychiatric Association [APA] [1]. The diagnostic criteria for individuals with ASD are determined by the symptomatic presence of difficulties in social interaction and communication, and the existence of repetitive and restrictive behaviours across three levels of severity, as outlined by the World Health Organisation (2015), as they corroborate the APA's findings. However, in addition to these two observable symptoms, currently available scientific research (Adorjan, et al. [2-8]) has advanced knowledge of brain development in relation to the neuroprocessing of information in persons with ASD.

The neuroprocessing level broadly affects the process of understanding information, from the initial perceptual level to the sensory level, where significant deficits have been found in the autonomous formation of source or contextual memory by individuals with ASD; this presents difficulties for working memory in the formation of episodic or contextual memory within long-term memory. In the absence of episodic memory, the incoming information stimulus in permanent semantic memory is isolated, which makes it difficult to develop interrelationships with new entering content and, above all, to recover information in keeping with the meaning of the external requirement. These deficits observed in persons with ASD are localised at the level of the brain's GABAergic neurotransmitter system, specifically affecting the GABA-A receptor, which is itself composed of 19 subunits, associated with the 15q11-q13 genetic locus; a deficiency in these subunits prevents the development of links between newly perceived information and previously associated information stored in permanent memory.

From these perspectives, the analysis of perceptual processes, attention, cognitive processing, the quality of semantic and episodic memory, and their global functioning should be regarded as essential elements in the assessment of the symptomatic group of individuals with ASD, although, of course, without overlooking the observable objective behavioural characteristics indicated by the official classifications; but always bearing in mind the systemic involvement of behavioural (social and behavioural) and perceptual-cognitive components, which are developed through the functioning of neural information processing. There's lots of very strong preliminary evidence showing that, compared with neurotypical children, persons with ASD have significant issues with the activation of cortical brain areas (Lai, et al. [9]). These authors showed the existence of increased activity in the fronto-posterior networks during the use of music as a complementary component.

These findings have contributed initial evidence that music processing might be a unique strength in children with ASD, which would justify the use of music-based interventions to facilitate participation in academic and social settings, for this reason, music might be that foundational component which helps people with ASD to construct the contextual framework related to incoming sensory-conceptual input-known as source memory-facilitating working memory's dual function of enabling access to information from the perceptual sensory register to semantic memory, but also, through its connection with source memory, the creation of episodic memory, duly completing the information neuropsychological processing circuit. The American Music Therapy Association [10] has found that music, when used as a fundamental therapeutic tool, could be a context-based process that facilitates holistic, interconceptual development in individuals with ASD; when complemented by input from the sensory-informational pathway, this becomes the context of the informational pathway-a context that individuals with ASD find extremely difficult to create independently; meaning that music education or other alternative activities, such as singing groups, dance, rhythmic activities, self-expression, socialisation, rehabilitation, psychological enhancement and recreation, could contribute to the effective functioning of executive processing, facilitating the development of the deficient components in information processing in persons with ASD and, consequently-and above all-by comprehensively improving the brain's neural circuitry, this also facilitates an overall improvement in the range of symptomatic clusters that constitute the disorder, in regards to social and behavioural skills.

There is a wide range of music therapy methods described by Geretsegger, et al. [11] and Kern, et al. [12], in which music becomes a fundamental component for improving conceptual interrelationships, due precisely to its role as a context for the input of information; consequently, it facilitates improved social interaction, verbal communication and language in the strict sense, behavioural initiative and socio-emotional reciprocity, and the facilitation of improvements in greater social adaptation (Fossum, et al. [13-15]). Therefore, curricular interventions, complemented by associated contextual processes-such as a musical framework-indicated significant progress in the understanding of people with ASD, which would affect the range of associated symptomatic groups (Bharathi, et al. [16,17]).

For a great deal of time now, music has been scientifically recognised as an effective therapeutic resource for enhancing cognitive and emotional development in children with ASD, owing to the synchronisation of brain waves and the resulting improvement in processing ability (Rubin, et al. [18]), as well as in basic psychological processes such as attention and concentration, which, in addition, encourages the development of psycho-cognitive processes and, consequently, comprehensive interconceptual development (Ezzeddine, et al. [19,20]). Perhaps because individuals with ASD are highly skilled in a very specific musical capacity, possibly owing to the process of synchronisation, which enhances their attention to events taking place around them (Baron-Cohen, et al. [21]). These specific abilities were also analysed by Quintin [22], who stated that music enhances the perception of stimuli and integrates incoming information with the musical context, particularly, as affirmed by Falter, et al. [23], Heaton [24] and Stanutz, et al. [25] when the musical stimuli involved have specific pitch, melody and rhythm. Musical engagement not only develops alongside psycho-socio-behavioural processes, but also positively influences the process of recognising one's own emotions and, above all, facilitates the understanding of emotions in others, or Theory of Mind (Quintin, et al. [26]).

