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Research Article

Research on Toy Design for Special Children Based on Sensory Integration Training, D-S Theory, and Extenics: Taking Physical Toys for ADHD Children as an Example

Shilin Wu

School of Fine Arts & Design, Guangzhou University, Guangzhou, Guangdong 511400, China

Correspondence should be addressed to Shilin Wu; wslw@gzhu.edu.cn

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Based on sensory integration training, D-S theory and extenics, this paper discusses the innovation and development of ADHD children's toys, so as to make the design scheme more real, scientific, and comprehensive and meet the internal needs of users. Considering the advantages of extenics and the D-S theory in dealing with uncertain and incompatible decision-making problems, an evaluation method of toy design scheme for special children based on extension analysis and the D-S theory is proposed. Through the combination of the D-S theory and extenics evaluation method and sensory integration training theory, the designed toy scheme has a certain auxiliary therapeutic effect on the rehabilitation of ADHD children. Through the design case of physical fitness for ADHD children, it is proved that the combination of the D-S theory and extenics based on the sensory integration training theory has a certain reference value for the generation of product scheme and makes the product design process more comprehensive and objective.

1. Introduction

With the progress of bioengineering, medical technology, electronic equipment, and other industries, more and more diseases have been found and paid attention to. Attention deficit hyperactivity disorder (ADHD) is one of the most common mental diseases in children [1–4]. According to domestic media reports, the incidence rate of ADHD in childhood is 2.59%~7.25%. Children with ADHD have lower basic abilities than normal children, such as learning ability, executive ability, activity ability, and social communication ability. Childhood is the main period of people's learning. If they are not treated in time, it will affect their adulthood and even their whole life [5, 6].

Physical toy design itself has the characteristics of diversity, complexity, and experience, which makes the evaluation of physical toy design scheme have obvious uncertainty and incompatibility. Specifically, the evaluation of physical toy design scheme is essentially a multicriteria decision-making (MCDM) problem [7–11], which needs to comprehensively consider many factors. The importance of each evaluation criterion has certain uncertainty, and the process of determining the importance of each evaluation criterion by expert evaluation method has obvious subjectivity and fuzziness, Therefore, the evaluation process of physical toy design scheme is actually an uncertain reasoning process with the characteristics of imprecision, fuzziness, and subjectivity. At the same time, there is a certain degree of incompatibility between multiple criteria for the evaluation of physical toy design scheme. For example, the selection of high-quality materials may not only significantly improve the quality of toys but also lead to the increase of cost and the reduction of economy. When the functional design is more complex, it meets the functional requirements, but may lead to the decline of security.

Extenics [12] is a new subject spanning philosophy, mathematics, and engineering. As the key application method of extenics, the extension analysis method takes the matter-element theory and the extension set theory as the theoretical framework [13–15]. Its basic idea is to establish the classical domain, node domain, and evaluation level of things, calculate the correlation function of the matter-element to be evaluated about the evaluation level according to the actual data, and quantitatively and objectively describe the degree to which the matter-element to be evaluated belongs to a certain evaluation level through the correlation function, The levels of different matter elements to be evaluated can be divided according to the large cell of the correlation function. It can be seen that extension analysis can deal with the incompatibility in evaluation and provides a new way for thing classification and pattern recognition. The Dempster Shafer theory (D-S theory) [16–18] can directly express uncertainty and provides an effective method for the expression and synthesis of uncertain information, but its evidence is mainly obtained through expert knowledge and experience, which is highly subjective. Extension analysis can effectively transform the contradictory problems existing in things into compatible ones, so as to reduce the conflict between various evidences and optimize the results of evidence fusion to the greatest extent.

At present, the treatment of ADHD children mainly focuses on behavioral intervention, rehabilitation training, and drugs, but the repeatability of behavioral intervention and the side effects of drugs lead to poor treatment effect, which promotes the gradual development of physical training methods of sensory integration [19]. Because of its advantages of safety, simplicity, and low cost, the sensory integration training is accepted and welcomed by many parents. In this paper, according to the characteristics of the sensory integration training theory, the correlation function matrix of the matter element to be evaluated is obtained by using the idea of extension analysis; after normalization, the discrimination framework of the D-S theory is established, and the basic probability assignment (BPA) function on the discrimination framework of the D-S theory is obtained. The critical method considering the contrast intensity and conflict is used to calculate the importance of each feature. Considering the importance of features, the evidence is fused. Finally, according to the nature of BPA function, the grading results of multiple physical toy design schemes for ADHD children and the ranking relationship of the same level schemes are obtained, so as to provide reference for the physical toy design of ADHD children.

2. Basic Concepts

2.1. Sensory Integration Training. Sensory integration (SI) is a process of unifying neuropsychology after connecting and selecting sensory information from various senses such as human vision, hearing, touch, proprioception, and vestibular perception. It is the basis of human life, learning, and work. Sensory integration training (SIT) refers to planned training activities to reduce sensory integration disorders and their negative impact on individual learning and life and to improve individual sensory integration ability [19–21]. SIT is divided into three areas: the tactile training, the vestibular function training, the and proprioception function training. The tactile training includes thermal training, pressure training, and perception training; the vestibular training includes balance ability, spatial perception abilityv and concentration ability; and the proprioception training includes joint static perception, joint dynamic perception, and muscle response [22].

2.2. Physical Toy Design for ADHD Children. Toys are closely related to children's healthy growth. They are a good spiritual partner in children's life and will accompany children through the purest time of their life. For ADHD children, toys are not only their friendly playmates but also can be treated during the game. ADHD children mainly have several characteristics: large emotional changes; inattention; large amount of activities; inflexible large action, or precision action [23]. According to these characteristics, children can complete sensory integration training with the help of corresponding toys. At present, the main types of common integration training toys include tactile ball, tactile plate, balance cap, and other toys. Such toys are proprietary equipment for sensory integration, but they will inevitably feel boring after long-term use, especially for ADHD children with attention deficit symptoms. This single toy is difficult to attract the attention of ADHD children for a long time. It is necessary to design suitable children's physical toys according to the inherent characteristics of ADHD children, so that they can exercise in play and recover in training [23].

