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Harmonic Scale of Development. A proposal of integration by which to assess child development

Francisco J. Abellán*, M. Teresa Calvo-Llena, and Rafael Rabadán

Universidad de Murcia (Spain).

Título: Escala de desarrollo armónico. Una propuesta integradora para la evaluación del desarrollo infantil.

Resumen: En el ámbito de la evaluación psicológica, cada vez más, los profesionales interesados en el desarrollo son sensibles a la necesidad de instrumentos capaces de integrar en su diseño el carácter sistémico y epigenético de este proceso. La mayoría de las explicaciones propuestas en las últimas décadas convergen en considerar el cambio evolutivo como el resultado de una compleja red de transacciones entre el sujeto y sus contextos de desarrollo a distintos niveles. La Escala de Desarrollo Armónico recoge elementos sensibles al dinamismo del proceso ontogenético: áreas y funciones de desarrollo que experimentan tensiones generadoras de cambios cuantitativos y cualitativos a través de diferentes niveles y etapas. Estas etapas, entendidas como "estados atractores" –concepto clave en la Teoría de Sistemas Dinámicos Autoorganizados–, pierden rigidez e integran la variabilidad. La escala aporta variables que permiten abordar simultáneamente la dimensión cuantitativa (el Cociente de Desarrollo Medio) y la calidad del proceso de desarrollo (el Indice de Armonía). Los primeros ensayos realizados desvelan su utilidad como un test de screening al servicio de la prevención desarrollo infantil.

Palabras clave: Psicología del desarrollo; escalas de evaluación del desarrollo infantil; teoría de sistemas dinámicos; desarrollo armónico.

Abstract: Professionals interested in the area of psychological assessment are becoming increasingly sensitive towards the need for instruments capable of integrating the systemic and epigenetic character of the developmental process into its design. Most of the proposals put forward in recent decades coincide in considering developmental change as the result of a complex network of transactions between the subject and its developmental contexts at different levels. The Scale of Harmonic Development combines elements sensitive to the dynamism of the ontogenetic process: areas and functions of development which experience generative tensions of quantitative and qualitative change across different levels and stages. These stages, understood as "attractor states –a key concept in the Self-organizing Dynamic Systems Theory–, lose rigidity and integrate variability. The scale provides variables which allow the quantitative dimension (the Average Development Quotient) and the quality of the process of development (the Index of Harmony**)** to be dealt with at the same time. Initial trials reveal their usefulness as a screening test to serve in child development prevention.

Key words: Development psychology; Child development evaluation scales; Dynamic systems theory; Harmonic development.

Introduction

The construction of assessment and measurement scales of psychological development will shortly be one century old, since Arnold Gesell initiated his research in Yale University in the 1920s. In parallel, research into Developmental Psychology has provided new explanatory theories and models. Both lines of investigation have since interacted. However, although the scales of measurement have been brought up to date at various times since, they have remained ascribed to the theoretical positions upon which they were built. Bronfrenbrenner's (1979), now classic, ecological model; Sameroff's (1982) transactional perspective; and, even, the model of developmental systems developed by Guralnick (2001), as the result of a long trajectory in the area of early intervention, are, along with Esther Thelen's (1985, 1989a, 1989b 1992, 1995) dynamic systems theory, examples of what we could call a new paradigm, which takes on, as a key element to its definition (Siegler & Shipley, 1995), the systemic and dynamic features of the process of developmental change as much as the inter-individual variable. To this extent, many researchers into this development are sensitive to the need for new methods to tackle its study (e.g.: Hollenstein, 2011; Puche & Martí, 2011; Schöner, 2014; Spencer, Austin, & Schutte, 2012; Spencer, Thomas, & McClelland, 2009; Witherington, 2011, 2014; Witherington & Margett, 2011) and to the value of combining micro-genetic and longitudinal analyses (e.g.: Garcia-Mila, Gilabert & Rojo, 2011; Lyra & Valsiner; 2011; Valsiner, 2011; van Dijk & van Geert, 2011).

In our opinion this need extends to the instruments of measurement of individual development. The results of an assessment may condition our interventions and, therefore, the course of a child's development (DeRobertis, 2011), for which reason it would be necessary to introduce into its design elements which were sensitive to the dynamism of the ontogenetic process. A scale constructed this way would serve to guide preventive interventions, respecting the individual developmental plan, by having available quantifiable control parameters as indicators of the quality of the process. This intention is integrated into the concept of harmony in our proposition, as an expression of proportion within certain limits (Castro-Martínez, Sierra-Mejía & Flórez Romero, 2012), something we will define forthwith. The Scale of Harmonic Development (SHD) appears in an effort to renew the tools used to assess development which approaches them to this new concept of developmental change. As this is a first attempt, our assessment model should continue evolving so as to be able to tackle the mechanisms of change. For the time-being it should be categorized as a filtering tool, which, in order to have a sufficiently well-founded etiologic diagnosis, will have to be complemented with other assessment procedures.

The classic theories of Piaget and Vygotski (Delval, 2002; Flavell, 1963, 1982; Kozulin, 1994; Piaget, 1986; Vygotski, 1934, 1995), are still applicable, as is the theoretical proposal

*** Dirección para correspondencia [Correspondence address]:** Francisco Javier Abellán Olivares. Facultad de Educación. Universidad de Murcia. 30100 Espinardo-Murcia (Spain). E-mail: javierao@um.es

of the processing of information (Gutiérrez-Martínez, 2005), and are, to a certain extent, simplified linear interpretations of reality. They do not reflect the complexity and dynamism found in the processes of balance and in the dialectic process established between the system and its context (Van Geert, 1995; Puche & Martí, 2011). Connectionism (Mareschal & Shultz, 1996; McClelland, 1989; Rumelhart, McClelland and the PDP group, 1992) attempted to overcome these limitations, but was unable to include in its explanation of development new ways of representing and analyzing the change, a change which, rather, appears to be characterized by complexity and chaos (Gutiérrez, Luque & García-Madruga, 2002; Puche & Martí, 2011).