And, although, until now, music research applied to students with ASD has focused on classical music therapy or instrumental music with simple rhythms (Sayed, et al. [27,28]), it's also possible to use more complex and distinctive rhythmic patterns, which significantly promote the development of psychosocial and behavioural skills (Lyle, et al. [29]). This would suggest that music involving light rhythmic melodies should be used as a contextual background to facilitate improved processing of sensory input, given the particular strength

that people with ASD demonstrate in this specific area. Zrilić, et al. [30] showed, through a single-case study involving a student with ASD, that the student displayed a particular aptitude for remembering musical melodies, reproducing them with a high degree of reliability in relationship to their initial musical perception. For Kardum [31], students with ASD are proof that well-planned and complementary music can serve as a stimulus for students with ASD, owing to their particular sensitivity and strong associative abilities.

The main aim of this study is therefore to analyse whether there are differences in the conceptual and interconceptual understanding of students with ASD, as they are divided into three experimental groups: the first related to the presentation of information accompanied by a musical melody playing in the background; the second group was made up of students who received the information in isolation, but whose musical knowledge is developed through music lessons as academic or extracurricular activities; and the third group were students who received the information in isolated form and did not have alternative support from musical or other alternative task-based activities.

Method

Research Design

The design is founded on the quantitative analysis of the data obtained from the study variables, analysed for three experimental research groups who experienced a story through their own sensory perception, according to three types of intervention corresponding to the 'group' variable:

1) Music played simultaneously with the story,

2) Music as an external aid outside the context of the story, and

3) Without music, in relation to the 'comprehension' variable.

Variables relating to the level of ASD, age and gender have also been analysed using the appropriate statistical procedures.

Participants

A total of 28 people participated in this study, divided into three experimental research groups; their cross-tabulation is shown in Table 1.

Table 1: participants´ group.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	music played simultaneously with the story	9	32.1	32.1	32.1
	music as an external support outside the context of the story	9	32.1	32.1	64.3
	without music	10	35.7	35.7	100
	Total	28	100	100	

Variables

Research variables are grouped into the 'group' variable, which features three experimental groups:

- Music played simultaneously with the story,
- Music as an external support outside the context of the story, and
- Without music; each group is characterised by the following criteria:

1. Experimental Group 1- Students in this group experience the sensory input of a story they are reading, simultaneously with music playing in the background while they read the story (G1).

2. Experimental Group 2- The students in this group read the same text, but do not simultaneously received background music; however, they attend music activities three days a week outside school hours, as a stand-alone activity (G2).

3. Experimental Group 3- The students listens to the story being read without any music, either simultaneously or as isolated external support (G3).

In the analysis of text comprehension, this has been assessed using the variable relating to 'understanding', which has been measured in accordance with the following codes:

1. There is no understanding (remembers practically nothing),
2. Very low (recalls words related to the text),
3. Low (recalls a significant phrase from the text),
4. Moderate (links two or more significant phrases),
5. High (understands the text, but very locally), and
6. Very high (displayed comprehensive understanding of the whole text's meaning).

Other variables have been analysed. The variable relating to the level of ASD 'level' (0: ASD-1, 1: ASD-2 and 2: ASD-3), the variable 'age' (0: 2–4 years, 1: 5–7 years and 2: 8–10 years old), and the variable 'gender' (0: male, 1: female). Data found regarding the participants and the corresponding variables, considered viewed as a whole, can be seen in Table 2.

