Expert support system for occupational therapist in the identification of sensory profile

Sistema especialista para apoiar o terapeuta ocupacional na identificação do perfil sensorial

Thais Caroline Pereira[a], Deborah Ribeiro Carvalho[b], Claudia Maria Cabral Moro[c]

[a] MSc, Pontifícia Universidade Católica do Paraná, Programa de Pós-Graduação em Tecnologia em Saúde, Curitiba, PR - Brazil, e-mail: tcpto1@gmail.com

[b] PhD, professor, Pontifícia Universidade Católica do Paraná, Programa de Pós-Graduação em Tecnologia em Saúde, Curitiba, PR - Brazil, e-mail: ribeiro.carvalho@pucpr.br

[c] PhD, professor, Pontifícia Universidade Católica do Paraná, Programa de Pós-Graduação em Tecnologia em Saúde, Curitiba, PR - Brazil, e-mail: c.moro@pucpr.br

Abstract

Introduction: Based on the increasing usability of technology in healthcare, this paper discusses the use of an expert system (ES) to identify the sensory profile of patients starting Occupational Therapy, allowing the professional to make assertive decisions in establishing priorities in the therapeutic plan. **Objective**: To develop a decision support system from the Infant/Toddler Sensory Profile. **Method**: Structuring of an ES based on Infant/Toddler Sensory Profile, from terms translation into Portuguese, identification of variables and domain values involved, and construction of production rules. **Results**: Twelve variables were registered for the construction of the ES, 6 of these were treated as goal-variables, 20 rules being built. **Conclusion**: This ES is an important support to the occupational therapist in the decision-making process of treatment plans, determining priorities and respecting the sensory profile of each child. In addition, it must be noted that there is no equivalent system.

Keywords: Expert system. Sensory. Occupational therapy.

Resumo

Introdução: Com a crescente usabilidade da tecnologia na área da saúde, este artigo aborda a utilização de um sistema especialista (SE) para identificar o perfil sensorial de pacientes a iniciarem o tratamento de Terapia Ocupacional, permitindo ao profissional tomar decisões assertivas no estabelecimento de prioridades no plano terapêutico. **Objetivo**: *Construir um sistema de apoio à decisão a partir do* Infant/Toddler Sensory Profile. **Método**: *Estruturação de um SE baseado no* Infant/Toddler Sensory Profile, *a partir da tradução para o português dos termos contidos neste instrumento, identificação das variáveis e valores de domínio envolvidos; e a construção das respectivas regras de produção.* **Resultados**: *Para a construção do SE foram cadastradas 12 variáveis, destas 6 foram tratadas como variáveis-objetivo, sendo construídas 20 regras.* **Conclusão**: *O SE construído constitui apoio importante ao terapeuta ocupacional no processo de tomada de decisão sobre o plano terapêutico, determinando as prioridades e respeitando o perfil sensorial de cada criança. Além disso, é preciso salientar que não há um sistema equivalente.*

Palavras-chave: *Sistema especialista. Sensorial. Terapia ocupacional.*

Introduction

Occupational therapy is an area of knowledge that investigates strategies for prevention and treatment of individuals with cognitive, affective, perceptual and psychomotor problems resulting from genetic or traumatic disorders or from acquired diseases, using human activity as a therapeutic tool (1). For this, it selects, prepares and proposes activities to be performed by the patient in order to achieve treatment goals. For this process to be successful, it is necessary that all the characteristics peculiar to the patient are considered in the preparation and monitoring of the therapeutic plan.

Currently, researchers have turned their attention to a disorder in the ability to process and integrate sensory information coming from the environment, resulting in inappropriate behaviors, the Sensory Processing Disorder (SPD) (2).

This disorder is observed in neurotypical children who have normal neuropsychomotor development. It is suggested that one in twenty children has some sensory processing disorder (3) and one in six has sensory experiences that interfere with their academic, social, and/or emotional development (4). There are studies showing a higher propensity among autistic children, because they have significantly different sensory responses (5, 6, 7, 8, 9) resulting from sensory processing problems (10).

Since sensory processing is crucial for the individual to be able to engage in daily (11) activities, this explains why the SPD is the focus of the occupational therapy area (12).