To this extent, a proposal in terms of self-organizing dynamic systems, along the lines developed by Thelen and collaborators in recent decades (Smith, 2003; Smith & Thelen, 2003; Spencer & Thelen, 2003; Thelen, 1995; Thelen & Bates, 2003; Thelen & Smith, 1994, 1998), appears suitable, though it is not the only one to accommodate the oscillations and fluctuations seen in the course of individual development (Fogel, Lyra & Valsiner, 1997; Lyra & Valsiner, 2011; Valsiner, 2011) within the framework of a scale of development, such as that presented here. Due to this, our scale adopts some of the fundamental approaches and concepts of this approximation.

The aim of the theory of dynamic systems (Smith, 2009; Spencer et al., 2006; van Geert & Steenbeek, 2005; Witherington, 2007) is to describe and explain how relationships and exchanges at the low levels of organization of a system can produce qualitatively new states and properties at the higher levels. This theory can be applied to any complex system, including that of human development. Developmental Psychology will interpret the processes of change and development as the emergent result of the interactive and dynamic operation of the system. Naturally, within a complex system, self-organization will take place, as a result of its own operation (Corbetta & Thelen, 2002; Smith, 2005; Smith & Breazeal, 2007; Smith & Pereira, 2009; Thelen, 1989a, 1992). The change will be the result of the interactions of variables within the organism itself and of its interaction with contextualized external variables. Predetermination and finality are not possible here. It is an epigenetic concept of development: structure and order emerge through interaction. Thus, the system adapts itself and does so openly, continually, irreversibly, spontaneously and naturally, reorganizing itself and dynamically self-correcting via internal and external interaction. Based on this concept, the trajectory of development responds to non-lineal equations (von Bertalanffy, 1968).

In order to adapt itself, the system requires collective variables or *parameters of order*, which provide a description of the state of coherence of the system, and the way its parts combine at a determined moment of balance. It also requires regulating variables or *control parameters* which compel or regulate the dynamics of the parameters of order in a non-determinist manner, presenting critical values over which they provoke an alteration in the system. Theoretically, in the dynamic interaction of all the elements of the system an infinite number of different states could be achieved, but this is not so due to to the intervention of the *attractor states* towards which the system converges in time.

Allow us to insist here in this idea, which shall be the key to understanding what is understood by a "stage" within the SHD. In general terms, the theory of dynamic systems define it as the *grouping* of properties towards which a system extends in order to evolve, attracting trajectories, whose only condition is that of its proximity to the state towards which it extends (attractor). As far as psychology is concerned, this idea has been used to understand the developmental change in diverse areas (for a review *cf*., for example, Fogel, Lyra & Valsiner, 1997; Mateo-García, 2003; Smith, & Breazeal, 2007; Smith & Pereira, 2009; Spencer, Austin, & Schutte, 2012; Thelen, 1992, 1995). In the words of Esther Thelen (1995), thought and behavior emerge as a result of the situation the subject encounters at any given moment (task, context, etc.) and the preferred states of the system, given its prior activity in terms of its particular organization and history. Some of the patterns of action and resultant thinking of the dynamics are very stable. These states attract closer trajectories in such a way that they can be considered attractors in behavioral space.

Development will appear to us as a changing landscape of preferential behavioral states (attractors) with diverse levels of stability/instability. The increased stability of some behavioral preferences confers on them qualities akin to a developmental stage. However, there exists an important difference: Stability is now a function of the organism-in-context and these attractor states are preferential behavioral patterns, and highly probable, but not obligatory. The system *prefers* certain states in its organization, and tends to regress towards them when it is disturbed. When the disturbance overcomes the threshold of the control parameter, the adaptive needs of the system then drive it towards a new state. Thus, the change is explained.

From this perspective, the temporal dimension could explain this operation, by which, at different times, the same conditions can produce different results. That is, that in natural development, an attractor state precedes another and conditions it, outlining the epigenetic landscape of individual development (van Geert, 1994).

This theory, which, initially, is configured in the area of early motor development (Thelen, 1989b), soon reaches explicative worth for other dimensions of behavior, such as language and cognition (*cf*. Port & Van Geert 1995) or social development (Fogel, Lyra y Valsiner, 1997). In the last decade, a variety of research into the learning of specific tasks has highlighted this vision of knowledge and dynamic models have been applied to studies which reflect development in its multiple aspects. Thus, Sandhofer and Smith (2004, 2007) revealed the interaction between the learning of nouns and adjectives; Zapf and Smith (2007) explained the generalization of the plural of nouns and Colunga and Smith (2008) explained the process of acquisition of the same items in

terms of attractor states and van Dijk and van Geert (2007; 2011) tackled in dynamic terms the variability in early development of language and grammar.

Equally, Sheya and Smith (2010) highlighted the role of the properties of objects in the production of new ideas, in line with these principles. Frank, van der Kamp and Savelsbergh (2010) explained the activation of perceptions and movement through the competitive interaction between perceptive patterns of the system and the stimuli of the environment. Fausto-Sterling, García-Coll, and Lamarre (2012a, 2012b) applied them to the process of sexual differentiation in early infancy; Simmering and Perone (2012) to the explanation of the memory of work as a flexible system which can adapt itself to the demands of tasks, despite its limitations. At the present time, Perone and Spencer (2014) have put forward a mechanism of neuro-development for visual discrimination based on simulations using fields of dynamic neurons.

Our proposal will be that, in order to explain change, it will be necessary to possess a mechanism capable of expressing the dynamics which link the levels (parameters of order), intra-individual variability (Siegler & Shipley, 1995) (quantified in the *index of harmony*, proposed by us as a control parameter) and the stages (attractor states). We call this a *cognitive tug*, in order to refer to the process through which the situation of stability or harmony reached in a specific state becomes unstable, prompting change as a consequence of the dynamics established between the activity of the subject and the conditions under which it takes place. Thus changes in operation occur, specifically between the states and levels in which observation has been frozen (Puche & Martí, 2011).