Table 2: understanding * group * level * age * genre Crosstabulation (N: 28).

genre	age	level	understanding		group			Total
					G1	G2	G3	
male	2-4	ASD-1	understanding	half	0		1	1
				high	1		0	1
		ASD-3	understanding	there is no understanding		1		1
	5-7	ASD-1	understanding	very low	0	0	1	1
				low	0	1	1	2
				half	0	4	1	5
				high	2	0	0	2
		ASD-2	understanding	very low			1	1
		ASD-3	understanding	there is no understanding	0		1	1
				very low	1		0	1
	8-10	ASD-1	understanding	very high	3			3
		ASD-2	understanding	very low		0	1	1
				low		1	0	1
				high		1	0	1
female	5-7	ASD-1	understanding	half	0	1		1
				high	2	0		2
	8-10	ASD-1	understanding	half			3	3
			Total		9	9	10	28

Hence, for the 'gender' variable, amongst the two- to four-year-old boys at ASD-1 level, one student in G1 demonstrates a high level of comprehension, whilst one student in Group 3 exhibits a comprehension deficit. Among men aged 5–7 years at ASD-1 level, two students in G1 showed a high level of understanding, whereas in G2, one student showed a low level and two showed a medium level of understandin'; and in G3, one student showed a very low level of understandin', one a low level and one a medium level. At ASD-2 level, one student in G3 displayed a very low level of comprehension. Among young men aged 8–10 at ASD-1 level, three students achieved a very high level of understanding. At ASD-2 level, in G2, one student was found to have a low level of comprehension and one a high level; in G3, one student was identified as having a very low level of comprehension. Likewise, within the 'gender' variable, among women aged 5–7 at ASD-1 level, there are two high-level students, while in G2 there is one student with a medium level of understanding. Among women aged 8–10 at ASD-1 level, there are three students with a medium level of histsory understanding.

Data Analysis

Statistical analyses were found through non-parametric tests, owing to the small sample size, which ensures a better goodness of adjustment. The tests used were ANOVA with Cochran's Test and the non-parametric Kruskal–Wallis Test for K Independent Samples. Nevertheless, these data have been cross-checked against the parametric t-Test for K Independent Samples, as this is considered to have greater statistical power, in the aim of corroborating the non-parametric data found.

Procedure

Students in the three experimental groups either read, or – if they were unable to read – listened to the text of the story: 'The Frog Who Wanted to Be a Real Frog': (…) Once there was a little frog who wanted to be a proper little frog, and every day she tried her hardest to achieve it. At first, she bought a mirror in which she would gaze at herself for ages, searching for the authenticity she so longed for. Sometimes she seemed to find it and sometimes not, depending on her daily mood or the timing, until she was tired of it all and ended up keeping the mirror in a trunk.

Finally, she decided that the only way to know her own worth was through other people's opinions, and she began to style her hair, get dressed and undress (when she had no other choice) to see if others approved of her and recognised that she was a real frog. One day she observed that what they admired most about her was her body, especially her legs, so she devoted herself to doing squats and skipping to develop ever better hind legs, and she felt as though everyone were applause her. And she continued making these efforts to the point where, willing to do anything to be recognized as a genuine Frog, she allowed her thighs to be torn off, and the others ate them, whilst she could still hear, with bitterness, them saying what a fine Frog she was, that she seemed like a Chicken (…)

- Source: https://www.profedeele.es/actividad/la-rana-que-queria-ser-una-rana-autentica/

Students in G1 were simultaneously presented with a light musical melody playing in the background, based on a piano sequence of chords in the following order: C major, A minor, F sharp major and G sharp major: https://www.youtube.com/watch?v=owOscl-6QZs&t=56. The musical accompaniment had been worked on on several previous occasions before being employed as background music; students were not, therefore, compelled to focus on the music, but it simply created a familiar background environment. G2´ students, who are exposed to music outside school hours in isolation, are introduced to music of various compositions. G3´ participants read or listened to the story exclusively. Finally, after one week, each student was asked about their comprehension of the story, which was assessed in accordance with the codes for the 'undwerstanding' variable, as set out in the section of variables.

Ethical Considerations

The study presented in this research has complied with all ethical requirements regarding the relevant procedures for obtaining families' consent to participate in the project.

Results

As regards the initial statistical analysis to determine whether the processes relating to the 'understanding' variable showed data indicating equality or were differentiated across the three experimental groups, an initial analysis was performed applying the Conchran´ Q Test (see Table 3). It would therefore be possible confirm that data for the 'understanding' variable are different according to the type of 'group', meaning that there's a significant statistical difference between the three experimental groups (Cochran's Q: 63.91, sig: .00), which could lead hope that music is a complementary component that improves histosry conceptual comprehension. The subsequent analysis of the non-parametric Kruskal–Wallis Test was applied to identify the specific variance explained by the 'understanding' variable, such as the other variables in the analysis: 'level', 'age' and 'gender', as per the three types of experimental groups belonging to the 'group' variable. The ranks from the Kruskal-Wallis Test have been analysed in depth to identify the variance explained by the variable 'understanding' as well as the other variables in the analysis: 'level', 'age' and 'gender', according to the three types of experimental groups corresponding to the 'group' variable.