3. Toy Evaluation Model for ADHD Children Based on Analytic Hierarchy Process

3.1. Construction of Evaluation Hierarchy of Toy Design Indexes for ADHD Children. Through the research on the design of toys for children with ADHD, we can understand the way and purpose of sensory integration training for children with ADHD. After consulting experts and experienced toy designers and reviewing relevant literature, starting from the tactile training, preauditory training, and proprioception training of sensory integration training for ADHD children, the criterion layer of ADHD children's toys is constructed into three aspects: the vestibular training B1, the proprioception training B2, and the tactile training B3.

For B1, B2, and B3, nine subcriteria indicators are subdivided, including balance ability training C11, spatial perception training C12, focus ability training C13, joint static perception ability C14, joint dynamic perception ability training C15, muscle response ability C16, heat perception training C17, pressure perception training C18, and perceived weight training C19.

After the criteria indicators and subcriteria indicators are established, three criteria indicators are compared each time, and then nine subcriteria indicators are compared with each other. Finally, the analytic hierarchy process model of toy evaluation indicators for ADHD children is obtained, as shown in Figure 1.

3.2. Extension Analysis of Physical Toy Design Schemes for ADHD Children. According to the extension analysis theory [12–15], the matter elements of physical toy design scheme are defined as ordered triples $R = (N, I, v)$ as follows:

$$R = \begin{bmatrix} N & I_1 & v_1 \\ & I_2 & v_2 \\ & \vdots & \vdots \\ & I_n & v_n \end{bmatrix}, \tag{1}$$

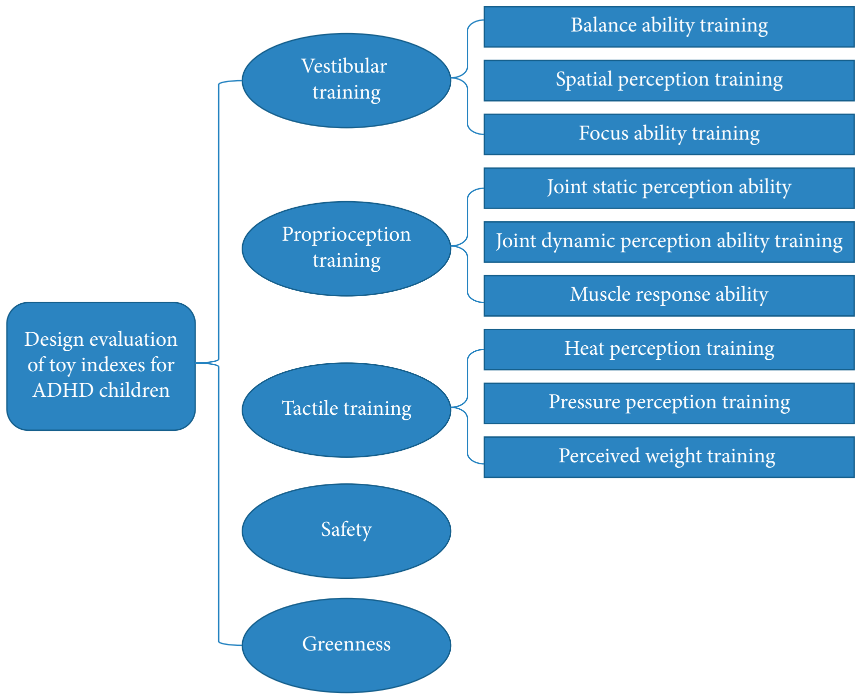


Figure 1: Analytic hierarchy process model of toy evaluation indicators for ADHD children.

where N stands for physical toy design scheme, $I = \{I_1, I_2, \ldots, I_n\}$ is the characteristic of physical toy design scheme, and $v = \{v_1, v_2, \ldots, v_n\}$ is the corresponding characteristic value.

The characteristics $I_1, I_2, \ldots, I_n$ of physical toy design scheme are divided into l evaluation levels, so that

$$R_j = \begin{bmatrix} N_j & I_1 & v_{j,1} \\ & I_2 & v_{j,2} \\ & \vdots & \vdots \\ & I_n & v_{j,n} \end{bmatrix} = \begin{bmatrix} N_j & I_1 & [a_{j,1}, b_{j,1}] \\ & I_2 & [a_{j,2}, b_{j,2}] \\ & \vdots & \vdots \\ & I_n & [a_{j,n}, b_{j,n}] \end{bmatrix}, \quad (2)$$

where R_j is the classical domain matter element of N, N_j represents the j-th $(j = 1, 2, \ldots, l)$ evaluation level of N, and $v_{j,i} = [a_{j,i}, b_{j,i}]$ is the value interval of N_j corresponding to the characteristic I_i $(i = 1, 2, \ldots, n)$, that is, the classical domain.

It is assumed that

$$R_p = \begin{bmatrix} N_p & I_1 & v_{p,1} \\ & I_2 & v_{p,2} \\ & \vdots & \vdots \\ & I_n & v_{p,n} \end{bmatrix} = \begin{bmatrix} N_p & I_1 & [a_{p,1}, b_{p,1}] \\ & I_2 & [a_{p,2}, b_{p,2}] \\ & \vdots & \vdots \\ & I_n & [a_{p,n}, b_{p,n}] \end{bmatrix}, \quad (3)$$

where R_{p} is the joint domain matter element of N, N_{p} represents all evaluation level of N, and $v_{p,i} = [a_{p,i}, b_{p,i}]$ is the value interval of N_{p} corresponding to the characteristic I_i $(i = 1, 2, \ldots, n)$, that is, the joint domain.

It is assumed that

$$R_0 = (N_0, I, x) = \begin{bmatrix} N_0 & I_1 & x_1 \\ & I_2 & x_2 \\ & \vdots & \vdots \\ & I_n & x_n \end{bmatrix}, \quad (4)$$

where R_0 is the matter element to be evaluated, N_0 is the unknown evaluation level of the matter element to be evaluated, and the value of R_0 corresponding to the characteristic I_i $(i = 1, 2, \ldots, n)$ is x_i, $x = \{x_1, x_2, \ldots, x_n\}$ is the value vector.

