Universidad de Alcalá

ISSN: 1135-9137

15.00€

CAIRON

REVISTA DE ESTUDIOS DE DANZA

DANCE STUDIES

2009

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STRUCTURAL ASPECTS IN *ACUSMATRIX*

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Acusmatrix is the first of a series of pieces focusing on the interaction between sonic and dance gestures in a three-dimensional sound space. The piece is based on digital transformations of the singings of four European bird species, which move and transform in the sound installation interacting with the dancer. The second is *Catexis*, constructed upon transformations of phonemic objects emitted by the dancer, that work as a sonic bio-extension of her corporeal movement. In this article, we will go through some of the used techniques and technologies, but we will above all reflect on the theoretical aspects that sustain them, and from which the problems and solutions exposed in the piece derive. We will start by mentioning the elements that compose it, to approach afterwards the structural or architectural aspects, of which we will say and explain that they are out of time. We will at last analyse the dynamic flux or realisation in time of the elements that constitute the piece.

A Hybrid Quintet

One of the first things that could be said about *Acusmatrix* is that although there is only one performer, it is a quintet, a hybrid one formed by a dancer and four species of European birds, whose singings work as real sound characters in ongoing transformation, creating a genealogy of perceptually interconnected sounds. Each of them (dance and sound) has its own discourse, and the connection between them is the organic nature of dance and the approach of sound as an organism in constant evolution.

Why work with birds? Birds are probably the biggest virtuosos on the planet and their repertoire provides a large spectromorphologic range of absolute contemporariness. The choice of the birds (Silvia Atricapilla, Lagopus Mutus, Tetrao Urogallus and Thachybaptu Ruficollis) was carried out acousmatically[1], i.e. in accordance with the intrinsic sonic qualities of the emitted singing. On the other hand, the choreography has nothing to do with the physiognomy or motion patterns of the chosen birds, but with the sound gesture inferred or imagined through their acousmatic listening.

In the following sections, we will discuss the ways in which the visual and sound elements of this quintet relate to one another. About this relation, we will say that it is not *between* but *before,* that is to say in the very nature of communication, namely in its verbal, paralinguistic, and kinetic parts. Our point of departure lies in the way kinetics has developed sophisticated forms such as dance (Bateson, 1998: 441-455), whilst paralinguistics can give rise to complex musical forms, and in the way both find a common substratum in the notion of gesture. We will then speak about the non-temporal structures that affect the organisation of both phenomena.

Temporal Structures and Structures that Are Out of Time

It is possible that the main difference between architecture on the one hand, and music and dance on the other, be that these latter take place within time, depending on it to happen, since they are both based upon transformation. Each moment is immediately different from the previous in a sound or a body, and as Heraclitus had it, we cannot cross the same river twice. However, architecture is static and does not depend upon the existence of an evolution (even if it is possible that movements be projected or that its structure suffers deterioration).

Indeed, the classic comparison carried out by Goethe between music and architecture focused on that aspect, i.e. that architecture is petrified music, and this could even conversely apply to dance. Yet, it is possible and important to consider certain constitutive elements of dance and sound as structures out of time, and go deeper in the analysis and the construction of symmetries that play an important part in both fields.

We can for example transpose the group formed by the possible rotations or transformations of the rectangle to the sound and dance fields (Varga, 1996: 86-87). If we apply them to a sound or to a series of movements of the body, we also obtain several transformations. We can read them backwards (retrogression), reverse the relation between the intervals or trajectories, what went up before is now going down and the other way around inversion and we can afterwards combine these two transformations (inverse retrogression) The number of transformations that forms the group (four in this case) gives us the level of symmetry that characterises the object in question. If we realise the same operation with the cube we obtain twenty-four transformations, for its level of symmetry is higher.

It is also possible to consider rhythm as a non-temporal structure, as points in an axis: the time axis that can be spatially represented as mileage signs in a highway or a façade's length in meters or centimetres. This is possible thanks to the mental processing that underlies time and space, i.e. the existence of an order in their structure. We can articulate this spatial axis in which we represent time and choose the points on which we will work (since time is a continuous variable, which means that it is composed of, or can be divided in infinite

points), using structures or relationships taken from several disciplines. In the scene *Lagopus Mutus,* the points that articulate the temporal axis arise from the distances between different prime numbers and their multiples. The result is a highly irregular structure, as the period or lowest common multiple, that is to say the point or moment in which the sequence is repeated again, is very far (beyond the duration of the piece). We call this technique an algebraic hoquetus[2] of prime numbers, for they work as modules of residual classes that are algebraic structures we will discuss in the next point.