Table 3: ANOVA with Cochran's Test*.

		Sum of Squares	df	Mean Square	Cochran's Q	Sig
Between People		10.08	27	.37	63.91	.00
Within People	Between Items	120.75	4	30.18		
	Residual	90.84	108	.84		
	Total	211.60	112	1.88		
Total		221.68	139	1.59		

Note: *Grand Mean: 1,12

Regarding the data found from both experimental groups can be observed the ranks from the Kruskal-Wallis Test are basic indicators of the mean values found across the different variables operationalized (see Table 4). The ranks showed that, for the understanding variable, G1 showed a higher mean than the other two experimental groups (22.00), higher than G2 (12.50) and significantly higher than G3 (9.55); consequently, G2 also showed higher mean ranges than G3. For the other variables – 'level', 'age' and 'gender' – the mean ranks were very similar, with insignificant differences between the three study experimental groups. Indeed, the Kruskal–Wallis Test definitively rejected these findings, based on the data analysed within all variables, in regards to the three experimental groups (see Table 5). Kruskal-Wallis Test effectively indicated that the 'inderstanding' variable showed significant differences between the three experimental groups (chi-squared (chi2): 12.37, df: 2, sig: .00), although there were no significant differences between the three experimental groups for the other variables studied: 'level' (sig: .59), 'age' (sig: .78) and 'genre' (sig: .61).

Table 4: Ranks of K-W Test.

	group	N	Mean Rank
understanding	G1	9	22.00
	G2	9	12.50
	G3	10	9.55
level	G1	9	12.78
	G2	9	15.56
	G3	10	15.10
age	G1	9	14.61
	G2	9	13.22
	G3	10	15.55
genre	G1	9	14.61
	G2	9	13.06
	G3	10	15.70
	Total	28	

Table 5: Kruskal Wallis Test (b).

	Understanding	Level	Age	Genre
Chi-Square	12.37	1.03	.89	.97
df	2	2	2	2
Asymp. Sig.	.00	.59	.78	.61

Note: b) Grouping variable: group.

It was therefore demonstrated that participants in G1 exhibited a higher level of conceptual understanding than those in G2 and G3, as determined by the analysis of the non-parametric test has been applied. However, in addition to these findings, the results have been verified further through tests with greater statistical power, such as the parametric comparative t-Test for K Independent Samples. Results of the Comparative t-Test, regarding the comparative analysis of the three experimental groups, corresponding to the 'understanding' variable, regarding 'group' variable, can be seen in Table 6. It's worth saying, though, that differences in the 'understanding' variable related to the three experimental groups were significantly different, both assuming equal variances and not assuming equal variances (sig. 2-tailed: .00). Meanwhile, by contrast, the other variables in the study showed no intergroup differences: 'level' (sig: .57), 'age' (sig: .80) and 'genre' (sig: .72, when equal variances are assumed, and sig: .71 when equal variances are not assumed).

Table 6: Independent Samples Test.

F		Levene's Test for Equality of Variances		t-Test for Equality of Means						
		Sig.	t	df	Sig. (2-tailed)	μ difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
understanding	Equal variances assumed	.89	.35	3.66	17	.00	2.00	.54	.84	3.15
	Equal variances not assumed			3.65	16.52	.00	2.00	.54	.84	3.15
level	Equal variances assumed	.64	.43	-.56	17	.57	-.17	.31	-.84	.48
	Equal variances not assumed			-.56	16.93	.57	-.17	.31	-.83	.48
age	Equal variances assumed	.06	.80	-.25	17	.80	-.07	.30	-.72	.57
	Equal variances not assumed			-.25	16.83	.80	-.07	.30	-.72	.57
genre	Equal variances assumed	.54	.47	-.36	17	.72	-.07	.21	-.52	.37
	Equal variances not assumed			-.36	16.99	.71	-.07	.21	-.52	.36

Study Limitations

This study, like many others when analysing specific disability groups, is limited, firstly, by the small number of participants comprising the samples for the three experimental groups; however, the total sample size (N: 28) is, on the whole, a fairly significant indicator for making decisions in regard to the set goals. Furthermore, a second limitation should be highlighted, owing to the low variation among students with regard to the 'level' variable, as the participants in ASD-1 (n: 21.75%) far outweigh those in ASD-2 (n: 4.14.3%) and ASD-3 (n: 3.10.7%). For this reason, it´d be necessary to replicate these findings using larger and more diversified study samples.