After determining the classical domain matter element, joint domain matter element, and the matter element to be evaluated of physical toy design scheme, the relationship between classical domain matter element, joint domain matter element, and matter element to be evaluated can be quantified by using the correlation function in extenics.

Specifically, correlation function $k_j(x_i)$ describes the quantitative relationship between the value x_i in matter element to be evaluated R_0 and two intervals (classical domain $v_{j,i} = [a_{j,i}, b_{j,i}]$, and joint domain $v_{p,i} = [a_{p,i}, b_{p,i}]$) represents the degree to which R_0 belongs to the evaluation level N_j $(j = 1, 2, \ldots, l)$ on feature I_i, and its calculation formula is

$$k_j(x_i) = \begin{cases} \dfrac{-D(x_i, v_{j,i})}{b_{j,i} - a_{j,i}}, & x_i \in v_{j,i}, \\ \\ \dfrac{D(x_i, v_{j,i})}{D(x_i, v_{p,i}) - D(x_i, v_{j,i})}, & x_i \notin v_{j,i}, \end{cases} \quad (5)$$

where $D(x_i, v_{p,i}) = |x_i - (a_{p,i} + b_{p,i})/2| - (b_{p,i} - a_{p,i})/2$ and $D(x_i, v_{j,i}) = |x_i - (a_{j,i} + b_{j,i})/2| - (b_{j,i} - a_{j,i})/2$ represent the distance between x_i and $v_{j,i} = [a_{j,i}, b_{j,i}]$ and the distance between x_i and $v_{p,i} = [a_{p,i}, b_{p,i}]$, respectively.

Thus, the correlation function matrix of R_0 is obtained as $K_0 = (K_{ji})_{l\times n}$, here $K_{ji} = k_j(x_i)$.

3.3. Evaluation of Physical Toy Design Schemes for ADHD Children Based on the D-S Theory

3.3.1. Solution of BPA Function Based on Correlation Function. The concept of correlation function in the extension analysis theory extends the logical value from {0, 1} to (−∞, +∞). According to the size of the correlation function, the membership relationship between elements and sets can be judged, so that the qualitative description of either or between elements and sets can be extended to quantitative description, which can more comprehensively and accurately characterize the relationship between elements in the set. When the correlation function is greater than 0, it indicates that the element has a certain property, and the larger the value is, the closer it is to the property; when the correlation function is less than 0, it means that the element does not have this property, and the smaller the value, the farther away from this property; when the correlation function is equal to 0, it indicates that the element may or may not have this property, which is a critical element. Therefore, the correlation function can be extended to the BPA function in the D-S theory, that is, the larger the correlation function is, the larger the value of BPA converted is, on the contrary, the smaller the value of BPA converted. In addition, the range of BPA assignment in the D-S theory is [0, 1], so normalization is required.

It can be seen that the matter-element concept of extension analysis theory quantitatively and objectively describes the degree of elements belonging to a certain property through the correlation function and can distinguish different levels of elements in the same domain according to the large cell of the correlation function, which provides a new method for the classification and pattern recognition of things. Using the classification idea of extension analysis, this paper establishes the D-S theoretical discrimination framework of physical toy design scheme evaluation and obtains the BPA function on the discrimination framework through normalization. The details are as follows:

First, a D-S theoretical discrimination framework [16–18] for physical toy design scheme evaluation is established as $\Theta = \{\theta_1, \theta_2, \ldots, \theta_l\}$, where $\theta_1, \theta_2, \ldots, \theta_l$ indicate the evaluation levels of physical toy design scheme in turn. The BPA function on discrimination framework Θ is represented by $m_i(\theta_j)$, where $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, l$.

Second, correlation function matrix $K_0 = (K_{ji})_{l\times n}$ of matter element to be evaluated R_0 is transformed into BPA function matrix $m = (m_{ji})_{l\times n}$ on the discrimination framework, that is,

$$m_{ji} = m_i(\theta_j) = \frac{e^{k_j(x_i)}}{\sum_{j=1}^{l} e^{k_j(x_i)}}. \quad (6)$$

As can be seen from equation (6), the value of $e^{k_j(x_i)}$ increases with the increase of $k_j(x_i)$, $0 \le m_i(\theta_j) \le 1$, $\sum_{j=1}^{l} m_i(\theta_j) = 1$. When $k_j(x_i) \longrightarrow +\infty$, $m_i(\theta_j) = 1$; when $k_j(x_i) \longrightarrow -\infty$, $m_i(\theta_j) = 0$. It can be seen that equation (6) can realize the transformation between the correlation function of extension analysis and the BPA function of the D-S theory, so as to solve the BPA function on discrimination framework Θ.

3.3.2. Calculation of Feature Importance Based on CRITIC Method. In multifeature evaluation and decision-making problems, the common calculation methods of feature importance include entropy weight method, standard deviation method, CRITIC method, and so on. Compared with the entropy weight method and the standard deviation method, the CRITIC method comprehensively considers the contrast strength and conflict between features and can more completely reflect the competitive relationship between features [24–26]. Here, the CRITIC method is selected to calculate the importance of features.

For n features of the physical toy design scheme, each feature has l different evaluation states (i.e. l evaluation levels). The contrast intensity in CRITIC method is expressed in the form of standard deviation, so the standard deviation of feature i $(i = 1, 2, \ldots, l)$ is as follows:

$$\sigma_i = \sqrt{\frac{1}{l-1}\sum_{j=1}^{l}\left(m_{ji} - \frac{1}{l}\sum_{j=1}^{l} m_{ji}\right)^2}. \quad (7)$$

The conflict is based on the correlation between the two features. If there is a strong positive correlation, the conflict between the two features is low. For two features i and h (i, $h = 1, 2, \ldots, n$ and $i \ne h$), their correlation coefficient is

$$\psi_{ih} = \frac{\sum_{j=1}^{l}\left(m_{ji} - 1/l\sum_{j=1}^{l} m_{ji}\right)\left(m_{jh} - 1/l\sum_{j=1}^{l} m_{jh}\right)}{\sqrt{\sum_{j=1}^{l}\left(m_{ji} - 1/l\sum_{j=1}^{l} m_{ji}\right)^2}\sqrt{\sum_{j=1}^{l}\left(m_{jh} - 1/l\sum_{j=1}^{l} m_{jh}\right)^2}}. \quad (8)$$

Therefore, the conflict between feature i and other features can be expressed as

$$\xi_i = \sum_{h=1, h\ne i}^{n} (1 - \psi_{ih}). \quad (9)$$

At last, the importance of feature i is

$$\omega_i = \frac{\delta_i}{\sum_{i=1}^{n} \delta_i}, \tag{10}$$

where $\delta_i = \sigma_i \cdot \xi_i$ represents the amount of information contained in feature i.