The concern with the SPD is growing so much that the American Academy of Child and Adolescent Psychiatry's annual meeting, held in 2006, presented the hypothetical case of a child previously diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), whose diagnosis was being investigated as a Nonverbal Learning Disability (NVLD) or Sensory Processing Disorder (SPD), and then there was the suggestion to put both in the Diagnostic and Statistical Manual of Mental Disorders – DSM, since the nosology existing in the current DSM IV does not include them, leading to erroneous diagnoses and treatments (13).

The SPD involves the misperception of the stimulus received from the environment, an aspect influenced by the sensory profile of the child, which results in high and/or decreased perception of sensory stimuli. Examples include behaviors such as: difficulty to brush the teeth, because the sensation is perceived as annoying; or the child who throw him/herself on the floor with frequency because the pain is perceived as insignificant or is even almost imperceptible.

There are several assessment tools to identify the SPD, such as: *Infant / Toddler Sensory Profile* (14), *Sensory Integration and Praxis Test – SIPT –* (15), *Sensory Profile* (16), *DeGangi-Berk Test of Sensory Integration* (17), *Observations Based on Sensory Integration Theory* (18) and *Test of Sensory Function in Infants* (19); but neither is validated in Brazil.

To develop this study, we opted for the *Infant/ Toddler Sensory Profile* (14). This choice was made

based on the following reasons: 1) it involves alteration of sensory perception and, consequently, affects the performance of daily activities and social relationships; the early identification of SPD is crucial, and this tool deals with the age group related to the early childhood, favoring its brief identification; 2) it is a significant educational tool, which facilitates the educational process; 3) its wide use and disclosure carries with it the social nature, because it allows disseminating the knowledge related to SPD, enabling people living with children with this disorder to better understand their atypical behaviors. Thus, it favors social relations since it avoids requirements and situations that may cause frustration for both the children and for those who take care of them, contributing significantly to the mental health of all.

The access to information regarding sensory responses is essential for the occupational therapist to identify the sensory profile of the individual and enable the development of an assertive treatment plan. This access to this information can be favored using Information Technology (IT), which favors the greater use of information electronically recorded by health professionals (20), which can be done on paper charts or in the Electronic Patient Record (EPR), allowing professionals not only to store information, but also to share them (21). Overall, IT offers a wide range of alternatives aiming to facilitate the decision-making in different areas of knowledge, particularly in healthcare, and one of the means of doing this is using an Expert System (ES).

The ESs are constructed based on the expert knowledge. This system consists of rules that help to solve problems and support decisions (22), and it consists of the following components: knowledge base, mechanism of inference and interface with the user. From the user interface, the query to the system is accomplished by establishing a connection to the inference engine, browsing the knowledge base in search of the best solution for the proposed problem. The knowledge base stores the reasoning process that involves all information, data, cases and relevant relations used by the ES. It also includes a set of concepts that can be represented by sentences that establish relations of cause and effect. One form of representation is widely used by rules of "if ... then" (23), called production rules, which allow the relation between a set of conditions and their respective action, for example, in a system for diagnosis support,

the respective differential diagnosis indication for a given set of conditions.

Its application has been employed in higher education, aiming to help the students to understand the criteria used to identify specific diagnoses. As an example, we have: "The use of Expert System to Support the Systematization in Orthopedic Examinations of Hip, Knee and Ankle" (24) and "Intelligent System to Aid Physiotherapy Treatment by Applying the Principle of Neuroplasticity in Patients with Cerebral Palsy" (25).

In the case of sensory processing, the ES contributes in the identification of sensory responses, in the decision-making regarding the therapeutic approach to be adopted, and also in academic teaching, helping in understanding and developing clinical reasoning.

Thus, due to the need for a system that assists the occupational therapist in identifying the sensory profile by supporting the development of the treatment plan, this article aims to present the construction of an expert system of decision support based on the *Infant/Toddler Sensory Profile* (14).

Materials and method

The *Infant/Toddler Sensory Profile* (14) has different versions according to the age group. The version adopted in this study regards the ages between 7 and 36 months, dated from 2002 (14). Since it is an instrument originally presented in English, for its use it was necessary to initiate the process by its translation into Portuguese, which was performed by the first author.

For the preparation of ES, we adopted Expert Sinta (26) tool, which was developed by the Artificial Intelligence Laboratory of the Federal University of Ceará, Brazil (27).

