Chapter 6
The Morphogenesis of Language and Morphodynamic Grammar

Abstract Language is the most prominent symbolic form and has been the focus of classical philosophy and semiotics. This book has placed the main focus on three symbolic forms, music, art, and myth/religion, because embodiment and morphogenesis are better expressed via these forms. The current chapter will complete the picture and view language from the same perspective as music, art, and myth/religion. The first section discusses an array of predispositions for the morphogenesis of human language, a possible intermediate step called protolanguage, and the route toward historically documented languages. The following chapters sketch a morphogenetic view of the grammar of human language with an emphasis on the lexicon and syntax. In this part, the author's research on René Thom's proposals for topological grammar is summarized, actualized, and elaborated.

6.1 Biological Predispositions for the Morphogenesis of Human Language

In the first section, conditions for the morphogenesis of human language capacity are discussed, and the fundamental bifurcations in the evolution of the language capacity common to our species (Homo sapiens) are specified.[1] Preadaptations for language are evolutionary and morphogenetic processes not directly leading to human language. Instead, they are selected for locomotion advantages, the correct detection and categorization of objects and events in the environment, and the stability and the further evolution of social relations (for instance, progeniture, child care, and social cohesion). In the evolution of human language, these factors continue to be relevant and eventually co-evolve with language capacity.

---

[1] Cf. Wildgen ([74, 75]: Chap. 2: 5–24) for major scenarios of language evolution. Results published after 2004 are summarized in Fitch [23], Dor et al. [20]. The author has also treated some questions concerning the evolution of language after 2004 in Wildgen [77–80] and Wildgen 2010).

W. Wildgen, *Morphogenesis of Symbolic Forms: Meaning in Music, Art, Religion, and Language*, Lecture Notes in Morphogenesis,
https://doi.org/10.1007/978-3-031-25651-6_6

523592_1_En_6_Chapter ✓ TYPESET ☐ DISK ☐ LE ✓ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

In evolutionary biology, the phenomenon of predisposition or pre-adaptation is known in various species. Cognitive evolution (e.g., of the brain and the sensory organs) probably had a specific advantage in the sensory and motor field. The increased imitative faculties and memory enhanced learning and the establishment of rituals and culture. Walking upright and transforming the forehead and the mouth produced the typical phonetic apparatus of man between the vocal cords and the lips. As language capacity involves motor, sensory, and neural abilities, all three domains must be investigated in terms of pre-adaptation. The development of the larynx is possibly the most specific predisposition.

We distinguish three phases: the predispositions for the morphogenesis of human language, an assumed intermediate stage called protolanguage, and the human language capacity that was decisive for the constitution of the species Homo sapiens.

6.1.1 Motor Programs as Predispositions for the Morphogenesis of Language at an Early Stage

The motor patterns of chewing and breathing could have been sophisticated to develop motor patterns of vocalization. The development of mirror neurons enabling quick learning (copying) of motor patterns from other individuals of the same species would have allowed the quick adaptation to traditions or rituals of vocalization (languages).[2] Possibly a gestured language preceded the syntactic organization and fine motor skills of vocalization and articulation. As soon as the muscular control of hand movements was achieved and learning capacities were increased, partial and ritualized hand movements could support semiolinguistic activities on a gestured basis.[3] Corballis (2009) suggests a sequence of evolutionary steps based on the function of mirror cells in the human lineage. He assumes the following steps:

1. Grasping of objects (non-human primates).
2. Facial gestures.
3. Manual gestures (in the miming of events).
4. Conventionalization of gestures (Homo erectus 2 my BP).
5. Phonic language and the capacity of episodic memory.
6. Mental time travel: Who did What to Whom, Where, and Why?

Evolutionary steps corresponding to (1) and (4) to (6) will be the focus of morphogenetic grammar in later sections of this chapter. The difficulties of such a sequence

[2] Lewis [43] reports that Ba Yaka pygmies, hunter-gatherer societies in Central Africa, imitate not only other members of the group but also animal sounds, nature sounds and the sounds of foreigners. Similar conditions probably prevailed in hominin species that lived in forests or at the rim of forests.

[3] Condillac had already considered the hypothesis of a gestural origin of language in the eighteenth century. The plausibility of this hypothesis stems from the parallelism between the gestural communication of deaf-mute persons and the vocal communication of humans without such disabilities. In the twentieth century, Allott [1–3] advocated such a model. The cognitive parallelism of gestures and language was also prominent for McNeill [44].

of scenarios are that transferring motor capacities to language would have created a conflict in using resources (muscular, respiratory, and cerebral). As cerebral resources are very costly, such a transfer is only possible if it “pays”. Therefore, one needs a causal/dynamic explanation in which social demands for these changes or other functions involving the survival context or social dynamics are empirically proven (there should exist an immediate payoff). As an alternative or in addition, one can draw on the dynamics of self-organization, enforcement, and rapid selection (cf. hypercycles in the sense of Eigen and Schuster [21]) and others. Evolutionary psychology has followed the first route but remained inconclusive because the payoff is only plausible for specialized, technical contexts, and even in actual language use. The following sections investigate the second route because it fits into the frame of morphogenesis.

The auditory, visual, olfactory, and tactile senses and motor schemata are necessary for creating stable object concepts and the construction of relations between these. They allow the evolution of a stable semantic framework in natural languages. Gibson ([24]: 46 f.) says:

> Similarly the ability to construct an object image from varied properties is absent among reptiles but present among most mammals. All monkeys and apes construct visual object concepts. Only the most intelligent primates, however, (Cebus monkeys, some baboons and macaques, and all great apes) construct and manipulate relationships between two or more objects. (...) Only humans, for instance, use tools to make tools or construct tools from multiple raw materials and then apply these tools in a second goal-directed object–object manipulation. Humans also by far exceed other primates in their ability to construct objects hierarchically.”

The capacity of relational thinking enables complex strategies in the search for food (memory for places, categories of food, time of ripeness, and value for different purposes). It is helpful for the preparation of food (cutting, grinding, cooking) and improves the faculty of collective hunting. Social relations may be better controlled, coalitions and power positions independent from actual force can be managed, and intrigues, strategies, and politics can be devised. Language may have become a primary faculty in the context of this increase in instrumental and social intelligence. The behavioral and social consequences of such a cognitive evolution created the conditions under which linguistic competencies “paid”, i.e., they triggered a Darwinian scenario that selected individuals or groups based on linguistic skills. In such a scenario, the (latent) language capacity could have made decisive steps at the time of Homo erectus (ca. 2 million years BP = before the present), allowing the migration of this species to Eurasia.

The growth of the brain is a general survival strategy and represents a trend in the evolution of mammals from basic insectivores upwards. The first massive pressure toward bigger brains occurred during the transition to active daylight hunting in the trees. The major transition occurred when early hominids adapted to life in the Savannah (or the borders of forests) by walking upright and hunting as groups. The cortex and, at a different rate, the brain stem grew most quickly. The temporal lobe and later the frontal lobe increased specifically in the cortex. Linked to the temporal lobes and their growth, the asymmetry between the hemispheres also increased. This feature was not "new" for humans but involved a quantitative change, which may have triggered qualitative and functional changes.

A larger brain involves a set of preconditions and consequences. First, brain size depends mainly on in-utero growth in contrast to the growth of bones and, thus, overall body size, which depends on nutritional and environmental conditions after birth. Second, in-utero growth is controlled by the energy supply available to the mother, e.g., the quality of her food. Therefore, a change in hominid diet was the primary precondition for an increased brain. Third, the individual growth dynamics of the brain and body are another key to language evolution. The birth of the human body in a relatively early stage of brain maturation and the considerable difference in brain plasticity and adaptive capacity compared to chimpanzees constitutes an important pre-adaptation for language use and language learning.

The change in the geometry of the larynx is one of the preconditions for spoken language, and it separates two major concavities; the tongue, which moves between them, can regulate the proportion between these "resonators". This proportion controls the formants, i.e., the central frequency bands of vowels. Thus, the articulation of vowels and velar pharyngeal consonants is due to the deeper and vertically transformable larynx.[4] The reduction of the temporal muscles in humans is another significant feature in the evolution of the phonic repertoire (cf. Fitch [23]: 263). The vertical position of the teeth and the closed circle of teeth in humans make the articulation of frontal consonants (dental, alveolar) possible.

In general, it seems that many anatomical and cognitive dispositions for a spoken language were already present before the separation of the lineages of Neanderthals and modern humans. Calculations based on the mutation rate in mitochondria point to a period of 660,000 ± 140,000 years BP and for the DNA of 440.00 to 270,000 years BP (cf. Dediu and Levinson [19]: 188).[5] It fully evolved in the phase of species formation. Still, it could have remained dormant until dramatic changes in the ecology or migrations out of Africa and inside Africa triggered a quick expansion of linguistic competencies and led to the divergence of languages with the distance of the migration routes.[6] Those who argue that language evolved later, say around 50,000 years BP, must reintroduce some (God-given) miracle or some macro mutation incompatible with evolutionary biology.[7]

[4] The nursing baby can still breathe and drink simultaneously because both pathways are independent. A sub-velar position of the epiglottis has also been observed in other primates (cf. Starck [54]: 586).

[5] Based on climatological data and a computer simulation of benign conditions for different species of hominins Timmermann et al. [58] suggest that the evolution of Homo sapiens is located between the disappearance of the Homo heidelbergensis (415,000–310,000 y. BP) and the appearance of Homo sapiens (in the archeological findings) 300,000–200,000 y. BP.

[6] At the genome level, Neanderthals and Denisovan hominids share the variant of the FOXP2 gene that distinguishes humans from chimpanzees. FOXP2 is a gene that was shown to be responsible for disabilities in language development if defective, cf. Fisher [22].

[7] Chomsky [17]: 58) assumes that 100,000 years ago, there were no languages, but about 50,000 years ago, the human language existed in many forms. He writes:"The evidence is compelling that since then the language faculty has remained essentially unchanged" (ibidem). In Hauser et al.

523592_1_En_6_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

Motor programs and their further morphogenesis are linked to the emergence of stone industries in the history of the human species. The first stone axes were produced around 2 million years BP. They make up the so-called pebble culture. Artifacts not only hint at the cognitive level of humans, but are also linked to social life. To produce artifacts and to keep fire, a socially organized exploitation of the environment, a division of labor, and a mode of the social distribution of products must be in place. This capacity requires rules of collective behavior, and language is the prototype of rule-governed social behavior; it not only helps to represent and enact social behavior, but it is also *the central* symbolic representation of social behavior.

The following section summarizes major bifurcations in the morphogenesis of the language capacity of pre-humans and humans. Bifurcation presupposes periods of structural stability, a transition zone, often dependent on aleatory and multiple causes, and a phase of structural stabilization after the transition. Therefore, adequate models must contain concepts of structural stability and abrupt changes (catastrophes). The mathematical models proposed by René Thom, Hermann Haken, and others are the proper background for such an analysis. We shall, however, limit mathematical arguments to a minimum.

6.1.2 Bifurcation Scenarios in the Morphogenesis of Language Capacity

In higher apes (e.g., chimpanzees), one finds two means of social communication: grooming (lousing, caring for one another) and social calls. The (manual) grooming mode dominates, consuming about 20% of the budget. The critical transition (from the common ancestors of chimpanzees and men to australopithecines) was probably a dominance shift due to larger groups (cf. Dunbar 1997) and richer social connectivity in groups. Moreover, the loss of fur, probably due to an adaptation to long-range running during daytime under the sun, reduced the grooming functionality. This development already began 4 million years before the present (BP). As a result, phonic communication was more time-economic, and phonic contact with socio-emotional content largely replaced bodily contact.

Figure 6.1 illustrates this shift of dominance, which had to cross a point of symmetry.

Studies of the behavior of apes in the wilderness have shown that some species have a simple system of calls with referential functions. They allow the other members of the group to distinguish different dangers. These may stem from animals like eagles (attacking from above), carnivores (e.g., lions attacking below), and snakes (creeping

([29]: 22–26), a language faculty in the broad sense (FLB) is separated from a language faculty in the narrow sense (FLN). The latter is a computational faculty, including recursion and discrete infinity. As in the basic publication of Chomsky [15], language is reduced to a set-theoretical automaton, excluding all questions of reference and social function.

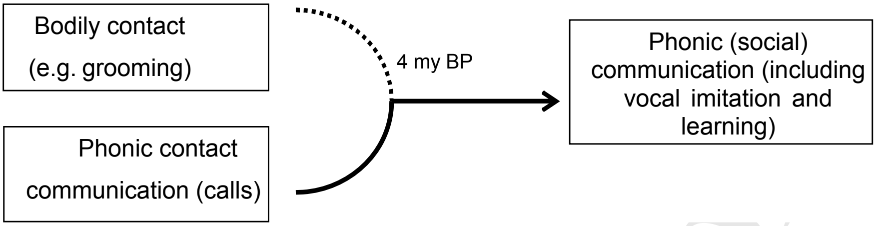

Fig. 6.1 The dominance shift made social phonic communication the central technique of social control and management

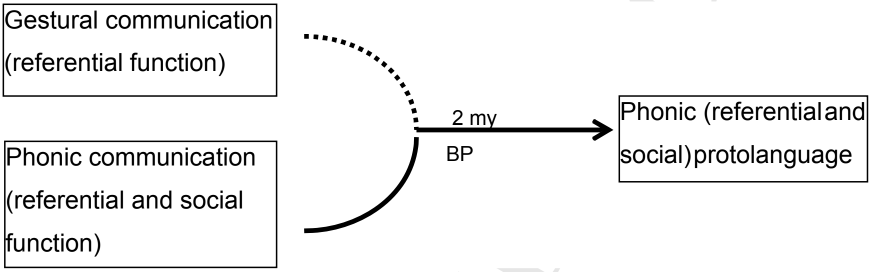

Fig. 6.2 The dominance shift from gestural to phonic in referential communication

in the trees).[8] Parallel to this simple system, bodily motions, gestures, and gaze directions give communicative cues, which allow for a spatial interpretation. They can thus be elaborated into a "language" of body postures and gestures. Therefore, the rich system of gestural signals was functionally parallel to a poorer system of calls.[9] For example, let us take the gestures of the hand. It is clear that as soon as hands are fully occupied with other functions like carrying tools and objects, or if communication occurs in the dark or at a distance (with obstacles between), the gestural "language" is ineffective. As such circumstances probably prevailed in the ecology of the australopithecines that lived in the savannah, and as the ear had to increase its capacity for discrimination due to the permanent danger of carnivores in the environment, the bimodality between reference by gesture and reference by phonic articulation shifted toward the latter. Figure 6.2 illustrates this transition.