Thus, the importance vector of n features is obtained as $\omega = [\omega_1, \omega_2, \ldots, \omega_n]$.

3.3.3. Evidence Fusion considering Feature Importance. The classical D-S theory holds that each evidence is equally important in evidence fusion, but in practice, each evidence has different importance. In other words, in the evaluation of physical toy design scheme, the importance of each feature is different, so the role of participating in evidence fusion is also different. Therefore, this paper introduces feature importance to make the result of evidence fusion more reasonable.

From the above, there are n features in the physical toy design scheme evaluation, and each feature has l states. The proposition elements in framework $\Theta = \{\theta_1, \theta_2, \ldots, \theta_l\}$ represent different evaluation states of the feature, then the BPA function on Θ is m: $m_1, m_2, \ldots, m_n$.

According to feature importance vector $\omega = [\omega_1, \omega_2, \ldots, \omega_n]$, the relative importance of feature i ($i = 1, 2, \ldots, n$) is

$$\mu_i = \frac{\omega_i}{\max\{\omega_1, \omega_2, \ldots, \omega_n\}}. \tag{11}$$

Then, after considering the feature importance, the BPA function equation (6) on discrimination framework Θ of physical toy design scheme evaluation is improved as: when $\theta_j \neq \Theta$, $\widetilde{m}_i(\theta_j) = \mu_i m_i(\theta_j)$; when $\theta_j = \Theta$, $\widetilde{m}_i(\theta_j) = 1 - \sum_{j=1}^{l} \widetilde{m}_i(\theta_j)$.

According to the idea of the D-S theory, for the discrimination framework $\Theta = \{\theta_1, \theta_2, \ldots, \theta_l\}$ of physical toy design scheme evaluation, all possible set in Θ are represented by power set 2^{Θ} . Obviously, there are l elements in Θ, and each element is incompatible with each other, so the number of elements in the power set 2^{Θ} is 2^l.

Let A be the evaluation conclusion of physical toy design scheme. A can be one of $\theta_1, \theta_2, \ldots, \theta_l$ (indicating that the physical toy design scheme to be evaluated belongs to this level) or several of them (indicating that the physical toy design scheme to be evaluated belongs to these levels). For $\forall A \subseteq \Theta$, the Dempster fusion rule for the finite BPA functions $\widetilde{m_1}, \widetilde{m_2}, \ldots, \widetilde{m_n}$ on the framework Θ is

$$M(A) = \frac{1}{K} \sum_{A_1 \cap A_2 \cap \ldots \cap A_n = A} \widetilde{m_1}(A_1) \cdot \widetilde{m_2}(A_2) \cdot \ldots \cdot \widetilde{m_n}(A_n), \tag{12}$$

where M is the BPA function after fusion and $M = \widetilde{m_1} \oplus \widetilde{m_2} \oplus \ldots \oplus \widetilde{m_n}$, here $\oplus$ 为is the evidence fusion symbol, K is the normalized constant and $K = \sum_{A_1 \cap A_2 \cap \ldots \cap A_n \neq \varnothing} \widetilde{m_1}(A_1) \cdot \widetilde{m_2}(A_2) \cdot \cdots \cdot \widetilde{m_n}(A_n)$.

According to the rules of equation (12), the n features of physical toy design scheme are fused to realize the evaluation of physical toy design scheme.

4. Case Study

4.1. Scheme Design. According to the actual needs of ADHD children's treatment and the analysis of existing products in the market, it is found that the toy equipment in the form of children's balance scooter has three characteristics that can exercise spatial perception ability, concentration ability, and balance ability. Then, taking children's scooter as the research object, this paper designs the physical toy equipment for ADHD children.

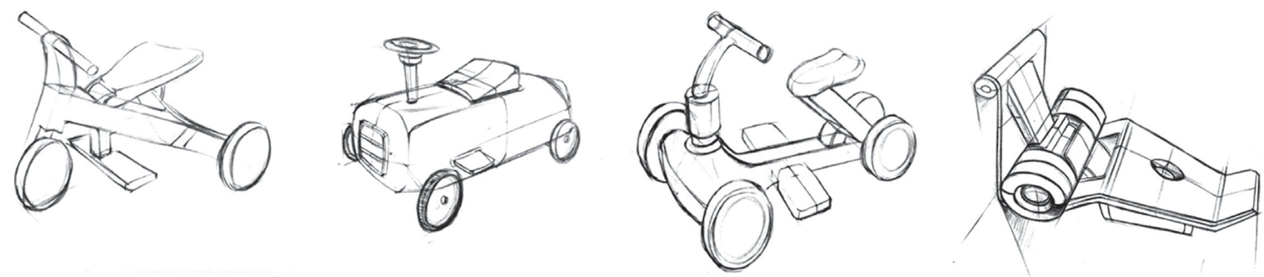
Through the investigation and visit to the families of 10 ADHD children, 10 ADHD children and their parents were exchanged and interviewed to obtain their cognition of the shape of children's balance scooters. The survey results show that for ADHD children and their parents, the most important characteristics of balance scooters are interest, visual impact, and sense of security. Summarizing the design expectations, three preliminary schemes are obtained from the perspectives of comfortable handling, interesting modeling, and lightness and flexibility, as shown in Figure 2.