In short, a musical scale is a *non-temporal* structure, since the vertical or horizontal combination of its elements cannot alter its architecture, whereas a motif or melody is a realisation *in time* of a *non-temporal* construction (Xenakis, 1992: 180-183). Similarly, if we take the set formed by the vertex of a cube and consider them as points in the space that articulate the movement of the body, their structure is beyond the temporal order established between the mentioned points. On the contrary, the technique *theme and variations*, omnipresent in dance and music in the last centuries (including this one), would be solely based on the development of temporal structures, i.e. on the reordering of elements of pre-existent non-temporal structures. This would be the case of the steps of classical ballet, which are recombined over and over work after work, or the case of the instrumental-notational model, in which the different heights or tones of the tempered tuning are obsessively reused and reordered.

Algebra: Dance and Residual Classes

Both in dance and in music the organisation of symmetries (at the spatial level) and of periodicity (at the temporal level) play a role of special relevance, since the capacity of our brain to recognize meaningful structures depends on it. When we contemplate a dance piece, we perceive spatial identities (symmetries) and temporal identities (periods) that work as a plot guiding our perception and activating our intelligence. We can find something similar to this process in astrophysics, which through gigantic radars searches signs of intelligent life under the form of symmetries or periodicities among the chaos of frequencies coming from the exterior space.

Algebra, through the theory of numerical congruences (residual classes), allows us to formulate a theory to construct symmetries as complex as we wish (Xenakis, 1992: 194-200). This system has already been introduced in the sound medium by Xenakis (*Sieve Theory*), yet its application to dance represents a novelty and a challenge. In the sound design of *Acusmatrix* the temporal, tonal-harmonic, and spatial levels are articulated in accordance with residual classes. Such structures are used in the development of movement and constitute the basis for a formalisation of the association between sonic and dance gesture.

We will briefly try to explain what numerical congruences are, as well as the residual classes of which they are derived. Later we will show a possible application to restructure and transform a dance phrase. Concerning their application to the sound medium, we refer to the existing bibliography.

We will say that from the whole numbers, *a* and *b* are congruent with another number that we will call module *M,* when the difference between the two numbers is a multiple of *M*. This relation expresses as follows: $a \equiv b \pmod{M}$. For example, $4 \equiv 13 \pmod 3$ o $5 \equiv 20 \pmod 5$.

A residual class is composed of a module *M* and a displacement *n* from the module in question, within the set of whole numbers *Z*. This residual class will be noted as follows: *Mn*. The module *M* can be any whole positive number bigger than or equal to 0, and the displacement for this module *M* can be any whole number between 0 and *M*-1. A residual class defines an infinite series of points. For example, 5_0 is [..,-10,-5,0,5,10,15,...]. While 5_2 would be [.....,-12, -7, -3, 2, 7,...].

These residual classes can be combined according to logic connectors (union $\vee$, intersection $\wedge$ and negation $\overline{\ }$) to create structures that work as filters, selecting points in the whole formed by the whole numbers, which can represent semitones, quarters of tones, decibels, seconds, milliseconds, meters or any other structure likely to provide an order. They can be, for example, the gestures in which we decompose a dance phrase. Let us suppose that we analyse a phrase and divide it into 13 gestures [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13] and filter it using a residual class that is not a factor of 13, for example: $A=2_1$

The result will be A=[2, 4, 6, 8, 10, 12, 14 (1), 16 (3), 18 (5), 20 (7), 22 (9), 24 (11), 26 (13)]. The period of the phrase is 13, i.e. from this point on the gestures repeat themselves: the 14 would correspond to the first gesture, the 16 to the third, ... (we have indicated this equivalence in brackets). From the 27 on the structure would repeat itself. This would be a simple metabolisation of the original phrase. Let us move on to a more complex example, in which we use the three first modules of the algebraic structure of prime numbers that we mentioned in the previous point, on the basis of which the rhythm of the scene *Lagopus Mutus* develops: $B=5_0 \vee 7_2 \vee 11_0$

The result is a less symmetric and more rarified metabolisation B=[1, 3, 5, 10, 11, 15 (2), 17 (4), 22 (9), 24 (11), 25 (12), 30 (4), 31 (5), 33 (7),.....]. The recombination of these 13 gestures, each time different, would not repeat until number 384, that is not even a multiple of 13 (the period of the original phrase).