[8] Hauser et al. ([29]: 31) argue that the calls lack intentionality and that the animals (velvet and rhesus monkeys) are only able to extract information from the acoustic signals. As we cannot interview monkeys, the question of intentionality must remain open. It would, however, be sufficient if a cooperative practice was genetically prepared and quickly developed in these species. Brain scanning results show that learning does not presuppose consciousness, thus even very low levels of consciousness in hominids would not preclude social learning of signs and their meaning, cf. Henke et al. [30].

[9] Kendon [36] shows that "some of the important capacities for the oral-vocal actions required for speech can be found quite widely in various non-human primate species, suggesting a long evolutionary history." (ibidem 73).

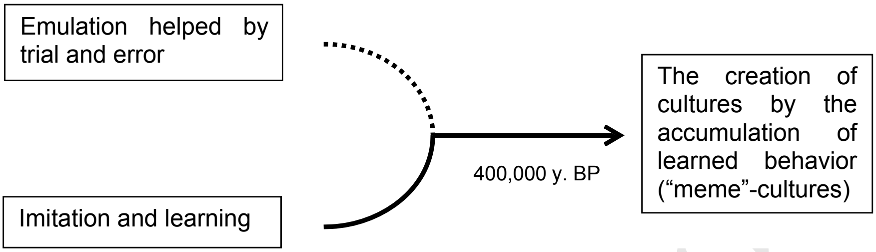

Fig. 6.3 The bifurcation which separates simple cultures based on emulation and "meme"-cultures[10]

The result of this functional evolution lies midway between biological and cultural evolution insofar as the repertoire of manual behavior in grooming and gestures and the repertoire of social and referential calls is acquired. Relatively to higher apes, the resulting protolanguage probably contained a rather large "lexicon" of social and referential calls (e.g., about 30 to 50 patterns), with different types of evaluative modulations (social calls) and categorical distinctions (referential calls). This stage prepares a referentially motivated sign architecture, i.e., language.

The capacity for imitation of phonic material, quick and stable memory entries and corresponding search procedures, and semantic network-building faculties presuppose a better-organized brain (cortex, centers of auditory and visual detection) and enough space (synaptic connectivity) to build a memory that associates phonic patterns with other (visual, olfactory) cues. This evolution leads us to a third bifurcation. It concerns imitation and learning in the case of motor behavior and symbol use. The baseline is defined by the presence of mirror neurons in higher primates and their capability of quick motor learning and motor control (cf. Rizzolatti and Arbib [51]) and the rise of a theory of mind in late hominins (e.g., chimpanzees). The bifurcation occurs between simple emulation and stable cultures with rich traditions. Simple "cultures" of tool use have even been documented for chimpanzees (cf. Boesch [10]). They are still linked to immediate success (reward) but prepare a more general strategy of imitation and learning from others without immediate pragmatic support (or "grounding"; cf. Cangelosi et al. [13]). In computer simulations, this distinction is called the "toil" versus "theft" strategy. In the case of symbolic learning, a label is either learned concerning its referent via trial and error or "stolen" from the symbolic behavior of others (the semantics are filled in later). Human infants systematically are "symbolic thieves" in the sense of these experiments. Human cultures accumulate information transmitted without being applied and tested extensively by every user. Dawkins called this information "memes"; cf. Blackmore [8] (Fig. 6.3).

The phonic protolanguage that integrated social and referential communication and was able to receive and transmit the accumulated cultural knowledge must have

[10] These bifurcation schemata were the content of a conference in Alicante and a publication in Spain; cf. Wildgen [79].

reached a first plateau, which was sufficient for the survival of this new species[11] and allowed its migration into Eurasia and its diffusion into Africa (Homo sapiens). The biological morphogenesis underlying the emergence of the language capacity of all human populations asks for this process's unusual rapidity and effectiveness. In the following section, we consider the hypercycle hypothesis introduced by Eigen and Schuster [21] in the context of the evolution of life on earth to explain the rapid evolution of human language.[12]

6.1.3 Autocatalytic Dynamics and the Evolutionary Hypercycle

The autocatalytic features are evident in the case of viral replication and variation, given the extreme efficiency of these systems. The simple catalytic cycle uses some catalyst (mediator) in the environment, and the rate of replication depends on the concentration of the catalyst. In the case of hypercycles, the system produces the medium (catalyst). As a consequence, the rate of replication does not grow exponentially. Instead, it grows hyperbolically, which allows for rapid evolutionary processes. However, hypercycles have other essential features:

- If different replication systems co-occur, the hypercycle can bind them together, eliminate rivaling (not bound) processes and stabilize the cooperative system (the hypercycle is a synergetic system; cf. Haken [26]: 315 f.).
- The whole cycle acts like one unit, rivals other hypercycles (if they exist), and eliminates less organized processes.
- The single systems bound by the hypercycle can still work with low complexity, but the cooperative system has access to higher levels of complexity.
- The hypercycle can reach optimality without external selection pressures.

Despite these advantages, hypercycles are endangered by changes in the external milieu. Suppose the biological or symbolic system survives for some period. In that case, it can trigger an all-or-none decision in the evolutionary line because all alternatives have been eliminated, and further evolution cannot return to an earlier situation. The evolution must follow the direction chosen during the operation of the hypercycle. In a sense, the hypercycle reduces the potential for selection and determines long-term evolution. It leads to a sequence of steps that seem to follow

[11] Although we know nothing about communication in Homo erectus, the principle of evolutionary continuity (on which Darwin founded his theses) motivates the hypothesis of a *protolanguage*, i.e. a way of phonic communication that prefigures the language typical for our species. For example, it could correspond to children's one- and two-word utterances in their early second year of language acquisition or rudimentary pidgins.

[12] This hypothesis was first presented at the conference "The Cradle of Language" (Stellenbosch, South Africa, 7th to10th of November 2006) and published it in an elaborated version in Wildgen [77].

523592_1_En_6_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

logically from an underlying principle. It looks like an intelligent design, although it only exploits natural processes and obeys the laws of nature.

Non-coupled self-replicative units guarantee the conservation of a limited amount of information that can be passed on from generation to generation. This proves to be one of the necessary prerequisites of Darwinian behavior, i.e., selection and evolution. Similarly, catalytic hypercycles are also selective, but in addition, they have integrating properties, which allow for cooperation between otherwise competitive units. Yet, they compete even more violently than Darwinian species with any replicative entity not being part of their own. Furthermore, they can establish global forms of organization as a consequence of their once-for-ever-selection behavior, which does not permit a coexistence with other hypercyclic systems, unless these are stabilized by higher-order linkages' (Eigen and Schuster [21]: 6).

The most dramatic difference between physiological microevolution and symbolic (linguistic) macroevolution concerns the fact that the first one stores and activates the phylogenetic memory of a species, whereas the latter stores the historical/cultural and the individual/biographical memory. The exciting feature of catalytic and hypercyclic organizations is that they enable faithful replication and dramatic selection by their hyperbolic growth. This means that all types of organizations, not part of an operative hypercycle (i.e., all competitors at a lower level), are repressed. In the following, this promising but abstract model is filled with further details from human evolution. One can choose two application routes: cognitive (neural) and social (cultural). The cognitive and the social route enter a cycle of coordination, which tends to induce individuals to select cultural content as cognitive content and to eliminate much potential content which is not socially relevant. This strongly selective (hyper) cycle may be called socio-cognitive. In the two periods in which new behavior surfaced (cf. at the stage of Homo erectus and Homo sapiens), the socio-cognitive hypercycle has selected humans for symbolic competence. In the co-evolutionary system between a cognizable ecology and symbolic competence, the following hierarchy is plausible:

(a) Already in the last common ancestor of chimpanzees and humans (LCA), contextual space acts as an external memory of affordances, which is indexically given by paths of social locomotion and predator/prey-locomotion, harvesting locations (and times), dangerous locations, places for sleep, courtship, housing, and frontiers of territories. Moreover, these indexically loaded areas and places function as a catalyst of social action as they coordinate social perception and action.
(b) As soon as social space is more organized explicitly concerning its perception and social use, it unfolds in a cycle of social "investment". Architecture and the spatial organization of a village (or later a town) are clear examples. This level is autocatalytic as the spatial organization becomes a cyclic structure in which different functions cooperate. Figure 6.4 sketches such an autocatalytic cycle.

In each subspace, specific symbolic media are evolved. Thus, the painted Paleolithic cave (in the Franco-Cantabric culture) is a specification of the mythical/ritual space and is also connected by its illusionist paintings to the outside space of hunting. The relation is iconic, indexical (in its magical impact), and symbolic (in its abstract

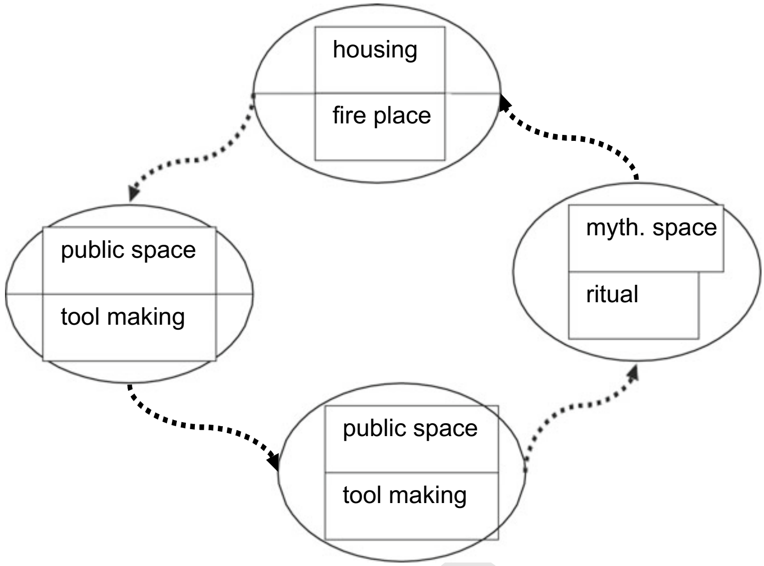

Fig. 6.4 Symbolically invested subspaces (above) and possible symbolic functions (below)

signs; cf. Wildgen [74]: 80–83; [75]). The dark, painted cave points to cave openings, and later, huts where people live. The open space in front of the cave openings or huts is a public space where the production of artifacts and the distribution of shared food occur. This public space borders the open field of chasing and harvesting. Human action patterns occur inside a specific space or make the transition from one space to the neighboring one. In rituals, the core of these action patterns is fixed. The coding of action patterns by rituals is a social preparation/presupposition for linguistic rules/grammar.

In further development, a new level of symbolic consciousness is reached when different symbolic modes (e.g., languages and myths) clash, e.g., in the large Neolithic societies of Egypt and Mesopotamia. The single fields in Fig. 6.4 reorganize in a hypercycle that produces a new, standardized symbolic system, e.g., a codified religion and a written language. Possibly the Franco-Cantabric culture (35,000–13,000 y. BP) and the Sahara cultures (later) had already reached this level. However, as the code of their abstract signs cannot be deciphered, this hypothesis cannot be substantiated.

In the course of cultural evolution, the effects of integration imply a network of symbolic forms. Symbolic forms are the manifestations of social knowledge, and language is the most prominent symbolic form that codes social knowledge. At the "higher" levels of learning, processes of self-organized reconstruction play a decisive role. Specific institutions had to be created to stabilize the social knowledge level or even increase it. The new codes called "religious code" and "written language" are at the heart of such institutions (cf. Chap. 5).

The symbolic forms are multiple and, in their specific elaboration, they are not species-universal, i.e., every separated community develops different symbolic systems, for instance, languages and dialects. Nevertheless, they are comparable via common principles of morphogenesis applied at different ontological levels (cf. Chap. 7).

6.2 The Semantics of Space and Time in a Protolanguage

One can distinguish two aspects: processes in space, such as spatial orientation and navigation, and temporal classifications and rhythmical patterns. The representation of *space* has to do with frontiers (their transition) and perspectives. A first perspective is centrifugal, i.e., starting from the self and its bodily motions and locomotions, an 'experienced' three-dimensional space is cognized: in front of–behind (go), above–below (climb, fall), and left–right (grasp with the left hand or the right hand). This space of bodily motion with feet and arms defines the immediate space where objects may be approached, reached, and manipulated. The intermediate space depends on man's ecology; it can be the housing; first, the cave, the shelter ("abri"); later, the village; the distal space contains roughly all possible itineraries (of hunting/gathering). The second perspective is centripetal, i.e., the self is seen as the place of effects triggered by external causes. The sky, the horizon (specific points where the sun sets or rises), the favored direction of winds, and the ridge of mountains may be the external locus of orientation for the self, who is at the center of a force field implicit in these delimitations. Many myths and religions refer to this extreme locus of orientation as they interpret the fate of humans as standing under the control of such distant (and often invisible) forces. The cognizing of such schemata for orientation may only show up in behavior (as it does in many animals), it may be gestured, or it can be deictically organized in a phonic language.[13] For the Homo erectus, the cognizing space is clear. The inner space is defined by hands and instruments, and the medium space by choice of dwelling places (to which the group could return). The centripetal organization is involved in long-range excursions and migration. As the orientation system cannot be genetically coded, it must be learned, adapted to changing contexts, and socially shared. Language is one possible solution to this problem, be it gestural (behavioral) or phonic. As humans have chosen the path of phonation, it is plausible that our ancestors began to proceed in this direction.