The toy car is driven forward by children squatting and reciprocating on the balance scooter, which plays the role of exercising children's proprioception and vestibular perception, and can train children's spatial perception ability, concentration ability, perceived weight, joint static perception ability, and balance ability. The finger pressing plate structure is used at the pedal to exercise children's touch. The whole design can enable ADHD children to achieve the comprehensive training effect of sensory integration in the whole process of using the balance scooter.

Scheme 1 has a simple and lovely shape, and the seat part is relatively wide, which can fully protect children's hips and make them more comfortable when riding. The wheel is designed to be fully enclosed without spokes, so as to prevent children's feet from being involved in spokes when playing and reduce potential safety hazards. Scheme 2 is generous in shape and imitates retro cars, which is interesting and easy to attract children's attention. At the same time, wide curve seats are also used to protect children's hips and non spoke wheels to prevent feet from being drawn into spokes. Scheme 3 and scheme 4 have simple and light shape and higher flexibility. The seat is suspended, which greatly improves the shock absorption effect. The chassis is in an equilateral triangle, which has the effect of stabilizing and preventing side fall, and improves the safety of the toy car.

4.2. Fuzzy Comprehensive Evaluation. The vestibular training, the proprioception training, the tactile training, safety, and greenness are selected as the features of physical toy design scheme evaluation, which are represented by $I_1, I_2, \ldots, I_5$ in turn. Through expert evaluation, the feature values of the four physical toy design schemes on $I_1, I_2, \ldots, I_5$ are shown in Table 1.

For evaluation level, $l = 4$, that is: acceptable (N1), fair (N2), good (N3), and excellent (N4). Referring to the feature value of each physical toy design scheme to be evaluated, the classical domain matter elements of four evaluation levels



Scheme 1 Scheme 2 Scheme 3 Scheme 4

Figure 2: Preliminary scheme set.

Table 1: The feature values of the four physical toy design schemes on $I_1, I_2, \ldots, I_5$.

Physical toy design scheme	I_1	I_2	I_3	I_4	I_5
1	0.9333	1.0000	0.8902	0.2500	0.2500
2	0.8615	0.6667	0.8295	0.2500	0.7500
3	1.0000	1.0000	1.0000	0.2500	0.2500
4	0.8000	0.6667	0.9125	1.0000	1.0000

during the evaluation of physical toy design scheme are obtained according to equation (2), which are, respectively:

$$R_1 = \begin{bmatrix} N_1 & I_1 & [0\cdot 7667, 0\cdot 8333] \\ & I_2 & [0\cdot 6111, 0\cdot 7222] \\ & I_3 & [0\cdot 8011, 0\cdot 8579] \\ & I_4 & [0\cdot 1250, 0\cdot 3750] \\ & I_5 & [0\cdot 1250, 0\cdot 3750] \end{bmatrix}, \quad R_2 = \begin{bmatrix} N_2 & I_1 & [0\cdot 8333, 0\cdot 9000] \\ & I_2 & [0\cdot 7222, 0\cdot 8333] \\ & I_3 & [0\cdot 8579, 0\cdot 9147] \\ & I_4 & [0\cdot 3750, 0\cdot 6250] \\ & I_5 & [0\cdot 3750, 0\cdot 6250] \end{bmatrix},$$
$$R_3 = \begin{bmatrix} N_3 & I_1 & [0\cdot 9000, 0\cdot 9667] \\ & I_2 & [0\cdot 8333, 0\cdot 9444] \\ & I_3 & [0\cdot 9147, 0\cdot 9716] \\ & I_4 & [0\cdot 6250, 0\cdot 8750] \\ & I_5 & [0\cdot 6250, 0\cdot 8750] \end{bmatrix}, \quad R_4 = \begin{bmatrix} N_4 & I_1 & [0\cdot 9667, 1\cdot 0333] \\ & I_2 & [0\cdot 9444, 1\cdot 0556] \\ & I_3 & [0\cdot 9716, 1\cdot 0284] \\ & I_4 & [0\cdot 8750, 1\cdot 1250] \\ & I_5 & [0\cdot 8750, 1\cdot 1250] \end{bmatrix}. \tag{13}$$

According to equation (3), the joint domain matter element during physical toy design scheme evaluation is obtained as follows:

$$R_p = \begin{bmatrix} N_p & I_1 & [0\cdot 7667, 1\cdot 0333] \\ & I_2 & [0\cdot 6111, 1\cdot 0556] \\ & I_3 & [0\cdot 8011, 1\cdot 0284] \\ & I_4 & [0\cdot 1250, 1\cdot 1250] \\ & I_5 & [0\cdot 1250, 1\cdot 1250] \end{bmatrix}. \tag{14}$$

First physical toy design scheme 1 is evaluated, and then the matter element to be evaluated is

$$R_0 = \begin{bmatrix} N_0 & I_1 & 0\cdot 9333 \\ & I_2 & 1\cdot 0000 \\ & I_3 & 0\cdot 8902 \\ & I_4 & 0\cdot 2500 \\ & I_5 & 0\cdot 2500 \end{bmatrix}. \tag{15}$$

By substituting into equation (5), the correlation function matrix obtained is

$$K_0 = \begin{bmatrix} -0\cdot 5000 & -0\cdot 8332 & -0\cdot 2661 & 0\cdot 5000 & 0\cdot 5000 \\ -0\cdot 2498 & -0\cdot 7499 & 0\cdot 4313 & -0\cdot 5000 & -0\cdot 5000 \\ 0\cdot 4993 & -0\cdot 5000 & -0\cdot 2157 & -0\cdot 7500 & -0\cdot 7500 \\ -0\cdot 2504 & 0\cdot 5000 & -0\cdot 4774 & -0\cdot 8333 & -0\cdot 8333 \end{bmatrix}. \tag{16}$$

The discrimination framework of physical toy design scheme evaluation is established as $\Theta = \{\theta_1, \theta_2, \theta_3, \theta_4\}$, where $\theta_1, \theta_2, \theta_3, \theta_4$ indicate the evaluation levels in turn: acceptable (N1), fair (N2), good (N3), and excellent (N4).