We can also take a pre-existent musical structure as transforming element, apply for example the asymmetry of the tempered scale (whose period is 12) to our dance phrase (whose period is 13), through its algebraic definition: $C = (\overline{3_2} \wedge 4_0) \vee (\overline{3_1 \wedge 4_1}) \vee (3_2 \wedge 4_2) \vee (\overline{3_0} \wedge 4_3)$

In this case the period or point in which the sequence repeats would be from 156 on (12x13).

The application of residual classes to the psychomotor field to which dance belongs offers interesting possibilities to carry out an algorithmic development of movement likely to be approached informatically (in choreographic design or to mechanise photograms in the frame of video dance). We can consider each of the gestures as *key frames* of an animated film, which after its algebraic metabolisation will be intermixed with one another (*inbetweening*), and this gives way to a new residual movement that has perhaps never been imagined. This technique (*inbetweening*) also applies to sound transformation, generating a series of intermediate passages between two related sounds (the destination sound can be a transformation of the first). This is the case of the transformation in heavier and heavier metallic objects, one of the recurrent movements in *Acusmatrix*. At this point we have already entered the flux and growth of bodies in time (sonic or not), which makes us focus on the gesture that originates it.

Sonic Gesture, dance Gesture and Acousmatics

Laban stated that the repertoire of modern dance was composed of all the movement repertoire of contemporary man (Laban, 1948). In the same way, we can say that the composing substratum of modern sound art is made up of all the sounds that inhabit the universe, their projection through imagination or the abstract sound realisations of formal systems coming from other disciplines (physics, biology, mathematics...). Let us think, for example, of the infinite human vocal repertoire (Wishart, 1994: 104), the multidimensional articulation of phonetic space associated with variables such as age, breathing rhythm, state of health or attributed sense (irony, questioning, command).

Both repertoires (sonic and motor) lie, originate, and converge in the notion of gesture, dance gesture and sonic gesture, which leads us to reflect on the existence of a substratum common to both phenomena. Gesture relates to tension and muscular relaxation (Smalley, 1997), to effort and resistance, and consists of a trajectory of sensorimotor energy that unleashes a configuration of the body in the space, in the case of dance, or the excitation of a vibratory body in the field of sound. We do not only listen to music; our brain realises inferences in regard to the physical or human activity that gives rise to a sound.

Rudolf Laban carried out an analysis of the internal energetic flux within movement, in a three-dimensional framework that he called *The Dynamosphere* (Newlove and Dalby, 2004: 141), in which he synthesised the infinite motor repertoire of the human body in eight gestures or types of effort, one for each vertex of the cube: *Pressing*, *Flicking*, *Wringing*, *Dabbing*, *Slashing*, *Gliding*, *Thrusting*, and *Floating*. Showing the dynamic development of these eight efforts or basic gestures in accordance with time (sudden-sustained), space (direct-flexible), and weight (light-strong).

These and other aspects of Laban's conception can likewise be considered in relation to the articulation and the nature of sound objects. In a concert we observe how the sound we listen to depends on the sensorimotor coupling of

the musician with the instrument. A violin pizzicato, for instance, originates according to short dabs (*dabbing*) and it is light and sudden, whereas a double-bass glissando glides (*gliding*) and is a heavy sound object sustained in time. We can transpose this analogy to the voice domain, in which the motor activity of the vocal tract organs (uvula, velum, tongue, larynx, teeth, etc.) engaged in phonetic production form a miniature choreography, in which we find these efforts or basic gestures again. If we take as an example the phonetic object 'sl-', we observe how the energy accumulated in 's' (*thrusting*), is followed by a gliding of the tongue over the palate in 'l' (*gliding*).