A protolanguage must categorize events and actions (by proto-verbs) and discriminate stable entities (by proto-nouns). The question arises as to whether temporal, dynamic, quantitative, and qualitative *relations* between them can be mastered, and if so, to what degree.

[13] Cf. the research on types of orientation in different ethnic groups, e.g., research conducted at the Max Planck Institute of Psycholinguistics, Nijmegen by the group of Prof. Levinson; cf. Levinson [42].

The manufacturing of stone tools (and *a fortiori* of tools shaped with the help of stone tools) goes cognitively beyond the basic grasp scenario. One hand (or one foot) must fix the pebble, and the other hand grasps the stone or bone which hits the stone. Finally, the planned breaking off subtracts material from the chosen stone and produces the desired sharp edge of the pebble after several strokes. This scenario involves two objects, two hands, and a change in the shape of the pebble (the separation of parts from it). Additionally, it manifests a branching sequence and iteration characteristic of the syntactic organization in natural languages (cf. phrase structures and repeated embedding).

6.3 The Morphogenetic Transition Between a Protolanguage and Full-Fletched (Modern) Languages

Our empirical knowledge concerning languages is based on the observation of historical languages documented in writing (e.g., Sanskrit, classical Greek, Latin, or Arabic) and the research on living languages, dialects, and sociolects. Therefore, hypotheses concerning unwritten, prehistorical languages and a fortiori, the stadium of protolanguage, must extrapolate our knowledge about known languages and refer to more general principles known from biology or neurology. Therefore, such hypotheses are just well-informed guesses. Nevertheless, they contribute to a global view of human cognition and culture and are relevant.

6.3.1 The Self-Organization of a Grammatical System

Self-organization is a principle formulated in the framework of cybernetics Ashby [5] and involves the search for a stable state in a deterministic system. As already programmatically expressed by Norbert Wiener [65], it is extrapolated from physical to biological, eventually symbolic systems. Moreover, in morphogenesis, equilibria and attractors (stable states) are also central notions. Therefore, self-organization and morphogenesis follow a similar strategy of explanation.

Kirby [37] argues that compositionality (and thus syntax) can already emerge if the size of the lexicon (meanings associated with linguistic expression) increases. “The number of meanings covered increases dramatically, as does the size of the grammar” (ibid. 313f). Steels [55] simulates language evolution based on evolutionary games. A stable state emerges when the number of meanings increases, and due to organizational economy, the size of the grammar drops. Given the lexicon’s specific size and the transmission dynamics (learning), languages tend to evolve a rather general syntax without any pressure from environmental or sexual selection.

Fitch ([23]: 385) is skeptical about the relevance of computer simulation for studying evolution. He writes: "In practice, however, the demonstration of a theoretical possibility does not by itself, tell us how the pattern was 'discovered' evolutionarily". This is true,but if we cannot observe or find documents of such a discovery, we must still choose between different theoretical possibilities. The simulation provides better arguments than aprioristic deductions from definitions like "recursive power" or the necessary existence of universal grammar (in Chomsky's tradition).

The purely syntactic problem of chaining elements of an existent vocabulary does not require a specific endowment and evolutionary processes enabling it. The real problem is semantic compositionality because the composition or blending of spaces with different topologies and the account of the dynamics inherent in verbs is crucial for sentential units. This tremendous problem must be resolved to allow stable and reliable communication via phrases and sentences. To arrive at a conventionalized system of syntactic behavior, early humans had to consider two major factors:

- The cognitive demands for a stable solution of semantic compositionality,
- and the communicative and social demands for a compositional level of referentiality.

The solution to this problem is the *gain* of the evolutionary game called human language.

Even if the cognitive capacity was given, human society must still have a strong demand for high performance. Probably rewarding situations often arose by chance, and the evolving species spontaneously used the "dormant " capacity. As soon as a protolanguage was developed, it brought about long traditions of language usage up until modern times. The central question is not how syntax came about but what made it rewarding to use the available cognitive potential for syntax. The payoff can be a social or an individual one (which can lead to higher social competence and thus to social gain). A plausible model for such higher communicative demands due to social evolution is still missing.

6.3.2 Further Steps of Complexification in Language

Sentential patterns may be elementary even in human languages, e.g., in pidgins, in learner languages, and even in standard languages with broad usage (e.g., the so-called minimal languages analyzed by Gil [25]). Human utterances are, however, not restricted to isolated sentences. On the contrary, natural units are sequences of sentences, so-called turns in conversation, adjacent pairs as in question–answer, and narratives or arguments. A fundamental problem concerns the stratum of language (from phonology to discourse) to which a selection process applies. As this is usually the level of holistic behavior, we presume that textual behavior is the proper level on which selection effects play a role. Therefore, human evolution must have been selected for the effective use of language in social communication and not at the level of sentences or words. These levels are only selection relevant insofar as they allow

523592_1_En_6_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

the construction of coherence in narratives, descriptions, or arguments. The increase of the lexicon and the availability of case-frames (action–schemata) and spatial categorizations establish the source domain, in which a very complex grammar system could emerge by self-organization. Another source domain in the morphogenesis of phrasal and sentential syntax is the capacity for producing and understanding a rapid sequence of phonic events due to short- and long-term phonetic memory. Studdert-Kennedy ([57]: 17) says: "Without a pre-adapted system for storing phonetic structure independently from its meaning, syntax could not have begun to evolve." Man's essential syntagmatic (sequence controlling) capacities are evident in morphological and phrase compositionality. The complexity of syntax seems overwhelming if we consider modern written languages that are the focus of most linguists. However, natural languages can be elementary on the syntactic level. Therefore, it is not necessary to consider this complexity as a general characteristic of human languages. They can achieve such complexity, but this is not necessary. Comrie and Kuroda ([18]: 202) conclude from their comparative analysis that "human language(s) might have been much simpler and highly functional, and might have lacked grammatical forms such as case inflections, agreement, voice markers, etc."

6.3.3 Summary of the Evolutionary Morphogenesis of Human Languages

The *biological* evolution of human language is a continuous process in which bodily preconditions are decisive. In the further *social* evolution that started with the increase of group size (and group organization) and new forms of symbolically ruled social behavior, bifurcations with symmetry-breaking and convergence occurred: from manual to phonic contact management, from gestural to phonic deixis and referential location, and from context-dependent emulation to cultural learning. After these dramatic shifts toward a complex phonic communication system with socio-emotional *and* referential functions and cultures based on symbolic transmission, the centrality of language for human survival and expansion was firmly established. Language capacity became a species-defining character of humans.

The advanced stone-age industries show that Homo sapiens crossed this barrier before they began to move beyond their limits in South-Eastern Africa (200–100,000 y. BP) and to migrate out of Africa (between 100,000 and 70,000 y BP); cf. Wildgen ([74]: Chaps. 4 and 5) and Wildgen [80].

The significant effects on language were:

- A more extensive and steadily growing lexicon;
- the mastery of rapid and complex strings of phonic signals and corresponding functional-semantic patterns as shown in lexical innovation, composition, grammaticalization, and complex phrasal syntax;
- a new level of creativity in language and art linked to the growing complexity and diversity of languages.

6.4 Morphogenetic Schematization in the Lexicon of Natural Languages

The following sections give a summary of a morphogenetic model of human language. The focus is not only on specific biological processes in the actual formation of a living being (e.g., gastrulation, cell division, and the genetic or epigenetic control of maturation and growth), but also on the existence and the further unfolding of abstract "morphogenetic" forms in the sense of Kant's schema-theory, Goethe's "Urformen", Saint-Hilaire's "structural plan".

Modern evolutionary biology accepts the persistence of a set of ancient genetic factors (the "homeobox") responsible for a kind of "unity of composition" observed by Saint-Hilaire in comparative anatomy (see the rise of "Evo-devo-models"). We cannot discuss these issues in evolutionary theory (cf. our remarks in Sect. 1.1.2). The underlying philosophical and theoretical position was already formulated in René Thom's book (1972, translation 1975: Structural Stability and Morphogenesis), and its consequences for linguistics and semiotics have been specified in Petitot [47] and Wildgen [67, 69, 71, 72].

6.4.1 Morphogenetic Principles Versus Universal Grammar

The topic of universal grammar or inborn ideas surfacing in an incomplete and deformed way in human languages goes back to antiquity and is lined to the topic of the naturalness of language contrasted with the appearance of arbitrariness (conventionality); cf. Platon's dialogue *Cratylus*. Descartes' epistemology and the theory of grammar and rhetoric of Port Royal assumed a logical blueprint of human language (logic understood as a theory of human thought). Chomsky assumed this historical position to be the backbone of his theory of Universal Grammar, based on set theory and (free) algebra (cf. Chomsky [15, 16]). In the seventeenth century, Leibniz had already criticized the rationalistic position of Descartes and advocated a continuous and dynamic view of universals and grammar. Leibniz's ideas for universal geometrical characteristics of human thinking and creativity led to the modern topology. Poincaré's philosophy of science and the applications of results in differential topology by René Thom and Sir Christopher Zeeman (under the label "catastrophe theory" in the seventies and eighties of the twentieth century) established a theoretical framework for dynamic semiotics and linguistics,cf. Wildgen ([70]: 31f.) for a short historiographical discussion. We take as our starting point the natural sciences and mathematics before and after the millennium (2000), specifically the morphogenetic theorizing by René Thom.

Starting from morphogenesis in the domain of nature (for instance, geological and biological processes), René Thom has proposed formal schemata derived from catastrophe theory that generalize major types of morphogenetic evolutions. In the grammar of human languages, such process types show up as invariant form-giving

523592_1_En_6_Chapter ✓ TYPESET DISK LE ✓ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

principles that constitute a "homeobox" constitutive for homologies between human languages. We do not assume the existence of universal grammar (based on innate "ideas") but a gradient in the invention and selection of grammatical forms that leads to the statistical prominence of certain types of grammatical organization (constructions). This does not mean that grammatical structures whose genesis can take thousands of years are the immediate outcome of specific morphogenetic processes. One must instead assume myriads of communicative acts involving entire populations that create ad hoc lexical ad syntactic patterns, select among a given inventory, and change them in detail. The cumulative outcome of these processes selects and optimizes certain organization features in the lexicon and the syntax.[14] The details of such a long-term process with many degrees of freedom cannot be reconstructed in linguistics (in the present state). Therefore, the morphogenetic analysis of grammar must take a detour and use the morphogenetic patterns abstracted from nature and seek plausible patterns discovered in languages until now that are possible realizations of these abstract morphogenetic structures. For a detailed analysis of catastrophe theoretical semantics motivated by René Thom's proposals, see the analyses in Wildgen ([67, 72]; in English; [69, 71] in German; [73, 81], in French) and Petitot [47–49].

Finding the most basic entities underlying a set of complex structures is similar to the search for basic figures in geometry. The analogy between geometry and psychobiological phenomena was already known to Aristotle (in his treatise on psychology, "De Anima", Aristoteles, 2016: § 414b16). The abstract geometrical character of elementary representations is also evident in neurophysiology (see Orban [45]) and in the psychology of vision Kosslyn [38], cf. for the discussion of this research and its relation to Thomian thought Petitot [50]. The analysis of sensory inputs consists of mappings from a three-dimensional input into a precise control of activity in space and time. The mapping must conserve essential topological and dynamic characteristics and can forget metrical details and variations of a type of object or event. Therefore, the problem of *structurally stable mapping* lies at the heart of every theory of representation and semantics. The crucial result in this field is the theorem by Whitney that says: We can only find three types of points (all other types become identical to these if perturbed):

(1) regular points (Morse points); they do not qualitatively change under perturbation; we may say that they have a static identity (of self-regulation),
(2) twofold-points (a frontier line between a stable and an unstable domain appears),
(3) cusp-points (two stable attractors conflict and one may appear or disappear).

[14] Evidence from language change documented by historical and comparative linguistics indicates that stability is maintained against forces of destabilization or new optima are sought. For example, Steels [56] simulated the language change from Old High German (ca.800–1000 AD) to New High German (ca. 1650–today) using computer agents in a language game. He concludes, "Although there have been phonetic processes (unrelated to function) that have eroded endings and merged forms, only those solutions that lead to a more optimal system from the viewpoint of semantics, morphosyntax, and phonology have undergone positive selection."(ibidem 348).