The BPA function matrix on the discrimination framework is obtained from equation (6):

$$m = \begin{bmatrix} 0\cdot 1591 & 0\cdot 1374 & 0\cdot 2054 & 0\cdot 5214 & 0\cdot 5214 \\ 0\cdot 2044 & 0\cdot 1494 & 0\cdot 4125 & 0\cdot 1918 & 0\cdot 1918 \\ 0\cdot 4322 & 0\cdot 1918 & 0\cdot 2160 & 0\cdot 1494 & 0\cdot 1494 \\ 0\cdot 2043 & 0\cdot 5214 & 0\cdot 1662 & 0\cdot 1374 & 0\cdot 1374 \end{bmatrix}. \tag{17}$$

The importance vector of features $I_1, I_2, \ldots, I_5$ is further obtained from equations (7)–(10):

$$\omega = [0\cdot 1745\; 0\cdot 2745\; 0\cdot 1461\; 0\cdot 2024\; 0\cdot 2024]. \tag{18}$$

Therefore, the relative importance vector of features $I_1, I_2, \ldots, I_5$ is

$$\mu = [0 \cdot 6358\ 1 \cdot 0000\ 0 \cdot 5320\ 0 \cdot 7375\ 0 \cdot 7375]. \quad (19)$$

The BPA function is improved according to the relative importance vector. The value of the improved BPA function is shown in Table 2.

The evidence fusion for the five features is conducted according to (12). For physical toy design scheme 1, the BPA function after fusion is $M = \widetilde{m_1} \oplus \widetilde{m_2} \oplus \widetilde{m_3} \oplus \widetilde{m_4} \oplus \widetilde{m_5}$. Therefore, $M(\theta_1) = 0.4773$, $M(\theta_2) = 0.1705$, $M(\theta_3) = 0.1701$, $M(\theta_4) = 0.1821$.

Similarly,for physical toy design scheme 2, $M(\theta_1) = 0.7198$, $M(\theta_2) = 0.1503$, $M(\theta_3) = 0.0983$, $M(\theta_4) = 0.0316$; for physical toy design scheme 3, $M(\theta_1) = 0.3905$, $M(\theta_2) = 0.0629$, $M(\theta_3) = 0.0645$, $M(\theta_4) = 0.4821$; for physical toy design scheme 4, $M(\theta_1) = 0.4238$, $M(\theta_2) = 0.0724$, $M(\theta_3) = 0.0722$, $M(\theta_4) = 0.4315$.

According to the D-S theory, the BPA function value after fusion actually represents the degree of support for a proposition after evidence fusion, as shown in Figure 3.

Taking physical toy design scheme1 as an example, the degree of support for the four propositions of "scheme 1 belongs to N1, N2, N3, and N4" after evidence fusion is 0.4773, 0.1705, 0.1701, and 0.1821, respectively, of which the degree of support for "scheme 1 belongs to N1" is the highest, so it is considered that scheme 1 belongs to N1 level. Similarly, scheme 2 belongs to N1 and schemes 3 and 4 belong to N4.

For schemes 1 and 2 belonging to N1 level, the total support for "scheme 1 belongs to higher level (i.e. N2, N3 and N4)" after evidence fusion is 0.5179, while the total support for "scheme 2 belongs to higher level (i.e. N2, N3 and N4)" after evidence fusion is 0.2802. It can be seen that compared with scheme 2, the degree of support for "scheme 1 belongs to a higher level" after evidence fusion is higher, so scheme 1 is better than scheme 2.

Similarly, for schemes 3 and 4 belonging to N4, it can be seen that after evidence fusion, the total support for "scheme 3 belongs to lower level (i.e. N1, N2 and N3)" is 0.5227, while after evidence fusion, the total support for "scheme 4 belongs to lower level (i.e. N1, N2 and N3)" is 0.5684. It can be seen that compared with scheme 3, the degree of support for "scheme 4 belongs to lower level" after evidence fusion is higher, so scheme 3 is better than scheme 4.

Therefore, for the scheme at the same level, the total support degree for the scheme at a higher level and a lower level after evidence fusion can be calculated, respectively, according to the connotation of BPA function, and the ranking relationship of the scheme at the same level can be obtained through further comparative analysis.

Finally, schemes 1 and 2 belong to N1 level, schemes 3 and 4 belong to N4 level, scheme 1 is better than scheme 2, and scheme 3 is better than scheme 4. The total ranking relationship of the four physical toy design schemes to be evaluated is 3≻4≻1≻2, where ≻ means "better than," and the optimal scheme is 3.

Extension analysis has been applied in many fields to verify that it can deal with the incompatibility in decision-making problems. In this paper, extension analysis is used to deal with the incompatibility between the characteristics of product physical toy design scheme under the background of green manufacturing, which has a strong theoretical basis. The evidence theory is an uncertain reasoning method with strong theoretical basis. It can reason without a priori probability and conditional probability and continuously reduce the hypothesis set by relying on evidence accumulation. It has also been widely used. Therefore, this paper combines the two methods to establish a physical toy design scheme evaluation framework. This method is easy to apply. It can not only solve the total ranking relationship of all schemes to be evaluated but also get the specific classification of each scheme to be evaluated. In addition, the classical domain matter elements of each evaluation level can be set according to the needs of decision makers, and different classification results can be obtained when the total ranking relationship to be evaluated remains unchanged.

According to the requirements of sensory integration training at the criterion level, scheme 3 is deeply and carefully designed, as shown in Figure 4. The children's balance scooter provides power for children by squatting and reciprocating on the car, which can effectively exercise children's spatial perception ability, concentration ability, balance ability, perceived weight, and balance ability; Placing a finger pressure plate at the pedal can achieve the effects of pressure training and weight perception training. At the same time, it has a simple and lovely appearance, which meets the aesthetic needs of children.

Table 2: Improved BPA function value.