The visualization of this mechanism requires a flat spatial representation with three dimensions: the level, the stage and then harmony of the graphic profile (Figure 1). The cognitive tug uses the force of disharmony to attract the system towards a new and following state of harmony, that is, in order to make a change of stage. From the disorder of a stage first is born the order which raises the development towards a second stage, and so on successively. This mechanism can be expressed in three phases. In each phase, the abscissa represents the different aspects of development (Table 1) and the ordinate represents the temporal dimension (Table 2).

In phase 1 of stage 1 (Phase 1.1), the system grows in a disharmonic fashion, adding on quantitative progress. Subsequently, the system tends to balance itself out (Phase 1.2) until it attains its maximum developmental direction: it experiences a qualitative state of harmony. At the end of stage 1, in the third phase (Phase 1.3), a critical point is reached from which the attractor state (stage 1) allows the cognitive functions to access a higher perceptive perspective. At that moment, the qualitative jump which will carry the system into stage 2 is produced.

The cognitive tug (represented by an ascending arrow in Figure 1) again destabilizes the system (Phase 2.1). The tonic-motor relations and the communicative, personal and social functions, have to respond to the new demands of perception, accompanied by neuropsychological maturity. In this second phase (Phase 2.2) the system once more tends to balance itself out until it attains its maximum developmental direction: it regains harmony at the end of stage 2. Finally, in the third phase (Phase 2.3), a critical point will be reached from which the attractor state (stage 2) will allow the cognitive functions to access another, new perceptual perspective. It will be then that the qualitative jump which will take the system into stage 3 will occur. And so on, successively.

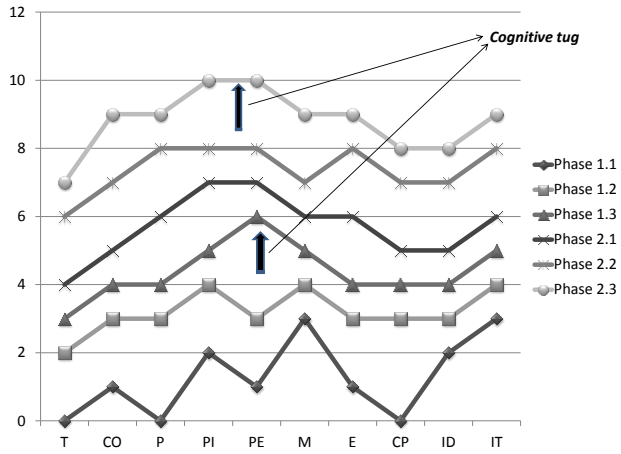

Figure 1. Dynamic mechanism of developmental change.

In short, the representation of the mechanism in the graph shows that each rebalancing is produced by gaining quantitative levels in each new qualitative stage, through the system's responding with developmental attainments in the rest of the functions to the demands of perception –which shows new possibilities and generates new needs–. To sum up, the system scales levels, propelled by a cognitive mechanism which is cause and effect of the intra-individual variability (harmony-disharmony variable).

Elements and functions of harmonic development

Our conception of development is supported by ten differentiated functions (Table 1): Muscle tone (T), Motor coordination (CO), motor accuracy (P), Internal perception (PI), External perception (PE), Neurological modulation (M), Communicative expression (E), Communicative comprehension (CP), Personal identity (ID), and Social integration (IT). These functions are representative of the four basic areas traditionally used for the generality of scales (Bayley, 1977; Bluma, Shearer, Frohman & Hilliard, 1995; Cordero, Seisdedos, De la Cruz & González, 1996; Fernández-Álvarez, 1991; Frankenburg, Dodds, Archer, Shapiro & Bresnick, 1992; García-Tornel, García, Reuter, Clow & Reuter, 1996; Ireton & Thwing, 1988; Josse, 1997; Newborg, 1984; Secadas, 1992).

In order to obtain a detailed analysis of the processes involved in each area (psychomotor activity; aptitudes, abilities

and academic performance; neurocognitive development; linguistic and oral development; personal development and social adaptation), and to group together the interests of the different disciplines which are involved in development and its alterations, we have subdivided them into other functions and have developed a construct definition for each one of them (see Table 1). Thus, the motor area is made up of three dimensions: *tone, coordination and precision*; the perception-cognitive area *by internal perception, and external and modulation perception*; the area of language by *expression and comprehension*, and, finally, the area of adaptive difference between *identity and integration*.

Table 1. Classic areas, functions and definitions of construct.

Classic area	Function	Definition
Motor area	1. Tone (T)	State of tension or relaxation of the muscular mantle when it is ready to initiate a motor action and while it is carrying it out.
	2. Coordination (CO)	Motor action performed by the large muscles which serve to move and displace the body.
	3. Precision (P)	Motor action of the small muscles which are coordinated in order to perform technical gestures such as speaking, looking or handling.
Perception-cognitive area	4. Internal Perception (PI)	Ability to represent the internal world, ranging from somatic sensations to meta-cognitive processes.
	5. External Perception (PE)	Progressive ability to represent the external world ranging from sensitive afferent inputs to the acquisition of the conceptual universe.
	6. Modulation (M)	Maturation of the information potential of the SNC thanks to stabilization of the neurological rhythms and the processes of myelinogenesis and of cortical hemispheric lateralization.
Language area	7. Expression (E)	Capacity to emit signals and messages originating in empathic binding and reaching the acquisition of speech and articulated verbal language.
	8. Comprehension (CP)	Capacity to receive significant messages via diverse means of communication and language present in the environment: gestural, oral, written, mathematical.
Adaptive area	9. Identity (ID)	Individual psychological development: awareness of ones´ own identity and gradual acquisition of personal autonomy for the resolution of needs.
	10. Integration (IT)	Development as a social subject: ranging from the perception of otherness to the sense of belonging to and participation in a variety of ecological circles.