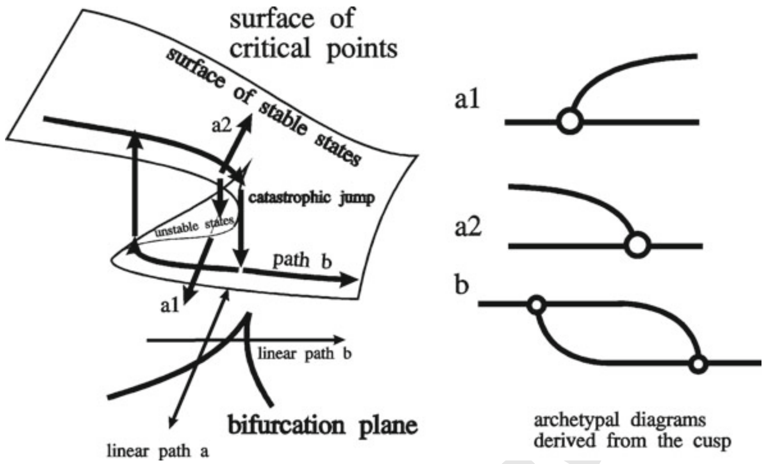

Fig. 6.5 The derivation of archetypal diagrams from the "cusp"

The classification theorem of catastrophe theory expanded this list to the cuspoïds and umbilics. After 1978, the embedding of umbilics in the double cusp was added (cf. Wildgen [67]: 81–92).

A further notion must be informally introduced: the linear path in an elementary unfolding.[15] If we consider linear paths in an unfolding, we can classify types of process schemata called EMISSION, CAPTURE, and (bimodal) CHANGE. They are derived from the catastrophe set (set of extrema) of the cusp. The diagrammatic simplification at the right of Fig. 6.5 eliminates the lines of (unstable) maxima; the circles symbolize the bifurcation points.

Thom proposed considering only catastrophes with a (co-)dimension equal to or lower than the dimensionality of spacetime. The basic scenarios of change and process in the cusp have two attractors. The butterfly has three attractors, and the elliptic umbilic has four attractors. Examples of these formal process types are given in the following sections.

We shall concentrate on the levels of lexicon and sentential syntax. Applications of the morphogenetic paradigm to phonology have been published in Wildgen ([71] in German and 1990 in English). Applications in text linguistics, narrative analysis, and discourse are not considered here due to lack of space (cf. Wildgen 1993, Wildgen [72, 73]: this chapter; in French).

[15] In the simplest case, the unfolding of a dynamical system under deformation (noise or perturbation) has a gradient dynamic without oscillations or chaos. This assumption allows the classification of all the structurally stable evolutions of the system. The practical consequences of the classification theorem are called "catastrophe theory".

6.4.2 Morphogenetic Structures in the Lexicon of Verbs

The lexical category of verbs that logicians traditionally neglected[16] becomes the theoretical core of a morphogenetic analysis. The first questions that the categorization of a process, an event, or an action raises are:

- What invariant structures underly the processes in question such that a lexicon of verbs can stably refer to them?
- What are the motor controls and perceptual patterns that mentally appropriate such processes?
- Finally, what mental representations link the perceptual-motor correlate and the linguistic forms?

We start from the psychophysical interface, i.e., the perceptual and motor systems, which establish a link between the world and the human body. As the work of Gibson [24] and, more recently, that of Haken [27, Kelso 35], and others show, the qualitative laws of external physics control this interface. The motor programs modify the autonomous dynamics of the body's extremities and their contact with objects (e.g., the floor for the feet). These autonomous dynamic structures determine variables for the perception of movements and the cognition that regulates these systems. It can be concluded that the brain reflects the external dynamics (by adding other parameters to it and distorting it in its metric). However, the question remains: Does this coordination with external physics also control the higher levels of cognition, especially linguistic cognition? We assume an intermediate level, called imaginal or schematic. It applies processes that become increasingly independent from the psychophysical grounding and more context-dependent (as a consequence, they depend on chance). In what follows, we will start from the psychophysical level to find schematizations (imaginal representations) that underlie the semantics of verbs. We distinguish three typical levels of organization in the lexicon of verbs and verb phrases (the lexicon of nouns and noun phrases will be the topic of the next section):

a. Locomotion and its linguistic schematization,
b. the control of an object by an agent,
c. and the interaction between agents.

ad a: The morphogenesis of the cognitive and semantic schematization of motor acts.

The psychophysical perspective has the advantage of creating a link between the cognitive, the sensory-motor, and the dynamics of the external world. Movements have two levels of control):

a. Control of the topology of the movement and the coordination of the different moving parts.
b. Control of the metric of the movement. It gives the necessary precision for a concrete situation/environment.

[16] See for example the logic of Port Royal which wanted to reduce this part of the lexicon to the single verb "to be".

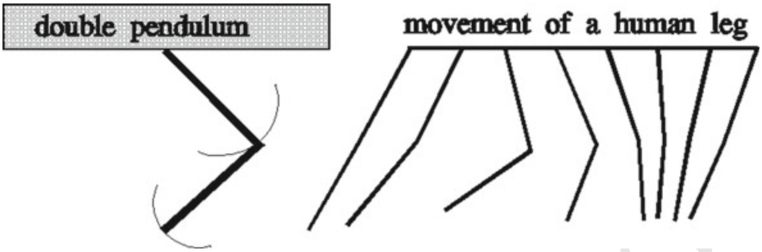

Fig. 6.6 The movements of the double pendulum and of a leg in walking

The first level eliminates factors that blur the general approach of a target. In this sense, the coarse (topological) control is locally teleological. Metrical control, on the contrary, has the effect of adjusting the movement and eliminating insecurities and vagueness.

In the case of the movement of the body's extremities (e.g., legs, arms), one can use the physical description of the pendulum (double pendulum) as a fundamental schema. Figure 6.6 shows the correspondence between the double pendulum and the walking motion. The movement of the body supported by the hips is in coordination with the relative movements of the thigh (measured at the knee) and the leg (measured at the ankle).

By moving from the rest position, the leg moves toward the goal, the new attractor. The iteration of local movements allows for a quasi-continuous movement. The rhythm of it can further specify the movement or even identify the agent of the movement. The movement zones with a very high degree of coordinated control are, at the same time, the domains that organize semiotic expression, for instance, the facial muscles and the movement of the hands and fingers. The complexity of motor programs is not directly related to lexical distinctions because the latter only classify recurrent types of movement in a much coarser way.

Specific movements are directed toward an attractor (a target). This orientation implies a separation of the starting and the ending point. This bimodality corresponds to the fundamental transition in space and its lexical correlates. Example: enter/*exit* or *come/leave.* Two essential types of elaboration must be considered:

(1) Instrumental elaboration. The control of the body's limbs and the coordination of complex movements can be modified or specified by inventing and using instruments (and machines).
(2) Causal elaboration. Further technical control uses the physical causalities discovered and implemented in science and technology.

ad b: The morphogenesis of an agent's control over an object.

In the intentional act of an agent directed at a less intentional object or entity, two aspects can be distinguished:

(a) The configurational aspect describes the topological and kinematic relations between the agent and object.

(b) The energetic (or intentional) aspect introduces the force of the agent and the effect of this force on the object. This force is first psychic; secondly, it has physical effects.

In their classification of the lexicon of German verbs, Ballmer and Brennenstuhl [6] distinguish, at this level of complexity, two groups of verbs:

(1) The creation, destruction, and regeneration of objects (elements of the environment).
(2) The subject's impact on the state of objects and subjects in its environment.

For group (1), it is easy to see the correspondence with the emission and capture schemata in catastrophe theoretical semantics (cf. Fig. 6.5 in Sect. 6.4.1). In the lexicon, the corresponding verbs are, in most cases, divalent, as in:

EMISSION
Albert tells a story
Berthe calculates the result
CAPTURE
Charles eats the soup.

Often the semantic type of the produced objects is incorporated into the verb, as shown by the following German verbs (EMISSION type):

– schneidern (to sew)
– töpfern (to make pottery)
– texten (to write texts).

The subgroup called regeneration/disaggregation by Ballmer and Brennenstuhl [6] refers to a space of qualities. We will look at some examples:

(a) verbiegen (distort, twist)
(b) reinigen (cleanse).

The processes that are classified by these verbs refer to a qualitative space with the following states:

1. right > twisted German: verbiegen (deform),
2. clean > dirty German: reinigen (English: to clean; French: nettoyer).

In the control space of the cusp (cf. the folded surface in Fig. 6.7), we have paths that go from:

(a) $(+) \rightarrow (-)$: verbiegen (to distort)
(b) $(-) \rightarrow (+)$: gerade biegen (to straighten).

Figure 6.7 shows the dynamic modeling of the French verbs: nettoyer (clean) and salir (make dirty) and corresponding adjective scales: proper (clean) and sale (dirty); cf. Wildgen ([73]: 99 and Chap. 3).

ad c: The morphogenesis of the cognitive and semantic schematization of interaction.

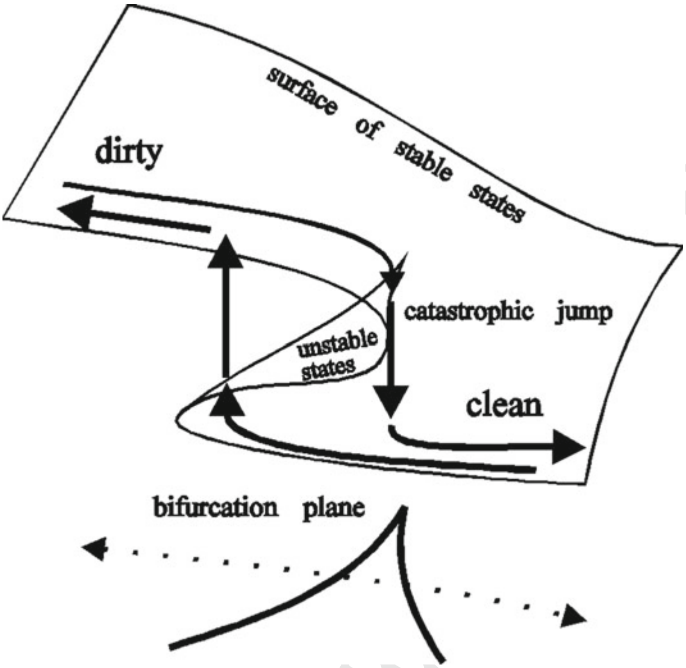

Fig. 6.7 The dynamics of the English verbs clean versus make dirty and the corresponding adjectives clean and dirty

An interaction scene that connects several human agents already presupposes a very complex perceptual and conceptual analysis in the individual observing the scene. Above all, it presupposes a degree of social perception that goes beyond the simple control of the action by the agent himself. For example, we know that primates can consider the perspective of another ("decentration") to a degree comparable to the decentration manifested by a two-year-old child. From a repertoire of action controls, one can reconstruct possible patterns of social interaction. However, it turns out that only a small group of these coordinated interactions achieve high stability, allowing schematization and semantic classification. This restriction requires an explanation.

From the angle of the spatial configuration, we can describe the gift, i.e., the scene during which two people exchange an object, by the topology of the attentional focuses. Petitot ([49]: 272ff) elaborated on a proposal by Christopher Zeeman for a model that uses cognitive algorithms, such as cut locus and diffusion contours. In this elaboration toward neuro-vision, the catastrophe theoretical model gains more theoretical depth because it shows that the mathematics of differential topology can be used in the specific context of visual scene analysis. The semantic archetype would, in this perspective, be first the result of morphogenesis in visual pattern recognition. As such, non-human primates could have possessed this faculty. Then, this pattern would have gained social and cultural significance in the ritualization of gestures.

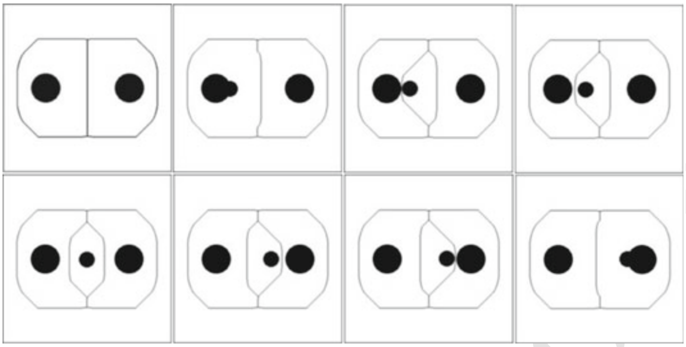

Fig. 6.8 Phases of the schema of transfer (give; from the left upper corner to the right lower corner) applying principles of neural dynamics in vision ("cut locus" analysis) in Petitot [49]: 274: Fig. 4.8)

Finally, with the transition to phonic language, evolutionary continuity would have created a stable reference pattern in early human communication (Fig. 6.8).

Petitot ([49]: 273) writes: "the temporal evolution of the cut locus itself is slow dynamics [...] and may present bifurcations, emergence, and vanishing of branches, or splitting of branches. These dynamics encode events of interaction between actants. We can, in this way, develop a program analogous to contour diffusion. Figure 4.8 gives an example of the transfer type".

The middle phase (lower left corner) coordinates the activities centered on two individuals in the starting and the goal positions; it is also the most unstable point of the whole process.

This scheme of interaction is transformed into language schematization by transfer verbs. The energy asymmetry defines an intentional direction. We can distinguish:

- the source agent that initiates a process;
- the object that changes the possessor going through a change of control and dominance;
- the target agent, the one who holds control of the object at the end. This state is the goal of the intentional action of M1, and it establishes, at the same time, an asymmetry, which may initiate M3 to fulfill a reciprocal exchange (Fig. 6.9).

The second large field of lexical entities has a nominal character and is classically labeled as nouns, adjectives, appositions, pronouns, and relative clauses.