	$\widetilde{m_1}(\theta_j)$	$\widetilde{m_2}(\theta_j)$	$\widetilde{m_3}(\theta_j)$	$\widetilde{m_4}(\theta_j)$	$\widetilde{m_5}(\theta_j)$
θ_1	0.1012	0.1374	0.1093	0.3845	0.3845
θ_2	0.1299	0.1494	0.2194	0.1414	0.1414
θ_3	0.2748	0.1918	0.1149	0.1102	0.1102
θ_4	0.1299	0.5214	0.0884	0.1014	0.1014
Θ	0.3642	0	0.4680	0.2625	0.2625

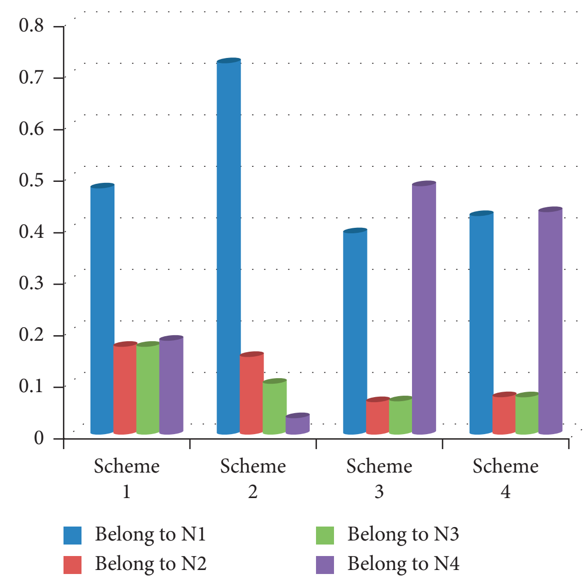


Figure 3: The support degree of evidence fusion to four process planning schemes at a level.

Figure 4: Design of physical toy for children with ADHD.

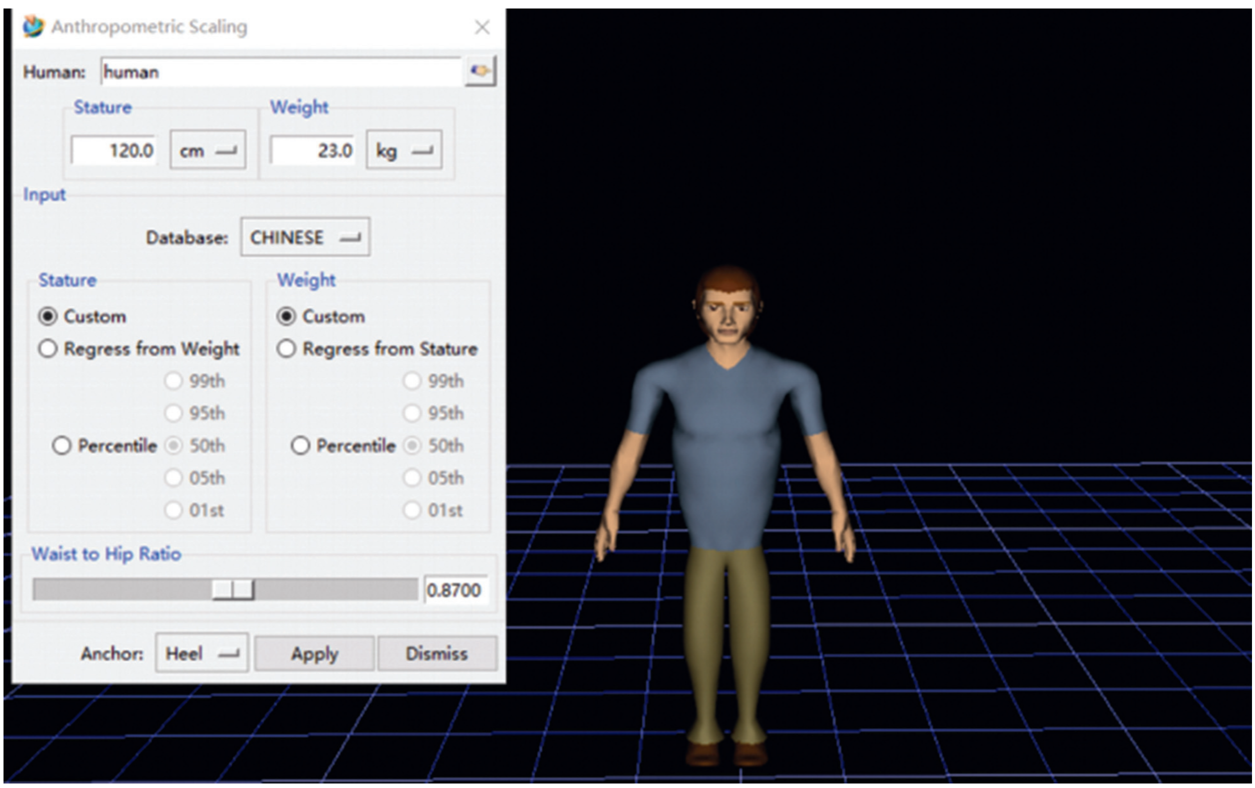


Figure 5: Establishment of virtual human body model size.

4.3. Product Testing. In the product test, Jack software of Siemens company is used for man-machine simulation of the product. Through the analysis of simulation data to verify whether the design scheme is safe and reasonable.

Input the parameters of the character model in Jack software and select the average height and weight of a normal 6-year-old Chinese boy of 120 cm and 23 kg, as shown in Figure 5.

Import the 3D digital model of the balance scooter into Jack software. Set the virtual human's posture through [human control], adjust the virtual human's hand to hold the handle through the [behaviors] command, place the virtual human's foot on the pedal, and seat the virtual human on the seat through the [attach to] command, as shown in Figure 6.

Use Jack software to simulate the loading process of the balance scooter and select [lower back analysis] and [NIOSH] functions to obtain the chart, as shown in Figure 7.

From the test and analysis results, the lower back analysis and lifting analysis values are within a reasonable range, so the loading process of the balance scooter is safe and reasonable. ADHD children can safely operate the product. By doing squat reciprocating motion and driving and playing, they can achieve the stimulation of rise and fall vibration, sudden start and emergency stop, and reflex adjustment. These stimulation forms can enable ADHD children to achieve the effect of rehabilitation training.