We can go further and establish an analogy between the physiological gesture produced in the vocal tract and the phenomenon referred by the very emitted term (Curtay, 1983). If we consider the term *slide,* in which we find this phonetic sequence (energetic accumulation and sliding of the tongue over the palate), we can compare it with the referred gesture, that is to say impulse capture and subsequent sliding (that constitutes also a technique or dance step). We have developed these notions in our piece *Catexis,* which is constructed out of phonemic gestures emitted by a dancer, which in their turn constitute the germ of the dance movement and work as a sound bio-extension of the very corporeal movement.

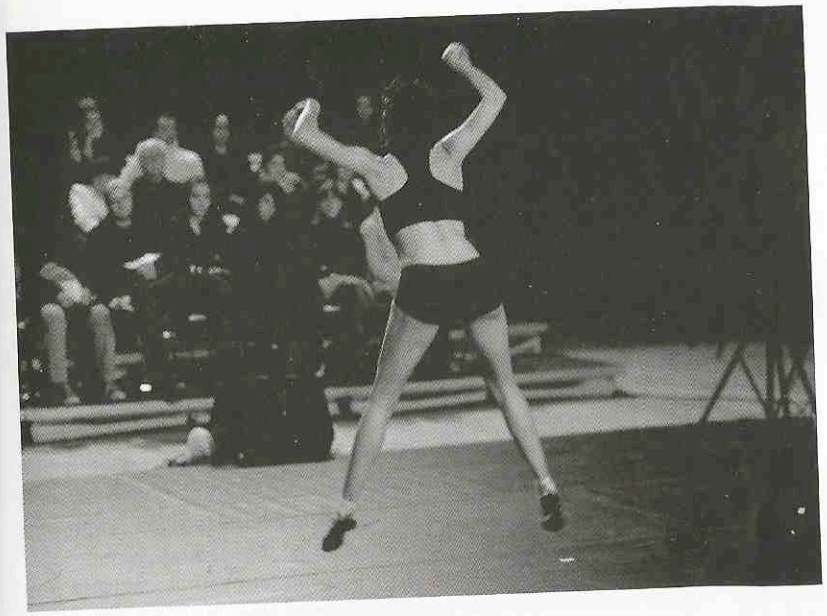
On the other hand, there is music in which we do not see the realisation of the gesture that originates the sound, for it is imagined or inferred, and its mysterious and ambiguous morphology makes us doubt about the causes that originate it. This is the case of acousmatic music, designed in the most part of the cases using electroacoustic procedures and to be diffused in public according to several configurations of speakers that emphasise the character of the work.

By masking the instrumental causes the acousmatic approach produces a dissociation between sight and hearing and induces us to perceive sound forms as such. In *Acusmatrix* the dance metaphorically fulfils that visual emptiness, drawing the Phytagoric curtain and completing the perceptive experience according to a new audiovisual association.

We will now comment on an example of gesture approach in *Acusmatrix.* In the section *Tetrao Urogallus 2,* the wood percussive nature of the singing of the wood grouse is transformed into a heavier and heavier and blunt metal (*light-strong*), whose shock wave gives way to big water-like waves that cross the installation transversally. In the crest of the first wave the lighting reveals the dancer, who is pushed (*thrusted*) onto the stage by the accumulated great sound mass. In the following section we will focus on the way these gestures evolve and interrelate in the space.

Geometry

We can divide the geometric approach of *Acusmatrix* in three parts. On the one hand the configuration of the sound installation that surrounds the audience and the stage, whose layout can vary, depending on the space in which



1. y 2. *Acusmatrix*, 2008. Pablo Palacio and Muriel Romero.
Foto 1: Enrique Escorza / La Casa Encendida. Foto 2: Jota

the piece is performed, between a three-dimensional layout (two rings of eight speakers, one of them in higher position and oriented downwards) and a bidimensional one –a ring or oval of sixteen speakers–.