6.4.3 Morphogenesis and Attractor Dynamics in the Lexicon of Nouns, Adjectives, and Other Nominal Attributes

The lexicon of human languages has a high degree of arbitrarity. It was evident to the comparatists of the nineteenth century, and de Saussure called this principle

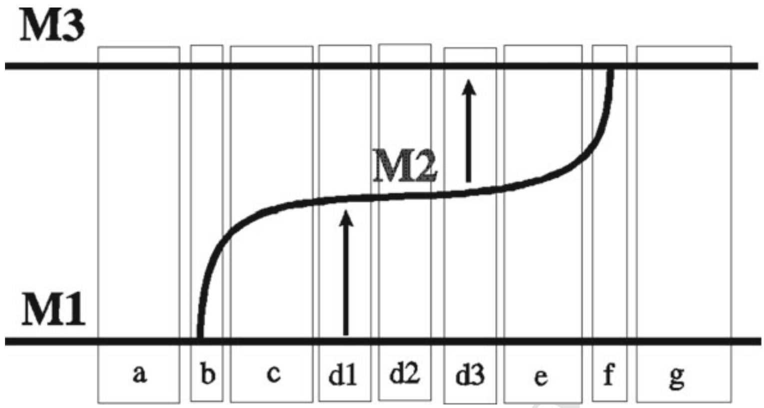

Fig. 6.9 Catastrophe theoretical schema of the transfer archetype “GIVE” with the critical phases d1, d2, and d3

“l’arbitraire du signe” (the arbitrariness of the (linguistic) sign). Although morphological and syntactic patterns of the languages in a family of languages can be stable over long periods, the lexical entities diverge very quickly. Even the dialects of the same language differ dramatically in the labels for plants, animals, and artifacts. This variability became evident in the systematic compilation of geographic variation in the atlases of languages established at the end of the nineteenth and the beginning of the twentieth century.

In lexicology and lexical semantics, since the twenties of the last century, models of field linguistics came to the fore; the notion of “field” implies gradient dynamics. However, elementary patterns of lexical semantics were already known in antique (Aristotelean) logic and rhetoric. For example, Aristotle used in his taxonomy of plants and animals the technique of specific difference between a general term and a more specific one: “genus proximum et differentia specifica”. This technique can be translated into a feature notation, i.e., a term higher in the hierarchy may be defined relative to the genus proximum, the next lower term, via the specific difference between them.[17] This idea was taken up by Katz and Fodor [34] and used in generative grammar after 1965. We shall exemplify the technique based on its usage in Labov [39], who elaborated on it in an empirical (sociolinguistic) context.

The meaning of bowl can be analyzed regarding a set of five features (defining predicates):

- feature 1: diameter; weight w_1,
- feature 2: height; weight w_2,
- feature 3: the existence of a handle; weight w_3,
- feature 4: use (food–non-food); weight w_4,

[17] Darwin appreciated Aristotle’s contribution to biology (in 1882) and D’Arcy Thompson translated Aristotle’s History of Animals in 1910. René Thom gave the under title “Physique aristotélienne” to his book on Semiophysics (1988).

- feature 5: material; weight w_5.

The features have different weights, and this weight may even depend on the contexts in which the word "bowl" is used. For example, as Labov [39] shows, the weight of feature 4 is higher in the context of "kitchen" and "restaurant", whereas in the context of craftwork and art, features 3 and 5 are more relevant. Fuzzy semantics (cf. Zadeh [83]) have generalized the use of "weights" as degrees of membership of an element in a set with values between 0 and 1 [0,1]. As the scale of values is continuous, we can define maxima and minima on the scale, i.e., use attractor dynamics.

Even the hierarchical branching of lexical items can show attractor dynamics. The ethno-taxonomies analyzed by Berlin [7] and Rosch-Heider (1977) show the prominence of intermediate (Berlin) or basic (Rosch) categories. Thus, the hierarchy in the series *tool, hammer,* and *claw-hammer* has the term hammer as its center. It is the attractor of this array; cf. Sect. 2.1.3. in Wildgen ([76]: 40–42; in German).

In antique rhetoric, two other relations between lexical items were distinguished: metonymy and metaphor. This tradition was transmitted without significant losses to modernity and is the starting point of the semantics of metaphors in Lakoff and Johnson [41]. Thus, the sentences:

- argument is war (metaphor)
- the part stands for the whole (metonymy)

define a type of semantic transition that can be applied to many words and utterances which fit both arguments of the metaphorical/metonymical relation (cf. ibid. 4). Examples[18]:

The metaphor:*argument is war* may be articulated in sentences like:

- John's *claims* are *indefensible,*
- His *criticisms* were right on *target,*
- He *shot down* all my *arguments.*

The metonymy: *the part stands for the whole is* articulated in sentences like:

- We don't hire *longhairs (longhairs stand for someone having long hair),*
- The Giants need a *stronger arm* in the right field (a strong arm stands for a player with strong arms).

However, some of Lakoff's and Johnson's results were basic knowledge in gestalt psychology, especially in "attribution theory", since the fifties of the twentieth century. What is new in Lakoff and Johnson [41] is the role played by locutions and proverbs like *time is money* and *argument is war*.[19]

[18] The "semantics of metaphors" initiated by Lakoff and Johnson is critically analyzed in Wildgen ([76], Chap. 3, pp. 65–90; in German).

[19] The orientational function of fixed locutions or frequent images points to Jung's earlier theory of psychological archetypes. C.G. Jung collected symbols from many cultures in the form of pictures and sculptures and compared them to pictures produced as individual transcriptions of dreams and visionary experiences. From the comparison of these materials, he concluded that there is a level

The flaw of lexical semantics lies in the subjectivity (on the part of the analyst) of all analyses. Charles Osgood (1916–1991) developed and applied a tool to analyze lexical meanings in a near-to-objective technique. It consists of choosing a set of polar adjectives in a given language and having experimental subjects rate the relative position of lexical items on a seven grades scale. The advantage of this method is that the subjective character of meanings is the target of the analysis and does not interfere with the subjective evaluation or prejudices of the psychologist or linguist as an analyst.

The multivariate statistical analysis leads to a low-dimensional construct of factors underlying the correlations between the tested items. One of several optimal factorizations is given the typical loading of relevant scales on three factors called Evaluation (E), Potency (P). and Activity (A). Osgood et al. [46] showed that this three-dimensional semantic space has a biological meaning, i.e., the general factors reconstructed statistically refer to basic dimensions of human behavior that underlie the lexicon of adjectives and nouns. The morphogenesis of the rich semantic space of a lexicon can be considered as the unfolding of a low-dimensional, biologically-based semantic space.

In the transition between the lexicon and the syntax of languages, there exist processes that are labeled as "grammaticalization", i.e., items belonging to the lexicon are transferred into items having a syntactic function. The opposite direction is also relevant; for instance, relative clauses derived from sentential structures acquire the character of adjectival determinations or restrictions in a noun phrase. The morphogenesis of case markers is one example of grammaticalization. As it is relevant for our analysis of valence patterns in Sect. 6.6, it will be discussed in more detail (cf. Wildgen [81] for a fuller account in French).

6.5 Morphogenesis and Grammaticalization (Applied to Case Marking)

The world's languages show astonishing diversity in the morphology of words, i.e., in suffixes, prefixes, and infixes. The basic process, i.e., the transition from (free) lexical entities to bound morphemes, is called grammaticalization. This process means bound morphemes constituting the grammatical architecture around the lexical stem or kernel are the product of transformations, derivations, and abstractions produced in a morphogenetic process during linguistic change. A standard example is the marking of cases in languages with inflection and their functional parallels in other languages. Four morphogenetic principles can be detected in this field:

---

of the collective, although unconscious, representation, which he called "archetypes" (a term from Greek philosophy). He assumed that these (cultural) archetypes cannot be explained by cultural heritage or geographical diffusion. Instead, they are rather abstract, geometrical constellations that reappear (in Jung's interpretation independently of one another) in many cultures and individuals (see Jung [33]: 45).

523592_1_En_6_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

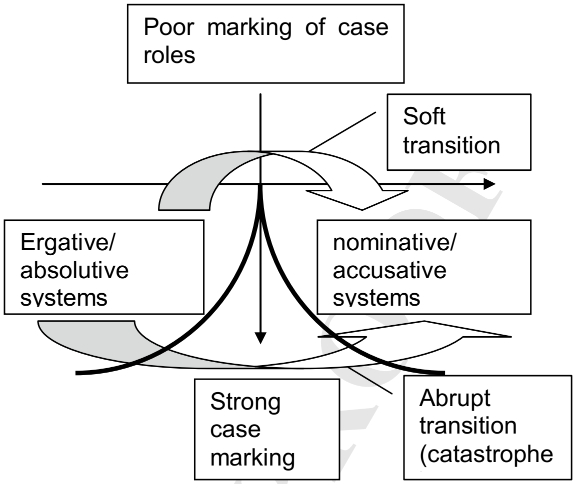

Fig. 6.10 The transition between the ergative and nominative system and the "cusp" catastrophe as the morphogenetic background of this process

(1) Two significant types of case systems emerge from research in comparative linguistics. Systems with a pair of cases called *ergative* and *absolutive* and a pair of cases called *nominative* and *accusative*. In systems with ergative and absolutive cases, the agent in the transitive sentence, which distinguishes an agent from a patient, is marked by the ergative case. The agent in the intransitive sentence (*John* runs) and the patient in the transitive sentence (John throws a *stone*) are marked by the same case category: the absolutive.[20] These languages put their dynamic focus on the agency in the transitive sentence, i.e., the effect of an agent on a patient. In systems of the nominative/accusative type, the patient of the transitive sentence is marked by the case called accusative. In contrast, the agent in both sentences is marked by the case called nominative. In English, this distinction is shown in the pronouns: *He* runs, she kisses him, and in the order of constituents (the case opposition is: he/she versus him/her). Historical linguists discussed whether the two systems have a historical relationship so that marking has transitioned. Such a transition could point to an underlying morphogenetic process with a bifurcation schema. The choice consists of a pole on the scale of the agency. It requires a second term: the patient. A neutral position is a simple type of movement/change. Figure 6.10 illustrates this polarity. The historical change would then be a catastrophic transition that surfaces in languages with a strong marking, for example, by a system of case suffixes or adpositions (see the arrow at the bottom).

(2) In the case of a strong marking appears either a case system of the type: ergative/absolutive (on the left) or nominative/accusative (on the right). The historical transition takes the form of a bimodal catastrophe. Strong marking can

[20] For simplicity, we do not cite original sentences in languages with an ergative/absolutive case system but the translation of such sentences into English, a language with a nominative/accusative case system.

523592_1_En_6_Chapter ✓ TYPESET DISK LE ✓ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

traverse a more or less abrupt line of change, while the transition is smooth for a weak (or minimal) marking system. This (smooth) transition zone can be observed in language contact, where the case marking is lost. In pidgin languages, a weak or minimal system uses context and contextual knowledge to compensate for the lack of information coded by case marking or adpositions.

Grammaticalization theories assume a gradient with several steps (see Butt [12]: 179): *relational noun > secondary adposition > primary adposition > morphological case affix*. The languages of Indo-European origin show historical transformations leading to a total or partial disappearance of inflectional marking. French and English only mark pronouns, but they have elaborate systems of prepositions. German marks cases in certain noun forms (in the singular or according to noun classes) and shows a replacement of case marking by a marking based on prepositions.

(3) The location of the markers depends on the order of the nominal groups (syntagmas) in a sentence: Subject (S), Verb (V), Object (O); see the simple sentence in German and English: Hans (S) wirft (V) den Stein (O)—John (S) throws (V) the stone (O). The whole series of combinations can be found in the languages of the world: SOV, VSO, VOS, OSV, and OVS. Beyond this typological classification, there exist significant statistical differences. Thus, the order that puts the object in the first position is sporadic; the dominant opposition is that which puts the subject or the verb in the first position.

(4) Local cases appear especially in languages with an extensive list of cases, such as Lesgi (South Dagestan, Caucasus), which has 14 local cases (see Haspelmath [28]). Case localism is generally pertinent, but the agent's field of forces and intentions seems to be the overriding factor. One can call it second-order localism.

Linguistic variation and change have been the central research area of comparative linguistics since its rise in the nineteenth century. Grammatical dynamics were discussed under the concept of "grammaticalization" by Antoine Meillet in 1912. Today we speak of a cycle of grammaticalization based on a scale that goes from lexical entities (especially with concrete, spatial, and imaginal content) to dependent forms to adpositions (prepositions and postpositions) and finally to endings and inflectional paradigms. If the inflectional system disappears, the dynamic restarts at the zero point, i.e., the linear scale is transformed into a cycle. However, cycles of grammaticalization often show transposed phases such that several stages coexist. Therefore, a language can simultaneously have inflectional cases and a set of prepositions that realize case roles (e.g., German or other Indo-European languages have preserved grammatical patterns of the Proto-Indo-European and have replaced many instances with prepositions).

Comparative research has found several routes in the morphogenesis of case markers. They can be derived from a chosen inventory of verbs (especially verbs of movement and spatial change, often in constructions with serial verbs), nouns (often relational), or adverbs. Depending on the typological characteristics of the languages or language families, the dynamics can lead to prepositions or postpositions, suffixes attached to the dependent noun (sometimes also to the verb), or dependent pronouns; see Blake ([9]: 170). Grammaticalization gradients function as morphogenetic fields with categorical transitions between:

- Free lexical units (verb, noun, adverb),
  ↓
- Linked pronouns, adpositions,
  ↓
- Suffixes of the noun (more rarely of the verb),
  ↓
- Inflectional paradigms.

The morphogenetic modeling in grammar can either consider long-term historical (at the limit evolutionary) changes or analyze actual and synchronic processes occurring in natural languages, i.e., either in actual use or short-term developments accessible to observation and analysis.