Sensory characteristics were initially identified and defined based on the *Infant/Toddler Sensory Profile* (14), which consists of a questionnaire to be answered by caregivers, and that addresses the child's sensory processing. It consists of quadrants arranged as follows: 1) 06 of them have a list of behaviors, totaling 48, which, as shown in Table 1, are related to different sensory processing (auditory, visual, tactile, vestibular and oral), and a quadrant related to the general processing; 2) 1 of them presents a Likert scale, with 5 scores to be allocated according to the frequency with which these

behaviors are observed (almost always, often, occasionally, rarely, almost never); 3) 4 of them are used to survey the scores of the processing; 4) 1 of them to determine the sensorial profile according to the attributed scores.

The steps for developing the structure of ES Expert Sinta (26) based on *Infant/Toddler Sensory Profile* (14), were as follows:

a) Translation into Portuguese, since its validation in Brazil has not been performed;
b) Identification of the variables involved;
c) Among the identified variables, referencing those to be adopted as the objective variables;
d) Establishment of the domain values that each variable can take;
e) Preparation of production rules.

Table 1 - Part of Infant/Toddler Sensory Profile

Item	Auditory processing	Almost always	Often	Occasionally	Rarely	Almost never
Low Registration	The child finds ways to make noise with toys.					
Low Registration	The child ignores you when you are talking.					
Sensation Seeking	The child startles easily at sound, compared to other children the same age.					
Low Registration	The child enjoys making sounds with his/her mouth;					
Sensory Sensitivity	It is necessary to speak loudly to get the child´s attention.					
Sensory Sensitivity	It takes a long time for the child to respond when her name is called.					
Low Registration	The child tries to escape from noisy environments.					
Sensation Avoiding	The child are distracted and/or has difficulty eating in noisy environments.					
Sensation Seeking	The child takes a long time to respond, even to familiar voices.					
Low Registration	It is necessary to touch the child to gain her attention.					

Source: The Psychological Corporation (14).

Results

Twelve variables involved were identified, six of these represent the behaviors that indicate the sensory profile of the processing; and other six were identified as goal-variables in order to represent the sensory profile. The 12 variables and their domain values are presented as follows:

a) **Variable 1**: auditory processing.
Domain values : the child finds ways to make noise with toys; the child ignores you when you are talking; the child startles easily at sound, compared to other children the same age; the child enjoys making sounds with his/her mouth; it is necessary to speak loudly to get the child´s attention; it takes a long time for

the child to respond when her name is called; the child tries to escape from noisy environments; the child are distracted and/or has difficulty eating in noisy environments; the child takes a long time to respond, even to familiar voices; it is necessary to touch the child to gain her attention.

In Figure 1 is shown the domain values related to the variable Auditory Processing.

b) **Variable 2**: general processing.
Domain values: the child avoid playing with others; the child withdraws from situations; the child´s behavior deteriorates when the schedule changes.
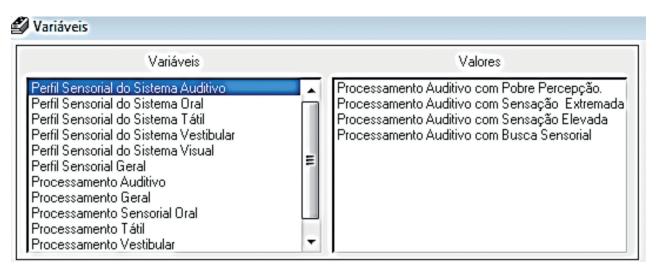

Figure 1 - Definition of variable auditory processing's domain values

c) **Variable 3**: oral sensory processing.
Domain values: the child is unaware of food or liquid left on lips; the child resists having teeth brushed; the child refuses to try new foods; the child mouths objects; the child licks/chews on nonfood objects; the child refuses all but a few food choices; the child refuses to drink from a cup.