On the other hand there is the geometry or spatial trajectory that the sonic bodies describe within the space defined by the sound installation, which develop, so to say, their own particular dance. This trajectory or position can be real –the sound is in such or such speaker– or virtual, i.e. we use psychoacoustic tracks to create the illusion of depth or spatial movement –logarithmical attenuation of amplitude, Doppler effect, elimination of components in the higher part of the spectrum–, so that the perceived sound space can be larger than the real space –be it circular, square, spherical, or no matter the geometry described by the position of the speakers. The types of spatial movement that can be found in the piece could be gathered in direct movements, which can be straight or curve and move along the perimeter of the installation or cross its interior, both from the left to the right and from the front to the back and vice versa. In the same way, this type of movement can start in the centre towards one of the exterior ends or the other way around. At the same time, there are cyclic and oscillatory movements that can also be concentric, eccentric or peripheral and describe straight, spiral or circular forms that contract and expand in the space. These types can be combined or also disturbed, and developed in an irregular form until they come to the absence of a perceptible pattern. When we approach these displacements according to time we can obtain constant speed movements that accelerate or decelerate as they arrive to their destination, or also elastic movements that bounce. A last type of special interest emerges when the sonic characters do not move independently but there is some symmetry between the movements of many of them at once. In this case we may have the sensation that it is the reference frame that alters in different ways: compression or expansion, rotation, oscillation or turn over (Wishart, 1996: 195-234). It is important to make clear that spatial trajectories and behaviours have to be associated with aspects related to the dynamic spectromorphology of sonic objects, that is to say, sounds should not be moved in the space just for the sake of moving them. Let us give an example, in which the displacement of the sonic objects also interacts psychologically with the audience. In the scene *Tetrao Urogallus 2*, the original singing is transformed in a liquid mass or sound waves that approach in the darkness, acquiring brightness and intensity and crossing the installation transversally from the back to the front. It is important to take into account that while it is psychologically equivalent that a sound moves from right to left or from left to right, it makes a difference whether the sound approaches from the front or from behind the listener. A sound that approaches from behind can provoke a state of unconscious alertness, since we do not see the causes or intentions that originate it, and having one's back turned places us in a situation of exposure. Of course to a considerable extent this depends on the morphology of the sound in question, which in

this case tends to have that effect because of its dimensions, its unusual character and the intensification due to the darkness in which it appears. In this way, we can introduce as a scenic element a phylogenetic adaptive mechanism of primary character, i.e. not consciously processed.

Thirdly, and as an intersensorial unifying element, there is the movement of the dancer, who in the sound installation keeps its own geometrical discourse in accordance with the corporeal articulation in the space and with the different reactions to the displacement of the sonic characters. Some of these operations consist of plane changes, association of points in the space or construction, rotation, compression and expansion of geometrical figures and anatomical representations of the very body of the dancer (Forsythe, 1999), which set themselves as characters or scattered *alter-egos*, transformed within the scenic space.

Stability and Instability

Dance oscillates between balance and unbalance. The residual movement that emerges out of this situation is to a good extent aleatory and chaotic, creating complex and irregular forms that our capacity of perceptive processing is not able to structure in a pattern. The articulation of the degree of ataxia[3] in accordance with time provides interesting and intense choreographic possibilities with deep sonic implications. The dynamic flux between order and chaos can easily be transposed to sonic space, since we perceive as noise the sound objects whose spectrum is completely instable from the point of view of their physical components or frequencies, i.e. that does not present a pattern that repeats in time, and we consider as harmonic the sounds whose spectrum is stable, for mathematically it means that its partials or components are ordered within a distance of integer multiples. On the other hand, we can also use a probability function that gradually disturbs the periodicity or regularity of sound objects in the temporal axis, until we reach an absence of period or rhythmic chaos. *Acusmatrix* develops several situations in which dance and sound evolve in counterpoint manner in this axis, which moves from order to disorder and vice versa. In the section *Tetrao Urogallus 2*, the rhythm and the spectrum evolve stochastically[4] from order to chaos. At the same time, dance moves between balance and instability, weaving clouds of points interconnected in the space, which create a more and more intrincate plot that affects its balance.

Time is a continuous variable, and it was approached accordingly in the previous example. We could divide it into seconds and know exactly how many went by, but not how much time has flown between each second. Besides, the articulation of a continuous variable in discrete steps offers an illusion of control that brings about the counterpart of a loss of information, because of the discontinuity that takes place between each of the chosen values or points. Similarly, the piano keys that relate to the tempered scale are twelve points in a continuous ocean of infinitely divisible frequencies, just as the origin of the

musical measures is due to an attempt of baroque dance to control the quantity of time spent in a step sequence. In the next point, we will consider the slippery nature of forms within time and space, as well as some of the solutions or techniques used in *Acusmatrix* to try to reflect on their flux and growth.