6.6 Morphogenetic Structures in the Syntax of Verbal Phrases and Sentences

In the tradition of Latin grammar, lexical items and morphology were the core. However, Humboldt, inspired by his study of polysynthetic languages, demanded that the grammar analysis should start from the sentence and not from the word (see his work on the language Kawi in Java, 1830–1835; Humbolt [31]). The psychologist and philosopher Karl Bühler proposed, in 1933, a compromise in the quarrel of contemporary linguists on this question. He postulated that any language knows (at least) two levels of conventionality, distinguishing it from a code of marine signals. These two levels form a scale. At one end, the world is almost torn to shreds, separated into isolated aspects so that each "piece" is associated with a (conventional) sign. On the other end, language tends to per-construct the same world with the help of relations ("Durchkonstruktion") and to establish meaningful gestalts in this construction process (see Bühler [11]: 88). Bühler introduces two levels of construction, segmentation versus construction.

In Chomsky's linguistics, the intermediate notion of the word has been abandoned, and the notion of the sentence has become the key notion of grammar. Fillmore and Kay show in their "Construction Grammar" (cf. Fillmore et al. 1987, Goldberg 1985) that the results of generative grammar are easily integrated within a more flexible conception that starts from the notion of construction without abolishing the difference between morphological and syntactic constructions. (Cf. Wildgen [76]: this chapter, pp. 143–169 for an overview in German).

6.6.1 The Morphogenetic Foundation of "Deep" Structures

The distinction between the *deep* form, the force (the "energeia"), and the static *product* was introduced in linguistics at the beginning of the nineteenth century by W. von Humboldt. Chomsky's distinction between deep structure and surface structure, which he abandoned after 1968, was only a technical reflection of this theoretical distinction. It was René Thom ([60]: 121) who reminded us of the deeper motivation of this distinction:

> We, therefore, admit that the hypothesis of a 'deep structure' of linguists consists essentially of our sensory representation of the external world (barely elaborated by perception). On the contrary, the surface structure will be constituted by automatisms of language themselves; they constitute a layer of spaces superficially attached to the "deep structure", and historically, in evolution, they come from it by process of permanent exfoliation, like our skin, made up of layers of cells secreted by the deep dermis and which go in the process of sclerosis towards the outside, where they disintegrate. (translation by the author)[21]

René Thom's biological interpretation of Humboldt's notion of "energeia" in grammar and the traditional notion of "deep" or crypto-structure in linguistics presupposes a very general concept of "morphology", as Goethe coined it in his "Morphologie überhaupt". It links the biological forms in morphogenesis to symbolic forms, such as language. Thom [60] argued that linguistics is an exemplary morphological discipline. This means that the reference to biological morphogenesis is not just a superficial analogy; morphological principles visible in biology are concentrated in symbolic forms, specifically in language. Linguistics is the prototype of morphology.[22]

6.6.2 Semantic Roles and the Dynamics of Sentential Frames

The intuition that sentences and verbal phrases operate with a finite and small set of schemes or construction types goes back to antiquity. Wildgen ([69]: Chap. 2, pp. 9–58; in German) discussed this tradition up to modern case theories. The morphogenetic approach proposes a radically biological/cognitive analysis. It is founded in the publications of René Thom, who formulated the initial conjecture and elaborated in Wildgen ([70]; short English version in Wildgen [67]). A detailed analysis was published in Wildgen [72], in English, Chaps. 3 and 5) and in Wildgen

[21] "Nous admettons donc que l'hypothétique d'une 'structure profonde' des linguistes est constituée essentiellement de notre représentation sensorielle du monde extérieur (à peine élaborée par la perception). Au contraire, la structure de surface sera constituée par des automatismes du langage proprement dits; ils constituent une couche d'espaces accolés superficiellement à la "structure profonde", et historiquement, dans l'évolution, ils en proviennent par un processus d'exfoliation permanente, à la manière de notre peau, constituée de couches de cellules secrétées par le derme profond et qui vont se sclérosant vers l'extérieur, où elles se désagrègent."

[22] The relation between Goethe's concept of "Morphologie überhaupt" and Thom's morphogenetic access to language is discussed in Wildgen ([68]; in German).

([73]; in French, First Part: "La grammaire morphodynamique"). The account in the present book only considers the general lines and principles. Two assumptions are characteristic:

- Semantic roles are primarily a cognitive classification of processes (states) subject to verbalization. Therefore, their projection in a morphological and syntactic classification is polysemic and lacunar, i.e., the role must not be expressed in every context and can be left to the listener's interpretation.
- Semantic roles are variables and depend on the phenomenological level in which the process (see the list below) is rooted.

We consider a hierarchy of levels centered on the individual speaker/hearer. The topological proximity to the ego (from the periphery to the center) motivates the following process levels (the stable state is considered the limiting case of a process):

(a) Processes in the ambient space of the speaker/actor,

   - *local* processes; the processes take place in the sphere of the subject, for instance, bodily movements of the agent.
   - *interlocal* processes; the support of the process, for instance, a subject or an object changes his/its location.

(b) Sensory processes: The center of the process is located in the (peripheral) apparatus of the senses.
(c) Mental (self-referential) processes: The center is the brain (cortex).
(d) Qualitative/quantitative changes: They are quasi-external to the individual but depend on quality dimensions and quantitative scales that the individual has internalized (often through language and cultural techniques).
(e) Abstract changes: They constitute a heterogeneous class. Their meaning is vaguer, and the referential source remains opaque.

The system of levels (a)–(e) can be represented as a system of containers (circles) around and inside the space centered on the Ego (Fig. 6.11).

The scene (the drama) described by a simple sentence (with a finite verb) is broken down into several regimes (sub-centers), which we call processual (semantic) roles. The verb represents the type of process. The classification of possible scenes gives a system of representations we call imaginal ("imaginistic" according to Kosslyn [38]). They are neither images nor perceptual structures but cognitive entities at a syncretic level on which the grammatical morphogenesis can operate.

The fundamental question that René Thom asked and to which he was able to give a surprising answer is the following: The scenes are continuous and contain an unlimited number of variables that can influence what happens. Is there a possibility of finding a finite list of stable patterns to which all these variations can be reduced? His solution has been elaborated regarding linguistic facts and neuro-cognitive research; cf. for the first direction Wildgen [67, 72, 80] and the second Petitot [48, 49].

As sketched in Thom [59], the morphology of sentential expressions points to morphogenesis rooted in fundamental biological and social behavior like grasp,

523592_1_En_6_Chapter ☑ TYPESET ☐ DISK ☐ LE ☑ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

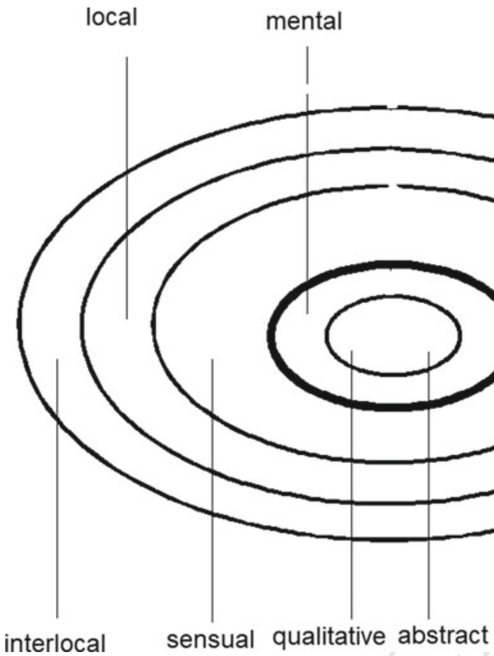

Fig. 6.11 The phenomenological levels of process scenarios

predate, gift, and media of exchange (commercial and symbolic). Basic invariants of these processes are analog to a classification of the stable unfolding of dynamical systems in differential topology (specifically in the results of catastrophe theory, further elaborated in bifurcation analysis and chaos theory). The realization of these schemata in the grammars of current or historically documented grammars is polysemic and lacunar. Still, the empirical evidence supports Thom's hypothesis (with a marge of statistical insecurity). As no better explanation is available (beyond a pure description of superficial evidence), his proposals remain relevant until better, biologically rooted theories come to the fore.

6.7 Morphogenetic Patterns in the Syntax of Nouns and Adjectives

The noun phrase is centered (usually) on a nominal nucleus (a noun) connected to a certain number of satellite words. According to Thom (1972), this connection is the product of a fundamental operation that appears in biological evolution and reappears in man's cognitive development. We can consider four possible sources of this relationship:

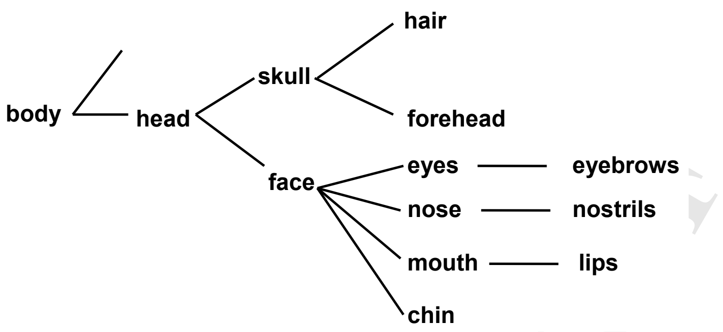

Fig. 6.12 Tree-like hierarchy of body (head) parts in French (body > head > face > eyes > brows)

(1) Aristotle had already noticed that the hierarchy of the genera in biology corresponds to the lexical hierarchy of classificatory labels. The "species" is distinguished from the "genus proximum" by a "differentia specifica".
Example: man (genus) is a social (specification) animal (species).

(2) The parts of the human body are cognized as a tree-like hierarchy (an acyclic graph). The different parts of the head can be hierarchized according to the way indicated in Fig. 6.12 (see Thom [63]: 187). Languages differ in the way they achieve the taxonomy of body parts.
The denominations of body parts, as well as those of any other hierarchies like that of kinship terms, are called relational because they always imply a whole network or a local neighborhood of this network:

- the forehead (of the skull),
- the mother (of a child).

The general idea that emerges from these systems is called: "diffusion de prégnance" (spread of relevance). If this diffusion is acyclic, it automatically leads to tree-like structures.

(3) The meaning of an adjective or some specifying attribute of the noun can be a secondary index. Already in animals, such an indexical mark can be the trace, the excretum of the predator that is perceived in its absence. In this case, an alarm call negates the predator's presence but tells its former (and possibly future) presence. In a nominal construction, the predator would be the noun, and the trace or excretum the attribute. In the context of religion, the attribute (epithet) is a sign for a god, for instance, thunder for the god Zeus. Thom ([63]: 28) argues that the trace is a typical morphogenetic source of attributes (epithets): In the case of a genitive construction in the noun phrase, it is derived from the noun by case marking.

"The 'genitive', a syntactical form which indicates the proximity of a being but at the same time denies its immediate presence, may have appeared to resolve this dilemma; at the sight of a trace, one raised the cry of alarm but affixing it with an affix that negates the actual presence of the predator, allowing for a more graded form of defense strategies."[23] In more general terms, the adjective, attribute, or ad-nominal modifier separates a qualification from its source, the substratum, in the process of abstraction.

(4) Children's drawings show an association of parts in the figure that hardly respect correct geometric and metric relations (measures). In these drawings, it is natural to see a trace of the conceptual structure acquired by the child, where parts and aspects are separated and then loosely associated with the whole figure. For example, Thom writes ([64]:179):

> However, when we put a concept in the genitive, we dissociate it into its fundamental elements, […] that is to say, we highlight all the sub-concepts which intervene in the meaning, that is, the regulation of the mental figure of the concept: the tail of the dog, the wheel of the car, etc.[24]

The different aspects mentioned by René Thom open the way to a (cognitive, even a biological) explanation of the adjective and the syntactic construction of nominal phrases.

6.7.1 *The Positional Hierarchies of the Adjective and Its Semantic Values*

The analysis by Hansjakob [53] will be our starting point. Seiler's model considers a continuum of determination with two extremes:

- The specifications of the referential relation (extension). Typical realizations are deictic gestures and demonstratives.
- Descriptive characterizations (intension).

The German sentence (translated word by word) shows the typical syntactic organization:

alle diese meine/erwähnten zehn schönen roten hölzernen Kugeln
all-those-my/mentioned ten beautiful red wooden balls
des Spiels auf dem Tisch, die ich dir jetzt gebe, ein Geschenk
of the game on the table that I give you now as a gift …(apposition).

The central noun is "Kugeln" (balls). It is preceded by two groups of determinatives (in the broad sense):

---

[23] «Le 'génitif', forme syntaxique qui indique la proximité d'un être mais en même temps nie sa présence immédiate, est peut-être apparu pour résoudre ce dilemme; à la vue d'une trace on a poussé le cri d'alarme mais en l'affectant d'un affixe qui niait la présence effective du prédateur, ce qui permettait une forme plus graduée des stratégies de défense.»

[24] «Or, quand on met un concept au génitif, on le dissocie en ses éléments fondamentaux, […], c'est-à-dire qu'on met en évidence l'ensemble des sous-concepts qui interviennent dans la signification, c'est-à-dire la régulation de la figure mentale du concept: la queue du chien, la roue de la voiture etc.»".

(a) “alle diese meine”,
(b) “erwähnten zehn schönen roten hölzernen”.

Seiler calls the border between (a) and (b) the turning or inflection point. While in (a) the order is rigid, it is flexible in (b) but governed by semantic laws. The order of epithetic adjectives responds to a criterion of specificity. Adjectives closer to the noun (relative to others) also have a more natural link to the center; they are more specific for that noun. In German, the order of categories corresponds to the following scale:

numerals (1), evaluative adjectives (2), color adjectives (3), adjectives of substance (4), and noun nucleus (5) (cf. for details Wildgen, 1999: 211–214; in French).