Levels and stages of development

We consider development from a temporal perspective using a double scale: chronological age as a quantitative scale, and developmental stage as a qualitative scale. The quantitative scale describes the first six months, dividing them into four periods each of one and a half months in length; it divides the following six months up until the first year of life into three periods of two months. The second year is studied in two periods of six months, and the remaining years in periods of twelve months. For its part, the qualitative scale reflects the seven stages which represent the attractor states, though not states strictly speaking, which attempt to gather together the fundamental aspects of other classifications (Table 2).

Each stage, as an attractor state, claims to respond to a particular form of organization of the functions. For their part, the levels respond to the quantitative aspects, which would indicate to what extent the functional requirements of the stage have been achieved (or will be achieved). We believe that the denomination of each of these stages responds to what is considered to be its central developmental task (see description in Table 3), although not only. These stages must, nevertheless, be submitted in the future to the demands of psychometric methods in order to accept them definitively as attractor states.

Table 2. Double scale of developmental monitoring.

Level	Age of Development	Stage of Dvelopment
20	12:0 to 12:11	Stage of Puberty
19	11:0 to 11:11	
18	10:0 to 10:11	
17	9:0 to 9:11	Schooling stage
16	8:0 to 8:11	
15	7:0 to 7:11	
14	6:0 to 6:11	Socialization stage
13	5:0 to 5:11	
12	4:0 to 4:11	Communication stage
11	3:0 to 3:11	
10	2:0 years to 2:11 (2 y. & 11 m.)	Exploration stage
9	1:6 to 1:11 (1 y. & 11m.)	
8	1:0 year to 1:5 (1 y. & 5 m.)	
7	10.1 to 11.9 months	Movement stage
6	8.1 to 10 months	
5	6.1 to 8.0 months	
4	4.6 to 6.0 months	
3	3.1 to 4.5 months	Bonding stage
2	1.6 to 3.0 months	
1	0.0 to 1.5 months	

Tabla 3. Stages of child development

Nº	Stage of development	Description
1	Bonding	Organization of basic rhythms and perceptions needed to relate to the environment.
2	Movement	Unfolds capacity of movement on the floor, while enriches communication.
3	Exploration	Walks, explores with hands and mentally imagines the physical environment and her/himself.
4	Communication	As movement becomes automatic, energy available to feed the emotional and linguistic function.
5	Socialization	Cognitive maladjustment improves sociability and allows Access to instrumental learning.
6	Schooling	As cognitive operations become automatic, higher levels of logical reasoning are permitted.
7	Puberty	Hormonal stimuli trigger adolescent psychology, so concluding childhood.

The description of each of the stages corresponds to the dominant developmental task which gives it sense: *bonding* with the environment, *movement* which multiplies experiences, the conceptual benefits of *exploration* of the surroundings, the deployment of the capacity of *communication* which facilitates *socialization*, and access to cultural contents which can be seen to increase in *schooling* until childhood leads into *puberty*, as the beginning of adolescence.

Description of the Scale of Harmonic Development (SHD)

The combination of the areas and functions designed with the levels and stages of development consist of what is termed Scale of Harmonic Development (SHD), (Abellán, 2011). The SHD has a bi-dimensional structure, also known as the developmental matrix (Annex 1), in which the ordinate presents chronological age in each level of development, and where the ten functional areas of the assessment of development are presented in the abscissa. Each area combines the representative items of each of the 20 age levels. The developmental targets (800 items) which simultaneously correspond to each age and each function are included in the intersection of lines and columns. This is an ordered description of development, expressed by the aforementioned targets, over which the developmental profile can be traced, the average age of development obtained, warning signs detected, and programs of stimulation planned.

The number of items (four) is the same for all the age/function intersections. By keeping the number of items constant, the calculation of results is simplified and homogeneous information is obtained throughout the whole period of measurement. Each of the 800 items is catalogued and described in its corresponding file. As an example, file 166 appears in Table 4.

Table 4. File of item 166.

Function	Co-ordination
Level of development	12 to 17 months (1:0 – 1:5 years)
Stage	Exploration
Description	When s/he sits on the ground and we provide plain building parts, without pivots or grooves and of various shapes and colors, we observe that s/he almost always grips a part with each hand, in a way that, if we show her/him how to pile them up to make walls or towers, s/he tends to want to place both parts at the same time, and proceeds to "build" a piece of work without a prior plan. S/he finds it equally enjoyable to destroy the construction at any time.

The same method is used to assess development during the whole period range (0-12 years, thereby allowing us to assess the child from birth to the start of adolescence, without changing the tool used. Thus, the procedures of analysis and the information obtained sustain continuity which facilitates their use and understanding throughout childhood.

The Index of Harmony

Based on the concept of development we propose, a control parameter which explains stability and developmental change is needed. In this sense, the SHD incorporates a new value, the Index of Harmony (IH, situated between 0 and 100), referring to variability, easily calculable using the dispersion of data within the individual file of the child. If an adequately broad period of time is taken into account – which is possible, as the same assessment instrument is available from birth to puberty–, the IH allows the individual dynamics of adjustments and readjustments amongst the ten functions described in each individual case to be observed and assessed. An average to low spread (IH $\geq$ 80) indicates and predicts an optimum developmental course. The points of greatest disharmony, in this type of profile, will signal a moment of change. On the other hand, a high dispersion (IH $<$ 80), maintained over time, will indicate the presence of a-synchronic functions or disharmonies and this ought to alert the professional from the point of view of the prediction of development.

This idea is fundamental to give independence to the comparison of individual development in relation to statistical norms, since it permits each case to be contrasted with itself over and over, without taking chronological age into account. In this way, individual development is understood as a non-linear course, and as the result of multiple variables, from which there emerges an outcome which is not forecast either by genetic inheritance or finalism.

The Co-efficient of Average Development

Based on the developmental profile reflected in the matrix of items for each case, it is possible to calculate the average level of development which relates to any given moment. Given that this level is the equivalent of a particular age of development, we can establish the Co-efficient of Average Development (CAD) based on the well-known formula which expresses the proportion between the age of development and chronological age.