d) **Variable 4:** tactile processing.
Domain values: the child uses hands to explore food and other textures; the child bumps into things, seeming to not notice objects in the way; the child enjoys playing with food; the child avoids contact with rough or cold surfaces (for example, squirms, arches, cries); the child becomes very upset if own clothes, hands, and/or face are messy; the child resists being held; the child avoids getting face/nose wiped; the child resists being cuddled; the child enjoys splashing during bath time; the child seeks opportunities to feel vibrations (for example, stereo speakers , washer, dryer); the child becomes anxious when walking or crawling on certain surfaces (for example, grass, sand,

carpet, tile); the child gets upset with extreme differences in room temperature (for example, hotter, colder); the child is upset by changes in the bath water temperature, from one bath to the next; the child is distressed when having nails trimmed; the child becomes agitated when having hair washed.

e) **Variable 5**: vestibular processing.
Domain values: the child cries fusses whenever someone try to move him/her; the child becomes upset when placed on back to change diapers; the child enjoys physical activity (for example, bouncing, being held up high in the air); the child resists having head tipped back during bathing; the child enjoys rhythmical (for example, swinging, rocking, car rides); the child requires more support for sitting than other children the same age (for example, infant seat, pillows, towel roll).

f) **Variable 6**: visual processing.
Domain values: the child enjoys looking at own reflection in the mirror; the child refuses to look at books with someone; the child enjoys looking at moving or spinning objects (for

example, ceiling fans, toys with wheels, floor fans); the child prefers fast-paced, brightly colored TV shows; the child does not recognize self in the mirror; the child avoids eye contact with someone; the child enjoys looking at shiny objects.

g) **Goal-variable 1**: sensory modulation of auditory processing.
Domain values: Low Registration of Auditory processing, Avoid Auditory Sensation, Auditory Processing with Sensory Sensitivity, Auditory Processing with com Sensation Seeking.

h) **Goal-variable 2**: sensory modulation of general processing.
Domain values: Avoid General Sensation, General Processing with Sensory Sensitivity.

i) **Goal-variable 3**: modulation of oral sensory processing.
Domain values: Oral Sensory Processing with Sensation Seeking, Low Registration of Oral Sensory Processing, Oral Sensory Processing with Sensory Sensitivity, Avoid Oral Sensation.

j) **Goal-variable 4**: Sensory Modulation of Tactile Processing.
Domain values: Tactile Processing with Sensation Seeking, Low Registration of Tactile Processing, Avoid Tactile Sensation, Tactile Processing with Sensory Sensitivity, Avoid Tactile Sensation.

k) **Goal-variable 5**: Sensory Modulation of Vestibular Processing.
Domain values: Vestibular Processing with Sensation Seeking, Low Registration of Vestibular Processing, Avoid Vestibular Sensation, Vestibular Processing with Sensory Sensitivity, Avoid Vestibular Sensation.

l) **Goal-variable 6**: Sensory Profile of Visual System.
Domain values: Visual Processing with Sensation Seeking, Low Registration of Visual Processing, Visual Processing with Sensory Sensitivity, Avoid Visual Sensation.

During ES utilization, screens indicating a sensory processing and behaviors related to it are presented, then, the system user must indicate behaviors corresponding to those observed in child. After finishing filling with information, the system shows sensory modulation, or sensory profile. The ES was develop with 20 rules.

1) **Rule 1**: IF Auditory Processing = Is necessary to speak loudly to get the child´s attention; OR Auditory Processing = Is necessary to touch the child to gain attention; OR Auditory Processing = The child takes a long time to respond, even to familiar voices; OR Auditory Processing = The child ignores when someone are talking with her/his; OR Auditory Processing = It takes a long time for the child to respond to his/her name when called; THEN Sensory Profile of Auditory Processing = Low Registration of Auditory Processing. CNF (confidence factor) 100%. The composition of this rule is present in Figure 2.

2) **Rule 2**: IF Visual Processing = The child avoids eye contact with someone; OR Visual Processing = The child does not recognize self in the mirror; THEN Sensory Profile of Visual System = Low Registration of Visual Processing, CNF 100%.

3) **Rule 3**: IF Tactile Processing = The child bumps into things, seeming to not notice objects in the way; THEN Sensory Profile of Tactile System = Low Registration of Tactile Processing CNF 100%.

4) **Rule 4**: IF Vestibular Processing = The child requires more support for sitting than other children at same age; THEN Sensory Profile of Vestibular System = Low Registration of Vestibular Processing CNF 100%.