The descriptive space of noun and adjective phrases is characterized by its semantic or informational complexity; cf. [61]: 81). For example, the proper name “René Thom” is semantically more complex than the nouns “mathematician”, “professor”, “French”, and “man” because by forgetting specific characteristics of the individual René Thom, we come to the mathematician, the professor, the French, and the man. The maximum value is given by a complete description that specifies for all predicates whether the subject fulfills them or not. Disjunctions (choices) instead of conjunctions diminish the informational value,finally, if none of the predicates is fixed in its truth value, the information is zero (cf. for the notion of semantic information Carnap and Har Hillel, 1952 and for its application Wildgen, 1977).

In general, it can be said that the noun phrase has its specific syntactic (morphological) and semantic laws. It refers to a semantic continuum with categorization (catastrophe) points, categorical focuses (attractors), and gradients on this continuum.

6.7.2 Sketch of the Morphogenetic Structure of Noun Phrases

Suppose we start from a continuum on which regions are defined around a focus (the categories of determinants and the nominal kernel). Then, we can choose a dynamical system with a dominant attractor and several attracting satellites as a basic model. Figure 6.13 shows us the graph of a potential function, and below, the Dynkin diagram retains only the critical points: maxima (–) and minima (+).

NN designates the noun category; typical members of this category are words that designate stable entities existing in the neighborhood of humans or their imagination rooted in this environment (for instance, discrete entities around the speaker). Mass nouns (water, milk, steam) and abstract nouns (whiteness, virtue, and happiness) are at a certain distance from the center of the prototype of the nominal category. We can predict that the satellites’ categorical weight (nominality) decreases with the distance from the central attractor. This distance from the prototype of the category noun (“nominality”) defines what we call the “categorical distance” in the noun phrase.

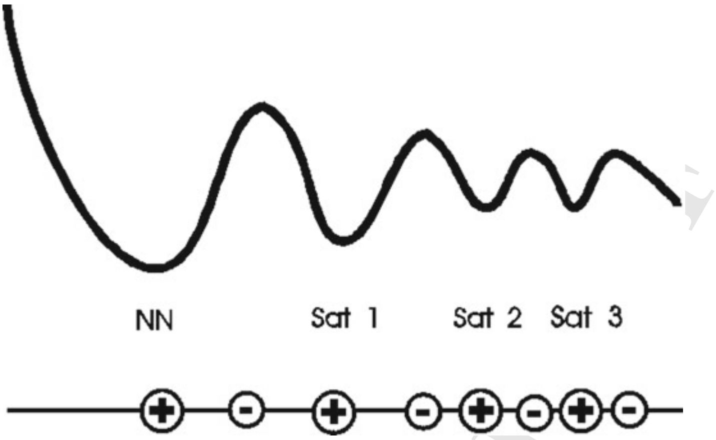

Fig. 6.13 Dynamic and discrete representation of a nominal kernel (NN) with its satellite concepts (Sat1, 2, 3)

Additionally, one has to consider a second dimension called information complexity. A third dimension is given by the context and the momentary state of the speaker and his interlocutor. In a nominal group, we can distinguish elements that refer to the situation from elements that contribute information. For example, the deictic determinatives (this, this one), pronouns (I, you, my, your), articles (one, the), and quantifiers (no, five, all) refer to the situation, i.e., to the third dimension. On the other hand, adjectives, nominal attributes, participles, and relative clauses contribute to the information in the nominal phrase, i.e., to the second dimension. Cf. Wildgen (1999: 218f) for more details on this spatial reconstruction of the semantics of noun phrases (in French).

Nominal constructions must provide positions that fill the dimension: information and contextual (indexical) rooting (second and third dimension) and provide enough distinctions. Languages differ in how they categorize this three-dimensional semantic space of noun phrases. What is universal is not a set of grammatical categories and subcategories but the space itself and the inherent dynamics of differentiation.[25]

The morphogenetic model allows us to predict the most frequent types of differentiation under the assumption that stable differentiations have maximally three or (under special conditions) four attractors (cf. the restrictions on valences treated in

[25] It was a flaw of typological and comparative research in linguistics that it tried to use the traditional labels introduced in the grammar of classical Greek or Latin in the analysis of a corpus of different languages. Even if this list is enlarged or modified, the problem remains that a list choosing ad hoc between distinctions found in specific languages cannot be a general background of linguistic analysis. In any human language, the selection of "deep cases" and their expression results from an epigenetic process depending on the contingent, i.e., aleatory factors.

523592_1_En_6_Chapter ✓ TYPESET ☐ DISK ☐ LE ✓ CP Disp.:25/1/2023 Pages: 183 Layout: T1-Standard

Sect. 6.6). Sequences on the same level can be iterated without theoretical limits but confined by limits of memory or attention.[26]

The construction of a low-dimensional semantic space is only a starting point. First, any theorization must pass through the stage of ideal construction. At this level, morphogenesis and possible biological or cognitive determinants may be treated. Beyond this basic level, the aleatory nature of symbolic systems (see the “arbitraire du signe” in de Saussure’s sémiologie) comes to the fore, and questions of explanatory relevance become opaque or even inaccessible.

6.8 Morphogenesis on Different Scales and the Stability of Language (and Other Symbolic Forms)

The morphogenetic perspective on language described in this chapter has highlighted several layers of semiosis that must be considered. These results can be extrapolated to the morphogenesis of the symbolic forms analyzed in Chaps. 3, 4 and 5). Moreover, it seems necessary to get a picture of the relevance of morphogenesis for humans and human societies as wholes. The list of layers starts from the oldest ones, those that have governed the history of humankind for many millennia:

(a) The emergence of a phonic language with a systematic impact on world knowledge and practical control of the ambient sphere. This morphogenetic process has separated the human species (Homo sapiens) not only from its predecessors, for instance, chimpanzees, the last common ancestor of chimpanzees and humans (LCA), but also from Homo erectus who expanded from Africa to many parts of the world, Homo heidelbergensis and finally from the subspecies of Neanderthals and Denisovans that have left a genetic trace in the genome of many human populations. It remains a controversial issue if the Neanderthals and the Denisovans had linguistic capacities comparable to those of ancient Homo sapiens or even to actual human populations. The morphogenesis of language has been modeled in this book using scenarios of (iterated) bifurcation and (tentatively) the consideration of hypercycles in the sense of [21]. Such highly competitive and selective processes could explain this evolution’s speed and quasi-goal-directed nature.

(b) Beyond the pure existence of a phonic language with the capacity to code referential meaning, the morphogenetic analysis of language must explain the organization of a rich lexicon and the emergence of techniques for the composition of meanings in morphology, syntax, and discourse, i.e., the richness of human languages in all known societies. Beyond a primitive lexicon (not far from

[26] Chomsky compared this iteration to complete algebraic induction and thus argued for an algebraic modelling in syntax. In reality, the phenomenon of recursiveness in natural languages is rather due to the lack of topological constraints. Semantically an infinite series of attributes has a chaotic attractor; the meaning of the nominal construction is annihilated. Cf. my remarks on the accumulation of attributes in the characterization of God in Sect. 5.8.2.

lists of referential cues in animals, i.e., 10 to 100 items) and a "syntax" of juxtaposition comparable to two-word utterances in early childhood or primitive (ad hoc) pidgins, we assumed a process of self-organization that reduces the insecurity/instability of a syntax of juxtaposition. The transition was only possible under the assumption of a precise and rapid production and memory of phonic patterns (syllables, words, phrases) and an efficient reorganization of the growing lexicon that is analogous to human mental capacities of spatial control in locomotion, handling of objects, fundamental interactions with other animate beings. The key to such semantics of phonic utterances is constructing a semantic space stabilized by its roots in a low-dimensional semantic space (basically three dimensions). The classification theorem of catastrophe theory can explain the generality of such a restriction valid for simple structurally stable dynamical systems and their unfolding in time. The schematizations of processes, scenarios of events, and actions on this basis are restricted in the elementary case to three dimensions, and under special conditions to a fourth dimension. Beyond these limits, the stability of meaning constructions (semiosis) is endangered, and specific measures must be taken to avoid chaotic or even aleatory effects. The technique of such a reduction for the sake of stability can be observed in the analysis of case systems and similar syntactic devices (this generalization is caught under the term "deep cases" and was a central concern of grammars already in antiquity). In Sect. 6.6, some results in catastrophe theoretic semantics were summarized (avoiding the technicality of a formal model).

(c) Schematizations in the lexicon of verbs (and other relational lexical items) and sentential constructions are the third manifestation of morphogenesis in language. They must have an image-like character (a quasi-spatiality). This means that scenarios of real life with a high degree of relevance ("prégnance" in terms of René [63] must be coded in every grammar of a human language such that despite the temporal/sequential mode of phonic language, a quasi-spatial meaning can be recovered by the addressee of the utterance. This technique is the key to effective communication and opens the door for efficiency in everyday practices like language, art, music, religion, and other symbolic forms. The rich epistemic systems characteristic of human cultures in science and other symbolic systems enable humans to grasp, manage, and control their environment (including the personal and socio-political sphere).

Chapters 3, 4 and 5 show that the symbolic forms of music, art, and religion responded to building highly organized spaces of meaning that allow for creativity and the establishment of prosperous and stable traditions. These are the necessary frames for communication and innovation, whereby the traditions are consistently adapted to changing conditions. Innovations may even enforce a radical change in the traditions, mainly if these are not appropriately adapted to new conditions). Beyond such a breaking of tradition, often accompanied by destructive decisions and social conflict, two basic demands must be fulfilled: First, an amount of successful understanding between community members must be guaranteed; second, a minimal level of reliability ("reality") must be sustained. Human populations cannot survive in an illusionary or fake "reality".

Suppose we venture into a global (historical and geographical) perspective. In that case, we may consider the past of humanity and possibly its future as a morphogenetic process in which individual decisions, even those of leaders and people with a maximal concentration of influence and power, are not decisive (their effect is just a kind of small-scale variation). The history of humankind and even the time in which the earth is habitable are only insignificant spots in astrophysical processes. The maximal range of individual decisions does not exceed two or three generations; societies and empires may exist for centuries (the range of the Roman empire covers fewer than 2000 years). Ratiogenetic processes like human planning and politics have a much shorter range. What remains relatively constant is the species that may stay more or less identical for 100,000 or even a million years. In the same period, innumerable other processes occur in parallel and dramatically change the conditions of survival and subsistence.

In Chap. 5 on myth and religion, the visions of the end times and the apocalypse have been discussed. Currently, many intellectual activities concern the future of the climate on earth, the danger of global diseases, and possible scenarios of a third world war. However, such projections into the future of humanity and possible interventions to influence this evolution must consider the diversity of morphogenetic and self-organizing processes beyond the influence of human agents.

The symbolic forms considered in this book, i.e., music, art, religion, and language (possibly also further ones like ethics, technologies, and science), have a common feature: They have a kind of autonomy concerning physical, economic, and political controls. Moreover, they belong to the realm of common goods[27] accessible to everybody, like the air we respire, the water we drink, and the ground we are moving on. In this sense, they cannot be subdued to the interests of single persons or social groups. Therefore, a kind of natural evolution in concert with other natural processes cannot be suppressed or evinced. Consequently, the impact of human caprice or despotism is limited. However, this does not mean that natural processes secure the future of humanity. On the contrary, humanity may naturally disappear or destroy itself.

References

1. Allott, R.: The origin of language: the general problem. In: Wind et al. (eds) pp. 1–24 (1989)
2. Allott, R.: The motor theory of language. In: Raffler-Engler et al. (eds.) pp. 123–157 (1991)
3. Allott, R.: Motor theory of language origin: the diversity of languages. In: Wind et al. (eds.) pp. 125–160 (1994)
4. Aristotle: de Anima. Clarendon Press (ed. Shields, Ch.J.). Oxford U.P., Oxford (2016)
5. Ashby, W.R.: Principles of the self-organizing dynamic system. J. Gen. Psychol. **37**(2), 125–128 (1947)

[27] This notion was already present in the work of Aristotle. Rousseau, in his book "The Social Contract", 1762), and Adam Smith, in his book "The Wealth of Nations", 1776), have elaborated the notion in terms of modern politics and economics..