Tools applied to harmonic development

The SHD allows development to be tackled from different fields of diagnostic interest. On the one hand, the clinical diagnosis of development and, as a result, the referring of the child to the most appropriate specialist. This is possible to the extent that, based on its basic indicators –the Co-efficient of Average Development and the Index of Harmony– the matrix itself displays the functions where problems can be found. Thus, for example, a low score in tonic-motor functions linked to high general disharmony may be an indicator of the presence of some type of neurological damage. In this sense, a tree of gnoseological criteria is in the process of development.

On the other hand, by providing information not only on the targets reached or not, but also on the moment of acquisition, our scale facilitates the planning of intervention in the field of education, in the shape of stimulation or rehabilitation within a harmonized strategy. A strategy which should be characterized by its respect of the internal logic of the attractor states, without contravening the natural sequence of acquisition. The contrary approach could, subsequently, become a paradoxical result in the course of the development. Take for example the inappropriateness of stimulating bipedal walking without sufficient tonic maturity (Hainaut, 1982; Vayer, 1980; Wallon, 1968), or in the emotional consequences of forcing the learning of reading and writing in children who do not possess the basic pre-requisites (Luque, Carrillo, Alegría, Bordoy & López-Zamora, 2012; Sánchez, 2010).

Graphic representation of results

The SHD is designed as a tool to follow the course of development during the whole childhood, for which we have suggested three types of graphs which help to illustrate diagnostic assessment. With the graphs referring to level, position and tendency of development, our scale aspires to position itself amongst the variables which influence that development**,** by understanding and explaining it, so as to help with suitable decision making. There follows an example which shows the tracking of a child with Down's syndrome on three occasions in a year:

The *profile of the level of evolution* (Figure 2), represented by the union of the average ages of each function is useful in comparing the child with herself on different dates according to her disharmonies (it can be seen that the Muscle Tone function remains low during the whole period), or, for the purpose of research, in comparing the characteristic profiles of individuals with the same pathology.

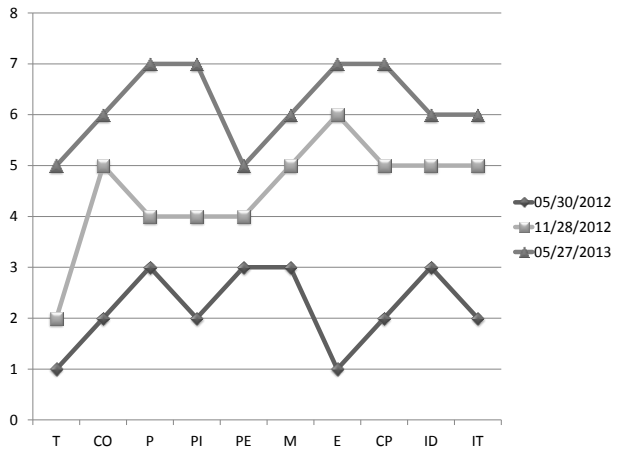

Figure 2. Comparative graph of developmental profile.

The *graph of the point of development* (Figure 3) shows the trajectory of the child's global development over the year, compared with the development one might expect according to her chronological age with no genetic influence. In this personal curve of development her epigenetic individuality is confirmed. This particular case (from May 2012), did not initially reach 37% (CAD = 0.31/0.83) and a year later (in May 2013) it was situated at 51% (CAD = 0.89/1.75), due to the fact that the CAD had undergone positive evolution.

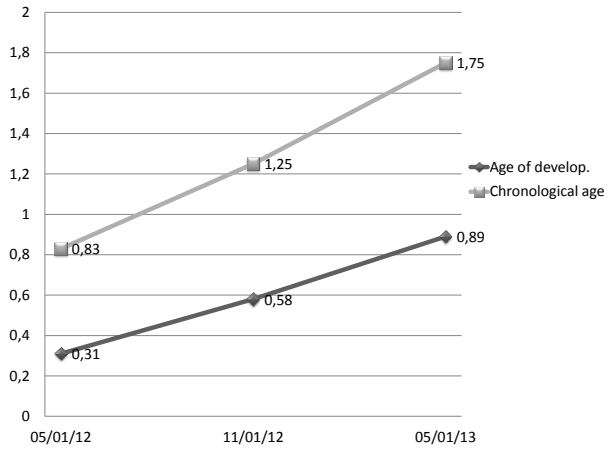

Figure 3. Graph of the point of development.

And, thirdly, there is the graph of tendency (Figure 4), which reflects the joint trajectory of the CAD and the IH. The contrasting evolution between both variables can be useful in making preventive decisions, by showing their joint tendency in relation to a line used as a graphic means of comparison.

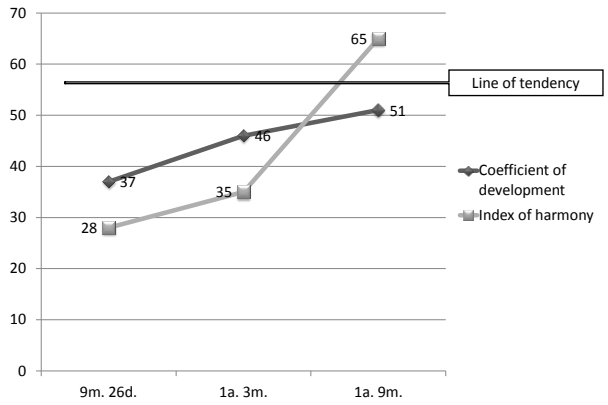

Figure 4. Graph of developmental tendencies.

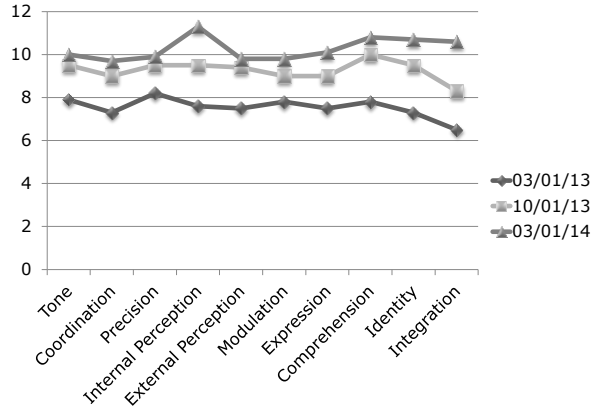

Figure 5. Graph comparing developmental profile.