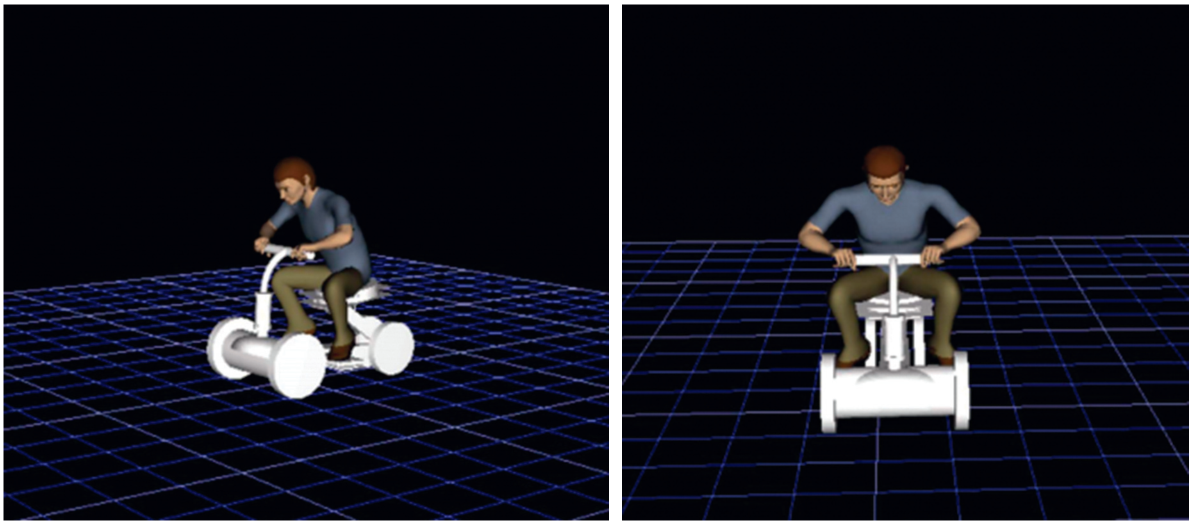


Figure 6: Simulation of balance sliding step vehicle.

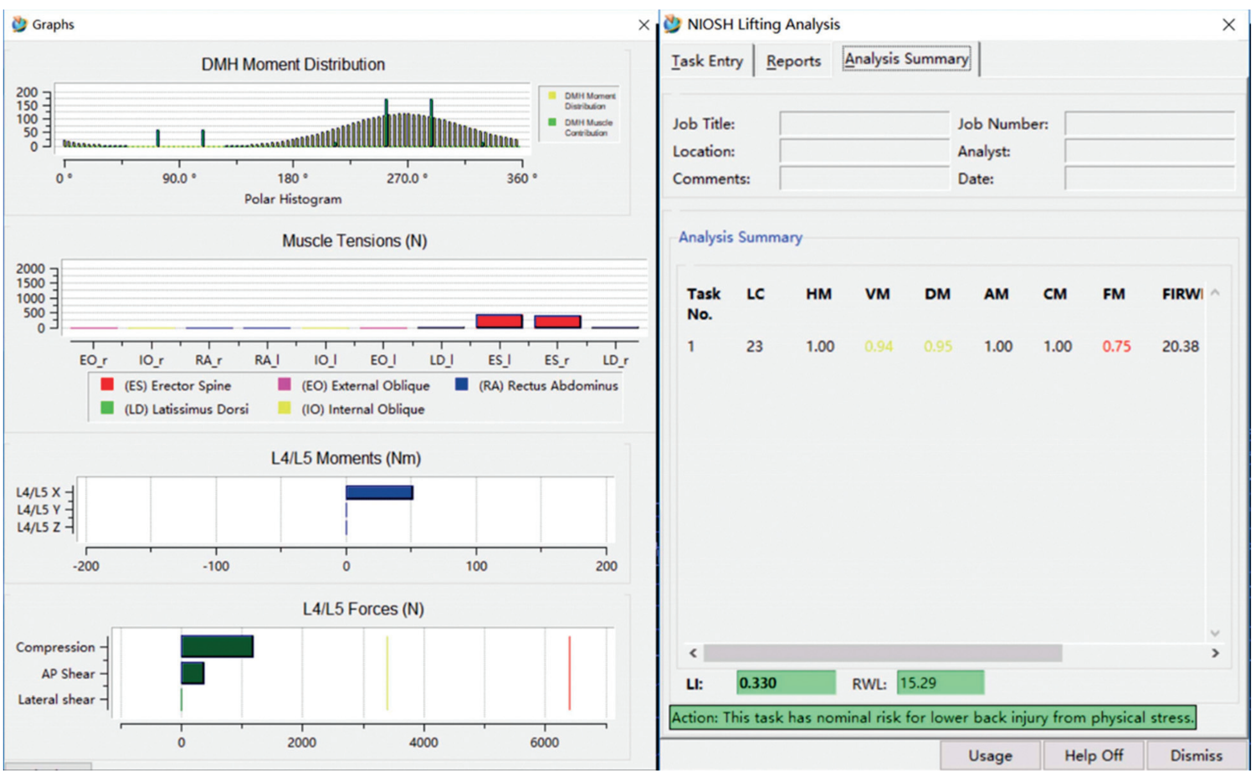


Figure 7: Data chart of lower back analysis and NIOSH.

5. Conclusions

At present, the treatment of ADHD children is mainly behavioral intervention, and its repeatability and drug side effects lead to poor treatment effect. The physical training method of sensory integration has the advantages of safety, simplicity, and low cost, which is accepted and welcomed by many parents. Extenics and the D-S theory combined with sensory integration training were used to evaluate the toy design of ADHD children. Integrating the rehabilitation criteria of sensory integration training, nine secondary indicators are extended from the three criteria level indicators of tactile training, the vestibular training, and the proprioceptive training to construct the evaluation system. According to the weight ranking of the indicators, clarify the toy type and toy function, design four primary schemes, and then score the three primary schemes by extenics and the D-S theory evaluation to obtain the best design scheme and refine it. In the product test, Jack software of Siemens is used to verify whether the final product is safe and reasonable through virtual simulation. This study takes children with psychological problems as the research object, provides new ideas for the design of children's toys, and improves the scientificity and reliability of the physical toy design for children with ADHD.

Data Availability

The data set can be accessed upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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