5) **Rule 5**: IF Oral Sensory Processing = The child are unaware of food or liquid left on lips; OR Oral Sensory Processing = The child refuses to drink from a cup; THEN Profile of Oral Sensory System = Low Registration of Oral Sensory Processing CNF 100%.

6) **Rule 6**: IF Auditory Processing = The child enjoys making sounds with his/her mouth; OR Auditory Processing = The child finds way to make noise with toys; THEN Sensory Profile of Auditory Processing = Auditory Processing with com Sensation Seeking CNF 100%.

7) **Rule 7**: IF Visual Processing = The child enjoys looking at moving or spinning objects; OR Visual Processing = The child enjoys looking at shiny objects; OR Visual Processing = The child enjoys looking at own reflection in the mirror; OR Visual Processing = The child prefers fast-paced, brightly colored TV shows; THEN Sensory Profile of Visual System = Visual Processing with Sensation Seeking CNF 100%.
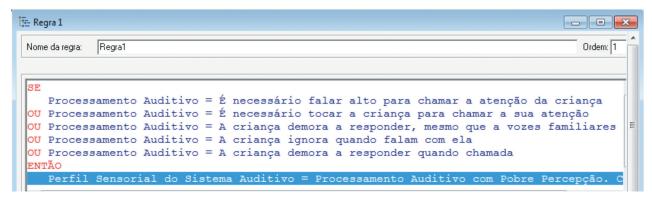
Figure 2 - Rule 1

8) **Rule 8**: IF Tactile Processing = The child enjoys playing with food; OR IF Tactile Processing = The child seeks opportunities to feel vibrations; OR IF Tactile Processing = The child enjoys splashing during bath time; OR IF Tactile Processing = The child uses hands to explore food and other textures; THEN Sensory Profile of Tactile System = Tactile Processing with Sensation Seeking CNF 100%.

9) **Rule 9**: IF Vestibular Processing = The child enjoys physical activity; OR Vestibular Processing = The child enjoys rhythmical activities; THEN Sensory Profile of Vestibular System = Vestibular Processing with Sensation Seeking CNF 100%.

10) **Rule 10**: IF Oral Sensory Processing = The child licks/chews on nonfood objects; OR Oral Sensory Processing = The child mouths objects; THEN Profile of Oral Sensory Processing = Oral Sensory Processing with Sensation Seeking CNF 100%.

11) **Rule 11**: IF General Processing = The child´s behavior deteriorates when the schedule changes; THEN General Sensory Profile = General Sensory Sensitivity CNF 100%.

12) **Rule 12**: IF Auditory Processing = The child startles easily at sound, compared to other children the same age; OR Auditory Processing = The child is distracted and/or has difficulty eating in noisy environments; THEN Sensory Profile of Auditory Processing = Auditory Processing with Sensory Sensitivity CNF 100%.

13) **Rule 13**: IF Tactile Processing = The child becomes agitated when having hair washed; OR Tactile Processing = The child is distressed when having nails trimmed; OR Tactile Processing = The child are upset by changes in the bath water temperature, from one bath to the next; OR Tactile Processing = The child becomes very upset if own clothing, hands, and/or face are messy; OR Tactile Processing = The child gets upset with extreme differences in room temperature; OR Tactile Processing = The child becomes anxious when walking or crawling on certain surfaces; THEN Sensory Profile of Vestibular System = Vestibular Processing with Sensory Sensitivity CNF 100%.

14) **Rule 14**: IF Vestibular Processing = The child becomes upset when placed on back to change diapers; OR Vestibular Processing = The child cries or fusses whenever someone try to move him/her; THEN Perfil Sensorial do Sistema Vestibular = Processamento Vestibular com Sensitividade Sensorial CNF 100%.

15) **Rule 15**: IF General Processing = The child avoids playing with others; OR General Processing = The child withdraws from situations; THEN General Sensory Profile = Avoids General Sensation CNF 100%.

16) **Rule 16**: IF Auditory Processing = The child tries to escape from noisy environments; THEN Sensory Profile of Auditory Processing = Avoid Auditory Sensation CNF 100%.

17) **Rule 17**: IF Visual Processing = The child refuses to look at books with you; THEN Sensory Profile of Visual System = Avoid Visual Sensation CNF 100%.