Conclusion

Perceived learning (sensory memory), when complemented by a relevant context – such as, in this study, the presence of a light background melody – enables working memory to create a source or contextual memory associated with the perceived sensory information and, consequently, by facilitating bidirectional access to the information, both to semantic memory (long-term memory) and, above all, to episodic or contextual memory, which is also stored in long-term memory and linked to semantic memory. In this regard, the recovery of information is adjusted to the context of the requirement, given the existence of this interrelational link between semantic memory and episodic memory; but, above all, it means that working memory can promptly develop conceptual interrelationships between stored information and new sensory input. Results obtained for the 'understanding' variable, in relationship to the comparison between the three experimental groups, were strong indicators of the importance of music as a contextual element that facilitated source recall, thereby improving the functioning of the neuropsychological information-processing circuit as a whole.

It's also worth highlighting that when students get musical support as an external aid at times other than while reading or listening to the story – which makes up G2 – they showed a marked improvement compared with participants in G3, who received no musical support whatever. This makes music an ideal method for improving the active neural conditions of students with ASD (see Figure 1). This isn't, however, appear to be the case for the other static variables in the study, which revealed equal variances across the three experimental groups, with no significant differences observed between them. That said, although it's right that if the 'level' variable were to become more heterogeneous, the study might get different results in regards to that variable (Justo, et al. [32]), there's no questioning that music being used therapeutically to support the academic process at school helps with the integrated development of neuropsychological information processing and, consequently, every symptomatic group that belongs to this disorder.