The example given shows the trajectories approaching the *line of tendency*, in addition to the crossover between variables, which, on this occasion, is explained by the success of harmonization (which has increased over the year from 28 to 65 points) and the obvious difficulty in reaching greater levels of development (CAD = 51).

An example of assessment using the SHD

There follows the tracking of the evolution of a healthy female child of 2 years 2 months (Maria) who was assessed on three occasions. The data is presented in the type of report which reflects the data obtained with the SHD:
Maria
Date of birth: 12-25-2011
Latest date of examination: 03-01-2014
Chronological age: 2 years 2 months

Level of development (Figure 5): The profile graph of 03-01-2014 shows the level of development achieved by Maria and her chronological age (CA) of 2 years 2 months. The age of average development (AAD) displayed corresponds to 2 years 9 months, which represents a coefficient of average development (CAD) of 127% in relation to the standard average for her age.

Warning functions: Table 5 displays the coefficient of development (CD) of each of the assessed functions. A warning can be identified in the Internal Perception, Comprehension, Identity and Integration functions, with a CD of 173%, 150%, 146% and 139% in relation to the average for that age. The Index of Harmony (HI) of the developmental profile is 52 points (the average IH being 80 points out of 100).

Table 5. Coefficients of development in each of the subscales of the SHD.

Scale	Coefficient of Development
Tone	115
Coordination	100
Precision	108
Internal Perception	173
External Perception	108
Modulation	108
Expression	119
Comprehension	150
Identity	146
Integration	139
Age of Average Development	2 years 9 months
Coefficient of Average development	127
Index of Harmony	52

Development Tendency (Figure 6): In the trend graph, one can see the joint evolution of the CAD and IH in relation to a trend line, something which eases the graphic perception of her evolution. On this occasion, the CAD is 127 and the IH 52. It is clear how the progressive increase of the percentage of development carries with it, in this case, a reduction of the harmony of the development itself.

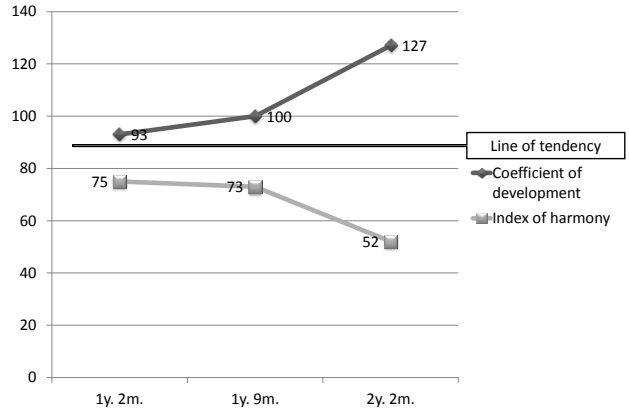

Figure 6. Graph of development trend.

Position of development (Figure 7): The position of current development corresponds to 2.75 years (2 years 2 months), as opposed to a chronological age of 2.16 years (2 years 2 months).

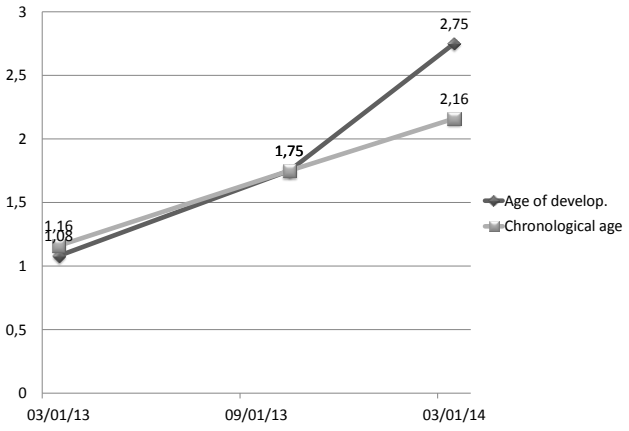

Figure 7. Graph of the position of development.

Developmental diagnosis: At the age of 2 years 2 months, Maria's general development reaches 2 years 9 months, which represents 127% compared to the average for her age. The functions of Internal Perception, Comprehension, Identity and Integration, with a CD of 173%, 150%, 146% and 139% can be seen as warning values. Moreover, it presents an IH of 52 points out of 100.

From the underlying perspective of this scale, the position of Maria's development appears to be at a moment of change (cognitive tug) (the CD of the Internal Perception function = 173), which may raise her general development towards a new developmental stage. This can be confirmed in subsequent following.

Discussion and conclusions

We have proposed a new scale, intending to integrate into our model of assessment an interpretation of development in terms of self-organizing dynamic systems. The contributions and limitations of the SHD will be reviewed so as to confirm to what extent they give answers to the proposed objective.

Our scale studies development by levels, ordered according to their evolution, in such a way that the age variable is not fundamental, rather it is the succession of plans of harmony which characterize natural development, though at no point the possibility of a return to previous states of behavior is excluded. What is important here is the sequence of development and the profile which that represents, not so much the age at which the transitions from one level to another take place, or the transition from one attractor state to another (Mareschal et al., 2007). For that reason, although changes tend to be observed at particular ages, that actual chronological age cannot be seen to be understood to be the motor of change. Thus, age becomes relative, and, thanks to this, the scale and the decisions which are derived from it will respect each child's individual *tempo*.