18) **Rule 18**: IF Tactile Processing = The child resists being held; OR Tactile Processing = The child avoids getting face/nose wiped; OR Tactile Processing = The child resists being cuddled; OR Tactile Processing = The child

avoids contact with rough or cold surfaces; THEN Sensory Profile of Tactile System = Avoids Tactile Sensation CNF 100%.

19) **Rule 19**: IF Vestibular Processing = The child resists having head tripped back during bathing; THEN Sensory Profile of Vestibular System = Avoids Vestibular Sensation CNF 100%.

20) **Rule 20**: IF Oral Sensory Processing = The child refuses all but a few food choices; OR Oral Sensory Processing = The child resists having teeth brushed; OR Oral Sensory Processing = The child refuses to try new foods; THEN Profile of Oral Sensory Processing = Avoid Oral Sensation CNF 100%.

After identification of behaviors related to a specific sensory system (Figure 3), the sensory profile identified is presented (Figure 4):

In order to elucidate, the following hypothetical case will be explained: J. is a child of 2 years and four months of age with stereotypies such as producing sounds with the mouth. She does not make eye contact and does not accept being touched. She does not socially interact, and she is slow to respond when she is called, she throws toys to the ground; she is agitated and gets even more agitated when the routine is modified, and she does not interact with other children and is very selective regarding her diet. She does not allow caregivers to brush her teeth. She does not recognize herself in the mirror. With this information, it is possible to ascertain, through the *Infant/Toddler Sensory Profile* (14) applied to the ES, that this is a child with low registration of auditory processing, general processing with sensory sensitivity, visual processing with low registration, and that avoids tactile sensation and prevents oral sensation. The decision structure to exemplify this case is shown in Figure 5, in which we adopted the color criterion for easy viewing and understanding. Each color route is a decision structure.
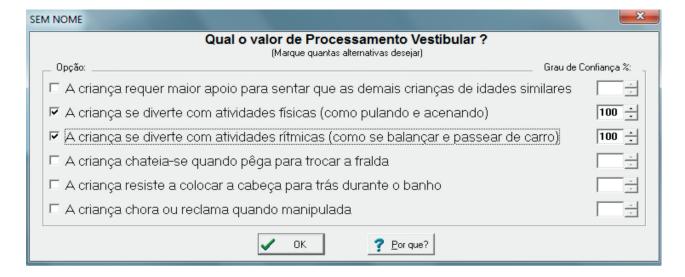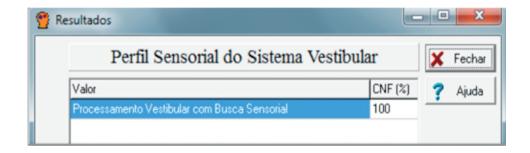

Figure 3 - Analysis of vestibular processing

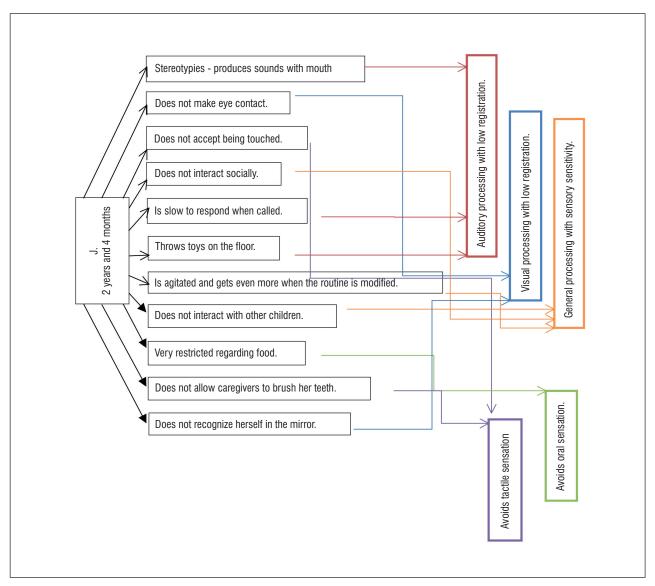Figure 4 - Sensory profile resulted from the processing analyzed

Figure 5 - Decision structure of the explanatory hypothetical case

Discussion

In the area of health, the use of paper records for the record of patient data still prevails, which hinders the access to information. One way to solve this is based on the adoption of an ES, in which, through the interface with the user, the query of information that may be deemed necessary is performed, such as the case of the early identification of the sensory profile of the child starting the treatment of Occupational Therapy.