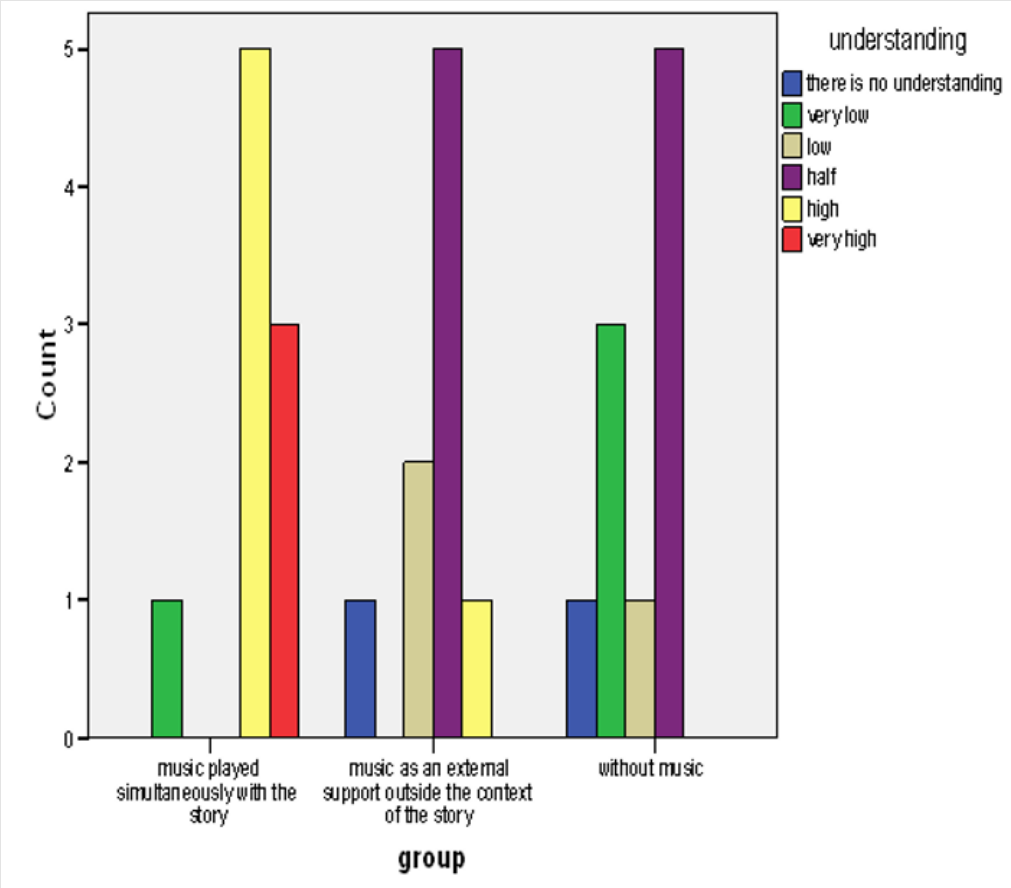

Figure 1: 'understanding' * 'group'.

Discussion

Effectively, the neural connections, which are located in the temporo-parietal junction, the medial prefrontal cortex, the orbitofrontal cortex and the amygdala (Frith [33]), which the anterior insula has recently been shown to be linked to, specifically owing to its role in observed social empathy, as well as the spindle-shaped convolutions, owing their involvement in the processing of observable facial expressions throughout social interaction and communication, underpin neuro-processing functions (Adolphs [34]). Significant deficits have been identified in persons with ASD regarding these regions of information processing (Redcay, et al. [35,36]), which highlights the importance of focusing on the creation and fine-tuning of the neural networks within the psychoneurological processing system through their influence on the GABAergic-A neurotransmitter (Ojea, et al. [37]), as also shown by studies contributed by Creative Music Therapy (Bakan [38]). Furthermore, Eschen [39], the British Society for Music Therapy [40] and the Benenzon Centre [41] have pointed out, in this respect, that music is an excellent method for facilitating the functional activity of working memory and, consequently, the weak, localised cognitive coherence of the perceptual process in individuals with ASD will be able to achieve higher levels of global coherence whilst undergoing the learning process.

Brownell [42], Kern, et al. [43] and Pasiali [44] have found similar results to those of this research study in their own studies, which therefore corroborated that musical activities were an effective method to improve the overall development of individuals with ASD, for which music also provided a motivational stimulus and encouraged social participation. This issue is strongly linked to personal development, as it supports understanding of the complementary task (Kern, et al. [45]), particularly when musical melodic intervention is familiar to individuals with ASD, which generally increases motivation towards the assignment and enhances executive function. These contributions have been provided, furthermore, by comparing students with ASD who received musical stimulation with those who did, demonstrating the effectiveness of music therapy in facilitating the development of individuals with ASD and, more importantly perhaps, raising their levels of emotional engagement and happiness while performing the activity, which helps them to mentally relax and thereby focus on the activities more effectively.

Music is, therefore, a fundamental component of learning in an intrinsic and complementary sense within the process of conceptual understanding; however, there's other strategies that might also be used to support the holistic development of individuals with ASD, like using visual schedules (Schneider, et al. [46]), activity sequences (Banda, et al. [47]) or social stories (Mancil, et al. [48]). Indeed, visual and sensory perception activities are a particular strength for individuals with ASD, as has already been demonstrated by Quill [49] and, most recently, by Rutherford, et al. [50]. This is attributed to the fact that visual and auditory sensory supports offer specific information through concrete signals, which facilitated global development as they were tangible and time-bound components that helped the content to be kept in long-term memory (Meadan, et al. [51]).

If autism spectrum disorder is compared, e.g., to Parkinson's disease – in which patients are observed to experience recurrent tremors – in the same way that individuals with ASD exhibit stereotyped, restrictive and social behavioural patterns. However, if attention is focused only on the symptoms inherent to these conditions, it will simply increase the anxiety and depression experienced by these individuals significantly. Therefore, in the case of both ASD and Parkinson's disease, it's needed to highlight the central cortical process; as fluidity and connectivity improve, so too will the external symptoms.

However, if symptoms still persist, even if less severe, it should be understood that both stereotyped behaviours and restricted behaviour forms are intrinsic components of people with ASD; consequently, even if they persist, they must be accepted as a matter of individual diversity-which is an inherent right of persons with disabilities-and this should be respected within the framework of social inclusion. In essence, all possible forms of visual, auditory and sensory motivational support should be integrated into standard support processes to promote the perceptual-cognitive, social and behavioural development of people with ASD, both at school – throughout all educational settings – and in the wider community, in the context of daily life activities. (Rao, et al. [52]).

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