In addition, the profile of level diagnosis clearly displays the disharmonies which need to be assessed in depth, in order to determine which should be the objectives of the programs of stimulation and rehabilitation. In practice, whether clinical, socio-sanitary or educational, taking decisions over priorities and strategies to plan the intervention is of exceeding concern. The SHD contributes objective criteria –which will be priorities for our research in the future– to help coordinate inter-disciplinarian treatments. The IH by itself, the CAD, and the connection between them, are a rich source of very useful information, which aid understanding of how to stimulate each individual child.

We believe that the structure of the SHD corresponds to the initial idea of development, as stated in Figure 8. Self-organization, parameters of order and of control, and attractor states come together to provide an explanation of the course of individual development.

In the scale of development, self-organization takes place through the internal interaction of the ten interdependent functions over the range of the twenty age levels, and through the external interaction (with its surroundings) represented by the eight hundred targets gathered together in the developmental matrix. The state of development reached at any given time is reflected in the numeric proportion of the CAD –as a parameter of order– and in the graphic profile. Moreover, the IH –as a control parameter– summarizes, in a single piece of data, the graphic information contained in the profile, thus indicating the degree of imbalance between the various functions and predicting the changes in the system when it assumes critical values. Lastly, the system

prefers to converge on attractor states, which we have distinguished as stages.

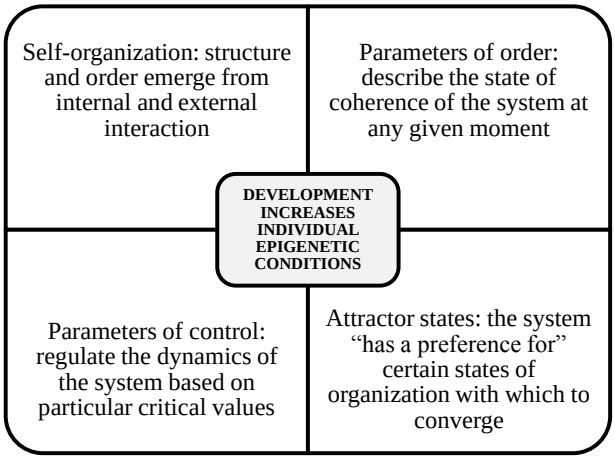

Figura 8. Model of dynamic development.

Research proposals

The possibility assessing development over the whole course of infancy and childhood, without having to change scale, provides additional advantages which we believe make it interesting as a tool to support research. As it is possible to follow the development of the same functions from the first assessment to the last, we can be in a position to respond to an incalculable number of questions which help us better understand child development: is there, perhaps, an interdependence between parallel processes, which would indicate an internal logic to the attractor states or developmental stages with their own meaning?, Is it probable that specific disharmonies can condition developmental courses within the predictable epigenetic landscape, according to the function of critical values of the indicators employed? Let us look closely at development and observe part of its complexity with the same tools, it can help us understand an extensive period, as a global reality within which everything can be connected in a way which we may possibly come to resolve.

Traditionally, longitudinal research has required years before the information which allows us to correlate prediction with the criterion is available, but, with the information provided by the CAD and the IH, we think it possible to anticipate a much earlier approximation. If we consider the CAD and the IH as variables of prediction, the interaction between them marks the future development trend. The trend profile represents this relationship on a particular date. Let us imagine that, if the value of the IH remains low for that particular date, the trend of the lines will clearly predict the future evolution of the profiles, since both the course of development and its internal consistency undergo alterations. Our clinical and educational decisions will, therefore, be derived from these prognoses, and we will probably manage to make them sooner than normally expected.

It is our opinion that the usefulness of the SHD opens up diverse lines for future investigation. For example, just as typical courses of development are identified, the level, position and trend graphs can be distinguished in longitudinal research focused on specific alterations. Using this data as a basis, it would be possible to design and test specific stimulation programs, adjusted to the profiles and in line with a strategy directed towards compensating and harmonizing development. Subsequently, it would be possible to compare this type of strategy with those that focus, on the other hand, on the early acquisition of developmental targets. Other research could be directed towards the identification of critical values of the Index of Harmony which provide information about the greater or lesser independence of the functions and their repercussions for specific development pathologies. All of this, of course, must be considered without forgetting that this is an instrument of assessment with a practical purpose, and not a suggested method of tackling developmental change.

Limitations

As we pointed out in the introduction, after recognizing that the Dynamic Systems theory constituted a radical contribution to understanding the mechanisms of human development, discussion on the issue has not been exhausted and, in recent years, threats which encourage theoreticians and researchers to continue making progress have started to appear (Witherington, 2014). In the same way, if we propose a renewal of the tools used in the assessment of development in order to align them more closely with the new theoretical positions, we must concede that this is but a first attempt and, therefore, our assessment model needs to continue to evolve. Many fronts remain open, and we shall mention a few of them.

The SHD, for the time being, should be classified as a *screening* tool which cannot be used to complete etiological diagnoses.

Anyone using the scale in a traditional format would find the task extremely complex, as much because of its size as because of the procedures applied to gather numeric and graphic results. It does not provide scales for instant comparison of individual results, nor does it allow simultaneous access to the files of 800 items. By contrast, as it is a digital tool, it is easy to handle and can be used by parents and professionals, since its operations are automatic. In this respect, we must provide adequate controls so as to guarantee its proper use and to avoid undesirable consequences.

A particular problem becomes evident when deciding which functions and criteria should be considered warnings which put into motion specific protocols for intervention. Should it be a value of deviation based on a normal distribution? Should the decisions be left to the good judgment of the clinic? When is the best time to decide whether a warning is valid? These are questions which, as yet, do not have an answer.

On the other hand, our reference to a cognitive tug or stages remains hypothetical. It still needs to be shown that, first of all, the perceptive-cognitive functions described are, indeed, at the forefront of the jump between stages, and, then, that it is, in fact, the stages proposed, or others, perhaps, which become attractor states with their own meaning in development.

We also raise the issue of whether to use the tendency line as a simple visual resource, or whether to attribute an objective value towards which to direct development, and whether, in this case, it should be professionals who determine the clinical strategies. From the outset, this graphic resource has generated doubts, including over its relevance, as initial values to underpin it are not stipulated. Future research could provide information about the trends of each kind of disorder.