The use of ES presents, in a didactic way, the clinical reasoning required to identify the sensory profile of the patient, as for example, when the system displays the description of behaviors such as "the child resists brushing teeth", "the child refuses to try novel foods","the child is selective in its diet " in order to identify a child who avoids oral sensation. These behaviors alone are already remarkable for hindering the lives of children and their families, and when they are combined, the need for actions to help regulating sensory modulation and promoting quality of life is an emergency and it should be prioritized by the Occupational Therapist when developing the therapeutic plan.

The presentation of the proposed ES promotes the understanding and learning by the user, which can be a family member, an academic on Occupational Therapy or a healthcare professional, showing that this approach can be adopted in other situations of Occupational Therapy.

Furthermore, the use of ES would contribute to the dissemination of SPD, which affects one (1) in each 20 children (28) and is not present in the DSM, so that its knowledge is limited in the medical field, which results in inappropriate diagnosis and treatment (13). Focusing on the sensory profile, the use of this instrument could contribute to a better understanding of what is happening with the child, allowing families and professionals to understand that behaviors often interpreted as stubbornness or lack of education, have neural explanations, and therefore are unviable to be controlled by the child, requiring an appropriate sensory diet, which considers sensory experiences necessary for the patients in order to meet their physical and emotional needs with the aim of adapting their behavior (29).

The idea is that occupational therapists uses the proposed ES during the treatment of the child, and from the selection of the identified behaviors, the system presents the sensory profile of the child.

It is necessary to emphasize that this study is not objective to the translation and adaptation of the *Infant/Toddler Sensory Profile*. The ES could use the terms in English. The terms of this instrument were used in Portuguese and when there is an official adaptation, it is easy to change the terms in the system.

Conclusion

This study presents the construction of an ES based on the *Infant/Toddler Sensory Profile* (14) using the Expert Sinta (26) tool, enabling the support to the Occupational Therapist in developing an assertive treatment plan. This prototype still does not access the required data from an EPR; on the contrary, it requires them via interaction with the user during its execution, because the provision of electronic records it is not yet common in consultation rooms.

To support the development of the therapeutic plan, the ES based on the *Infant/Toddler Sensory Profile* (14) required that 12 variables were defined for the construction of 20 rules.

It was observed that the use of an ES as aid tool is of significant value, since it enables the identification of data that favor the decision-making regarding the development of the therapeutic plan of the patient and, in association with the EPR it allows us to relate data, optimizing the information in order to benefit the patient's health.

For future studies, we suggest the validation of this ES prototype developed by experts in the field, observing a few steps: 1) identifying occupational therapists who work with the methodology of Sensory Integration; 2) implementing an assessment tool that addresses the time of training, experience with the use of IT and the application of the *Infant/Toddler Sensory Profile* (14); 3) providing this ES for evaluation; 4) collecting opinions on the potential use (29).

References

1. Conselho Federal de Fisioterapia e Terapia Ocupacional. Definição de Terapia Ocupacional. Brasília: Coffito (cited 2013 Jan 31). Available from: http://www.coffito.org.br/conteudo/con_view.asp?secao=46

2. Sensory Processing Disorder. Greenwood Village: Sensory Processing Disorder Foundation; 2012 (cited 2012 May 19). Available from: http://www.sinetwork.org/about-sensory-processing-disorder.html

3. Miller LJ, Anzalone ME, Lane SJ, Cermak SA, Osten ET. Concept evolution in sensory integration: a proposed nosology for diagnosis. Am J Occup Ther. 2007; 61(2):135-40.

4. Ben-Sasson A, Carter AS, Briggs-Gowan MJ. Sensory over-responsivity in elementary school: prevalence and social-emotional correlates. J Abnorm Child Psychol. 2009;37(5):705-16.

5. Coleman M. The autistic spectrums. Amsterdam: North Holland; 1976.

6. Coleman M, Gillberg C. The biology of the autistic spectrums. New York: Praeger; 1985.

7. Ornitz EM. Autism at the interface between sensory and information processing. In: Dawson G (Ed.). Autism: Nature, diagnosis and treatment. New York: Guilford; 1989.