Morphodynamic Trajectory

As we said before, both the movement of the physical body and the sound sent out by vibratory bodies are the result of a trajectory of motor energy that gives rise to a form in the space, in the case of dance, or generates, in the sound domain, a mechanical energy that displaces the air around. This trajectory is a dynamic flux within continuous space, in which crossing forms in constant transformation take place. Likewise, the forms of the live beings that we perceive are the result of a process of permanent transformation of which we capture a snapshot that is but the flux of time captured in space. We can also capture a dance step or *freeze* or suspend the development of sound in time, arresting its changing spectrum in a determined moment (*spectral freezing*). This technique is used in one of the scenes of *Acusmatrix* (*Silvia Atricapilla 1*), in which the singing of the Sardinian warbler is frozen and suspended in time and space, giving way to a dialogue with the dance, which proposes a series of geometrical rotations as response. However, *Acusmatrix* emphasises the development of forms based in ongoing transformations of sound objects and the transposition of this morphic flux to dance movement.

For example, in the beginning of the scene *Tetrao Urogallus 1,* the percussive sound grain of the original singing is repeated throughout time, following a rhythm that accelerates exponentially until the distance between each of the events is so small that they melt in a sound line that increases its tone and displaces across the space, modifying the body of the dancer with its trajectories (reducing the period makes the frequency increase, for the relation between them is inversely proportional). We go from individuation to coalescence, from a moment in which we are aware of the number, order, and position of each of the events to another one, in which we perceive a mass whose proportions increase or decrease. This transformation is interesting because it realises a transition between two forms of perceptual processing that relate, moreover, to different parts of our brain. The initial individual events are numerically processed within the left hemisphere of our brain, which relates to digital calculation and counting, whereas the sound mass that results from the dense agglomeration belongs to the world of analogical and probabilistic calculation, which is the domain of our right hemisphere. In this way, we are composing a transformation that affects not only sound and visual events, but also the perceptive mechanisms engaged in their processing.

Conclusion

Until now we have talked about some processes that underlie the creation of *Acusmatrix*. It is important to make clear that when we talk about an artistic piece we can analyse the processes but not the result, which is always too complex to be submitted to the digital logic-analytical capacity of the left hemisphere of our brain. What is said about it, what it is, or the sensorial experience it gives way to are different things, although it is more and more obvious that the importance of things in our society depends on what can be said about them. No wonder that contemporary art has gone through a rationalist tendency, to such an extent that the essence of a work can be in the commentary or explanation that the artist provides. The other side of this phenomenon would be the inhibition felt by the *layman* watching a show of which (s)he does not know what to say (or what should be said...) and (s)he apologises for it. Notwithstanding, our capacity of conscious analysis is a drop in a sea of unconscious processes, and the combination of rational and intuitive mechanisms necessary to any creation process has a lot to do with this fact. Sometimes we get to new and interesting forms and transformations in an aleatory and unconscious way, in the same way as changes or mutant forms arise stochastically in the evolution of organisms. We can use the knowledge that scientific psychology provides us to think and reorient the process of artistic creation on the basis of the real potential of processing of the human being. As Milton Erikson said, it is important for people to know that they are more intelligent than their conscious apparatus, for one of the dominant impulses in human nature consists in segmenting, controlling, and reducing the experience of the world that surrounds us to permanent and stable categories.

It is possible to see and hear examples of *Acusmatrix* and *Catexis* in http://pablopalacio.com/SONIC_DANCE_.html

Translated by Paula Caspão.

Notes

[1] Acusmatic: the name given to Pythagoras' disciples, who for five years have listened to his lessons without seeing him, hidden behind a curtain and observing the most rigorous silence. Adjective: refers to a noise or sound that one hears without seeing from where it comes (Schaeffer, 2003: 56).

[2] Hoquetus: a stylistic device that has its origin in the polyphony of the 13th and 14th centuries, characterised by the distribution of the melodic line among separate voices, so that when one of them sounds the others keep silent. In the commented example (*Lagopus Mutus*), this relation is achieved by using prime numbers, which are only divisible by themselves and by the unit. The result is that dance does not move with the music but bouncing against it.

[3] Ataxia: lack of order or organisation (*taxis*). It also refers to the lack of coordination of the limbs or parts of the body.

[4] Stochastic: process in which the passage from a state into another is defined probabilistically.

Bibliography: See p. 51.