Finally, it must de stated that the SHD has already undergone an initial process of ratification, whose results profile it as a new tool for the assessment of development for 0 to 12 years, available for use by professionals. We reserve for a future research report (in preparation) the study of its structural validity, of its internal consistency, and the obtaining of proof of converging and discriminating validity.

In the near future, supported by a program to be available on the Internet, the SHD will be capable of carrying out a wider mission, and be available for general prevention programs. Moreover, thanks to the collaboration between editors and users, it will obtain sample data of interest, and, after a period of time, having been translated into various languages, it will include representative items from other cultures, such that they can be legitimately used by other groups in society. The SHD is, definitively, an organic scale produced to be modified and to be adapted according to its interaction with the diverse settings within which it must carry out its diagnostic activity.

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Annex 1. Scale of Harmonic Development: Design of the developmental matrix.

		Motor			Perception-cognitive			Language		Adaptive	
Level	Age	T	CO	P	PI	PE	M	E	CP	ID	IT
1	0.0 to 1.5	1 2 51 52	101 102 151 152	201 202 251 252	301 302 351 352	401 402 451 452	501 502 551 552	601 602 651 652	701 702 751 752	801 802 851 852	901 902 951 952
2	1.6 to 3.0	3 4 53 54	103 104 153 154	203 204 253 254	303 304 353 354	403 404 453 454	503 504 553 554	603 604 653 654	703 704 753 754	803 804 853 854	903 904 953 954
3	3.1 to 4.5	5 6 55 56	105 106 155 156	205 206 255 256	305 306 355 356	405 406 455 456	505 506 555 556	605 606 655 656	705 706 755 756	805 806 855 856	905 906 955 956
4	4.6 to 6.0	7 8 57 58	107 108 157 158	207 208 257 258	307 308 357 358	407 408 457 458	507 508 557 558	607 608 657 658	707 708 757 758	807 808 857 858	907 908 957 958
5	6.1 to 8.0	9 10 59 60	109 110 159 160	209 210 259 260	309 310 359 260	409 410 459 460	509 510 559 560	609 610 659 660	709 710 759 760	809 810 859 860	909 910 959 960
6	8.1 to 10.0	11 12 61 62	111 112 161 162	211 212 261 262	311 312 361 362	411 412 461 462	511 512 561 562	611 612 661 662	711 712 761 762	811 812 861 862	911 912 961 962
7	10.1 to 11.9	13 14 63 64	113 114 163 164	213 214 263 264	313 314 363 364	413 414 463 464	513 514 563 564	613 614 663 664	713 714 763 764	813 814 863 864	913 914 963 964
8	1:0 to 1:5	15 16 65 66	115 116 165 166	215 216 265 266	315 316 365 366	415 416 465 466	515 516 565 566	615 616 665 666	715 716 765 766	815 816 865 866	915 916 965 966
9	1:6 to 1:11	17 18 67 68	117 118 167 168	217 218 267 268	317 318 367 368	417 418 467 468	517 518 567 568	617 618 667 668	717 718 767 768	817 818 867 868	917 918 967 968
10	2:0 to 2:11	19 20 69 70	119 120 169 170	219 220 269 270	319 320 369 370	419 420 469 470	519 520 569 570	619 620 669 670	719 720 769 770	819 820 869 870	919 920 969 970
11	3:0 to 4:11	21 22 71 72	121 122 171 172	221 222 271 272	321 322 371 372	421 422 471 472	521 522 571 572	621 622 671 672	721 722 771 772	821 822 871 872	921 922 971 972
12	4:0 to 4:11	23 24 73 74	123 124 173 174	223 224 273 274	323 324 373 374	423 424 473 474	523 524 573 574	623 624 673 674	723 724 773 774	823 824 873 874	923 924 973 974
13	5:0 to 5:11	25 26 75 76	125 126 175 176	225 226 275 276	325 326 375 376	425 426 475 476	525 526 575 576	625 626 675 676	725 726 775 776	825 826 875 876	925 926 975 976
14	6:0 to 6:11	27 28 77 78	127 128 177 178	227 228 277 278	327 328 377 378	427 428 477 478	527 528 577 578	627 628 677 678	727 728 777 778	827 828 877 878	927 928 977 978
15	7:0 to 7:11	29 30 79 80	129 130 179 180	229 230 279 280	329 330 379 380	429 430 479 480	529 530 579 580	629 630 679 680	729 730 779 780	829 830 879 880	929 930 979 980
16	8:0 to 8:11	31 32 81 82	131 132 181 182	231 232 281 282	331 332 381 382	431 432 481 482	531 532 581 582	631 632 681 682	731 732 781 782	831 832 881 882	931 932 981 982
17	9:0 to 9:11	33 34 83 84	133 134 183 184	233 234 283 284	333 334 383 384	433 434 483 484	533 534 583 584	633 634 683 684	733 734 783 784	833 834 883 884	933 934 983 984
18	10:0 to 10:11	35 36 85 86	135 136 185 186	235 236 285 286	335 336 385 386	435 436 485 486	535 536 585 586	635 636 685 686	735 736 785 786	835 836 885 886	935 936 985 986
19	11:0 to 11:11	37 38 87 88	137 138 187 188	237 238 287 288	337 338 387 388	437 438 487 488	537 538 587 588	637 638 687 688	737 738 787 788	837 838 887 888	937 938 987 988
20	12:0 to 12:11	39 40 89 90	139 140 189 190	239 240 289 290	339 340 389 390	439 440 489 490	539 540 589 590	639 640 689 690	739 740 789 790	839 840 889 890	939 940 989 990

Notes: T: Muscle Tone; CO: Coordination; P: Precision; PI: Internal Perception; PE: External Perception; M: Modulation; E: Expression; CP: Comprehension; ID: Identity; IT: Integration. Levels 1 to 7 are expressed in months. Levels 8 to 20 are expressed in years and months.