8. Gillberg C, Coleman M. The biology of autistic syndromes. London: Cambridge Press; 2000.

9. Tomchek SD, Dunn W. Sensory processing in children with and without autism: a comparative study using the short sensory profile. Am J Occup Ther. 2007;61(2):190-200.

10. Ashburner J, Rodger S, Ziviani J. Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. Am J Occup Ther. 2008;62(5):564-73.

11. Humphry R. Young children's occupations: explicating the dynamics of developmental processes. Am J Occup Ther. 2002;56(2):171-9.

12. Brown C, Tollefson N, Dunn W, Cromwell R, Filion D. The adult sensory profile: measuring patterns of sensory processing. Am J Occup Ther. 2001;55(1):75-82.

13. Dobbins, M, Sunder T, Soltys S. Nonverbal learning disabilities and sensory processing disorders. Psychiatr Times. 2007 (cited 2014 June 23);24(9):(about 3 pp.). Available from: http://www.psychiatrictimes.com/articles/nonverbal-learning-disabilities-and-sensory-processing-disorders

14. Dunn W, Daniels, DB. Infant/todler sensory profile: caregiver questionnaire 7 to 36 months. San Antonio: The Psychological Corporation; 2002.

15. Ayres AJ. Sensory integration and praxis tests. Los Angeles: Western Psychological Services; 1989.

16. Dunn W. Sensory profile: user´s manual. San Antonio: The Psychological Corporation; 1999.

17. Berk R, De Gangi GA. De Gangi-Berk test of sensory integration. 5. ed. Los Angeles: Western Psychological Services; 2000.

18. Blanche EI. Observations based on sensory integration theory. Torrance: Pediatric Therapy Network; 2002.

19. De Gangi GA, Greenspan SI. Test of sensory functions in infants. 3. ed. Los Angeles: Western Psychological Services; 2001.

20. Carvalho DR, Moser AD, Da Silva VA, Dallagassa MR. Mineração de dados aplicada à fisioterapia. Fisioter Mov. 2012;25(3):595-605.

21. Conselho federal de Medicina; Sociedade Brasileira de Informática em Saúde. Cartilha sobre prontuário eletrônico: a certificação de sistemas de registro eletrônico de saúde. 2012 (cited 2012 Nov 28). Available from: http://www.sbis.org.br/certificacao/Cartilha_SBIS_CFM_Prontuario_Eletronico_fev_2012.pdf

22. Nilsson NS. Principles of artificial intelligence. New York: Springer Verlag; 1982.

23. Mendes RD. Inteligência artificial: sistemas especialistas no gerenciamento da informação. Ci Inf. 1997;26(1):1-7.

24. Cardoso JP, de Queiroz RS, Lopes CRS, Rosa VA. O uso de sistemas especialistas para apoio à sistematização em exames ortopédicos do quadril, joelho e tornozelo. Rev Saúde Com. 2005;1(1):24-34.

25. Oberto LDM, De Azevedo FM. Sistema inteligente de auxilio ao tratamento fisioterapêutico aplicando o princípio da neuroplasticidade em portadores cerebral. In: 4. Workshop de Informática Aplicada à Saúde – CBComp; 2004 (cited 2013 Jan 14). Available from: http://www.niee.ufrgs.br/eventos/CBCOMP/2004/pdf/Workshop_Saude/Teses_Dissertacoes/t170100223_3.pdf

26. Universidade Federal do Ceará. Expert Sinta versão 1.1: manual do usuário. Laboratório de Pesquisa em Ciência da Computação/Universidade Federal do Ceará (cited 2012 Nov 10). Available from: http://www.lia.ufc.br

27. Keller R. Tecnologias do sistema especialista. São Paulo: Mcgraw-Hill; 1991.

28. Ahn RR, Miller LJ, Milberger S, McIntosh DN. Prevalence of parents' perceptions of sensory processing disorders among kindergarten children. Am J Occup Ther. 2004;58(3):287-93.

29. Ronchi DCM, Spigolon DN, Garcia D, Cicogna PESL, Bulegon H, Moro CMC. Desafios no desenvolvimento de prontuários eletrônicos baseados em arquétipos: avaliação fisioterapêutica funcional. Fisioter Mov. 2012;25(3):497-506.