6. Ballmer, T.T., Brennenstuhl, W.: Deutsche Verben. Eine sprachanalytische Untersuchung des Deutschen Wortschatzes. Narr, Tübingen (1986)
7. Berlin, B.: Ethnobiological classification. In: Rosch, B., Lloyd, B.B. (eds.) Cognition and Categorization. Wiley, New York (1978)
8. Blackmore, S.: The Meme Machine. Oxford U.P, New York (1999)
9. Blake, B.J.: Case. Cambridge U.P., Cambridge (2001)
10. Boesch, Ch: Aspects of transmission of tool-use in wild chimpanzees. In: Gibson, K.R., Ingold, T. (eds.) Tools, pp. 171–183. Language and Cognition in Human Evolution. Cambridge U.P, Cambridge (1993)
11. Bühler, K.: Sprachtheorie. Die Darstellungsfunktion der Sprache, 2nd edn. Fischer, Stuttgart (1965)
12. Butt, M.: Theories of Case. Cambridge U.P, New York (2006)
13. Cangelosi, A., Greco, A., Harnad, St.: Symbol grounding and the symbolic theft hypothesis. In: Cangelosi A., Parisi, D. (eds)Simulating the Evolution of Language, pp. 191–210. Springer, Leipzig (2002)
14. Carnap, R., Bar-Hillel, Y.: An Outline of a Theory of Semantic Information. Reprinted in Bar-Hillel, Y.: Language and Information. Jerusalem, pp. 221–274. 1984 (1952)
15. Chomsky, N.: Syntactic Structures. Mouton, The Hague (1957)
16. Chomsky, N.: Cartesian linguistics. Harper & Row, New York (1966)
17. Chomsky, N.: Some simple evo devo yheses: how true might they be for language? In: Larson, R.K., Déprez, V., Yamakido, H. (eds.) The Evolution of Human Language, pp. 45–62. Biolinguistic Perspectives. Cambridge U.P, Cambridge (2010)
18. Comrie, B., Kuroda, T.: chapter 9, pp. 185–207. In: Tallermann, M.: Language Origins: Perspectives on Evolution. Oxford U.P., Oxford (2005)
19. Dediu, D., Lewinson, St.: The Time Frame of the Emergence of Modern Language and its Implications. In: Dor, Knight, and Lewis, pp. 184–195 (2014)
20. Dor, D., Knight Ch., Lewis, J.: The Social Origins of Language. Oxford U.P., Oxford (2014)
21. Eigen, M., Schuster, P.: The Hypercycle: A Principle of Natural Self-organization. Springer, Berlin (1979)
22. Fisher, S.E.: Evolution of language: lessons from the genome. Psychon. Bull. Rev. **24**, 34–40 (2017). https://doi.org/10.3758/s13423-016-1112-8
23. Fitch, T.W.: The Evolution of Language. Cambridge U.P, Cambridge (2010)
24. Gibson, J.J.: The Ecological Approach to Visual Perception. Houghton Mifflin, Boston (1979)
25. Gil, D.: Early Human Language was Isolating-Monocategorical-Associational (2006) http://www3.isrl.uiuc.edu/~junwang4/langev/localcopy/pdf/gil06evolang.pdf
26. Haken, H.: Synergetics. An Introduction (third revised and augmented edition). Springer, Berlin (1983)
27. Haken, H.: Principles of Brain Functioning: A Synergetic Approach to Brain Activity, Behavior, and Cognition. Springer, Berlin (1996)
28. Haspelmath, M.: Grammar of Lezgian. deGruyter, Berlin (1993)
29. Hauser, M.D., Chomsky, N.: Fitch: the language faculty: what is it, who has it, and how did it evolve? Science **89**, 1569–1579 (2002)
30. Henke, K., Reber, T.P., Duss, S.B.: Integrating events across levels of consciousness. Conscious Cogn. **21**(2), 953–960 (2012). https://doi.org/10.1016/j.concog.2012.02.013. Epub 2012 Mar 17
31. von Humboldt, W.: Über die Kawi-Sprache auf der Insel Java : nebst einer Einleitung über die Verschiedenheit des menschlichen Sprachbaues und ihren Einfluss auf die geistige Entwickelung des Menschengeschlechts. Dümmler, Berlin (1839)
32. Hurford, J.R.: Social transmission favours linguistic generalization. In: Knight et al. (chap. 19), pp. 324–352 (2000)
33. Jung, C.G.: Die Archetypen und das kollektive Unbewußte. Gesammelte Werke, vol. 9 (1) (1984)
34. Katz, J., Fodor, J.: The structure of a semantic theory. Language **39**, 170–210 (1963)

35. Kelso, J.A.S.: Dynamic Patterns: The Self-organization of Brain and Behavior MIT Press, Cambridge (Mass.) (1995)
36. Kendon, A.: The 'Polymodalic' Nature of Utterances and its Relevance for Inquiring into Language Origins. In: Dor, Knight, Lewis, pp. 67–76 (2014)
37. Kirby, S.: Syntax without natural selection: how compositionality emerges from vocabulary in a population of learners. In: Knight, Ch., Studdert-Kennedy, J M., Hurford, R. (eds.): The Evolutionary Emergence of Language. Social Functions and the Origins of Linguistic Form, , pp. 303–323. Cambridge U.P., Cambridge (2000)
38. Kosslyn, S.M.: Image and Mind. Harvard U.P, Cambridge MA (1980)
39. Labov, W.: The Boundaries of words and their meanings. In: Fishman, J. (ed.) New Ways of Analysing Variation in English, pp. 340–373. Georgetown U.P., Washington D.C. (1973)
40. Lakoff, G.: Women, Fire, and Dangerous Things: What Categories Reveal about the Mind. Chicago University Press, Chicago (1987)
41. Lakoff, G., Johnson, M.: Metaphors We Live By. Chicago U.P, Chicago (1980)
42. Levinson, S.C.: Space, Language, and Cognition: Explorations in Cognitive Diversity. Cambridge U.P., Cambridge (Mass.) (2001)
43. Lewis, J.: BaYaka Pygmy Multimodal and mimetic communication traditions. In: Dor, Knight, and Lewis, pp. 77–91 (2014)
44. McNeill, D.: Hand and Mind: What Gestures Reveal About Thought. Chicago U.P, Chicago (1992)
45. Orban, G.A.: Neuronal Operations in the Visual Cortex. Springer, Berlin (1984)
46. Osgood, Ch. E., Suci, G.J., Tannenbaum, P.H.: The Measurement of Meaning. Urbana (1957)
47. Petitot, J.: Morphogenèse du sens, Presses Universitaires de France, Paris. (1985) [English translation: Morphogenesis of Meaning. Lang, Bern (2004)]
48. Petitot, J.: Physique du sens. De la théorie des singularités aux structures sémio-narratives. Éditions du CNRS, Paris (1992)
49. Petitot, J.: Cognitive Morphodynamics: Dynamical Morphological Models of Constituency in Perception and Syntax, Peter Lang, Bern (2011)
50. Petitot, J.: Neurogéométrie de la vision. Les Éditions de l'École Polytechnique, Paris (2008) English translation : Elements of Neurogeometry: Functional Architectures of Vision (Lecture Notes in Morphogenesis). Cham, Springer (2018)
51. Rizzolatti, G., Arbib, M.A.: Language within our grasp. Trends Neurosci. **21**(5), 188–194 (1998)
52. Rosch-Heider, E., Olivier, D.C.: The structure of the color space in naming and memory for two languages. Cogn. Psychol. **3**, 337–354 (1972)
53. Seiler, H.: La dynamique dans la dimension de la possessivité. In Petitot, J. (ed.): Logos et théorie des catastrophes. À partir de l'œuvre de René Thom, pp. 409–418. Geneva, Editions Patiño (1988)
54. Starck, D.: Stammesgeschichtliche Voraussetzungen der Entwicklung der menschlichen Sprache. Nova Acta Leopoldina N.V. 54 (245), 581–596 (1981)
55. Steels, L.: Grounding symbols through evolutionary language games. In: Cangelosi, A., Parisi, D. (eds.) Simulating the Evolution of Language, pp. 211–226. Springer, London (2002)
56. Steels, L.: Breaking down False Barriers to Understanding. In: Dor, D., Knight Ch., Lewis, J. (eds) The Social Origins of Language, pp. 336–339. Oxford U.P., Oxford (2014)
57. Studdert-Kennedy, M.: Evolutionary implications of the particulate principle: imitation and the dissociation of phonetic form from semantic function.In: Knight, Ch., Studdert-Kennedy, J M., Hurford, R. (eds.) The Evolutionary Emergence of Language. Social Functions and the Origins of Linguistic Form, , pp. 161–176. Cambridge U.P., Cambridge (2000)
58. Timmermann, A. et al.: Climate effects on archaic human habitats and species successions. Nature **604** (2021)
59. Thom, R.: Stabilité structurelle et morphogenèse, Interéditions, Paris (English translation: Structural stability and morphogenesis. Benjamin, Reading, 1975) (1972)
60. Thom, R.: La linguistique, discipline morphologique exemplaire. Critique **30**(1), 235–245 (1974)

61. Thom, R.: La double dimension de la grammaire universelle. In: Seiler H-J. (ed.) Language Universals. Papers from the Conference held at Gummersbach. Narr, Tübingen, pp. 79–87 (1978)
62. Thom, R.: Modèles mathématiques de la morphogenèse, Union Générale des Éditions, Paris, 1974. (English translation: Mathematical Models of Morphogenesis. Horwood (Wiley), New York, 1983) (1974/1983)
63. Thom, R.: Esquisse d'une sémiophysique: Physique aristotélienne et théorie des catastrophes. Interéditions, Paris [English translation: Semiophysics. A Sketch. Addison-Wesley, Boston 1990] (1988)
64. Thom, R.: Apologie du Logos. Hachette, Paris (1990)
65. Wiener, N.: Cybernetics: Or Control and Communication in the Animal and the Machine. Hermann & Cie, Paris & MIT Press, Camb. Mass (1951)
66. Wildgen, W.: Differentielle Linguistik, Entwurf eines Modells zur Beschreibung und Messung semantischer und pragmatischer Variation. Niemeyer, Tübingen. [Differential Linguistics. A Model for the Description and Measurement of Semantic and Pragmatic Variation] (1977)
67. Wildgen, W.: Catastrophe Theoretic Semantics: An Elaboration and Application of René Thom's Theory. Benjamins, Amsterdam (1982)
68. Wildgen, W.: Goethe als Wegbereiter einer universalen Morphologie (unter besonderer Berücksichtigung der Sprachform). In: Jahresbericht des Präsidenten 1982, University of Bayreuth, pp. 235–277 (1983)
69. Wildgen, W.: Archetypensemantik. Grundlagen einer dynamischen Semantik auf der Basis der Katastrophentheorie. Narr, Tübingen (1985a)
70. Wildgen, W.: Dynamische Sprach- und Weltauffassungen (in ihrer Entwicklung von der Antike bis zur Gegenwart. Universitätsverlag, Bremen. academia.edu (1985b)
71. Wildgen, W.: Das dynamische Paradigma in der Linguistik .[The Dynamical Paradigm in Linguistics], electronic version of part 1 in: Wildgen and Mottron Dynamische Sprachtheorie. Sprachbeschreibung und Spracherklärung nach den Prinzipien der Selbstorganisation und der Morphogenese, Brockmeyer, Bochum. [Dynamic Theory of Language. Linguistic Description and Explanation Following the Principles of Self-Organization and Morphogenesis] (1987) https://elib.suub.uni-bremen.de/ip/docs/00010028.pdf (1987/2005)
72. Wildgen, W.: Process, Image, and Meaning. A Realistic Model of the Meanings of Sentences and Narrative Text. Benjamins, Amsterdam (1994)
73. Wildgen, W. : De la grammaire au discours. Une approche morphodynamique. Bern, Peter Lang [From Grammar to Discourse. A Morphodynamic Aproach] (1999)
74. Wildgen, W.: The Evolution of Human Languages, Scenarios, Principles, and Cultural Dynamics, Benjamins, Amsterdam (2004a)
75. Wildgen, W.: The paleolithic origins of art, its dynamic and topological aspects, and the transition to writing. In: Bax, van Heusden, Wildgen (eds.) Semiotic Evolution and the Dynamics of Culture, pp.117–153. Lang, Bern (2004b)
76. Wildgen, W.: Kognitive Grammatik: Klassische Paradigmen und neue Perspektiven. de Gruyter, Berlin (2008a)
77. Wildgen, W.: Semiotic hypercycles driving the evolution of language. Axiomathes **18**(1), 91–116 (2008b)
78. Wildgen, W.: Sketch of an evolutionary grammar based on comparative biolinguistics. In: Röska-Hardy, L.S., Neumann-Held, E.M. (eds.) Learning from Animals? Examining the Nature of Human Uniqueness, pp. 45–59. Psychology Press. Hove and New York (2009)
79. Wildgen, W.: Language evolution as a cascade of behavioral bifurcations. ELUA **26**, 359–382 (2012)
80. Wildgen, W.: The cultural individuation of human language capacity and the morphogenesis of basic argument-schemata. In: Sarti, A., Montanari, F., Galofaro, F. (eds.) Morphogenesis and Individuation, pp. 93–110. Springer, Berlin (2015)
81. Wildgen, W.: En cas de catastrophe. Les systèmes casuels et la dynamique qualitative. Estudos Semióticos **13**(1), 1–15 (2017). https://www.revistas.usp.br/esse/article/download/138414/133874

82. Wildgen, W.: The dynamics of human symbolic behavior: language, visual art, and music. In: Lear, A., Street, M. (eds.) Art and Music. Past, Present, and Future Perspectives, chapter 2, pp. 32–64. Nova Publishers, New York (2018) http://www.fb10.uni-bremen.de/homepages/wildgen/pdf/THE_DYNAMICS_OF_HUMAN_SYMBOLIC_BEHAVIOR.pdf (2018)
83. Zadeh, L.A.: Fuzzy sets. Inf. Control **8**(3), 338–353 (1965) https://web.archive.org/web/20150813153834/http:/www.cs.berkeley.edu/~zadeh/papers/Fuzzy%20Sets-Information%20and%20Control-1965.pdf
84. Zeeman, Ch.: Catastrophe Theory: Selected Papers 1972–1977. Addison-Wesley, Cambridge (Mass) (1977)

Author Queries

Chapter 6

Query Refs.	Details Required	Author's response
AQ1	Please check and confirm if the inserted citation of Figs. 6.3, 6.8, 6.9 and 6.11 are correct. If not, please suggest an alternate citation. Please note that figures should be cited sequentially in the text.	
AQ2	References Corballis (2009), Dunbar (1997), Fillmore et al. (1987), Goldberg (1985) and Wildgen (1993) are cited in the text but not provided in the reference list. Please provide the respective references in the list or delete these citations.	
AQ3	References [4, 14, 32, 40, 52, 62, 66, 82, 84] are given in the list but not cited in the text. Please cite them in text or delete them from the list.	